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REPORT

OF THE

ISTHMIAN CANAL COMMISSION,

1899-1901.

REAR-ADMIRAL JOHN G. WALKER,
UNITED STATES NAVY,
President.

HON. SAMUEL PASCO.
MR. GEORGE S. MORISON.
LIEUT. COL. OSWALD H. ERNST,
Corps of Engineers, U. S. Army.
LEWIS M. HAUPT, C. E.
ALFRED NOBLE, C. E.
COL. PETER C. HAINS,
Corps of Engineers, U. S. Army.
WILLIAM H. BURR, C. E.
PROF. EMORY R. JOHNSON.

LIEUT. COMMANDER SIDNEY A. STAUNTON,
UNITED STATES NAVY,
Secretary.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1901.

To the Congress of the United States:

I transmit herewith the report, with appendices in three parts, of the Isthmian Canal Commission, established under section 4 of the river and harbor act, approved March 3, 1899, of its investigations made in pursuance of section 3 of said act.

THEODORE ROOSEVELT.

WHITE HOUSE, *December 4, 1901.*

DEPARTMENT OF STATE,
Washington, November 30, 1901.

SIR: I have the honor to transmit the Report of the Isthmian Canal Commission, with appendices in three parts, all in duplicate, accompanied by one set of maps, profiles, and illustrations, which have this day been delivered at this Department by Rear-Admiral John G. Walker, president of the Commission.

I am, sir, your obedient servant,

JOHN HAY.

The PRESIDENT.

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PLATES.

AN ACT Making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That * * *

SEC. 3. That the President of the United States of America be, and he is hereby, authorized and empowered to make full and complete investigation of the Isthmus of Panama with a view to the construction of a canal by the United States across the same to connect the Atlantic and Pacific oceans; that the President is authorized to make investigation of any and all practicable routes for a canal across said Isthmus of Panama, and particularly to investigate the two routes known respectively as the Nicaraguan route and the Panama route, with a view to determining the most practicable and feasible route for such canal, together with the proximate and probable cost of constructing a canal at each of two or more of said routes; and the President is further authorized to investigate and ascertain what rights, privileges, and franchises, if any, may be held and owned by any corporations, associations, or individuals, and what work, if any, has been done by such corporations, associations, or individuals in the construction of a canal at either or any of said routes, and particularly at the so-called Nicaraguan and Panama routes, respectively; and likewise to ascertain the cost of purchasing all of the rights, privileges, and franchises held and owned by any such corporations, associations, and individuals in any and all of such routes, particularly the said Nicaraguan route and the said Panama route; and likewise to ascertain the probable or proximate cost of constructing a suitable harbor at each of the termini of said canal, with the probable annual cost of maintenance of said harbors, respectively; and generally the President is authorized to make such full and complete investigation as to determine the most feasible and practicable route across said isthmus for a canal, together with the cost of constructing the same and placing the same under the control, management, and ownership of the United States.

SEC. 4. To enable the President to make the investigations and ascertainments herein provided for, he is hereby authorized to employ in said service any of the engineers of the United States Army at his discretion, and likewise to employ any engineers in civil life, at his discretion, and any other persons necessary to make such investigation, and to fix the compensation of any and all of such engineers and other persons.

SEC. 5. For the purpose of defraying the expenses necessary to be incurred in making the investigations herein provided for, there is hereby appropriated, out of any money in the Treasury not otherwise appropriated, the sum of one million dollars, or so much thereof as may be necessary, to be disbursed by order of the President.

SEC. 6. That the President is hereby requested to report to Congress the results of such investigations, together with his recommendations in the premises.

* * * * * * *

Approved, March 3, 1899.

DEPARTMENT OF STATE,
Washington, June 10, 1899.

Rear-Admiral JOHN G. WALKER, U. S. N., retired,
Member of the Interoceanic Canal Commission appointed under sections 3 and 4 of the act of Congress approved March 3, 1899.

SIR: The Congress of the United States passed at its recent session, and the President, on the 3d of March, 1899, approved, "An act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," the third, fourth, and sixth sections of which read as follows:

SEC. 3. That the President of the United States of America be, and he is hereby, authorized and empowered to make full and complete investigation of the Isthmus of Panama with a view to the construction of a canal by the United States across the same to connect the Atlantic and Pacific oceans; that the President is authorized to make investigation of any and all practicable routes for a canal across said Isthmus of Panama, and particularly to investigate the two routes known, respectively, as the Nicaraguan route and the Panama route, with a view to determining the most practicable and feasible route for such canal, together with the proximate and probable cost of constructing a canal at each of two or more of said routes; and the President is further authorized to investigate and ascertain what rights, privileges, and franchises, if any, may be held and owned by any corporations, associations, or individuals, and what work, if any, has been done by such corporations, associations, or individuals in the construction of a canal at either or any of said routes, and particularly at the so-called Nicaraguan and Panama routes, respectively; and likewise to ascertain the cost of purchasing all of the rights, privileges, and franchises held and owned by any such corporations, associations, and individuals in any and all of such routes, particularly the said Nicaraguan route and the said Panama route, and likewise to ascertain the probable or proximate cost of constructing a suitable harbor at each of the termini of said canal, with the probable annual cost of maintenance of said harbors, respectively. And generally the President is authorized to make such full and complete investigation as to determine the most feasible and practicable route across said isthmus for a canal, together with the cost of constructing the same and placing the same under the control, management, and ownership of the United States.

SEC. 4. To enable the President to make the investigations and ascertainments herein provided for, he is hereby authorized to employ in said service any of the engineers of the United States Army at his discretion, and likewise to employ any engineers in civil life, at his discretion, and any other persons necessary to make such investigation, and to fix the compensation of any and all such engineers and other persons.

SEC. 6. That the President is hereby requested to report to Congress the results of such investigations, together with his recommendations in the premises.

The President, in pursuance of the provisions of this act, has appointed you one of the members of the Isthmian Canal Commission provided for in it. You will be guided in the execution of the trust thus confided to you by the provisions of the act of Congress which I have quoted above, and your eminence in your profession is a sufficient guaranty of the energy and ability which the President is sure you will bring to the accomplishment of this task. At the same time your duties will not be limited by the terms of the act, but if any line of inquiry should suggest itself to you in the course of your work as being of interest or benefit, I am confident you will not fail to give it whatever attention it may seem to deserve. The President trusts that the Commission will fulfill the important duties confided to them in such a manner that when their report is prepared it will embrace all the elements required for his own guidance and for the final action of Congress upon the subject of the location and construction of the interoceanic canal.

I am, sir, with great respect, your obedient servant,

JOHN HAY.

ORGANIZATION OF COMMISSION BY COMMITTEES, THE PRESIDENT BEING EX OFFICIO A MEMBER OF EACH COMMITTEE.

For the investigation of the Nicaragua route:
- Mr. Noble.
- Mr. Burr.
- Colonel Hains.

For the investigation of the Panama route:
- Mr. Burr.
- Mr. Morison.
- Lieutenant-Colonel Ernst.

For the investigation of other possible routes:
- Mr. Morison.
- Mr. Noble.
- Colonel Hains.

For the investigation of the industrial, commercial, and military value of an interoceanic canal:
- Mr. Johnson.
- Mr. Haupt.
- Mr. Pasco.

For the investigation of rights, privileges, and franchises:
- Mr. Pascoe.
- Lieutenant-Colonel Ernst.
- Mr Johnson.

Department of State,
Isthmian Canal Commission,
Washington, D. C., November 16, 1901.

The President of the United States.

Sir: The Isthmian Canal Commission having completed the investigations with which it was charged under the act of Congress approved March 3, 1899, and your instructions thereunder, communicated through the Secretary of State by letter of June 10, 1899, has the honor to submit the following report:

Chapter I.

INTRODUCTION.

Organization of Commission.

The Commission was organized in the city of Washington, with Rear-Admiral John G. Walker as president, on the 15th day of June, 1899, and at a subsequent meeting, held on the 6th day of July, Lieut. Commander Sidney A. Staunton, of the United States Navy, was chosen as secretary. It at once entered upon its duties, taking as a guide the sections of the act of Congress entitled "An act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," approved March 3, 1899, under which its members were appointed, and also the instructions communicated to them by the Secretary of State in his letter of June 10, 1899.

Law.

Instructions.

The investigations and ascertainments provided for in the law involved many different lines of inquiry, and in order to promote the progress of the work and procure the best results it was divided among several committees, each of which was to take the lead in examining the particular subject intrusted to it; but before entering upon its special work each committee was to prepare an outline of its plan of investigation and submit it to the Commission for amendment or approval. The acts and conclusions of these committees were to be reported to the Commission, subject to modification and amendment before approval and adoption, so that the final results and determinations represent not only the views and opinions of the several committees, but of the entire Commission.

Committees.

Subjects of investigation.

The following subjects of investigation were then determined upon, and each was referred to a separate committee, to be designated accordingly:

The Nicaragua route.

The Panama route.

Other possible routes.

The industrial, commercial, and military value of an interoceanic canal.

Rights, privileges, and franchises.

The president of the Commission was made ex officio a member of each of these committees.

Appointment of chief engineers.

The two canal routes to which the attention of the Commission was specially directed by the law were in Nicaragua and Panama, and a chief engineer was appointed for each, to make his headquarters in the country and take the general control of the field operations to be inaugurated upon each line.

After considering the results of surveys made in the past, it was judged best to limit the explorations in the search for other possible routes to that part of Colombia known as Darien, extending from Panama to the Atrato River, and a third chief engineer was appointed to direct the field work there.

Employment of assistants and laborers.

Competent assistants, whose education and training had fitted them for the special work to be done, were assigned to service under the chief engineers, and laborers, boatmen, and other workmen were employed wherever their services were required. In all 20 working parties were organized in Nicaragua, with 159 engineers and other assistants and 455 laborers; 5 in Panama, with 20 engineers and other assistants and 41 laborers; and 6 in Darien, with 54 engineers and other assistants and 112 laborers, making a total force of about 850, the number varying from time to time according to the requirements of the work.

Directions for the work.

The chief engineers were directed, with the aid of these working parties, to examine the geography, topography, hydrology, and other physical features of the different countries and to make a special study of the routes in Nicaragua and Panama. The schemes already planned were to be thoroughly tested and further surveys were to be made, in order to vary the line and select better locations wherever the conditions were found to be unsatisfactory. A complete project was to be prepared for each route and the center line of a canal was to be marked upon the ground where it had not already been done. The cost of a canal in each country, according to these projects, could then be closely approximated, the advantages of each be compared, and an intelligent conclusion be reached as to which of the two routes is the more desirable from an engineering standpoint.

This study involved examinations of the terminal harbors and approaches and the locations selected for dams, locks, and other auxiliary works; a series of borings to determine the nature of the subsurface material at the sites for locks and dams and along the canal lines, and a continuance of the observations of rainfall and stream flow, and of the lake fluctuations in Nicaragua. Attention was also to be given to the supply of rock, timber, and other materials in each country available for purposes of construction and maintenance.

The results of these examinations and observations and the data and material obtained were sent from time to time to the headquarters of the Commission at Washington, where they were arranged and entered upon the plats and profiles of the canals, under the direction of the committees, for examination and consideration in reaching their conclusions and making their recommendations.

Visit to Paris.

On the 9th of August, 1899, the Commission left New York for Paris, where the New Panama Canal Company opened to its members its records, maps, plans, and profiles, and the results of the surveys made and the data collected by it and the old Panama Canal Company. Mr. Maurice Hutin, the director-general, Mr. L. Choron, the chief engineer, and other officers of the company received the commissioners with great courtesy and were ready at all times to assist them in making a study of this route in all its aspects. A special meeting of the Comité Technique was also called to give the commissioners such oral explanations as they might desire, some of its members coming from distant parts of Europe for the purpose.

Other visits while in Europe.

While in Europe the Commission also visited and examined the Kiel Canal in Germany, the North Sea Canal in Holland, and the Manchester Canal and Liverpool docks in England and returned to New York on the 29th of September.

Visit to Central and South America.

In accordance with the plan of investigation determined upon, a visit was afterwards made by the Commissioners to Central and South America. The purposes of this visit were to make a personal inspection of the entire canal lines in Nicaragua and Panama, examine the work already done by the parties in the field, give instructions as to its continuance, familiarize themselves with the local surroundings and physical features of the sections in which these routes are located, and gather such information as would promote the object for which the Commission was organized.

Nicaragua.

They left New York on the 6th of January, 1900, for Greytown, Nicaragua. After spending a week in inspecting the harbor, the coast line near the eastern terminus of the canal, the work commenced by the Maritime Canal Company of Nicaragua, and the dredges, railroad plant, and other property it had left there, they passed over the canal line from the mouth of the San Juan to Brito on the Pacific, stopping at the locations selected or deemed suitable for dams, locks, and other auxiliary works, and at other points where a careful examination was desirable, and making detours from the main line when necessary. From Brito they returned to the lake and proceeded to Managua, the capital, where they had several interviews with President Zelaya, with reference to the construction of a navigable canal through Nicaraguan territory by the United States. They were cordially welcomed by the President, and he expressed himself favorably with reference to the proposed maritime communication. They went from Managua to Corinto, and there took a steamer for Panama, where they arrived on the 3d of March.

Managua.

Panama.

As the disturbed conditions in Colombia rendered it inadvisable for the Commission to attempt to meet the President at Bogota, the State Department, at the request of this Commission, communicated with the Colombian authorities through the United States minister there and asked that a representative of the Government be appointed to meet the commissioners when they reached the country and give them such information and assistance relative to their mission as he conveniently could. In accordance with this request Mr. J. T. Ford, the consulting engineer of the Republic in technical matters connected with the Panama Canal, was assigned to this duty. He met them in this official capacity on their arrival at Panama, courteously expressed an entire willingness to aid them in their investigations, and accompanied them from day to day upon their visits to different points upon the canal line and elsewhere during their stay upon the isthmus.

Fifteen days were spent in the department of Panama, during which an investigation of the route from sea to sea was made, as had been done in Nicaragua. The work was greatly facilitated by the local officers of the New Panama Canal Company, who placed two houses in Colon at the service of the commissioners, furnished a special train each day to take them from point to point as the work progressed, permitted them to use their maps and plans, informed them as to the work then going on, accompanied them in their inspection of the line, and exhibited to them the plant and materials purchased by the old canal company for construction purposes, much of which was stored in sheds and warehouses at different points on the isthmus. During this period the commissioners went over the entire line of the canal from Colon to Panama, and examined the sites for the different auxiliary works. This included a trip to the upper waters of the Chagres, in the Alhajuela region, and they returned in boats, so as to have an opportunity of seeing the river.

The Commission is indebted to Mr. Louis Royer, director on the isthmus of the New Panama Canal Company, and to Col. J. R. Shaler, superintendent of the Panama Railroad Company, for courteous attentions.

Visit of Mr. Morison to Darien.

On the 16th of March Mr. George S. Morison left the party on the U. S. S. *Scorpion* to ascertain the progress of the explorations in Darien, with full authority to give instructions as to the continuance of the work according to the conditions which he might find upon reaching the camps of the different working parties. The *Scorpion* had been assigned by the Navy Department to aid in the search for other possible routes in Darien, and was commanded by Lieut. Commander Nathan Sargent, United States Navy, who rendered valuable assistance in the explorations made in that section, and met the responsibilities which rested upon him creditably and successfully.

The Scorpion.

Costa Rica.

San José.

From Colon the majority of the commissioners went to Limon, in Costa Rica. Here a special train was placed at their disposal to convey them to San José, the capital. During the week that they spent in this city they conferred freely with President Iglesias upon the subject of an interoceanic canal and the use of the territory of the Republic, as far as necessary, in case the United States should desire to use the Nicaragua route. The President manifested a deep interest in the canal project and expressed the hope that it would be successfully accomplished.

In the absence of Mr. William L. Merry, envoy extraordinary and minister plenipotentiary, accredited to Nicaragua as well as to Costa Rica, the Commission was greatly aided in accomplishing the purposes of its visits at San José by Mr. Rufus A. Lane, secretary of legation and chargé d'affaires, and at Managua by Mr. Chester Donaldson, United States consul. The members of the Commission are also indebted to these gentlemen for many personal courtesies which were highly appreciated.

Dimensions and unit prices.

After returning to the United States, the Commission took up for consideration certain questions relating to canal construction, which had to be determined before completing the projects, preparing the plans, and making the calculations and estimates for the principal work at each route and its auxiliaries. The most important of these were the dimensions of such a canal as was contemplated, its locks and other works, the best method of constructing the dams and the materials to be used, and the unit prices of work and materials. The settlement of these questions required a knowledge not only of vessels then in use but of those which were being constructed and planned, so as to form a correct judgment as to what the shipping interests will demand by the time a canal can be completed; also the cost of excavating and removing vast quantities of earth and rock, at different depths and under different conditions, by using the most satisfactory methods and the latest improvements and inventions in machinery. The conclusions reached were used in making the subsequent plans, computations, and estimates.

Other questions considered.

Besides these questions of a preliminary character, which related to the engineering features of the canals, there were others which had to be considered. Among them were the treaty relations which the Republics, within whose boundaries these canal routes are situated, hold toward the United States and other powers; the grants and concessions made by them to corporations, associations, and individuals, and the cost of purchasing those still in force; the industrial and military value of an interoceanic canal; the cost of operation and maintenance at each route; also the liability of seismic and other disturbances in the isthmian country and their probable effect upon a canal and its auxiliary works when completed and in operation.

Visit of Mr. Noble to Nicaragua.

A second visit was made to Nicaragua by Mr. Alfred Noble to make some special examinations, inspect the work of the parties in the field, and give them such further information as he deemed proper. He left New York February 16, 1901, and returned March 26.

The different working parties were disbanded as they finished their work, the laborers were at once discharged, and the engineers and other assistants were brought back to the United States, where some of them have since been employed in office work in Washington under the direction of the Commission. The field work was not completed till June, 1901, when the last detachment of assistants returned from Nicaragua.

Results.

The results of all these investigations and the final conclusions of the Commission are embraced in different chapters of this report. In order that these chapters may not be incumbered with matter which is useful mainly for reference, verification, and special study, many of the papers, documents, treaties, concessions, grants, special reports, and discussions mentioned in the text are attached as appendixes and are appropriately designated so that easy reference may be made to them when their examination is desired.

Appendixes.

Special report on industrial and commercial value of canal.

In order to present a fuller view of the industrial and commercial value of an isthmian canal than could be conveniently done within the limits of the report of the Commission, Prof. Emory R. Johnson, a member of the Commission, whose previous studies had qualified him to deal with these questions, was requested to make a thorough investigation of this subject and present the results in a special report. This has been done, and it is submitted in connection with this report, accompanied by appropriate charts and diagrams.

Maps, etc.

The report is also accompanied by maps of the canal routes and the countries where they are located, charts of the terminal harbors, plans and profiles of the projects, sketches and views taken at different points along and in the vicinity of the canal lines, and diagrams and other representations for purposes of description and explanation.

History.

A chapter has also been included, giving a history of the early efforts to find a waterway to the Orient, of the transit routes used and established across the American isthmus, when no strait could be found there connecting the Atlantic and Pacific oceans, and of the different plans for establishing an artificial maritime communication.

The explorations and researches of the past have developed the projects which now exist, and it is believed that this account will add to the value and completeness of the report and be in harmony with the purposes of the investigation.

Chapter II.

HISTORY OF INTEROCEANIC PROJECTS AND COMMUNICATIONS.

During the fifteenth century the subject of a maritime communication with the countries and people in the far East engaged the earnest attention of many enterprising and thoughtful men in the European States bordering upon the Mediterranean Sea and the Atlantic Ocean in the belief and expectation that a more direct route to those distant lands would result in greatly increasing the interchange of productions which had for many centuries contributed to the wealth of the Western nations, notwithstanding the difficulties and disadvantages under which commercial intercourse had been maintained.

During this period the art of navigation was largely and continuously developed, the mariner's compass was evolved from the electric needle, the properties of which had long been known, rough instruments were devised for ascertaining and determining the position of vessels upon the great deep, and the mariner began to venture beyond the sight of familiar landmarks; the Portuguese resolutely pushed forward their explorations southward along and near the west side of Africa, new capes and headlands and river mouths were passed, and islands and groups of islands distant from the coast line were discovered, some by those who were driven from their course, others by the more daring who steered from the land and risked for a while the dangers of the open sea. The diffusion of the geographic knowledge thus gained and the constant improvement in nautical appliances and charts inspired increased confidence in the theory of the maritime communication and its ultimate discovery, and, in the latter part of the century, brave navigators and seamen voluntarily entered upon long voyages, through untried seas, in search of new pathways, eastward and westward, to India, China, and the spice islands, under the patronage of enlightened monarchs, who, in addition to their desire to advance the commercial interests of their people, hoped and expected that new possessions, abounding in wealth, would be added to their dominions.

Early voyages.

It is claimed that Africa had been circumnavigated and was known to be a great peninsula many centuries before the Christian era. Herodotus states that Pharaoh Necho, who reigned in Egypt from 616 to 600 B. C., sent out an expedition from the Red Sea to explore its coast, which passed around the continent, sailed through the Straits of Gibraltar, and in the third year returned to Egypt by the Mediterranean. But the evidence upon which this and other early voyages rest is scarcely more than traditional and they left no permanent impressions and were followed by no practical results.

Portuguese explorations along the African coast.

But if there was a sea route to India eastward it was surely in this direction, and the Portuguese had been persistent in their efforts to discover it. By 1486 their explorations along the west coast of Africa had extended to about the twentieth degree of south latitude. In 1487 an expedition was sent out by John II, under the command of Bartholemew Dias, to continue the explorations until the southern point of the continent should be reached. Near Cape Voltas, on the southern bank of Orange River, he met tempestuous weather and was driven far below the cape of which he was in search without seeing it. When he regained the land he advanced easterly as far as a point he named Santa Cruz, near Algoa Bay, where he raised a stone cross, as had been done at other points along the coast, in proof of the fact that he claimed the country for his king. The cape was not seen till he sailed homeward, and in memory of the trying circumstances under which he had gone by it on the outward voyage he named it the Stormy Cape, but King John, in full belief that the gateway to the East was now open, directed that it should be called the Cape of Good Hope.

Cape of Good Hope discovered.

Notwithstanding the general rejoicing over the successful voyage made by Dias, this hope was not realized till eleven years later. Various causes delayed the sending out of another expedition, but at length Vasco de Gama sailed with four vessels to follow up the results already obtained and, if practicable, to proceed to the eastern countries. He left Lisbon July 8, 1497, passed safely around the southernmost point of Africa, crossed the Indian Ocean, touching at various points on his way, and on the 17th of May, 1498, sighted the high land on the coast of India. Three days later he anchored his fleet before Calicut on the Malibar coast. After an eventful voyage he returned to Portugal in August or September, 1499, and was received with distinguished honors and magnificent displays. Two of his vessels and more than half of his men had been lost, but the great problem of opening a maritime communication with the eastern countries had been solved and the most sanguine expectations that had been indulged in were more than realized.

First voyage around Africa to India.

Results of maritime communication with Orient.

Portugal improved the opportunities which this great discovery opened; other expeditions were sent by this new route to the Orient; every sea was entered and every coast explored; she planted her colonies and trading stations wherever desirable locations were found; her arms were everywhere triumphant; her ships opened and maintained a lucrative commerce with India, China, and the Spice Islands. This commerce stimulated her home industries and brought vast wealth to the Kingdom, and for nearly half a century she enjoyed wonderful prosperity and power and held a foremost place among the nations of Europe.

Columbus.

But before the discovery of the eastern communication had been completed the studies of Columbus had convinced him that the same countries could be more speedily reached by sailing westward. He had no correct idea of the size of the world nor of the distance from Europe to the Asiatic coast and the neighboring islands, but supposed that it was several thousand miles less than it afterwards proved to be. He reached this conclusion from the delineations upon the rude maps of the world then in existence, based upon actual geographic knowledge when it was available, and when it was wanting upon hearsay and imagination and conjecture.

When he embarked, under the auspices of Ferdinand and Isabella, at Palos on the 3d day of August, 1492, upon the voyage which resulted in the discovery of America, it was with the confident expectation that a favorable result would carry him to the eastern shores of the Old World or to some island in those regions which might lie across the track of his vessels. He was therefore not disappointed when he discovered island after island but not the mainland, and he believed that by sailing beyond these the continent could be found. When upon his second voyage he passed along the southern coast of Cuba, in 1494, he announced that it was some part of the Old World far remote from Europe, and his officers and crew joined in certifying their belief in this opinion. When he felt obliged to turn back, he still believed that if he could continue his voyage in the same direction some port would in the end be reached whence he could communicate with the Grand Khan of Tartary, to whom Ferdinand had given him letters. On his third voyage, in 1498, he discovered South America, near the delta of the Orinoco. He named it Tierra Firma and regarded it as another part of the Asiatic continent. When he left Spain in 1502, on his fourth and last voyage, his intention was to go still farther westward and endeavor to find a strait that would lead to India. He would thus complete his great discovery and demonstrate the correctness of the theories upon which his expeditions had been undertaken. He reached Honduras and followed the coast line to Darien, but long-continued and severe storms, the hostile attitude of the Indians, and the discouragement of his followers interfered with his plans and progress, and with sorrow and regret he turned toward Hispaniola with his shattered ships before he had accomplished the long-hoped-for result, in which, however, his faith had not abated. When he died, on the 26th day of May, 1506, he was still fully satisfied that his discoveries were in the eastern part of the Old World and never fully realized the extent and grandeur of his achievements.

Other expeditions westward for discovery.

The success of these voyages aroused the activity of other nations, and England, France, and Portugal vied with Spain in this field of enterprise and adventure. Each expedition returned with reports of additional discoveries, northward and southward, from Labrador to Brazil, but no strait was found which opened a way to the Asiatic coast, and it began to be realized that these newly found islands and countries did not belong to the Eastern continent, but that a new world had been discovered.

Balboa discovers the Pacific.

Strong confirmatory proof in support of this view was afforded in September, 1513, by Vasco Nuñez de Balboa, then governor of a province in Darien known as Castilla del Oro. The Indians had told him of a great sea beyond the mountains, and he determined to organize an expedition and go in search of it. He crossed from Santa Maria de la Antigua, the capital of his province, a city founded in 1509 or 1510, near the Atrato River, to a point near Caledonia Bay, where Acla was afterwards built; thence he proceeded with a considerable force of Spaniards and Indians across the divide, and on the 25th day of the month reached a high ridge above the gulf which he named San Miguel. Advancing beyond his companions to a favorable elevation, he was the first European to behold the great ocean to the south, which he called the South Sea, from the direction in which he viewed it. The march was continued to the coast, and four days later he entered the sea and with great ceremony claimed it by the right of discovery for his royal master, the King of Spain.

Before the news of this great achievement reached the King, Balboa had been superseded as governor, through the efforts of his enemies, by Pedro Arias de Avila, better known as Pedrarias. This was a bitter disappointment to him, for the Indians had told him when he crossed the isthmus of a rich country to the south, abounding in the precious metals, and he had planned the construction of a fleet to navigate the new sea, confident of his ability to discover this country and make himself master of its wealth. The accomplishment of these results twenty years later by Pizarro, who was with Balboa upon his famous expedition, shows that his plans and expectations were not unreasonable.

Balboa hears from Indians of gold southward.

Plans expedition southward for gold.

When Ferdinand received the report that a great sea, beyond his possessions in the new world, had been added to his empire he desired to recognize the importance of the event by bestowing suitable honors upon the discoverer, but was not willing to restore him to the governorship. The reward came in 1515, when Balboa was appointed adelantado of the

Southern Sea and captain-general, but these distinctions were to be enjoyed under the supervision of Pedrarias as his superior. In the following year the adelantado obtained the consent of the governor to enter upon the long desired voyage and he established his headquarters on the north side of Caledonia Bay, at his former starting point, where he laid out the town of Acla. The expedition required ships on the opposite side of the isthmus and he undertook their construction.

Transports material for ships across isthmus.

Suitable trees were abundant only on the Atlantic side, and he conceived the project of preparing all his materials there and transporting them over the mountain range on the backs of Indians, to be put together at some navigable point on one of the streams flowing into the waters of the South Sea. The place selected was on a river, then called Rio de las Balsas, or River of the Rafts, probably the same as the Savana, though the authorities are not agreed. Thousands of Indians were brought together from all directions, materials for four brigantines were prepared, and the work was carried forward under merciless taskmasters, Spaniards and negroes. When the builders began to put the timbers together, many of them were found to be worm-eaten, and a new lot had to be prepared; then a tempest arose, and the deluging rains swept away the materials and buried them with mud in the swamps and low grounds. Balboa with unshaken resolution sent out the woodcutters again, and dispatched parties for fresh supplies of provisions, and others to forage on the natives to satisfy the immediate wants of his force.

Toil and suffering of Indians.

For months the Indians continued their unaccustomed toil, through swamps, across streams, over mountain heights, ill fed, under a tropical sun, and if made desperate by their hardships and sufferings any tried to escape bloodhounds were put on their tracks.

Transit of isthmus.

Bishop Quevado testified before the Spanish court that 500 poor wretches perished in this work, while Las Casas says the deaths were nearer 2,000 in number. But the undertaking was accomplished, the four brigantines, in separate pieces, were carried from sea to sea, put together on the Balsas, and Balboa selected Isla Rica, the largest of the Pearl Islands, as his rendezvous, and frequent journeys were made thither from Acla in connection with the arrangements for the expedition. A short trip was made to the eastward and the little fleet returned to Isla Rica ready for the southern voyage; but before he set out Balboa was summoned by Pedrarias to Acla, charged with treasonable conduct, and, after the form of a trial, was condemned and beheaded in the latter part of 1517. Thus closed the career of the brave and unfortunate man who first marked out a line of transit across the isthmus and demonstrated its practicability.

Execution of Balboa.

Meanwhile the search for a westward waterway to the eastern side of the old continent had been continued, and after many fruitless efforts its existence was finally demonstrated by Ferdinand Magellan, twenty years after the famous voyage of Vasco de Gama around the Cape of Good Hope to India, and the result was accomplished, as in the case of the eastern passage, by sailing around the southern point of the continent and not by a strait connecting the two oceans farther north.

Voyage of Magellan.

Magellan was a Portuguese navigator in the service of Charles V, the successor of Ferdinand upon the Spanish throne. He set sail from San Lucar de Barrameda on the 20th of September, 1519, with five ships, reached the mouth of the La Plata, sailed southerly along the coast of Patagonia, and discovered the strait which still bears his name, which separates the island of Terra del Fuego from the mainland. He supposed this island belonged to a southern continent, and this view prevailed until 1616, when two Dutch navigators, Van Schouten and Le Maire, found the passage around Cape Horn. Magellan successfully worked his way through the strait and on the 28th of November, 1520, found the great sea beyond, which he named the Pacific Ocean, on account of the fine weather which he experienced there. His crews were discouraged and mutinous and his provisions ran short, but with undaunted resolution he continued his voyage toward the Asiatic coast, making additional discoveries on his way, until he reached the Philippine Islands. There, on the island of Matan, near Zebu, he lost his life in an encounter with the natives on the 27th of April, 1521. One vessel had been wrecked on the eastern coast of Patagonia, another deserted the expedition and sailed homeward after the western opening of the strait had been discovered but before its passage, and a third became unseaworthy and was burned at the Moluccas. The two remaining separated after the death of Magellan. The *Trinidad* sailed for Panama and the *Victory* returned homeward around the Cape of Good Hope and reached San Lucar, the port from which the expedition had started three years before, on the 6th of September, 1522, under the command of John Sebastian del Cano, having on board only 18 of the 265 persons who had embarked with Magellan. Espinosa, captain of the *Trinidad*, and three of his men returned to Spain five years later in a Portuguese vessel. The voyage to Panama had been abandoned in consequence of continued storms, and the *Trinidad* returned to the Moluccas and was seized by the Portuguese. It finally reached Ternate, a small island of this group, where it went ashore in a squall and went to pieces. For the first time a continuous voyage had been made around the world, and a new maritime route had been found to the far eastern countries and islands in both directions, but this western passage did not reduce the distance nor satisfy

Discovers strait.

World circumnavigated.

the wishes of those who sought a direct way thither by the discovery of a connecting strait along the coast line of the new continent.

Though all previous attempts had been baffled, the belief in the existence of such a strait was not entirely abandoned, and efforts to discover it were still prosecuted, but they were mainly confined to the isthmian section, from Mexico to Darien, where it had been developed that the two oceans were least widely separated.

Charles V is interested in discovery of interoceanic communication.

After Charles V came to the throne of Spain in 1516 he took great interest in the exploration of the South Sea and the discovery of a connecting strait. He charged the governors of his American provinces to have the entire coast line thoroughly examined and every bay and river mouth that offered a possible solution of the problem was entered and explored. In 1523 the Emperor wrote from Valladolid to Cortes to make careful search for the passage which would connect the eastern and western shores of the New World and shorten by two-thirds the route from Cadiz to Cathay. Cortes, in replying, assured him that his wishes would be diligently carried out, and that he had great hopes of success, adding that such a discovery "would render the King of Spain master of so many kingdoms that he might call himself lord of the world."

Gil Gonzales sent to Pacific.

It was in accordance with this policy that Gil Gonzales de Avila was sent out from Spain to succeed Balboa, with instructions to search along the coast of the South Sea for the western opening of a strait connecting with the Atlantic. He had authority to use the vessels that Balboa had constructed, but Pedrarias refused to deliver them to him, and in order to carry out the royal commands he took to pieces the two caravels in which he and his followers crossed the ocean, transported them across the isthmus along the route used by Balboa, and rebuilt them at the Balsas on the Pacific side. These were lost, and he constructed others with which he sailed northward along the coast from the Bay of Panama in January, 1522, until they were found to be unseaworthy. They were repaired and the exploration was continued to the Bay of Fonseca, but Gil Gonzales proceeded by land with 4 horses and 100 men and discovered Lake Nicaragua, which he named after Nicarao, a chief whom he met at or near the present site of Rivas and from whom he at first received kind treatment. He found the country rich in gold, and took formal possession of it for his sovereign. Afterwards, encountering serious opposition from the Indians, he retreated to the coast and was so fortunate as to meet the vessels on their return voyage after an unsuccessful search for the strait. When they reached Panama the news soon spread that a great inland sea had been dis-

Transports his vessels in pieces across isthmus.

Discovers Lake Nicaragua.

covered only a few leagues from the Pacific. Pedrarias claimed that it was within the limits of his jurisdiction and at once undertook its conquest. He established a city at Granada, near the shore of the lake, and reduced the Indians to subjection. It was at first reported that there was an opening from the lake to the South Sea, but a careful examination of the surrounding country failed to develop such a connecting channel. Among the early settlers was Capt. Diego Machuca, who, in 1529, undertook a thorough exploration of Lake Nicaragua and its eastern outlet. A felucca and brigantine were constructed on its shores and were placed under his command with 200 men and some canoes. His land force kept within reach of his flotilla and he entered the Desaguadero River, now the San Juan, and attempted its passage. He found the navigation difficult in places because of the rapids, and those in one part of the river still bear his name. Overcoming all difficulties, he reached the Atlantic, but was uncertain as to the locality, and kept along the coast with his vessels in a southeasterly direction till he reached the Spanish settlement at Nombre de Dios. At a later period sea vessels passed regularly up and down the river, making voyages between Granada and Spain, Cuba and South America. This commerce was maintained as late as 1637, according to Thomas Gage, an English monk, who visited Nicaragua in that year, but there were delays and difficulties in passing the rapids.

Granada founded on Lake Nicaragua.

Machuca's expedition from Lake Nicaragua down San Juan to sea.

Rapids in the San Juan.

While efforts were being made to find a maritime channel between the two oceans which washed the shores of the Spanish provinces in the new world, the importance of a permanent communication across the isthmus by land was not overlooked. Soon after the discovery by Balboa, Ferdinand ordered that a line of posts be established from sea to sea, and the plan was carried out by his successor. Acla was first selected as the Atlantic terminus, but it was afterwards determined that it was too far to the east, and in 1519 Nombre de Dios was founded and the Atlantic port was there established. After an examination of the Pacific coast, the site of old Panama was fixed upon as a suitable place to establish a city upon the western side of the isthmus. A settlement was commenced there in August, 1517, and in September, 1521, it was made a city by royal decree, with special privileges and a coat of arms. It became the Pacific terminus of the line of posts, and a road was at once constructed between the two cities, crossing the Chagres at Cruces. This road was cut through the forests, the trees often being used to make the swamps passable; bridges were laid across the streams, and rocks were

Line of posts across isthmus.

Panama founded.

Construction of road across isthmus.

removed from their beds to make the passage over the mountains less difficult. The way was paved, and according to some accounts was only wide enough for riders and beasts of burden, but Peter Martyr says that two carts could pass one another upon it. In 1597 Porto Bello was made the eastern port of entry instead of Nombre de Dios. It had a better harbor, was easier of access, was well supplied with fresh water the year round, was nearer to Panama, and the location was more healthy than Nombre de Dios, which had frequently been denounced in memorials to the Spanish court as "the sepulcher of Spaniards."

In 1534, or soon after that date, a route by water for boats and light-draft vessels was established from Nombre de Dios along the coast and up the Chagres to Cruces. This was accomplished by removing obstructions which had interfered with the navigation of the river, but the use of the paved way was not discontinued.

Commerce across Isthmus.

The value of this interoceanic communication increased every year. After the conquest of Pizarro vast quantities of gold and silver were brought from the mines of Peru to Panama, carried across the isthmus on the king's horses, kept for that purpose, and transported from the eastern terminus of the paved way in royal galleons to Spain.

Fairs at Cartagena, Nombre de Dios, and Porto Bello.

As the Spanish colonies and provinces increased in population the commerce and travel across the isthmus grew in importance. At certain times when vessels were due from Spain fairs were held at Cartagena and Nombre de Dios, and later at Porto Bello, which were attended by the merchants of the Spanish Main and the countries bordering upon the Pacific. Caravans from Panama crossed to the Atlantic terminus with products to be disposed of at these fairs. With the proceeds such manufactured articles as were needed by the colonists and settlers were purchased from the Spanish ships and distributed at Panama after recrossing the isthmus, many of them going to Peru and Central America, where the abundance of gold assured a ready and profitable market.

Prosperity of Panama.

The commerce of the isthmus increased during the century and Panama became a place of great mercantile importance, with a profitable trade extending to the Spice Islands and the Asiatic coast. It was at the height of its prosperity in 1585, and was called with good reason the tollgate between western Europe and eastern Asia. Meanwhile the commerce, whose tolls only brought such benefits to Panama, enriched Spain, and her people were generously rewarded for the aid given by Ferdinand and Isabella in the effort to open a direct route westward to Cathay, notwithstanding the disadvantages of the isthmian transit.

Another of the early transits across the isthmian country was at Tehuantepec. When Cortes was instructed by Charles V to search for the desired strait he proceeded with his usual energy to carry out the wishes of the Emperor. He had obtained from Montezuma in 1520 a description of the country to the south, with a drawing of the gulf coast representing the bays and rivers. The indications at the mouth of the Coatzacoalcos appearing favorable, he had it examined and, though no strait was discovered, the isthmus presented advantages for transit which he found serviceable in his subsequent operations. When he had completed the conquest of Mexico he sent out vessels to explore the coast in all directions, along the Pacific as well as the Gulf of Mexico, and in 1527 he sent an expedition to the Moluccas, hoping to establish a direct trade with those regions. The forests of Tarifa, on the Atlantic slope, supplied abundance of timber suitable for shipbuilding, and it was transported to each coast to be used in both seas. With timber from this source he constructed vessels on the coast near Tehuantepec for his expeditions in the Pacific, the other materials being carried from the Gulf of Mexico across the isthmus. The most important result of the coastwise explorations was the discovery of the Gulf of California and the adjacent peninsula, but neither along the shore of this gulf nor elsewhere upon the Pacific side did any channel open a passage to the Atlantic. But though Cortes failed to find the strait, the course he marked, up the Coatzacoalcos, across the dividing ridge, and down the Pacific slope to Tehuantepec, became an important route of communication between the Atlantic and Pacific. A port and extensive works were established at the western terminus, and a profitable trade was opened and maintained with the Spanish provinces on the Pacific and with the countries and islands in and near the eastern part of Asia on the one side and with the Atlantic ports and Spain on the other.

Tehuantepec.

Cortes sent expeditions in search of strait.

Transit route.

The importance of a maritime connection and the discouraging results of the efforts to discover a natural channel between the two oceans suggested to many minds the idea of a ship canal, and the successful transits at the different points mentioned and the relatively short distance across the isthmus at each caused them to be regarded at an early period as favorable locations for canal routes. Tehuantepec, Nicaragua, Panama, and Darien each had its advocates.

Ship canal.

According to one authority Charles V directed that the isthmus of Panama be surveyed with this purpose in view as early as 1520. In February, 1534, a royal decree was confirmed directing that the space between the Chagres and the Pacific be examined by experienced men and that they ascertain the best and most convenient means of effecting a communication between the navigable waters of the river and the ocean and the difficulties to be met in the execution of such a project. The governor, Pascual Andagoya, reported that such a work was impracticable, and that no king, however powerful he might be, was capable of forming a junction of the two seas or of furnishing the means of carrying out such an undertaking.

Survey of Isthmus of Panama.

Charles abdicated the throne of Spain in 1555 and was succeeded by his son, Philip II, who reigned till 1598. Under the new monarch the policy of the kingdom changed, the search for the strait was abandoned, the number of ports through which the gold and silver from the mines of his American provinces flowed to Spain was limited, and the project of a ship canal between the two oceans, across the American peninsula, was no longer prosecuted. While these new possessions opened a constantly widening field for commerce and furnished an inexhaustible supply of the precious metals, why seek for or construct a maritime communication through the continent into the ocean beyond for other explorations in the hope of new discoveries? Here was actual fruition. Why waste effort and time and money in regions still more remote, where all was uncertainty? Besides, an opening through the isthmus would afford rival nations favorable opportunities to visit the shores of the new possessions, gain information as to their resources and advantages, and invite aggression and conquest in case of war. It was also urged that the opening of a canal through the isthmus would be in opposition to the will of the Almighty, who had placed this barrier in the way of navigation between the two oceans, and they who should attempt to remove it would incur the Divine displeasure. The Atrato region offered favorable conditions for a transit, particularly for the commerce between Peru and the Spanish main. Some of its tributaries take their rise far to the south and near the Pacific coast, but the policy of Philip prevented the establishment of a channel of communication there, and the navigation of the river was forbidden under penalty of death.

Policy of Philip II.

Atrato.

This policy adopted by Philip II continued for two centuries after his death. The subject of a maritime connection was an attractive one and was often discussed. In connection with it explorations were made from time to time and much geographic and topographic information relating to the Spanish provinces in the isthmian country was collected, but it was not published to the world, and if any scientific data valuable for canal purposes were obtained they were not available when the subject was revived in the nineteenth century and the question of the feasibility of the different projects began to receive serious consideration.

Paterson's colony at New Caledonia.

The most notable event relating to the connection of the two oceans which occurred while this policy of King Philip was maintained was the attempt of William Paterson to establish a Scotch colony in Darien. In 1695 the Scotch Parliament passed an act authorizing the formation of a company to trade from Scotland to Africa and the Indies. It received the royal sanction June 26, 1695, and William III issued letters patent to carry out the terms of the act. The company organized under this authority is generally known as the Darien Company, and in July, 1698, it sent out an expedition from Edinburgh with three ships and two tenders, having 1,200 men on board, with the intention of settling on the American isthmus. William Paterson was the originator of this scheme. He had become acquainted with the advantages of the Darien section while engaged as a merchant in the West Indies, and from a knowledge of the movements and exploits of the buccaneers. The vessels arrived safely at Darien and anchored in a bay which they called Caledonia Bay, a name it still retains. The colonists entered into friendly relations with the Indians and bought lands from them. They named the country Caledonia and established a settlement, which they called New Edinburgh, on a small peninsula, which formed a harbor, which still bears the name of Port Escoces. A fort was built for the protection of the settlement, which they named New St. Andrews, and a channel was cut across the peninsula, so that the sea might encompass the city and fort.

Paterson's plans for interoceanic communication.

While no attempt was made to construct a canal or to open a communication with the South Sea, the patent under which the company was organized authorized colonies to be planted in Asia, Africa, or America, and Paterson's plan contemplated the ultimate establishment of settlements and ports on both oceans, so as to open commercial connections with all parts of the world. One of the first acts of the colonial government was to declare freedom of trade to those of all nations who might be concerned with them, and full and free liberty of conscience in matters of religion. The success of this first colony would have been followed by efforts to establish others on the Pacific side, with which a transit route would then have been opened, but the colonists became discouraged, the supply of provisions failed, a vessel sent out with fresh stores foundered off Cartagena, the unhealthfulness of the climate filled their hospitals and graveyard, and in less than eight months the survivors abandoned the settlement, and only a small remnant lived to return to Scotland. Other vessels were sent out with more emigrants before these disasters were known, others followed them a few months later, and fresh attempts were made to establish a permanent colony, but with no better results. In addition to their other troubles and misfor-

Settlement abandoned.

tunes, Spain protested that her territory was being invaded, and a military force was sent to drive them from the country. The few survivors at length capitulated, and after the loss of more than 2,000 lives and the expenditure of vast sums of money the company abandoned the promising scheme which Paterson had planned and inaugurated.

During this period communication between the two seas was maintained at the locations already mentioned. As Panama declined in importance much of its business was transferred to Nicaragua. The shortest distance from ocean to ocean was in the Darien section. The general course marked out by Balboa was followed by the buccaneers in some of their incursions against the Spanish settlements and posts in the seventeenth century. Captain Sharp crossed here when he made his successful attack in 1680 upon Villa Maria on the Tuyra River, but no continuous transit was ever maintained, probably because of the fierce and persistent hostility of the Indians toward the Spaniards. They aided the buccaneers because they were warring against their special enemies and not because they wanted white men to enter their borders. The Indians in this section were never subdued, though forts and strongholds and mission stations were from time to time established on Caledonia Bay and at other points on the Atlantic side and on the rivers emptying into the Gulf of San Miguel. They had secret passes through the mountains, caves in which their canoes could be safely concealed, trails from their villages by which they could pass freely from point to point, and a system of signals by which they could give notice of the movements and approach of their enemies; with these advantages they often made successful raids upon the Spanish settlements, slaughtered the garrisons, and destroyed their works.

Transit routes.

Indians hostile to Spaniards.

Ariza's road in Darien.

Under the administration of Andrés de Ariza, who became governor of the province in 1774, a determined effort was made to bring the Indians under subjection to the Spanish. Military posts were again established on both sides of the isthmus; Puerto Principi, on the Savana River, was fortified and garrisoned, and a trail was cut thence to the Chucunaque, near the mouth of the La Paz, which was afterwards known as Ariza's road. It was deemed best to connect these posts on the Atlantic and Pacific by a military road, and with this purpose in view a reconnaissance was made from Caledonia Bay across the divide to the terminus of Ariza's road, under the direction of Manuel Milla de Santa Ella, who found that it was practicable. But the Indians objected to the occupation of their country for this purpose and threatened resistance. Their opposition was so serious that the plan was abandoned, and no regular communication between the two coasts was ever accomplished. The

Spaniards became satisfied that their supremacy yielded them no advantages commensurate with its cost, and in 1790 entered into a treaty with the Indians, by which they agreed to abandon their military posts and withdraw from the country.

Spaniards abandon their military posts.

Examination of Tehuantepec route.

Toward the latter part of the eighteenth century there was a revival of interest in the subject of a maritime communication between the two oceans through the American isthmus. Some pieces of ancient bronze cannon in the castle of San Juan d'Ulloa, at Vera Cruz, in Mexico, were accidentally discovered in 1771 to have been cast in Manila, in the Philippine Islands. It seemed improbable that they had been transported thither by water around either continent, as the only commercial intercourse with the islands had been through the Pacific port of Tehuantepec. The subject was investigated and it was satisfactorily proved by old records and traditions among the inhabitants of the isthmus that the cannon had been transported from Tehuantepec to the mouth of the Coatzacoalcos by the route established in the days of Cortez. This transit had long been abandoned, but the remembrance of its former importance had been preserved, though in the lapse of time the difficulties and obstructions attending the passage had been forgotton. The viceroy of Mexico, in the hope that it would afford a favorable location for a canal, determined to have the country examined, so as to ascertain its topography and the practicability of opening a maritime communication between the two oceans, and two engineers, Augustin Cramer and Miguel del Corral, were directed to survey the isthmus and report the result of their investigations. They made an exploration up the Coatzacoalcos and found that its source was not near Tehuantepec, as they had been led to suppose; nor did any river have a channel flowing into each ocean. Instead of a river communication they found a range of mountains of considerable height between the headwaters of the streams emptying into opposite seas. In one place they reported that the mountains formed a group rather than a continuous chain, and that a valley existed, through which a canal of small dimensions was practicable, connecting two rivers on opposite slopes, which would form a continuous communication across the isthmus.

Report of Cramer.

Charles III was then upon the throne of Spain and had interested himself in the work that had been undertaken at Tehuantepec. Not satisfied with its results, he authorized an investigation to be made in Nicaragua to determine the practicability of connecting the lakes with the Pacific. The work was undertaken by Manuel Galisteo in 1779, and a report was made in 1781 full of discouragement. In it he stated that Lake Nicaragua was 134 feet higher than the Pacific, and that high

Examination of Nicaragua route by Galisteo.

mountains intervened between the lakes and the ocean which, in his opinion, made their connection impracticable.

Notwithstanding this report, a company was afterwards formed under the patronage of the Crown to undertake the project, and the route selected was from Lake Nicaragua along the Sanoa River to the Gulf of Nicoya. The royal fleet in the Pacific was directed to aid this work by further surveys, but the project was never commenced and no further progress was made in the construction of an interoceanic communication.

When Galisteo's party set out in 1779 they were accompanied in a private capacity by the British agents at Belize, and the territory claimed in the name of the Mosquito Indians. After their return they made favorable representations of the country they had visited, and declared that the canal project was entirely feasible. This manifestation of interest in the subject was followed by an invasion of the country early in 1780, after Spain had declared war against Great Britain. The invading expedition, under the command of Captain Polson, set out from Jamaica. Admiral Horatio Nelson, then a post captain, was in charge of the naval operations. Nelson, in his dispatches, states the general purpose of the expedition as follows: "In order to give facility to the great object of government I intend to possess the Lake of Nicaragua, which for the present may be looked upon as the inland Gibraltar of Spanish America. As it commands the only water pass between the oceans, its situation must ever render it a principal post to insure passage to the Southern Ocean, and by our possession of it Spanish America is divided in two."

Invasion of Nicaragua by British forces.

Plan of campaign.

The plan of the campaign was to enter the mouth of the San Juan River, capture Fort San Juan, at Castillo Viejo, take possession of all other fortified positions on the river and lakes, occupy the cities of Granada and Leon, then push on to Realejo, by the seizure of which they would complete their control of the province and the lines of communication between the two oceans.

Capture of Castillo Viejo.

The attacking party went up the San Juan in boats and met with no resistance till a small island, named San Bartolomé, an outpost of the enemy, was reached. This was soon captured, and two days later Fort San Juan at Castillo Viejo was besieged. After a stubborn resistance, protracted for ten days, the fort was surrendered and the garrison was allowed to march out with the honors of war. The invading force had little protection from the constant rains, their numbers were daily reduced by deadly fevers and other prostrating diseases, their situation became distressing, longer stay was useless and would have been fatal to the few survivors, and reluctantly the expedition was abandoned. Of the crew of Nelson's ship, the *Hinchinbrook*, 200 in number, 87 fell sick in one night, only 10 were living soon after the return of the expedition to Jamaica, and Nelson himself was in such an enfeebled condition that his life was saved only by careful nursing.

Treaty of 1783 between England and Spain.

This terminated the effort to weaken the Spanish power in Central America, and in the treaty of 1783, which terminated the war, Great Britain relinquished whatever territorial rights she may have claimed there. While the privilege of cutting wood for dyeing was granted to English settlers, it was only to be exercised in a part of Honduras with certain specified boundaries, within which the woodcutters, then dispersed through the country, were required to retire within eighteen months. The British agreed to demolish their fortifications within this district and to instruct their settlers to build no new ones, and they recognized and declared Spain's rights of sovereignty.

Owing to delays in the retirement of the woodcutters within the agreed limits by the time specified, new complications arose between the two powers and the negotiations which followed resulted in another treaty which was signed at London in July, 1786.

Treaty of 1786.

By the new convention the district allotted to the woodcutters was enlarged and their privileges were increased, but they were not to establish any plantation of sugar, coffee, cocoa, or other like article, or any manufacture by means of mills or other machines except sawmills for preparing their timber for use. The reason given for this restriction was that "all the lands in question being indisputably acknowledged to belong of right to the Crown of Spain, no settlement of that kind or the population which would follow could be allowed." In another article all the restrictions specified in the treaty of 1783 for the entire preservation of the right of the Spanish sovereignty over the country were confirmed. Another article related to the Mosquito country, in which England had exercised a protectorate over the Indians and had assisted them in resisting the authority of Spain. In it Spain was pledged, by motives of humanity, not to exercise any severity against the Mosquitos on account of their former connection with the English, and his Britannic Majesty agreed to prohibit his subjects from furnishing arms or military supplies to the Indians.

These treaty obligations were disregarded by Great Britain as no longer binding after the Spanish provinces acquired their independence. The protectorate over the Mosquito Indians was revived and new territorial rights were set up in Central America. Nicaragua claimed sovereignty over the Mosquitos and resisted what she regarded as the encroachment of the British. The latter claimed, on behalf of the Indians, that their territory extended to the San Juan, and in 1848 took possession of the port at the mouth of the river, raised the Mosquito flag there, and changed its name from San Juan to Greytown. In 1859 a treaty was made between Great Britain and Guatemala by which the title of the former to the settlements made in and near the Bay of Honduras, known as Belize, was recognized and the boundaries were defined. In 1860 a treaty was made between Great Britain and Nicaragua by which the protectorate over the Mosquitos was to cease in three months, the territory occupied by them was to be under the sovereignty of Nicaragua, its boundaries were defined, extending no farther south than the river Rama, and Greytown was declared a free port. But the Indians were to have the right of self-government, and Nicaragua was pledged to respect their customs and regulations and not to interfere with them, provided they were not inconsistent with the sovereign rights of the Republic. It was also provided that Nicaragua should, for ten years, pay to the Mosquito authorities $5,000 annually to promote their improvement and provide for the maintenance of the government they were to establish for themselves within their district.

Treaty between Great Britain and Guatemala of 1859 as to Belize.

Treaty between Great Britain and Nicaragua of 1860 as to Mosquito Indians.

In another article it was declared by the contracting parties that the treaty was not to be construed so as to prevent the Mosquito Indians at any time in the future from agreeing to absolute incorporation into the Republic of Nicaragua, on the same footing and subject to the same laws as other citizens. This solution of a long-existing cause of irritation and disturbance was reached in November, 1894, when a convention of the tribes assembled under the direction of their chief and agreed that their territory should become a department of the Republic.

Mosquito Indians incorporated into Republic of Nicaragua in 1894.

At the close of the eighteenth century Spain continued to maintain her sovereignty over the entire isthmian country, but the Cordilleras still kept the two oceans apart; the old transits had fallen into disuse and her intercourse with the western ports of her American provinces was maintained almost entirely by way of Cape Horn and the Cape of Good Hope; the chief exception being at Tehuantepec, where a communication across the isthmus had once more been opened.

Situation at the close of the 18th century.

No actual progress in the way of establishing a maritime communication from the Atlantic to the Pacific had been made during the three hundred years of Spanish occupation. Baron Von Humboldt, who visited New Spain about this time and took a great interest in this subject, deplored the lack of accurate knowledge of the physical features of the isthmian country. After making his investigations he said that there was not

Von Humboldt's statement.

a single mountain, plain, or city from Granada to Mexico of which the elevation above the sea was known. It was even a matter of doubt whether an uninterrupted chain of mountains existed in the provinces of Veragua and Nicaragua.

The publications of Humboldt were extensively read and revived the interest of the commercial nations of the world in this subject. The Spanish Cortes was aroused to action and in April, 1814, passed a formal decree for the construction of a canal through the peninsula for vessels of the largest size and provided for the formation of a company to undertake the enterprise, but it led to no results and Spain's opportunities to obtain the glory of opening this great highway for the commerce of the world terminated in 1823, when the last of her Central and South American provinces succeeded in establishing their ndependence.

Republic of Colombia formed.

The States of New Granada, Venezuela, and Ecuador united in 1819 in forming the Republic of Colombia, with Simon Bolivar as President. This continued till 1831, when they separated into three independent republics.

Formation of Federal Republic of the United Provinces of Central America.

In 1823 Gautemala, San Salvador, Honduras, Nicaragua, and Costo Rica, having successfully resisted the efforts of Iturbide to extend the power of Mexico over them, established the Federal Republic of the United Provinces of Central America.

The governmental changes wrought by these successful revolutions and the formation of these new confederations were followed by a revival of interest in the interoceanic communication. Aaron H. Palmer, of New York, and his associates made proposals to the new Republic of Central America with a view to the construction of such a work, which were favorably regarded. But before any action was taken Don Antonio José Cañaz, the envoy extraordinary representing the Republic at Washington, was instructed to call the attention of the Government of the United States to the subject. He accordingly addressed a letter to Mr. Clay, then Secretary of State, on the 8th day of February, 1825, assuring him that nothing would be more grateful to "the Republic of the Centre of America" than the cooperation of the American people in the construction of a canal of communication through Nicaragua, so that they might share, not only in the merit of the enterprise, but also in the great advantages which it would produce. He stated that a company of respectable American merchants was ready to undertake the work as soon as it could be arranged by a treaty between the two governments, and that if a diplomatic agent were appointed and instructed upon the matter,

Republic of Central America makes propositions to United States.

he was prepared to do what he could on the part of the Republic he represented in the arrangement of the business. Mr. Clay made a favorable response to this communication, assuring the minister that the importance of uniting the two seas by canal navigation was fully realized and that the President had determined to instruct the chargé d'affaires of the United States to investigate with the greatest care the facilities which Nicaragua offered. He added that, if this investigation confirmed the preference which it was believed this route possessed, it would be necessary to consult Congress as to the nature and extent of the cooperation which should be given toward the completion of the work.

Response of Secretary Clay.

Instructions to minister.

The proposed instructions were not, however, given until February, 1826, when a letter was addressed to Mr. Williams, the chargé d'affaires, in which he was informed that the President desired to be put in possession of such full information upon the subject as would serve to guide the judgment of the constituted authorities of the United States in determining their interests and duties in regard to it. The matter was afterwards referred to in the official correspondence with the Department, but it does not appear that the desired information was ever furnished.

Congress of Panama.

When it was proposed to hold a congress of different nations at Panama in 1826, and President Adams had appointed commissioners to represent the United States, they were advised in their letter of instructions that a cut or canal for purposes of navigation somewhere through the isthmus that connects the two Americas, to unite the Pacific and Atlantic oceans, would form a proper subject of consideration at the congress when it should assemble. The opinion was also expressed that, if the work should ever be executed, the benefits of it ought not to be exclusively appropriated to any one nation, but should be extended to all parts of the globe upon the payment of just compensation or reasonable tolls.

But without waiting for governmental action on the part of the United States, the Republic of Central America, on the 16th of June, 1826, decreed that proposals should be received for the right to construct an interoceanic canal, accepted the terms offered by Aaron H. Palmer and his associates and entered into a contract with them. The canal was to be for the navigation of vessels of the largest burden and was to be commenced twelve months after the signing of the contract, or sooner if possible, but in case of insurmountable difficulty, the time for beginning was to be extended for not more than six months. The contract was to remain in force as long as might be necessary for the reimbursement of the capital invested in the construction of the canal and the fortifications for its defense, together

Central America makes contract for construction of canal.

with interest at the rate of 10 per cent per annum, and for seven years after such reimbursement the company of construction was to receive half of the net proceeds of the canal, the expense of collection and repairs being deducted. The navigation and passage through the canal was to be common to all friendly and neutral nations, without any exclusive privilege. The contract can be seen in full by reference to Report No. 145, House of Representatives, Thirtieth Congress, second session, pages 362–367.

Central American and United States Atlantic and Pacific Canal Company.

Mr. Palmer next attempted to organize a company to undertake the construction of a canal under this contract, to be called the Central American and United States Atlantic and Pacific Canal Company, with a capital stock of $5,000,000. With this purpose in view, in October, 1826, he assigned the contract in trust to De Witt Clinton and four others, to be held by them until an act of incorporation could be obtained for the proposed company. In December he went to London, furnished with letters of introduction to the American minister and other influential persons, issued a prospectus, and for ten months endeavored to secure the aid of capitalists there in disposing of the stock, but was unsuccessful and the contract was never executed.

Contract with a Netherlands Company.

The Central American Republic afterwards entered into negotiations with a company in the Netherlands for the construction of a canal across Nicaragua, and a basis for an agreement was adopted by the two Houses of Congress in September and December, 1830. When the Administration at Washington heard that such a contract had been made or was about to be made, Mr. Edward Livingston, then Secretary of State, directed the United States minister at Guatemala to ascertain the facts and to signify to the Government that the United States would consider themselves as entitled to the same advantages, in passing through the canal or using the terminals, as were accorded to other nations. The effort, however, ended in failure and the project was abandoned.

Further negotiations of Central American Republics with United States.

After this failure the Congress of the Republic of Central America again turned to the United States and offered to grant to the Government the right to construct a canal. In response to this action the Senate, on March 3, 1835, passed a resolution requesting the President to consider the expediency of opening negotiations with other nations, particularly with the republics of Central America and New Granada, for the purpose of protecting by suitable treaty stipulations such individuals or companies as might undertake to unite the At[illegible] and Pacific oceans by the construction of a ship canal across [illegible] ican isthmus and of securing forever to all nations th[illegible] right of navigating it on the payment of reason[illegible]

President Jackson acted upon this resolution by sending Mr. Charles Biddle to visit Nicaragua and Panama, with instructions to examine the different routes of communication that had been contemplated, whether by canal or railroad, making such observations and inquiries on his route as would enable him to procure copious and accurate information in regard to the practicability of the different projects, and to procure such public documents as were obtainable relating to the different plans, and copies of all laws and contracts made and entered into by the two Governments with reference to the construction of such a communication, and any surveys and estimates of cost of any of the projects that could be procured. But the mission led to no satisfactory results, and on January 9, 1837, a message was sent to the Senate to the effect that it was not expedient at that time to enter into negotiations with foreign governments with reference to a transisthmian connection.

Mr. Biddle sent to Central America and Colombia.

In January, 1838, Aaron Clark, mayor of New York, and a few other influential citizens presented the subject to the House of Representatives in a memorial, urging the great national importance of a navigable waterway between the Atlantic and Pacific, and recommending that negotiations be opened with New Granada and Central America and the great powers of Europe for the purpose of entering into a general agreement for the promotion of this object, and, as a preliminary step, that competent engineers be sent to the sthmian country to make explorations and surveys, so as to determine the most eligible route and the cost of constructing such a work.

Memorial of Aaron Clark to Congress urging action with reference to canal.

This memorial was referred to the Committee on Roads and Canals and led to an interesting and valuable report, which was presented by Mr. C. F. Mercer March 2, 1839, in the Twenty-fifth Congress, third session, and is designated as H. R. Report 322. The value of a canal was fully recognized, but no action was recommended, except to request the President to open or continue negotiations with foreign nations according to the terms of the former Senate resolution and in harmony with the wishes of the memorialists. The resolution favoring this action was at once adopted.

Report of Committee on Roads and Canals, 1839.

President Van Buren sent another agent, Mr. John L. Stephens, to the isthmus. He recommended the Nicaragua route as the most desirable, and estimated the cost of a canal there at $25,000,000, but did not think the time was favorable for undertaking such a ... of the unsettled and revolutionary condition of the

Mr. Stephens sent as agent to isthmian coun...

... these memorials and resolutions were being considered by Congress, and efforts were being made to obtain concessions from the States through whose territory the canal routes extended, examinations were made from time to time to determine the feasibility and cost of the different projects.

Examination of routes.

In 1824 the Mexican Government and the State of Vera Cruz each appointed a commission to make a reconnaissance of the isthmus of Tehuantepec, the former under the supervision of Juan de Orbegoso, the latter under Tadeo Ortiz. Their reports contain much valuable information relating to the geography, topography, productions, and resources of the country. But their examinations demonstrated that great difficulties opposed the construction of a navigable canal through the isthmus, and they reported that the only available expedient to be adopted was a carriage road from the navigable waters of the Coatzacoalcos River to the lagoons on the south coast. This they considered both easy and advantageous. The report of Orbegoso is found in House Report 322, Twenty-fifth Congress, third session.

Tehuantepec by Orbegoso and Ortiz.

A survey of the Nicaragua route was made by Mr. John Baily, who had been sent out by an English company in 1826 to explore the country and negotiate for a concession. Failing in his main purpose, he had remained in Central America, and in 1837 was employed by President Morazin to determine the best location for a canal. The route that he favored was from San Juan, now Greytown, to Lake Nicaragua, across the lake to the Lajas, and thence to San Juan del Sur on the Pacific.

Nicaragua, by John Baily.

The harbor of Greytown presented "as many conveniences as would be required;" it could "be entered at all seasons and in all weathers without risk;" it furnished good anchorage in 4 or 5 fathoms of water, and there was no danger within it. San Juan del Sur offered similar advantages as a Pacific terminus, with a depth of 10 fathoms. He proposed to use the San Juan through its entire length. This would require the removal of the rocks at the rapids, the closing of the Colorado so as to divert its waters through the channel of the San Juan to Greytown Harbor, and the deepening of this part of the San Juan.

He stated that the four principal rapids were within a space of 12 miles, and were formed by a transverse elevation of rocks, rising in sharp and broken masses above the water when low, but leaving a channel on either side sufficient for the passage of boats, with a depth of from 3 to 6 fathoms. The river was then navigated by piraguas, or large flat-bottom boats of 5 to 8 tons burden, with crews of ten or twelve men, whose chief labor was at the rapids, which, however, were passed without serious hazard. From a series of levels along his line, taken in 1838, he reported that the lake was 128 feet 3 inches above the level of the Pacific at low water at San Juan del Sur, and he accepted the conclusions reached by others that the Pacific at low water was 6 feet 6 inches lower than the Atlantic. His line from the mouth of the Lajas was 28,408 yards in length, the summit level was 487 feet above the lake, and the canal was to be navigable for ships of 1,200 tons burden, with a depth of 18 feet of water. By straightening the line in a few places it could be shortened 2,000 yards and the Lajas could be made available for 5,460 yards. He proposed an alternative plan which would reduce the summit level to 122 feet above the lake, and the connection of two of his stations by a tunnel 3,833 yards long. He pointed out the difficulties of the work, and in case it should not be regarded as an advisable project suggested the consideration of a route through the Tipitapa and Lake Managua to the port of Realejo, but could not speak of the feasibility of this route with confidence, as it had not been surveyed. He had, however, traveled over the country between Lake Managua and the ocean, and regarded it as worthy of examination.

Panama, by J. A. Lloyd.

In November, 1827, Mr. J. A. Lloyd received a commission from President Bolivar to survey the Isthmus of Panama, in order to ascertain the most eligible line of communication across it, whether by road or canal. At this time neither the relative height of the two oceans nor the height of the mountain range between them had been accurately determined, and the geographic features of the isthmus were imperfectly understood. He spent two seasons in exploring the country and carried his line of levels from Panama to La Bruja, a place on the Chagres River about 12 miles above its mouth. He reported that the mean height of the Pacific at Panama was 3.52 feet higher than that of the Atlantic at Chagres. He recommended a new line across the isthmus, instead of those in use from Porto Bello and Chagres by Cruces to Panama, beginning at the Bay of Limon, thence to the Chagres by a canal and up the river to a favorable situation on the south bank of the Trinidad River, and thence by a railroad to Panama or Chorrera, the latter being the nearer terminus, but the former being preferable as a better port, and the capital of the State, where its trade was already centered. He made no recommendation in favor of a canal, but said that if a time should arrive when a project of a water communication across the isthmus might be entertained, the River Trinidad would probably offer the most favorable route. For some distance he found it both broad and deep, and its banks well suited for wharves, especially in the neighborhood of the place designated as suitable for railroad communication.

Republic of New Granada established in 1831.

After the Republic of Colombia was divided, in November, 1831, the control of the Panama route belonged to New Granada, within whose territorial boundaries it was located. This Republic, in 1838, granted to a French company a concession, authorizing the construction of macadamized roads, railroads, or canals across the isthmus with the Pacific terminus at Panama. The company spent several years in making explorations and communicated the results to the French Government through M. M. Salomon, the leading spirit in the enterprise, in the hope of securing its aid in constructing the proposed work. These results presented the project in an attractive way, and it was stated that a depression in the mountain range offered a passage only 11.28 meters, about 37 feet, above the average level of the sea at Panama. The representations were of a character so surprising that it was decided to send an officer to the spot to study the subject, and in September, 1843, M. Guizot, minister of foreign affairs, instructed Napoleon Garella to proceed to Panama to investigate the question of the junction of both seas by cutting through the isthmus, and to report the means of effecting it, the obstacles to be overcome, and the cost of such an enterprise.

Makes grant to a French Company.

Results of explorations of Panama route.

Examined by Garella.

He favored a canal as the only means of communication adequate to the demands of commerce, and, as the representative of a great commercial nation, directed all his labors to this object. He preferred to establish the Atlantic terminus at the Bay of Limon rather than at the mouth of the Chagres, following the recommendation made by Lloyd; a connection with the river was to be made somewhat below the mouth of the Gatun. The low depression, making a sea level canal practicable within a reasonable limit of cost, could not be found, and he proposed to cross the divide through a tunnel 5,350 meters, a little more than 3⅓ miles, long, but he also estimated for a cut through the ridge instead of a tunnel. The bottom of the tunnel was to be 41 meters, about 134½ feet, above the ocean; 99 meters, nearly 325 feet, below the summit, and the level of the water 48 meters, nearly 158 feet, above the ocean at extreme high tide on the Pacific at Panama. The summit level was to be reached by 18 locks on the Atlantic slope and 16 on the Pacific, with a guard lock at each extremity to protect the entrance. The supply of water was to be furnished by two lateral canals from the Chagres. The Pacific terminus was to be in the small bay of Vaca de Monte, about 12 miles southwest of Panama. The estimate of cost was 130,000,000 francs, about $25,000,000, if the summit level was established by means of a tunnel. By establishing the summit level by means of a trench of a maximum depth of 84 meters, about 275 feet, the bottom of which would be 15 meters, nearly 50 feet above that of the tunnel, the cost would be increased to 149,000,000 francs, or about $28,000,000.

These estimates were made for a canal that would accommodate vessels of 1,200 tons burden, 198$\frac{1}{6}$ feet long, with extreme breadth of beam of 45$\frac{1}{4}$ feet and a maximum draft when loaded of 21$\frac{1}{3}$ feet, giving a depth of 23 feet.

Garella's report is found in House Report 322, Twenty-fifth Congress, third session. It disappointed the expectations that had been raised by the projectors; no further steps were taken in the matter and the concession was forfeited.

Increased importance of maritime communication.

About the middle of the century a succession of great events vastly increased the importance of a maritime connection between the two oceans to the United States. The dispute with Great Britain, as to the boundary line west of the Rocky Mountains, was settled by the Buchanan-Packenham treaty in 1846, and in August, 1848, an act of Congress was passed under which Oregon became an organized Territory. The war with Mexico was commenced early in 1846, and by the terms of the Guadalupe-Hidalgo treaty, which closed it in 1848, California was ceded to the United States. Before the treaty had been ratified gold was discovered there, and in a few months many thousands from the eastern part of the country were seeking a way to the mining regions. To avoid the hardships and delays of the journey across the plains or the voyage around the continent, lines of steamers and packets were established from New York to Chagres and San Juan del Norte and from Panama to San Francisco, some of the latter touching at the Pacific ports in Nicaragua. For a while those traveling by these routes had to make arrangements for crossing the isthmus after their arrival there, and were often subjected to serious personal inconveniences and suffering as well as to exorbitant charges.

The requirements of travel and commerce demanded better methods of transportation between the Eastern States and the Pacific coast, but there were other reasons of a more public character for bringing these sections into closer communication. The establishment and maintenance of army posts and naval stations in the newly acquired and settled regions in the Far West, the extension of mail facilities to the inhabitants, and the discharge of other governmental functions, all required a connection in the shortest time and at the least distance that was possible and practicable. The importance of this connection was so manifest that the Government was aroused to action before all the enumerated causes had come into operation, and negotiations were entered into with the Republic of New Granada to secure a right of transit across the Isthmus of Panama. This was effected by a treaty concluded in December, 1846, though the ratifications were not exchanged until June, 1848. A copy of it is attached to this report, marked "Appendix BB."

Treaty negotiated with New Granada in 1846.

Resolutions relating to interoceanic communications come before Congress.

The increased importance of an interoceanic communication brought the subject also before Congress. A joint resolution was introduced in the House of Representatives during the Thirtieth Congress, authorizing the survey of certain routes for a canal or railroad between the two oceans, which with other papers of a like character was referred to a select committee of which Mr. John A. Rockwell was made chairman.

Referred to select committee.

Report of Rockwell committee.

The committee did not feel prepared to say to what extent, if any, the aid of the Government should be rendered to these projects, but recognized the importance of a communication from ocean to ocean, and presented such information as was available in relation to the principal routes to which public attention had been directed. The superior importance of a ship canal was recognized, but it was suggested that until one could be constructed a railroad would be valuable for earlier use and as an auxiliary to a canal.

The passage of the joint resolution was recommended with an amendment, authorizing surveys from some point on the Gulf of Mexico to the Pacific Ocean, in addition to the surveys provided for in the joint resolution.

The report of this committee was made to the House February 20, 1849, in the second session of this Congress, and is numbered 145.

Memorial of projectors of Panama railroad.

At the same session, William H. Aspinwall, John L. Stephens, and Henry Chauncey, who, as will appear a little farther on, had undertaken the construction of the Panama railroad, presented a memorial, asking that the Secretary of the Navy be empowered to enter into a contract with them for the transportation over their road, when completed, for a period of twenty years, of naval and army supplies, troops, munitions of war, the United States mails, and public agents or officials, at a rate not exceeding the amount then specified by law to be paid for the transportation of the mails alone from New York to Liverpool, on condition that they commence within one year, and complete within three years their proposed road across the isthmus. The memorial was referred in the House of Representatives to the Committee on Naval Affairs, and a report was made recommending that they be granted $250,000 a year to aid in building the road. No action was taken upon this report, but annual appropriations were made for carrying the mails across the isthmus after the road was completed.

Negotiations for treaty with Nicaragua.

Soon after the convention with New Granada had been ratified and proclaimed, efforts were made to negotiate a treaty with Nicaragua, so as to obtain favorable transit rights through that country for the Government and citizens of the United States.

Advantages of Nicaragua route.

The advantages which this country offered for an interoceanic canal had been known for centuries, and the desire to secure them led to the negotiation of a treaty with Nicaragua by Mr. Elijah Hise, chargé d'affaires of the United States, in June, 1849. By its terms the Republic undertook to confer upon the United States, or a company of its citizens, the exclusive right to construct through its territory canals, turnpikes, railways, or any other kind of roads, so as to open a passage and communication by land or water, or both, for the transit and passage of ships or vehicles, or both, between the Caribbean Sea and the Pacific Ocean. The terms of the treaty were most liberal, and in return the United States was to aid and protect Nicaragua in all defensive wars, the Army and Navy and all available means and resources of both countries to be used, if necessary, to defend the territories of the latter or to recover such as might have been seized or occupied by force. Nicaragua consented to these terms because it was desired to secure the aid of the United States, in resisting the policy which Great Britain was then pursuing in Central America, with the apparent intention of securing the permanent control of the lower waters of the San Juan, under a claim already mentioned, that the boundaries of the Mosquito district extended to and included the mouth of that river, where at this time the Mosquito flag was maintained under British protection.

Hise treaty.

Hise succeeded by Squier.

Mr. Hise had exceeded his authority in making this treaty and it was not approved by the Administration at Washington. He was afterwards recalled and was succeeded by Mr. E. G. Squier, who negotiated another treaty upon the subject and a contract for facilitating the transit from the Atlantic to the Pacific, by means of a ship canal or railroad, in the interest of the American, Atlantic and Pacific Ship Canal Company, composed of Cornelius Vanderbilt, Joseph L. White, Nathaniel H. Wolfe, and their associates.

Contract of American, Atlantic and Pacific Ship Canal Company with Nicaragua.

These two treaties were never ratified, but they were subjects of conference and discussion during the negotiations which led to the Clayton-Bulwer treaty of July 5, 1850. By this it was agreed, among other things, that the two contracting parties would support and encourage such persons or company as might first commence a ship canal through Nicaragua with the necessary capital and with the consent of the local authorities and on principles in accord with the spirit and intention of the convention. And if any such person or company had already entered into a contract for the construction of such a canal, with the State through which the same was to pass, it was agreed that such person or company should have a priority of claim, if the parties to the treaty had no just cause of objection to such contract.

Clayton-Bulwer treaty.

This provision was understood to be in the interest of the company for which Mr. Squier had obtained a contract in August, 1849. By its terms the State had granted to it, for a period of eighty-five years, to be counted from the completion and opening of the work to public use, the exclusive right and privilege of excavating a ship canal for vessels of all sizes, from Grey Town, or any other feasible point on the Atlantic, to the port of Realejo, Gulf of Amapala or Fonseca, Tamorinda, San Juan del Sur, or any other point on the Pacific, by means of the San Juan River, Lake Nicaragua, the Tipitapa River, and Lake Managua, or any other waters within its jurisdiction. The contract also gave to the company the exclusive right to construct rail or carriage roads and bridges. and to establish steamboats and other vessels on the rivers and lakes as accessories to and in furtherance of the execution of the canal project. And if the construction of the canal or any part of it should be found to be impracticable, then the company was authorized to establish a railroad or some other communication between the two oceans within the time limited and subject to the same terms and conditions.

Terms of contract with Canal Company.

Subsequently in March, 1850, the company was incorporated by the Republic of Nicaragua to prevent any embarrassments in the development and prosecution of its enterprise.

Canal company incorporated in Nicaragua.

A new arrangement was made in August, 1851, by which the part of the contract relating to steam navigation upon the waters of the State was separated from that relating to the canal. This was desired by the company so as to establish a transit route across the isthmus connecting with steamship lines at the terminal ports. It was accomplished by a new charter, authorizing the organization of another company with the same membership, but distinct and separate, to be known as the Accessory Transit Company, with the understanding, however, that neither party was to be relieved from the performance of the obligations imposed by the former contract and charter.

Organization of Accessory Transit Company.

The accessory company, during the following year, availed itself of the privileges of the new contract and established a transportation line from Grey Town up the San Juan River and across Lake Nicaragua by steamboats to Virgin Bay on the western side of the lake, and thence by stage coaches 13 miles over a good road to San Juan del Sur. In connection with steamship lines in the two oceans, at the ends of the transit, running to and from New York and San Francisco, a regular communication was thus maintained between the Atlantic and Pacific ports. This line was kept up for many years and was traveled by thousands on their way to and from the gold regions in California; it

Transit route established by accessory company.

was finally terminated by the disturbed conditions which resulted from the expeditions of Walker into Central America. At a later date the transit route was reopened for a short time under a new charter in the name of the Central American Transit Company.

Central American Transit Company.

The American Atlantic and Pacific Ship Canal Company also took preliminary steps for the accomplishment of the larger matters involved in its contract. Though there had been before this time many explorations, reconnoissances, and examinations of this country with a view to the location and excavation of a ship canal, it does not appear that any thorough and complete survey had ever been attempted, and if any had ever been made there was no record of its existence, or of any basis for even the roughest estimate of the cost of such a work upon any of the proposed lines through Nicaragua. It was now determined that there should be a careful instrumental survey from ocean to ocean and that a line of location should be determined upon. Col. Orville W. Childs, of Philadelphia, was appointed as chief engineer to take charge of this work in August, 1850, and he completed it in March, 1852.

Colonel Childs appointed to survey canal route.

The results of this survey are given in another chapter of this report, in connection with the engineering features of the Nicaragua route.

At the request of the company the report of the survey and location was submitted by President Fillmore to Col. J. J. Abert and Lieut. Col. W. Turnbull, United States topographical engineers, for their inspection and opinion, and on the 20th of March, 1852, they reported that the plan proposed by Colonel Childs was practicable, but recommended some changes and modifications.

Report submitted to Colonel Abert and Lieutenant-Colonel Turnbull.

In view of the joint agreement to protect such a canal entered into by the United States and Great Britain, it was deemed advisable to invite the British Government to submit the Childs report to engineers of well-known skill and experience, and at the request of Abbott Lawrence, the American minister, Lord Malmesbury designated Lieut. Col. Edward Aldrich, of the royal engineers, and Mr. James Walker, an eminent civil engineer, to make the desired examination.

Submitted to British engineers by request of American minister.

They submitted their report on the 16th day of July, 1852, in which they expressed the opinion that the Childs project was practicable and would not be attended with engineering difficulties beyond what might be naturally expected in a work of such magnitude; that the survey had every appearance of accuracy; that the details had been worked out with great care, and that Colonel Childs had impressed them with a conviction of perfect fairness and candor. They, however, favored an

Pronounced to be practicable.

increase of the depth to 20 feet, the breadth to 50 feet, and the length of the locks to 300 feet. These dimensions they said would render the navigation more efficient for the general purposes of trade, and the increased expense would be unimportant when compared with the advantages.

Value of Childs report.

Nothing further was done by the American Atlantic and Pacific Ship Canal Company toward the construction of a maritime canal, but the value of the Childs survey and report has ever since been recognized, and the results and conclusions reached by him have served as a basis for the operations of his successors.

Contracts of companies annulled for nonperformance.

No progress having been made in the construction of the canal, it was claimed by the President of Nicaragua that the undertaking had been abandoned and that the company had failed to make the annual payments due under its contract, and the decree was made on the 18th day of February, 1856, revoking and annulling the contracts made with the ship canal company and the accessory transit company and all the privileges contained therein, and also the act of incorporation, and dissolving and abolishing the companies. It was further decreed that all the company property be seized to secure the payment of such amount as might be due the State, to be ascertained by a board appointed to make a thorough examination of its affairs. The company denied the right of the Government to annul the contract and withdraw the charter, and various attempts were made from time to time to settle their differences, but the decrees were renewed and reaffirmed and no work was ever done by the company upon the project which Colonel Childs had prepared.

After the Nicaraguan Government had declared the concession to the American Atlantic and Pacific Ship Canal Company terminated, because of noncompliance with its terms, and while the company claimed that it was still entitled to the privileges it contained, Nicaragua and Costa Rica united, in May, 1858, in granting a like concession to Felix Belly, a citizen of France, to construct a canal from the mouth of the San Juan, by way of the river and Lake Nicaragua, to the Pacific. This concession was to be executed by a company which he was to organize. The neutrality of the canal was to be maintained by the great powers, in harmony with the policy of the Clayton-Bulwer treaty, and the privilege was to continue for ninety-nine years. Another article of the contract provided that the French Government should have the right to keep two ships of war stationed in Lake Nicaragua for the entire duration of the works. Mr. Cass, then Secretary of State, declared this arrangement obnoxious, and added that the equality and security of these interoceanic routes constitute a great portion of their value to the world, and that an exclusive right in one of these powers to exercise a permanent armed intervention would give serious cause of dissatisfaction to all the others. But no effort was made to carry the obnoxious clause into effect, for the company failed to execute its project and the concession was annulled. In October, 1868, the two Republics entered into a contract with Michel Chevalier, another citizen of France, with the same purpose in view. They also entered into a treaty with one another in the following year, in support of the contract, which is presented more fully in the chapter on "Rights, privileges, and franchises," and some articles from the treaty are contained in Appendix X. This effort to secure the construction of a canal also failed, and the contract was forfeited.

New Granada makes contract with French Company for railroad at Panama.

Before the treaty with New Granada already referred to had been ratified, that Republic, in May, 1847, had granted to the Panama Company, an association of Frenchmen represented by one Mateo Kline, the exclusive privilege of building a railroad between the two oceans across the isthmus for ninety-nine years, to be counted from the day of the completion and opening of the road to public use. The company failed to carry out this contract and it was declared forfeited.

New contract with American Company.

Subsequently, in December, 1848, the Government transferred the privileges of the Kline contract, with some modifications which will appear in another chapter of this report, to Aspinwall, Stephens, and Chauncey, who, with their associates, organized the Panama Railroad Company, by which the road was constructed and opened to public use early in 1855 from Aspinwall, or Colon, to Panama, a distance of 47¾ miles.

Panama Railroad completed in 1855.

But this railroad, valuable and useful as it promised to be, was only a forward movement. The barrier was more easily passed, but it still remained. The desire for a maritime canal was increased rather than abated, and further examinations and surveys were diligently prosecuted at different locations in the isthmian country to ascertain and develop the advantages and possibilities of the different routes and schemes that had been from time to time proposed.

New examinations of different canal routes.

The Government and people of the United States, Great Britain, and France were the most active in these explorations. They were confined for a time mainly to the Darien country, between Panama and the Atrato River. It was known that there were good harbors in this section in both oceans, and in several places the distance across the isthmus was comparatively short, but only the native Indians were acquainted with the interior. The early Spanish settlers had often crossed the country, and the buccaneers had frequently penetrated it successfully in their incursions.

Darien.

There were traditions and reports of the existence of low depressions in the mountain range and of passages for canoes used by the Indians when they wished to cross from sea to sea. So when the difficulties of the Nicaragua and Panama canal routes were made known by the Childs survey and the survey for the railroad, public attention was directed to this region in the hope of finding a shorter and easier transit, where a sea-level canal might be excavated.

Three general lines were examined—the San Blas, Caledonia Bay, and the Atrato. They derived their names in each case from the Atlantic terminus, but there were variations of each, following the courses of different rivers, and, in case of the Atrato, reaching the Pacific at different points from the Gulf of San Miguel to the mouth of the San Juan at Chirambira Bay, more than 300 miles farther south.

United States Government aids in the examinations.

These examinations were made in some cases at the expense of private individuals and companies, but the aid of the Government was sometimes extended through the Navy Department, and parties of officers and men from the United States vessels on the coasts of the isthmus explored the country to determine whether any practicable and desirable canal routes existed there. The country was also visited by other exploring parties from Great Britain and France.

General results.

Some of the results of these examinations are stated and considered in another chapter of this report. It is sufficient to say here that they added greatly to the topographic and geographic knowledge of these regions and that the expectations of those who had anticipated that an easy route would be found where a canal could be constructed at comparatively little cost were not realized, though some of the reports were so favorable as to encourage further investigation. Accounts of some of these expeditions are to be found in the report on the isthmus of Darien, made to the Secretary of the Navy by Lieut. I. G. Strain in 1854, published during the Thirty-third Congress, second session, as Senate Ex. Doc. No. 1, and in the report of Lieut. John T. Sullivan, United States Navy, published during the Forty-seventh Congress, second session, as House Ex. Doc. No. 107.

Senate requests report of results of examinations in Darien.

In March, 1866, a resolution was adopted by the Senate, requesting the Secretary of the Navy to furnish, through a report of the Superintendent of the Naval Observatory, such information as had been collected with reference to the various proposed lines for interoceanic canals and rail roads between the waters of the Atlantic and Pacific oceans and to state whether the isthmus of Darien had been sufficiently explored the report to be accompanied with charts, plans, lines of level, and a statement of the authority upon which they were based. The purpose of the resolution was understood to be to obtain a basis for a continuance of the examination of the routes not already sufficiently known, without any useless expenditure of money upon schemes already found to be infeasible and unpromising.

Report of Admiral Davis.

In response to the resolution, Secretary Welles, in the following July, transmitted a report of Rear-Admiral Charles H. Davis, which was printed as Senate Executive Document No. 62, during the first session of the Thirty-ninth Congress. It was accompanied with a general map of the American isthmus and maps and profiles of the different routes included in the investigations made under the resolution.

The report enumerates 19 canal and 7 road projects in the isthmian country, extending from Tehuantepec to the Atrato. It excludes from further consideration the projects in Tehuantepec and Honduras as possessing little merit as practicable canal lines. With reference to the eight routes in Nicaragua, Admiral Davis says:

"It may be safely asserted that no enterprise, presenting such formidable difficulties, will ever be undertaken with even our present knowledge of the American isthmuses. Still less is it likely to be entered upon while such strong and well-founded hopes are entertained by the promoters of the union of the Atlantic and Pacific oceans of finding elsewhere a very much easier, cheaper, and more practicable route for a canal in every way suited to the present demands of commerce and navigation."

In speaking of the project of connecting the Upper Atrato with the San Juan, he says:

"The examination of the headwaters of the Atrato, of the intervening watershed, and of the headwaters of the San Juan satisfactorily proved that nature forbids us altogether to entertain an idea of a union of the two oceans in this direction."

He gives a general description of the other lines in Panama, Darien, and the Atrato valley, and favors further examinations for the reason that, according to his statement, "there does not exist in the libraries of the world the means of determining, even approximately, the most practicable route for a ship canal across the isthmus." He further says, "The Isthmus of Darien has not been satisfactorily explored," and afterwards adds, "It is to the Isthmus of Darien that we are first to look for the solution of the great problem of an interoceanic canal."

President Grant calls attention to subject of interoceanic canal in his first message.

In 1869 General Grant became President and in his first message to Congress commended an American canal, on American soil, to the American people. Congress promptly responded to this sentiment by adopting a joint resolution providing for further explorations of the isthmus by officers of the Navy, and Admiral Ammen, as Chief of the Bureau of Navigation, was authorized to organize and send out expeditions for this purpose. In March, 1872, a further resolution was adopted for the appointment of a commission to study the results of the explorations and to obtain from other reliable sources all available information regarding the practicability of the construction of a canal across the American continent. The President appointed on this Interoceanic Canal Commission Gen. A. A. Humphreys, Chief of Engineers, United States Army; C. P. Patterson, Superintendent of the Coast Survey, and Commodore Daniel Ammen, Chief of the Bureau of Navigation of the Navy.

Congress authorizes further explorations.

Appointment of Interoceanic Canal Commission.

The commissioners considered the results of investigations which had been made before their appointment and those still in progress, and under their directions further explorations and examinations were made in the isthmian country wherever they regarded additional information as necessary to enable them to carry out the purposes of the law.

Tehuantepec.

Capt. R. W. Shufeldt, United States Navy, had been placed in charge of an expedition to Tehuantepec in the fall of 1870; he reached the Atlantic terminus of the route early in November and completed his examination in the latter part of the following April. A level and transit line was run from Salina Cruz, on the Pacific, to the dividing ridge at Tarifa, and was continued from there to the junction of the Upper Coatzacoalcos, or Corte River, with the Blanco.

The want of sufficient force and the season of the year prevented the running of the line from Tarifa to the Atlantic, but the party had the results of former surveys for railroad purposes and careful observations made by those employed in the expedition, during their frequent journeys along the route, to aid them in reaching their conclusions.

The canal line, which was recommended in the report of the expedition, commenced at the head of navigation in the Coatzacoalcos, at the island of Tacamichipa, thence through the valley of the river, utilizing it whenever desirable, to the dividing ridge at Tarifa, thence descending through Tarifa Pass, probably by the valley of the Chicapa, to the harbors of Salina Cruz, the Pacific terminus. The proposed canal was to be 144 miles long, and would require the improvement of the navigable part of the Coatzacoalcos for about 35 miles. The summit level was 754.4 feet high; this could be reduced to 732 feet; to cross it would require about 140 locks. The harbors at each terminus would have to be improved. The water supply could only be furnished from the Upper Coatzacoalcos, or Corte, near its junction with the Blanco, through a feeder, about 27 miles long, to the canal at Tarifa.

Captain Shufeldt entered upon his work, maintaining that "with the advantages of modern science a canal can be built anywhere, involving only the question of expense, provided water can be found to fill it." But when he reported the result of his survey, and considered the difficulties and expense of executing the plan, he expressed the opinion that it "can only be deemed practicable to the extent of its political and commercial necessity, measured by the progress of the age." The report was printed as Senate Executive Document No. 6, in the second session of the Forty-second Congress.

Nicaragua.

Commander A. F. Crosman, United States Navy, was placed in charge of an expedition to examine the Nicaragua route in 1872, but was drowned on the 12th of April in attempting to effect a landing at Greytown. The command was then assumed by Commander Chester Hatfield, United States Navy, the officer next in rank, who began a survey on the west side of Lake Nicaragua, and continued the work until the rainy season. In October, 1872, he was relieved by Commander Edward P. Lull, United States Navy; the expedition was reorganized in November, and a survey of the entire route from Greytown to Brito was completed during the following year. Mr. A. G. Menocal served in this expedition as chief civil engineer. An account of this survey will appear in another chapter of this report. It follows the Childs route, except that on the west side of the lake it crosses the divide farther to the north and follows the valley of the Medio to the lake, making a shorter line, but requiring deeper cutting at the divide.

Lull survey.

The Hatfield and Lull report was printed as Senate Executive Document No. 57, in the first session of the Forty-third Congress.

McFarland report.

The Interoceanic Canal Commission had also before them a report on the Nicaragua route made by Maj. Walter McFarland, Corps of Engineers, United States Army, who was detailed by the War Department to aid in making these examinations. He went over the country through which the canal passes in March, 1874, and made a favorable report upon the route, including a rough estimate of the cost of canal 26 feet deep at $140,000,000. The report was printed as Senate Executive Document No. 46, in the second session of the Fifty-second Congress.

Panama.

In the absence of any accurate information of the Panama route along the line of the railroad, obtained with reference to the construction of a canal, the Commission deemed it best to have it examined, and the Secretary of the Navy assigned Capt. Edward P. Lull to this work, with Mr. A. G. Menocal as his principal assistant. They made a careful instrumental examination of the isthmus in 1875 and reported in favor of a line 41.7 miles long

Survey made by Lull and Menocal.

from the Bay of Limon to the Chagres, ascending its valley and that of the Obispo to the divide and descending the Pacific slope by the valley of the Rio Grande to the Bay of Panama. It follows the general line of the Panama Railroad, and the plan of construction, with some variations, has been adopted in most of the subsequent surveys. The report was printed as Senate Executive Document No. 75, in the third session of the Forty-fifth Congress, and the project is more fully described in another chapter of this report.

Darien.

The Interoceanic Canal Commission had before it the surveys which had been made of the various routes in Darien and the Atrato Valley and further examinations were made of parts of these regions by Captain Lull and Major McFarland, the results of which are printed in the volumes already referred to, in connection with their reports upon the Panama and Nicaragua routes.

Lull and McFarland.

Selfridge.

Prior to this, Commander T. O. Selfridge, United States Navy, was engaged for many months in 1870–1873 in exploring this part of the isthmian country. He was first placed in command of an expedition by Secretary Robeson in 1870, with a corps of junior officers of the Navy and others from the Coast Survey and a number of skilled assistants, besides a large guard of marines, and was directed to make a survey of the isthmus of Darien to ascertain the point at which to cut a canal from the Atlantic to the Pacific Ocean. Two vessels were placed under his immediate command and a third was detailed to cooperate with him on the Pacific side. A similar expedition under the same principal officers was sent out to continue the work in the following year, and under a later order from the Navy Department the work was completed in April, 1873. Commander Lull assisted in the work of the expeditions of 1870 and 1871, and was in command of one of the vessels on the Atlantic side.

The parties working under these orders made tentative surveys from San Blas Bay to the headwaters of the Chepo, from Caledonia Bay to the Morti, and from the same vicinity on the eastern coast to the Sucubti across the divide; also the Depuydt route and that of the Cocarica and Tuyra rivers.

The report of these surveys was printed as House Mis. Doc. No. 113 in the third session of the Forty-second Congress.

"After a long, careful, and minute study of the several surveys of the various routes across the continent," the Interoceanic Canal Commission, in February, 1876, unanimously reported as follows:

Report of Interoceanic Canal Commission.

"That the route known as the 'Nicaragua route,' beginning on the Atlantic side at or near Grey Town; running by canal to the San Juan River; thence * * * to * * * Lake Nicaragua; from thence across the lake and through the valleys of the Rio del Medio and the Rio Grande to * * * Brito, on the Pacific coast, possesses, both for the construction and maintenance of a canal, greater advantages and offers fewer difficulties from engineering, commercial, and economic points of view than any one of the other routes shown to be practicable by surveys sufficient in detail to enable a judgment to be formed of their respective merits."

This report was not transmitted to Congress till April, 1879, when it was called for by a resolution of the Senate. It was printed as Senate Ex. Doc. No. 15 in the first session of the Forty-sixth Congress.

While the Interoceanic Canal Commission was examining into the merits of the different canal routes a provisional company was organized in France for the purpose of inaugurating a scheme for the connection of the Atlantic and Pacific oceans by a navigable waterway across the American isthmus. Lieut. L. N. B. Wyse, as the representative of this organization, visited the Republic of Colombia to examine the isthmian section there and, if practicable, to negotiate a favorable concession as a basis for their plans. In May, 1876, he entered into a contract with the Colombian Government, which was afterwards, in May, 1878, modified and extended so as to give to the promoters the exclusive privilege, for ninety-nine years, of constructing and operating a canal across the territory of the Republic, between the two oceans, without any restrictive stipulations of any kind, provided that if the company of execution selected a route in that part of the isthmus in which the Panama Railroad Company already had exclusive privileges an amicable arrangement must be made with it under which the new canal company could occupy the territory in which these privileges existed.

Colombia grants concession to L. N. B. Wyse.

Under this latter contract the general route of the proposed canal was to be determined by an international congress of engineers and others, to be assembled not later than 1881. In accordance with this provision an "International Scientific Congress" was assembled at Paris in May, 1879, and a decision was reached that the best line for a maritime canal across the American isthmus was from the Gulf of Limon to the Bay of Panama. An account of this congress will appear in another chapter of this report.

International Scientific Congress at Paris in 1879.

This concession was transferred to La Compagnie Universelle du Canal Interoceanique de Panama, better known in the United States as the Panama Canal Company, which was organized early in 1881 to construct a sea-level canal by the proposed route. The history of this company and of the New Panama Canal Company, which undertook the work after it failed and went into liquidation, and a description of the engineer-

Transfer of concession to Panama Canal Company.

ing features of the different plans upon which they have operated, will appear in another chapter of this report.

The report of the Interoceanic Canal Commission was generally accepted with reference to the feasibility of the proposed canal routes in the Tehuantepec, Darien, and Atrato regions, and no further surveys were made under the authority of the United States. But when Mr. James B. Eads, in 1881, endeavored to carry out his project for a ship railway, he recognized the advantages of the Tehuantepec transit for his purposes and obtained a charter from the Government of Mexico authorizing him to use this route. His plan for transporting vessels from ocean to ocean had many advocates, who believed that such a communication was entirely practicable, and could be constructed at less cost than a maritime canal by any of the routes that have been considered. The plan was brought before Congress in an effort to secure governmental aid, but without success, and since the death of Mr. Eads, in 1887, no further efforts have been made to carry the project into execution.

Eads selects Tehuantepec route for ship railway.

The Nicaragua route was again surveyed in 1885, under an order of the Secretary of the Navy, by Mr. A. G. Menocal. In his report he recommended a plan which is stated in the chapter of this report on the Nicaragua route.

Nicaragua Menocal survey.

The report of this survey was printed as Senate Ex. Doc. No. 99 in the first session of the Forty-ninth Congress.

In December, 1884, a treaty had been negotiated between the United States and Nicaragua, authorizing the construction of a canal by the former over the territory of the latter, to be owned by the two contracting parties. It is more particularly referred to in another part of this report and appears as Appendix L. In December, 1885, while the treaty was still pending in the Senate, it was withdrawn from further consideration by the Chief Executive, who stated as a reason for his action that it proposed a perpetual alliance with Nicaragua and the protection of the integrity of the territory of that State, contrary to the declared policy of the United States.

Treaty negotiated with Nicaragua in 1884.

Not ratified.

In April, 1887, Nicaragua granted a concession to Mr. A. G. Menocal and others, authorizing the construction of a ship canal from Grey Town to Brito, and as the proposed canal would affect the territory of Costa Rica also the promoters found it necessary to secure a like concession from that Republic, which was accomplished in August, 1888. These contracts appear as appendices, marked "R" and "Z."

Nicaragua grants concession to Menocal and associates.

Like concession from Costa Rica.

A company of execution was organized, under the name of The Maritime Canal Company of Nicaragua, to construct and operate a canal under these contracts, and it was incorporated by Congress in February, 1889.

Maritime Canal Company.

The features of the project adopted by this company, the work it accomplished, the subsequent failure of the construction company organized in connection with it, and the action of the Government of Nicaragua in declaring its contract forfeited and terminated because of the lack of fulfillment of its most essential clauses are stated in another chapter of this report. Propositions to aid the company were before Congress for several years, through an arrangement by which the Government was to become a stockholder and an indorser of the company's bonds, and a bill for the accomplishment of this purpose was passed by the Senate in January, 1895, but failed in the House of Representatives. Another bill, retaining the company organization, but eliminating the private or individual stockholders, was passed by the Senate in January, 1896, but no final action was taken upon it by the House before the close of the Congress.

While the former bill was pending in the House an amendment to the sundry civil appropriation bill was adopted in the Senate for the purpose of ascertaining the feasibility, permanence, and cost of the construction and completion of the canal through Nicaragua by the contemplated route. A board of three engineers was provided for, to be appointed by the President—one from the Corps of Engineeers of the Army, one from the engineers of the Navy, and one from civil life. Under regulations to be made by the Secretary of State, with the approval of the President, this board was to visit and personally inspect the route, examine and consider the plans, profiles, sections, prisms, and specifications for its various parts, and report to the President. In case it should be ascertained that any deviation from the general line of the proposed route was desirable, the board was directed so to state in its findings and conclusions.

Nicaragua Canal Board.

The bill was passed with this amendment and was approved March 2, 1895. The President appointed Lieut. Col. William Ludlow, Corps of Engineers, United States Army; Civil Engineer M. T. Endicott, United States Navy, and Alfred Noble, civil engineer, to constitute this board, which was designated as the Nicaragua Canal Board. The appointments were made April 25, and the members of the board proceeded early in the following month to Nicaragua and, after their examinations there, completed their work in time to make their report by the 1st of November, as required by law. This report was printed during the first session of the Fifty-fourth Congress as House Doc. No. 279.

The Nicaragua Canal Board found it impracticable within the time fixed in the law, and with the limited means appropriated for the accomplishment of its work, to make a full and thorough examination of the route and obtain the necessary data for the formation of a final project of a canal, and in the report a recommendation was included that there be further explorations and observations, so as to collect the information and data regarded as essential to the comprehension of the fundamental features of the canal problem, which should decide the final location and cost of the work.

In accordance with the views of the board, there was included in the sundry civil appropriation act, which was approved June 4, 1897, an appropriation to continue the surveys and examinations in Nicaragua, authorized by the former act, under which the Ludlow Board had been appointed. By this latter act the President was empowered to appoint, by and with the advice and consent of the Senate, a commission to consist of one engineer from the Corps of Engineers of the United States Army, one officer of the Navy, from the active or retired list, and one engineer from civil life. This Commission was to have all the powers and duties conferred upon the former board and was to report upon the proper route for a canal in Nicaragua and the feasibility and cost of the work, with the view of making complete plans for the construction of such a canal as was contemplated.

Nicaragua Canal Commission.

Pursuant to this authority, the President appointed Rear-Admiral John G. Walker, United States Navy, Col. Peter C. Hains, Corps of Engineers, United States Army, and Prof. Lewis M. Haupt, civil engineer, to constitute the Commission, which was designated as the Nicaragua Canal Commission, Admiral Walker being named as president. The Commission performed the duties assigned to it and made its report to the President May 9, 1899; it includes the results of the latest investigations made of this route prior to the appointment of the present Commission. A limited number of copies of this report, including an atlas which was prepared to accompany it, was printed under the direction of the present Commission for its information, but it has not yet been published as a Congressional document.

This brings the history of the transits of the American isthmus and of the efforts to discover or construct a navigable waterway from the Atlantic to the Pacific to the close of the nineteenth century. Four hundred years have passed since Columbus sailed westward, hopeful and confident that his voyage would be continued without interruption to the Asiatic coast. He reached the shores of Panama and Darien, where the waters of the two oceans are less than half a degree of latitude apart, and no progress has been made since his day in accomplishing his original purpose. The search for the strait was soon given up and the narrow neck of land which hindered his progress, fortified by the Cordilleras, has ever since obstructed the advance of navigation in that direction.

Nor has any line of transportation by land or sea been developed in either hemisphere that has furnished the advantages expected from the desired waterway.

The passages to the Orient around the Cape of Good Hope, through the Strait of Magellan and around Cape Horn have not satisfied the desire for a direct line of communication eastward or westward. The passage north of the American continent, discovered in 1851, and that north of Asia, first made in 1879, were valuable only as contributions to geographic knowledge, for they are through arctic regions where the ice seldom permits a continuous voyage. Lines of transcontinental railroad connecting Atlantic and Pacific ports have facilitated travel and commercial intercourse, but they have not filled the place of a ship canal. The reopening of the ancient communication, mainly upon a new line, between the Mediterranean Sea and the Indian Ocean by the completion of the Suez Canal in 1869 has made the interoceanic connection westward of less importance to the people of Europe, but it has had little effect on the American continent. The demand that the American isthmus be opened to navigation from sea to sea is each year becoming more imperative. The extension of our territory to include the Hawaiian Islands and afterwards the Philippines has made this connection most desirable for the proper exercise of governmental functions wherever they are to be discharged.

The preparatory work has been practically completed. The examinations and surveys, made under the authority of the United States, have furnished accurate knowledge of the geography, topography, and other physical features of the isthmian country, and dispelled the exaggerations and fictions which were brought back many years ago from some sections by credulous travelers and unreliable explorers. The comparative merits of the different routes are better understood than ever before, and those involving engineering difficulties and cost disproportionate to their value have been eliminated.

The two remaining routes—the Nicaragua and Panama—have been carefully studied by the present Commission, and this report will contain a statement of the advantages and disadvantages of each and an approximate estimate of their costs, and also the judgment of the Commission as to which, in view of all the facts, is the more practicable and feasible route.

Time has also developed that the only well-grounded hope of accomplishing the desired result is through the power and resources of a great nation. The republics, through whose territory they extend, seem to be now impressed with this belief. They have made many contracts with individuals and companies for the construction and operation of canals, and the general result has been failure, followed by forfeiture and annulment. These contracts usually contain provisions forbidding their transfer to foreign Governments, indicating an unwillingness to permit the occupation of their territory by another power for these purposes; but their great desire to see the two oceans thus connected and their willingness to promote such an enterprise has, it is believed, modified their views and policy to such an extent that they are ready to enter into negotiations with the treaty-making power for the occupation of their territory by the United States for canal purposes, provided they receive satisfactory assurance that their rights of sovereignty will be respected.

When these international questions are definitely settled and Congress has enacted the necessary legislation, the removal of the barrier between the two oceans and the opening of the long-desired maritime passage to the ships and navies of the world can be accomplished.

Chapter III.

DIMENSIONS AND UNIT PRICES.

In fixing the dimensions of the canal, it is necessary to consider carefully the dimensions of the ships which will use it; the prevailing as well as the exceptional types of the present day, and the probable developments of the near future. If the dimensions adopted are too large, the cost of the work will be augmented unnecessarily; if too small, the canal will not fulfill its intended purpose.

The greater part of the world's commerce by sea is carried on by ships of moderate size. Lloyd's Register for 1900-1901 contains the names and dimensions of 16,264 steam vessels of all kinds, of which about 8,900 are more than 200 feet long on the keel. This number may be taken as approximately the number of cargo vessels. Only 421 seagoing ships have as great a beam as 50 feet, and only about 800 would require a lock more than 400 feet long. Until recently the larger ships were employed mainly on the North Atlantic route, and the largest were fast passenger ships not adapted to any other trade. The building of large freight ships with more or less passenger accommodations has now become a marked feature of the development of ship building. In the years 1897 to 1900 there were put in service on the North Atlantic route several ships of this type, about 600 feet long over all, 63 to 65 feet beam, and drawing, when fully loaded, 30 to 32 feet. These were followed by the White Star ship *Celtic*, recently built, said to be 698 feet 8 inches long over all, and 75 feet 4½ inches beam. On other routes ships of similar dimensions are being introduced, the largest now in use being the White Star ships of the *Afric* class, built for the British colonial service via the Cape of Good Hope, which are about 550 feet long between perpendiculars, 64 feet beam, and have a load draft of 32½ feet, and the Cape mail steamship *Saxon*, built for the Union Company, which is 585 feet 6 inches long over all, and 64 feet beam. The ships now building at New London for the Great Northern Railway Company are particularly noteworthy, being designed for the trans-Pacific trade; they are to be 630 feet long and 73 feet beam. They will be in the same class as the *Celtic*.

Dimensions of ships now in use.

Recent increase in ship dimensions.

The steady growth in ships' dimensions, the introduction of large ships on so many different routes, and the undoubted fact that for long routes and for freight which can be quickly handled at the ports, the large ship is the more economical carrier, gives these ships an importance in determining canal dimensions much greater than their relative number or aggregate tonnage would indicate. A ship drawing $32\frac{1}{2}$ feet in salt water, which is no longer exceptional, will draw nearly 1 foot more in fresh water, and requires for safe navigation not less than 35 feet of water in the canal. This depth is therefore fixed as the minimum in all the channels.

Depth of canal.

In fixing the width of locks and prism it is not necessary to take into account the fast passenger ships of the North Atlantic routes. Such a trade is not likely to develop through the Isthmus. Limiting the inquiry to freight or combined freight and passenger ships like those mentioned, it will be noted that the maximum beam of 73 to 76 feet is found in very few ships; excepting these, the greatest is 63 to 65 feet, which is found in quite a numerous class. If the canal were intended for commercial uses only, it might be questioned whether dimensions should be fixed for the extreme beam of 75 feet or more, with the added cost of construction and minor disadvantages, but the imperative requirement that the canal shall afford a passage for the largest war ships makes it necessary to provide for a beam considerably greater. The broadest ships building for the United States Navy are those of the *Virginia* class which have a beam of 76 feet and $2\frac{1}{2}$ inches. The broadest battle ship afloat is the Italian ship *Regina Margherita*, recently launched, which has a beam of 78.2 feet. While the increase in beam of war ships has for some years been less rapid than that of commercial ships, it is unmistakable. For convenience in operating the locks the width should be 2 or 3 feet greater than the beam of the ship. The width is therefore fixed at 84 feet with a view to provide for some further increase in beam of ships.

Beam of commercial ships.

Beam of war ships.

Width of locks.

The largest ships of war are shorter than commercial ships of like beam, and a clear length of lock chamber of 600 feet would be sufficient for any war ship now afloat or building. In order to make the canal practicable for the largest existing commercial ships, and also to provide for a considerable increase in size, the only additional expense to be incurred in the building of the canal, after providing for warship requirements, is to increase the length of the locks. This added cost is so small in comparison with the advantage gained that it is unquestionably judicious to incur it, and the length is therefore fixed at 740 feet in the clear.

Length of lock chambers.

Dimensions of prism of canal.

The width of the canal has been fixed after careful consideration of the dimensions adopted and experience gained elsewhere. The Suez Canal had originally a bottom width of 22 meters (72 feet 2 inches). It had been intended, when the work was projected, to make this width 44 meters (144 feet 4 inches) between the Bitter Lakes and the Mediterranean, and 64 meters (209 feet 11 inches) between the Bitter Lakes and the Red Sea, but the resources of the company proved insufficient to carry out the work on this plan. The width finally adopted proved inconveniently small, and it has since been increased to about 115 feet. At the same time the depth has been increased from 26 feet 3 inches to 27 feet 10 inches. The ratio of present width to depth is about 4:1. In the Manchester Canal the depth is 26 feet, but is to be increased to 28 feet. When this is done the bottom width will be about 114 feet, and the ratio of width to depth will also be about 4:1. The Amsterdam Canal is at present 36 meters (118 feet 1 inch) wide at the bottom and 8.5 meters (27 feet 10 inches) deep, giving a ratio of width to depth of 4:2. These dimensions are to be increased to 50 meters (164 feet) width and 9.8 meters (32 feet 2 inches) depth, with a ratio of 5:1. The bottom width of 150 feet, which has been adopted by the Commission for the canal sections of the Isthmian routes, gives a ratio of width to depth of 4:3, which is slightly greater than at the Suez, Manchester, and Amsterdam canals, and considerably less than the enlarged Amsterdam Canal will give.

Prism dimensions of foreign canals.

Bottom width of prism adopted.

Mention should be made of the Kiel Canal, which has the bottom width first given to the Suez Canal, viz, 72 feet, and has a depth of 29.5 feet, giving a ratio of width to depth of 2.5. This has not been taken into account in the preceding comparison, for the reason that the width is clearly shown to be insufficient for commercial purposes by experience at Suez. The Kiel Canal was built primarily for an outlet to the North Sea for the German navy, and is adapted for the possible transfer of warships rather than for the convenience of commercial ones. Few commercial ships of large size traverse it. The average tonnage of the vessels passing in 1899 was about 100 tons, which may be compared with the average of nearly 4,000 tons for the ships passing through the Suez Canal during the same year.

Prism dimensions of Kiel Canal.

The side slopes of the isthmian canal sections vary with the materials. In soft earth or sand they are taken 1 on 3 below water and 1 on 2 above water; in firm earth, 2 on 3 below a berme 10 feet wide 6 feet under water and 1 on 1 above such berme. The 1 on 1 slopes are to be protected by paving from the berme to 6 feet above water. In rock the sides are vertical from the bottom to a berme 5 feet above water, with slopes of 4 on 1 in hard rock and 2 on 1 in soft rock above

Prism in soft earth and sand.

Prism in firm earth.

Prism in rock.

such berme, the berme being of such width that the extended slopes would intersect the bottom of the canal at the foot of the vertical sides. In several places a slope of 1 on 1 is used, as in the Culebra Cut, on account of the peculiar nature of the material, and in places on the Nicaragua route where rock is underlaid by clay. Where the material is liable to disintegrate in water, as in the Culebra Cut, or where the rock is shattered or deficient in hardness, as in many places on the Nicaragua route, retaining walls are provided, taking the place of the vertical sides of rock cuts.

Channels in open water.

Where channels are excavated in open water and the sides will be submerged, the width is made greater. In Panama Bay the bottom width is to be 200 feet, with side slopes of 1 on 3, but at mean tide the width 35 feet below water will be 260 feet and at high tide 320 feet. In the San Juan River the excavated channel will be 250 feet wide at bottom with side slopes of 1 on 1, and in Lake Nicaragua 300 feet with side slopes of 1 on 2 in firm clay and 1 on 6 in overlying mud. In the artificial harbors at Colon and Greytown it will be 500 feet with turning places 800 feet wide. The entrance to Brito Harbor will also be 500 feet wide, but the harbor itself, on account of its restricted length, will be 800 feet wide.

The channel widths above given are for straight sections. On curves of less than 12,000 feet radius, in channels less than 500 feet wide, the width is increased at the rate of 1 foot for each 200 feet reduction of radius, the widening on a curve of 6,000 feet radius being 30 feet. This is an arbitrary allowance. It is the same as the allowance in Kiel Canal for a radius of 5,000 feet; less than in the Kiel Canal for radii under 5,000 feet and more for radii over 5,000 feet.

Widening on curves.

Description of locks.

As already stated, the locks are to have a clear length of 740 feet and a width of 84 feet between the side walls. The depth over the head wall and over the miter sills at the lower end of the locks, which fix the available depth for ships, is to be 35 feet, the same as in the prism of the canal. The miter sills at the head of the locks are placed 1 foot lower, the slightly greater safety thus afforded for these sills being secured by merely exchanging 1 foot in height of gate for 1 foot in height of miter sill wall and without appreciable cost. In order to give the required clear length, all single locks and the upper locks of combined systems are to be made 788 feet long from quoin to quoin. The lower locks of combined systems will be 793 feet from quoin to quoin, the greater length being due to the greater thickness of the cross wall at the middle gates.

Twin locks provided.

Twin locks are provided in every case. This will insure uninterrupted navigation if one lock at any locality is closed for repairs. To facilitate making these repairs

Guard gates.

with the least possible delay, guard gates of the ordinary miter form are placed at both ends of every lock or flight of locks, those at the foot opening downstream. When repairs to the lock are needed, these gates can be closed and the lock pumped out immediately, thus avoiding the delay of building cofferdams or the uncertainties attending the use of caisson gates. This provision is not usual, but has been adopted for all the locks of the St. Marys Falls canals, and its utility has been frequently demonstrated there. These gates are supported by extensions of the lock walls. The extreme length of the masonry is 1,031.5 feet for a single lock and 1,829.5 for a flight of two locks.

While these locks provide for the passage of the largest ships anticipated in the near future, it is realized that the larger part of the sea traffic of the present day is carried on by much smaller ships.

Smaller locks than those adopted could be operated more quickly and would effect a material aggregate saving of time to the greater part of the traffic and reduce the amount of water consumed. The width of the locks can not be reduced without excluding the large ships. It is practicable, however, to provide a shorter lock by the introduction of intermediate gates, whereby two smaller chambers can be obtained and some of the advantages secured of having a small lock for small ships. By the arrangement shown in the plans the whole chamber can be used, the intermediate gates remaining open; by using these gates in connection with the upper lock gates, a chamber is provided having a clear length of 292 feet, and by using them in connection with the lower lock gates, a chamber is provided having a clear length of 400 feet, sufficient for most of the freight ships now in use. With two locks combined in a flight, only one of the smaller chambers in each lock is available, the intermediate gates being so placed that either the full length of the 400-foot chamber can be used. It may be found expedient in construction to make the length of the reduced chamber 450 feet.

Foundations of locks on rock.

All the locks on both routes will have rock foundations. The rock varies greatly from hard to soft and partially disintegrated. The poorest will carry safely the imposed load, but will permit slow seepage for considerable distances, and will offer little resistance to abrasion. The floors of the locks are protected by inverts of concrete, the thickness being greater in soft rock. In the vicinity of the lock gates the floor is of sufficient thickness to sustain the full hydrostatic head.

Walls to be of concrete.

The walls are also to be of concrete throughout, except the quoins, the tops of the miter-sill walls, and exposed angles at the inlets and outlets of the culverts. The use of concrete for the construction of locks is of comparatively recent ntroduction. The locks of the Manchester Canal are perhaps the most notable example, the great mass of masonry being concrete, granite being used only for quoins, copings, and exposed angles, and brick burned to the point of incipient vitrification for facing the walls above low water and for culvert linings. The moist, warm climate of the Isthmus is particularly favorable for concrete.

Culvert linings.

In the locks of greatest lift the velocity of water in the culverts will reach 50 to 60 feet per second, which would severely test any masonry, even of the best brick or cut stone. Even in locks of the smaller lifts some kind of protection for the surfaces of the culverts will probably be necessary. As a basis for estimates a lining of cast iron of a minimum thickness of 1 inch is provided where the extreme head of water in the culverts exceeds 30 feet and a lining of vitrified brick for smaller heads.

Lock gates.

The gates are designed of steel of the ordinary miter form. They are based on actual designs of gates of nearly equal dimensions prepared under the direction of the United States Board of Engineers on Deep Waterways.

In designing the locks the varying height of rock at each of the lock sites has been taken into account. The details of the studies concerning the stability of the walls, as well as of the loss of water by leakage, etc., are given in Appendix A.

Approach walls.

In order to facilitate the movement of ships into the locks, as well as to afford a safe place for ships to tie up while awaiting lockage, a vertical approach wall 1,200 feet long is provided on one side of the canal at each end of every lock or flight.

Unit prices.

Unit prices have been fixed by agreement of all the members of the Commission, on the principle that, whatever differences of opinion or circumstances may exist, they are not enough to interfere with a fair and close comparison of the different routes. These prices are as follows:

Removal of hard rock, per cubic yard	$1.15
Removal of soft rock, per cubic yard	.80
Removal of earth, not handled by dredge, per cubic yard	.45
Removal of dredgable material, per cubic yard	.20
Removal of rock, under water, per cubic yard	4.75
Embankments and back filling, per cubic yard	.60
Rock in jetty construction, per cubic yard	2.50
Stone pitching, including necessary backing, per square yard	2.00
Clearing and grubbing, in swamp sections of Nicaragua, per acre	200.00
Other clearing and grubbing, on both routes, per acre	100.00
Concrete, in place, per cubic yard	8.00
Finished granite, per cubic yard	60.00

Brick in culvert lining, per cubic yard	$15.00
All metal in locks, exclusive of machinery and culvert linings, per pound	.075
All metal in sluices, per pound	.075
Cast iron in culvert lining, per pound	.04
Allowance for each lock chamber for operating machinery	50,000.00
Additional allowance for each group of locks for power plant	100,000.00
Price of timber in locks, per M. B. M	100.00
Sheet piling in spillways, per M. B. M	75.00
Bearing piles in spillways, per linear foot	.50
Average price of pneumatic work for the Bohio Dam, below elevation −30, per cubic yard	29.50
Caisson work for the Conchuda Dam, in place, per cubic yard	20.00
Single-track railroad, complete, with switches, stations, and rolling stock, per mile of main line	75,000.00

Contingencies, etc.

It has been determined to add 20 per cent to the estimates of the cost of construction to cover expenses that will be incurred for engineering, police, sanitation, and general contingencies. The prices are based on efficient organization and thorough equipment, with the understanding that while the work would be vigorously handled it would not be so driven as to call for unnecessary duplication of machinery. The cost of the equipment and plant will be large, but it will be distributed over a very large work.

Chapter IV.

OTHER POSSIBLE ROUTES.

General description American isthmus.

The American isthmus, in the most extensive meaning, is about 1,400 miles long, extending from the seventy-seventh to the ninety-fifth meridian of longitude and from the eighth to eighteenth parallel of latitude. It embraces that portion of the Republic of Colombia which lies west of the Atrato River in South America, the whole of the five republics which are grouped together as Central America, and so much of Mexico as lies east of Tehuantepec. The general direction of the isthmus is from southeast to northwest. For the eastern 600 miles the width of this isthmus is comparatively small, varying from a minimum of barely 30 miles to a maximum of 120 miles. It then widens to 300 miles near the boundary between Nicaragua and Honduras, narrows to about 120 miles opposite the Bay of Honduras, widens again into the great peninsula of Yucatan, and finally narrows to 120 miles at Tehuantepec. A glance at a map indicates that the only possible routes for an interoceanic canal must be at Tehuantepec, at the Bay of Honduras, or within the eastern 600 miles.

Tehuantepec route.

So far as convenience of approach and accessibility from United States ports on both sides of the continent are concerned, Tehuantepec is by far the best location. Practically the whole length of the isthmus is eliminated on the distance to Pacific ports, and while the distance from New York is practically the same to all ports on the Atlantic side of the isthmus, the mouth of the Mississippi River is only about half as far from Tehuantepec as from the Atrato. For these reasons Tehuantepec was selected by Capt. James B. Eads as the location for a ship railway across the isthmus. If a ship railway is to be built it is probably the best location. The duties of this Commission, however, are confined to finding a route for a canal between the two oceans. The Tehuantepec summit is in the neighborhood of 700 feet above tide water. It is, moreover, a broad summit which can not be materially lowered by any excavation of practicable dimensions. It is doubtful whether a water supply can be found for a summit level. It would require 20 locks of an average lift of nearly 35 feet on each side of the summit. The cost of these locks alone, on the basis of the estimates considered in another chapter of this report, would be about

$200,000,000, while the canal would probably at least double this estimate. Attractive as the Tehuantepec route is from its geographical location, it must be discarded as impracticable for a canal.

Bay of Honduras.

The next point is at the head of the Bay of Honduras. This location would be nearly as accessible as Tehuantepec on the Atlantic side, but the Pacific terminus would be 400 miles farther from north Pacific ports. The passage of the isthmus here by a canal, or even by a railroad of moderate grades, is out of the question; it is a mountain region which must be dismissed from consideration.

Narrow eastern portion of isthmus.

There remains the 600-mile stretch at the eastern end of the isthmus, within the limits of which several routes have been proposed. At the western limit of this stretch lies Lake Nicaragua. The features of the Nicaragua route are thoroughly considered in another chapter of this report, and nothing more need be said of it here. From Lake Nicaragua to the promontory which terminates in Mariato Point and Cape Mala, and which forms the western boundary of the Gulf of Panama, the isthmus, though narrow, is traversed by a high range of mountains, which prohibits its consideration as a location for a canal. The Gulf of Panama measures about 120 miles from east to west between the headlands known as Cape Mala and Piñas Point, which practically form its southern limit, and about 100 miles from a line connecting these two points to its northern extremity. The southern limit corresponds closely with the 100-fathom curve. The isthmus sweeps around this gulf on a curve which forms a rough approximation to a half circle; the narrowest part of the whole isthmus lies north of the center of the Gulf of Panama.

Atrato River.

The Atrato River, rising near the fifth degree of north latitude, flows northward about 300 miles at a comparatively short distance from the Pacific and parallel to it, thus forming what resembles an extension of the Isthmus southward; but the eastern boundary of this extension is not the ocean. The Atrato is a silt-bearing river having a considerable fall, and not in itself adapted to the use of ocean-going craft, without large expenditures for improvement and maintenance. With the exception of Nicaragua and Tehuantepec, all the routes which have been proposed for an isthmian canal terminate in the Gulf of Panama or on the South American coast south of that gulf, the latter using the Atrato for their Atlantic approach.

Routes terminating on Gulf of Panama.

Three routes which terminate on the Gulf of Panama have been talked of for many years. They are commonly known as the Panama route, the San Blas route, and the Caledonia route. The Panama route is the most westerly of the three, and the one of earliest use and occupation. The old city of Panama was founded in 1517. The Spanish crossing was by a paved road from Nombre de Dios, and later from Porto Bello, on the Atlantic side, to Panama, on the Pacific. Porto Bello Harbor was discovered and named by Columbus in 1502, and the town of Porto Bello was founded in 1584. The Panama Railroad was built fifty years ago near this ancient crossing, and its location is practically identical with that selected for a canal. As the Panama route is treated in full detail in another chapter of this report, nothing further need be said of it here.

Atrato routes.

The distance from the mouth of the Atrato River to tide water on the Pacific at the nearest point is about 70 miles. Anything like a direct passage is entirely out of the question, and it is manifestly impossible to find a canal line from the mouth of the Atrato to the Pacific which will be less than 100 miles long, if the improvements on the Atrato are considered a part of the canal; the lines which have been suggested for this purpose are generally much longer. While it is not impossible that a practicable line on which to construct a canal can be found with its terminus in the Atrato Valley, the necessary length of the line, together with the difficulties which would attend a terminus at the mouth of a large silt-bearing river, are enough to show that in use it would be inferior to either the Panama or the Nicaragua location.

Limits of field work.

In the search for other possible routes the field work of this Commission has been confined to the region lying between the Panama route and the Atrato River, not including the routes which would utilize this river. Throughout the portion of the Isthmus thus explored the continental divide, which elsewhere lies near the Pacific, lies close to the Atlantic coast, and there are intermediate valleys separated from the Pacific coast by ranges of less importance. The Chepo River enters the Gulf of Panama 30 miles east of the city of Panama, coming from the east and draining a valley nearly 70 miles long. On the easterly side of the Gulf of Panama lies the Gulf of San Miguel, which is an excellent harbor, carrying tide water halfway across the Isthmus. The Savana River enters this gulf from the north and the Tuyra River from the southeast, while the Chucunaque, heading near the Chepo and flowing southeasterly, is a tributary of the Tuyra. The continental divide on this section of the Isthmus is therefore the divide between the Caribbean Sea on the northeast and the Chepo, the Chucunaque, and the Tuyra rivers successively on the southwest. The divide at the head of the Chepo and the Chucunaque rivers connects the continental divide with the chains of hills which separate those rivers from the Pacific. The general situation is fully shown in pl. 2, accompanying this report. Within these limits two routes, each of them presenting possibilities of several varieties of location, have long been suggested. One of these is known as the San Blas route and the other as the Caledonia route.

San Blas route.

The San Blas route was explored under the direction of Mr. Frederick M. Kelley in 1857, and was subsequently examined by the United States Darien expedition, under the command of Commander Thomas Oliver Selfridge, jr., United States Navy, in 1870. The Kelley examination, starting from the Pacific, was carried with level and transit up the Chepo and the Mamoni rivers across the summit to a point on the Carti, following the valleys of these streams. The Selfridge surveys, starting from the Atlantic side were carried with level and transit up the Mandinga River, across the divide, and up the Nercalagua River nearly to the divide, while barometrical reconnaissances were made up the Carti River overlapping the Kelley survey. This is the narrowest place on the isthmus, it being less than 31 miles from shore line to shore line and only about two-thirds of this distance from the Atlantic to tide water in the Chepo River. Furthermore, the Pacific harbor is quite as good as that at Panama, while Mandinga Harbor, in the Gulf of San Blas, at the northern end of the route, is all that could be desired. The difficulty of the line lies in the height of the summit, to cross which tunnels from 8 to 10 miles in length were proposed.

Caledonia route.

The Caledonia route has the distinction of being the location where the isthmus was first crossed by white men. In 1513 Balboa started with his band of followers from Caledonia Bay and crossed by a tiresome march to San Miguel Bay. Nearly two hundred years later, in 1698, William Paterson chose this location for his Scotch colony of New Edinburgh, which by occupying the line of transit across the isthmus was to control the trade of the Pacific and the East. The bay, which would be the northern terminus of the canal, is still known as Caledonia Bay, while the promontory at the southern end of the bay, near where he founded his town, is called Point Escoces. All vestiges of Paterson's work have long since disappeared and it would be hard to find any spot in America where there are fewer signs of the work of the white man.

Caledonia Bay is a beautiful body of water separated from the Caribbean Sea by a series of coral keys and furnishing fairly good anchorages at both ends, though the intermediate portion is shallow. The route for a canal in this location would be from Caledonia Bay to San Miguel Bay. As seen from the sea, the Caledonia gap is a very marked depression in the mountains and the summit is less than 4 miles from the bay. It looks much lower than it really is and the first impression made is that it is an ideal location for a transisthmian line. This route was advocated as early as 1850 by Dr. Edward Cullen, of Dublin. It was explored in 1852 by an English engineer, Mr. Lionel Gisborne, and it was subsequently examined by Lieut. Isaac G. Strain, U. S. N., in 1854. Reconnaissances were subsequently made by others, the most important being by the United States Darien expedition in 1870. It was claimed by Dr. Cullen that the height of the summit on this line was not more than 150 feet and that from a ridge only 2 miles wide a level plain extended to the Savana River, the northern tributary of the Gulf of San Miguel. Mr. Gisborne, whose examination was not continued completely across the isthmus, reaffirmed this claim. Strain's examination and all subsequent ones failed to find any such condition.

Divide traced.

All the examinations of which there is sufficient information to give them any authentic value were made on the principle of following up streams. While this method of examination is permissible when time and means do not allow the use of better ones, conclusive results can not be obtained in this way. The claims made for some of these routes, especially in the neighborhood Caledonia Bay, were such that if substantiated they would be better than any others. It became necessary either to find these locations or to disprove their existence. The proof derived from the examinations of the several valleys must always be of negative character; it can not be conclusive until it is shown that every stream has been explored. If, however, the divide could be traced continuously, positive proof would be substituted for negative proof. The Commission therefore organized a force for the purpose of tracing the divide and determining its continuity. It was at first proposed to trace this divide continuously from the Chagres to the Atrato. This has not been done, but the divide has been traced from the Chagres to San Blas and far enough beyond to cover all routes that have been suggested for this location. It has been traced in both directions from Caledonia Bay far enough to cover all the locations which have been suggested there. The mountain range has been examined from the coast continuously from San Blas to the Atrato. The results of these surveys and this examination are embodied in the maps and sketches which accompany this report. While they have not been absolutely complete, they have proved conclusively that no low summit exists within the limits by which a canal line would approach either San Blas Bay or Caledonia Bay. Any canal terminating at either of these harbors will involve the construction of a tunnel. There is a bare possibility that some low summit may exist in the portion of the range which was only examined from the sea, but the general topography of the country indicates that this is extremely improbable, while the appearance of the range shows that if any such low summit can by any possibility exist, it must be approached by valleys of such crooked and restricted character that it would almost certainly be impracticable for a canal.

The divide has been traced continuously from latitude 9° 19′ N., longitude 78° 59′ W., westward to the headwaters of the Chagres River. The lowest summit found within these limits was 956 feet;

this elevation was determined by actual leveling. The Chagres River was then followed down to the Panama Railroad, thus connecting this survey with the Panama route.

The ridge has been continuously traced from the Carreto summit, latitude 8° 45′ N., longitude 77° 38′ W., to the Sassardi summit, latitude 8° 58′ N., longitude 77° 52′ W., covering the entire divide in the vicinity of Caledonia Bay. The lowest summit within this limit is the Caledonia gap, with an elevation of 681 feet. Five other gaps, with elevations respectively of 815, 740, 827, 994, and 1,098 feet, were observed within these limits. All of these elevations were determined by actual leveling.

Observations from the sea

Between the limit of these two actual surveys there is a distance of 81 miles in an air line where the divide has not been traced. There is also a distance of about 60 miles from the Carreto summit southeast to the Atrato where no actual surveys have been made. Through these distances the divide has been carefully reconnoitered from the sea, the elevations of the higher peaks being ascertained as well as those of the visible gaps, and the distances being determined by observation made with two sextants. While this method of examination is not absolutely conclusive, the results are such as to show that there is no probability of any low summit existing within these limits; this improbability is further increased by the general character of the watershed of the country.

Examination from Pacific side.

All this summit examination was made from the Atlantic side. In addition to this, a survey was made up the Chucunaque and the Chucurti rivers which was not quite connected with the work done from the Atlantic side, owing to the threatening attitude of the Indians. The gap of 2 or 3 miles has been supplied from the Selfridge survey of 1870. These surveys were extended up the Tuyra and Aputi rivers and up the Savana and Lara rivers, besides running a survey from the mouth of the Lara in an easterly course to the Chucunaque.

The explorations of other possible routes, while not entirely complete, have shown that it is practicable to follow the divide in this section of the isthmus and that this is the method of exploring which is applicable to the isthmus. The good health of the field parties has shown that this country is not one which is exceptionally unhealthy to explore.

No canal without a tunnel.

The result of these examinations and surveys shows that there is no probability of the existence of any practicable canal location between Panama and the mouth of the Atrato River except by the adoption of a tunnel line.

The objections to a tunnel on a canal are so great that a tunnel location should not be adopted unless there are manifest advantages of sufficient weight to overcome these objections. No such advantages appear to exist. The surveys, however, have shown that there is a possible tunnel location on the San Blas route and at least three on the Caledonia route. Each of these four locations, though involving a tunnel, provides for a sea-level canal.

Design of tunnel.

With a view to determine the approximate cost of a canal tunnel a section of tunnel was worked out, and this section is shown in fig. 1. This section provides for a depth of 35 feet, for a width of 100 feet at the bottom, of 117 feet on the water line, and for a height of 115 feet from the water surface to the intrados of the lining. The estimate is made on the basis of the entire tunnel being lined with concrete 5 feet thick. The quantities and estimated cost of a single foot of this tunnel are as follows:

676.2 cubic yards excavation, at $5	$3,381
88.7 cubic yards concrete, at $10	887
Total	4,268

This corresponds to $22,535,040 per mile. In the estimates the tunnel has been assumed to cost $22,500,000 per mile.

Tunnel tide level, San Blas Canal.

The location which seems to promise best for such a canal is shown in pl. 3 accompanying this report. The line starting from Mandinga Harbor follows up the Rio Carti, passes through a tunnel 4.5 miles long, and descends by the valley of the Chorrah to the Chepo. Open excavations are maintained on both sides of the tunnel to a maximum depth of 400 feet. The total length of the line of canal is 37 miles, and the length from tidewater to tidewater 21 miles. There has been no actual examination of the valley of the Chorrah because of the revolution existing at the time the attempt was made. A profile of this location is shown in pl. 4, and the following is a rough estimate of the possible cost of such a canal. In the absence of any means of classification the soft-rock price has been adopted as a fair average for all dry excavation outside of the tunnel.

166,000,000 cubic yards excavation, at 80 cents	$132,800,000
39,000,000 cubic yards dredging, at 20 cents	7,800,000
Clearing	500,000
4.2 miles tunnel, at $22,500,000	94,500,000
Tide lock	4,000,000
25 miles railroad, at $75,000	1,875,000
Total	241,475,000
20 per cent engineering, contingencies, etc	48,295,000
Total	289,770,000

Caledonia tunnel tide-level canals.

The distance from Caledonia Bay to tide water on the Savana River is about 30 miles in a straight line. Studies have been made of three lines across the divide, all of them striking the same point on the Savana River near the mouth of the Lara, the approaches on the Atlantic side being through the three valleys of the Caledonia, the Aglaseniqua, and the Sassardi. The distance from Caledonia Bay to the mouth of the Lara varies from 32 miles by the Sassardi route to 36 miles by the Caledonia route. The Sassardi route has not, however, been explored through its whole length, and it is quite possible that an actual survey would make it as long as the Caledonia route. Each line would require a tunnel. If the Sassardi route is taken, the length of this tunnel, assuming open cuts to be used to a depth of 400 feet at each end, would be about 1.6 miles. On either of the other two the tunnel would be about 2 miles longer, while the approaches on the south side would be much heavier.

Caledonia Bay is virtually tideless. San Miguel Bay has a tidal range of 20 feet or more. This heavy tide causes currents in the Savana River strong enough to be a serious menace to navigation, and it would be necessary to build a tide lock and dam near the mouth of the Savana. The distance from the mouth of the Lara to the tide lock is about 14 miles, the upper portion of which is in a narrow river which would require enlargement for a canal. This makes the total length of canal navigation from Caledonia Bay to the tide lock about 50 miles.

The locations of these three canal routes are given in plate 5 accompanying this report. Approximate profiles of each location are given in plate 6, and from these the following estimates of the possible cost of such canals have been made.

The more extended examination of the country gives an indication of the character of material which has been used in making a rough classification into hard rock and earth.

Sassardi location.

80,000,000 cubic yards hard rock, at $1.15	$92,000,000
137,000,000 cubic yards earth, at 45 cents	61,650,000
9,000,000 cubic yards dredging, at 20 cents	1,800,000
4,000,000 cubic yards submerged rock, at $4.75	19,000,000
Clearing	1,000,000
1.6 miles tunnel, at $22,500,000	36,000,000
Tide lock and dam	5,000,000
40 miles railroad, at $75,000	3,000,000
Total	219,450,000
20 per cent engineering, contingencies, etc	43,890,000
Total	263,340,000

Aglaseniqua location.

66,000,000 cubic yards hard rock, at $1.15	$75,900,000
110,000,000 cubic yards earth, at 45 cents	49,500,000
9,000,000 cubic yards dredging, at 20 cents	1,800,000
4,000,000 cubic yards submerged rock, at $4.75	19,000,000
Clearing	1,000,000
3.6 miles tunnel, at $22,500,000	81,000,000
Tide lock and dam	5,000,000
40 miles railroad, at $75,000	3,000,000
Total	236,200,000
20 per cent engineering, contingencies, etc	47,240,000
Total	283,440,000

Caledonia location.

77,000,000 cubic yards hard rock, at $1.15	$88,550,000
129,000,000 cubic yards earth, at 45 cents	58,050,000
9,000,000 cubic yards dredging, at 20 cents	1,800,000
4,000,000 cubic yards submerged rock, at $4.75	19,000,000
Clearing	1,000,000
4 miles tunnel, at $22,500,000	90,000,000
Tide lock and dam	5,000,000
44 miles railroad, at $75,000	3,300,000
Total	266,700,000
20 per cent engineering, contingencies, etc	53,340,000
Total	320,040,000

These estimates minimum estimates.

These estimates are made without the careful examination which is necessary for accurate figures. They may be regarded as minimum estimates; favorable material has been assumed for tunnels and favorable material for excavation in the body of the canal; in fact, these estimates represent the best possible results which can be looked for on either of the four locations. If borings either on the divide or in the low country south of the divide should show unfavorable material, these estimates must be increased. It is even possible that material might be found in the tunnel sections which would render tunnel construction virtually impracticable and compel the adoption of open cuts of enormous depth.

All these estimates are made on the basis of a tide-level canal. The only restriction on the length of a ship passing through such a canal would be the curves. The tunnels would be as absolute restrictions on depth and width as the locks of Nicaragua or Panama.

Harbors the only advantage over Panama.

A tide-level canal at Panama would be without a tunnel. The only advantage which any of these canals would have over the tide-level canal at Panama would be in the superiority of their Atlantic harbors, Mandinga Harbor in San Blas Bay and Caledonia Bay, both being very much superior to the harbor at Colon. The advantage of the harbors would not be enough to overcome the disadvantage of the tunnel.

Darien routes within limits of Panama concession.

The only reason for constructing a canal on either of these locations in preference to Panama would be that the territory is entirely wild and the work would be untrammeled by vested rights of occupation. This advantage is more apparent than real. Many of the legal complications involved in obtaining the right to complete the Panama Canal would interfere equally with the construction of a canal at San Blas or Caledonia. The Wyse concession, under which all the French operations at Panama have been conducted, confers the exclusive privilege for excavation and construction of a maritime canal across the territory of the Republic of Colombia between the Atlantic and Pacific oceans; all possible routes east of Panama, including the various Atrato lines, come within the limits of the Republic of Colombia. The contract of 1867, under which the Panama Railroad now holds its concession, gives to that company the exclusive right of isthmian transit west of a line connecting Cape Tiburon on the Atlantic with Point Garachine on the Pacific; the San Blas and the Caledonia routes both fall west of this line. No canal can therefore be constructed at either of these places unless some arrangement is made with the holders of the Wyse and the Panama Railroad concessions.

Maps and other drawings.

The results of the surveys made under the direction of the Commission on this portion of the isthmus have been embodied in a series of maps and other plans which accompany this report. They embrace a general map covering the entire isthmus and the Gulf of Panama, pl. 2; two maps on a larger scale covering, respectively, the San Blas, pls. 3 and 4, and the Caledonia and San Miguel regions, pl. 5; two maps on same scale as the last showing the coast and elevation observed from the sea, pls. 7 and 8, besides 12 panoramic sketches taken from the sea, pls. 9 to 20, and profiles of the routes already mentioned, pls. 4 and 6.

Thanks for U. S. S. Scorpion.

The thanks of the Commission are due to the Navy Department, which detailed the steamer *Scorpion* for service on the Atlantic side of the isthmus during these surveys, and especially to her commander, Lieut. Commander Nathan Sargent, her executive officer, Lieut. Roger Welles, and her other officers. The presence of this vessel rendered practicable a task which otherwise might have been impossible of execution.

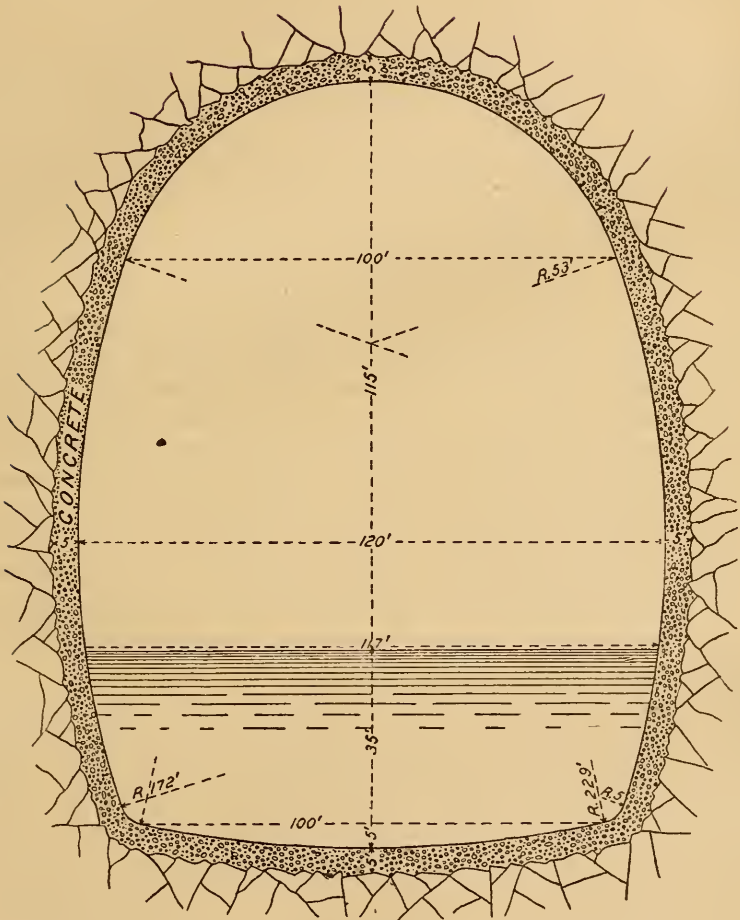

Fig. 1.

Chapter V.

THE PANAMA ROUTE.

The natural attractions of the Panama route lie in the combination of a very narrow isthmus with a low summit. The width of the isthmus is less than 36 miles in a straight line, only 5 miles more than at San Blas, the narrowest place, while the original summit was less than 300 feet above tide water, which, though higher than the Nicaragua summit, is less than half the height of any other summit which has been investigated. Furthermore, the high portion of the isthmus is limited to a width of about 6 miles near the Pacific side, and the Chagres River affords access by canoe navigation from the Atlantic to within 16 miles of the Pacific. When steamship lines to California were first opened the Atlantic steamers discharged their passengers at the mouth of the Chagres, whence they were conveyed up that river in canoes to Las Cruces and thence overland to Panama, where they took the Pacific steamer. When the Panama Railroad was built, in the early fifties, its Atlantic terminus was fixed at the Bay of Limon, 7 miles east of the mouth of the Chagres. The road followed the valley of the Chagres to Obispo, a few miles below Las Cruces, and thence crossed through the lowest gap to Panama. This location is almost identical with that subsequently adopted for the canal. (See pl. 21.)

General description.

The isthmus here runs nearly east and west, but the course of the railroad or canal is from northwest to southeast, the Pacific terminus being about 22 miles farther east than the Atlantic terminus. The Atlantic port is Colon, and the Pacific port Panama. At Colon the mean tidal range is about 1 foot; at Panama it is about 20 feet. The harbors are not of the first class. They have served the demands of a limited commerce heretofore. Some improvements at Colon would be necessary if the canal should be built. The defect of Colon Harbor is that it is exposed to "northers." When these are severe, ships are now compelled to go to sea. This may occur once or more each year. Panama Harbor is a roadstead behind islands at the head of a great bay or gulf. For the terminus of a canal it is sufficient, as the stay of vessels is expected to be short.

The Panama route was surveyed by Commander E. P. Lull, United States Navy, in 1875. He recommended a canal with locks and with a location generally above the overflow bottom of the Chagres. It was to have a depth of 26 feet and

Lull survey, 1875.

a bottom width of 60 to 72 feet. The locks were to have a length 450 feet between miter sills and width 65 feet. He fixed his summit level at 124 feet above tide level and proposed to use 12 locks on each side. To supply the summit level water was to be impounded by a dam to be built across the Chagres River at a site not far from the one subsequently selected by the new French company at Alhajuela, from which a feeder of complicated character would lead it to the canal. He estimated the cost of this canal at $94,511,360.

In the year 1876 an association entitled "Societe Civile Internationale du Canal Interoceanique" was organized in Paris, with Gen. Etienne Türr as president, to make surveys and explorations for a ship canal across the Isthmus of Panama. An expedition under the direction of Lieut. L. N. B. Wyse, an officer of the French navy, was sent to the Isthmus. In May, 1878, Lieutenant Wyse in the name of the association obtained a concession from the Colombian Government, commonly known as the Wyse concession.

The Wyse concession.

In May, 1879, an international congress, composed of 135 delegates from various nations, including the United States, Great Britain, and Germany, but the majority of whom were French, was convened in Paris under the auspices of Ferdinand de Lesseps to consider the question of the best location and plan for a canal across the American isthmus. After a session of two weeks, the congress decided that the canal should be located on the Panama route, and should be at the sea level and without locks. Immediately after the adjournment of the congress, the Panama Canal Company was organized under a general law of France with the title "Compagnie Universelle du Canal Interocéanique," with Ferdinand de Lesseps as president. It purchased the Wyse concession from the first-named company, paying therefor 10,000,000 francs. An attempt to float the stock of this company in August, 1879, failed, but a second attempt, made in December, 1880, was fully successful. The issue was fixed at 600,000 shares of 500 francs each. It was all sold. The next two years were devoted to surveys and examinations and preliminary work upon the canal. Operations upon a large scale were inaugurated in the early part of 1883. The plan adopted was for a sea-level canal having a depth of 29.5 feet and bottom width of 72 feet, involving excavation estimated at 157,000,000 cubic yards. The terminus on the Atlantic side was fixed by the anchorage at Colon and that on the Pacific side by the anchorage at Panama. Leaving Colon the canal passes through low ground by a direct line for a distance of 6 miles to Gatun, where it intersects the valley of the Chagres River, passes up that valley a distance of 21 miles to Obispo, where it leaves the Chagres and, following the

The old company.

valley of a small tributary, cuts through the continental divide at Culebra and thence descends by the valley of the Rio Grande to Panama Bay. Its total length from 30 feet depth in the Atlantic to 30 feet depth in the Pacific is about 47 miles. Its location is such as to give easy curvature everywhere. To secure this, it was necessary to select a point for crossing the divide where the height was somewhat greater than that of the lowest pass. The maximum height on the center line in the Culebra cut is about 333 feet above the sea. To control the floods of the Chagres, various schemes were proposed, the most prominent being the construction of a dam at Gamboa to impound the water of the upper river and the excavation of independent channels to the sea. The dam was afterwards decided to be impracticable, and the problem remained unsolved. The cost was estimated by de Lesseps in 1880 at $127,600,000, and the time required at eight years. Work under this plan continued until the latter part of 1887. The fact had by that time become evident to all, which had for a long time been evident to the well informed, that the canal could not be completed at the sea level with the resources of time and money then available. A provisional change of plan was accordingly made, under which the final completion at the sea level was to be deferred to a future time, and the opening of a canal to navigation was to be hastened by the introduction of locks. This being considered a temporary expedient, the summit level was to be supplied with water from the Chagres River by pumps. Work under this plan was pushed with vigor until 1889, when the company becoming bankrupt it was dissolved by a judgment of the Tribunal Civil de la Seine, dated February 4, 1889, and a liquidator was appointed by that court to take charge of its affairs.

Liquidation.

In the appointment of the liquidator the court kept prominently in view the completion of the canal, and it authorized him to cede to a new association all or part of the assets, to make or ratify agreements with the contractors which had for their object the continuation of the works, and to borrow money for that purpose. The liquidator reduced the force gradually and finally suspended the works May 15, 1889. He then proceeded to satisfy himself that the canal project was feasible, a question about which the failure of the company had caused grave doubts. He appointed a "commission d'etudes," composed of French and foreign engineers, 11 in number, having at their head Inspector-General Guillemain, director of the Ecole Nationale des Ponts et Chaussées, which, after a study of the entire subject and visiting the isthmus, rendered a report May 5, 1890, in which it submitted a plan for a canal with locks. It expressed the opinion that the canal could be constructed within eight years. It reported that the plant on hand was in good condition and would probably suffice for finishing the canal. It estimated the cost of completion at $112,500,000 for the works, which it thought should be increased to $174,600,000 (900,000,000 francs) to include administration and financing. It found much difficulty in estimating the value of the work done and of the plant, but gave as a rough approximation one-half the estimated cost of completing the canal, or $87,300,000 (450,000,000 francs). It called this an "intuitive estimate." More weight has been attached to this estimate in recent documents by the New Panama Canal Company than its authors claimed for it.

The time within which the canal was to be completed under the Wyse concession having nearly expired, the liquidator sought and obtained from the Colombian Government an extension of ten years. The law of Colombia granting this extension is dated December 26, 1890. It provided that a new company should be formed and work upon the canal resumed on or before February 28, 1893. This condition not having been fulfilled, a second extension was sought and obtained April 4, 1893. It provided that the term of ten years granted by the extension of 1890 should begin to run not later than October 31, 1894. By an agreement dated April 26, 1900, the time was still further extended to October 31, 1910. The validity of the last extension has been called in question. Full copies of the concession and its various extensions will be found in Appendices GG, HH, II, JJ.

The liquidator found himself laboring under special legal difficulties, from which he obtained relief by the special law of the French Chambers, dated July 1, 1893. (See Appendix KK.) He finally secured the organization of a new company on the 20th, of October, 1894, with a capital stock of 650,000 shares of 100 francs each. Six hundred thousand shares had been subscribed to be paid for in cash, and 50,000 shares were given as full-paid stock to the Colombian Government in compliance with the terms of the extension of the concession, dated December 26, 1890. Thus the cash capital of the company was 60,000,000 francs, or $11,640,000, a sum deemed sufficient for the provisional operations contemplated. The scandals connected with the failure of the old company, which had led to the prosecution and conviction of De Lesseps and other prominent persons, had made it difficult to secure even that amount. Suits had been brought against certain loan associations, administrators, contractors, and others who were supposed to have unduly profited by the extravagant management of the old company. A series of compromises were made with these persons, by which it was agreed that they should subscribe for stock in the new company on condition that the suits should be dropped. Whatever amount remained to make up the 60,000,000 francs, after deducting the sums thus obtained and those to be obtained by public subscription, was to be subscribed by the liquidator. The stock was subscribed as follows, viz:

	Francs.
Eiffel	10,000,000
Credit Lyonnais	4,000,000
Societe Generale	4,000,000
Credit Industriel et Commercial	2,000,000
Administrators of the old company	7,885,000
Artigue, Sonderegger & Co	2,200,000
Baratoux, Letellier & Co	2,200,000
Jacob heirs	750,000
Couvreux, Hersent & Co	500,000
Various persons to the number of sixty, who had profited by syndicates created by the old company	3,285,700
Hugo Oberndorffer	3,800,000
Public subscription	3,484,300
The liquidator	15,895,000
Total	60,000,000

See fourth report of the liquidator to the court, dated November 26, 1895, pages 8, 9, and 13.

The old company and the liquidator had raised by the sale of stock and bonds the sum of $246,706,431.68. The securities issued to raise this money had a face value of $435,559,332.80. The number of persons holding them is estimated at over 200,000.[1] There have been

Expenditure and results.

excavated in all about 72,000,000 cubic yards. There had been purchased and transported to the isthmus an enormous quantity of machinery and other plant, at an estimated cost of $29,000,000. Nearly all of the stock of the Panama Railroad—about 68,500 of the 70,000 shares existing—also had been purchased at a cost of about $18,094,000. A general statement of the receipts and expenditures and further details of the history of the enterprise down to the formation of the new company, furnished by M. Maurice Hutin, director-general New Panama Canal Company, will be found in Appendix B.

The new company.

The new company took possession of the property immediately after its organization in 1894—except the Panama Railroad shares, which are held in trust for its benefit—and proceeded to make a new study of the entire subject of the canal in its engineering and commercial aspects. It undertook to finish the canal, if after the completion of these studies that should be found expedient. It resumed the work of excavation, with a force large enough to comply with its concession, on a part of the line, the Emperador and Culebra cuts, where such excavation was sure to con-

[1] See second report of the liquidator to the court, dated November 12, 1891.

tribute to the enterprise if completed under any plan. By the middle of 1895 a force of about 2,000 men had been collected, and the work has progressed continuously since that time with a force reported as varying between 1,900 and 3,600 men. According to the annual reports of the company, the amount of material taken out was about 485,000 cubic yards in 1895, 915,000 in 1896, 1,225,000 in 1897, 1,200,000 in 1898, and about 1,210,000 in 1899, or about 5,000,000 cubic yards in all. The amount expended to June 30, 1899, was about $7,000,000, besides about $1,284,000 advanced to the Panama Railroad Company for building a pier at La Boca.

The company's charter provided for the appointment by the company and the liquidator of a special engineering commission of five members to report upon the work done and upon the conclusions to be drawn therefrom, this report to be rendered when the amounts expended by the new company should have reached about one-half its capital. The report was to be made public and a special meeting of the stockholders was then to be held to finally determine whether or not the canal should be completed and to provide ways and means. The time for this report and special meeting arrived in 1898. In the meantime the company had called to its aid a technical committee composed of fourteen engineers, European and American, some of them among the most eminent in their profession. After a study of all the data available and of such additional surveys and examinations as it had considered necessary to be made, this committee rendered an elaborate report dated November 16, 1898. It was reproduced in Senate document No. 188, Fifty-sixth Congress, first session, pages 43–83. This report was referred to the above-mentioned statutory commission of five, which reported in 1899 that the canal could be built according to that project within the limits of time and money estimated. The special meeting of stockholders was called immediately after the regular annual meeting of December 30, 1899. It is understood that the liquidator, who is one of the largest stockholders, refused to take part in it, and that no conclusions were reached as to the expediency of completing the canal or as to providing ways and means. The engineering questions had been solved to the satisfaction of the company, but the financial questions had been made extremely difficult, if not insoluble, by the appearance of the United States Government in the field as a probable builder of an isthmian canal. The company is conducting its operations in the same provisional way as in the last five years and has not yet appealed to the public for capital.

New company's plan.

The plan adopted by the company involves two levels above the sea-level—one of them an artificial lake to be created by a dam at Bohio, to be reached from the Atlantic side by a flight of two locks, and the other, the summit level, to be reached by another flight of two locks from the preceding; the summit level to have its bottom 68 feet above the sea and to be supplied with water by a feeder leading from an artificial reservoir to be constructed at Alhajueala, in the Upper Chagres Valley; the ascent on the Pacific side to be likewise by four locks, of which the two middle ones are combined in a flight. The canal is to have a depth of 29.5 feet and a bottom width of about 98 feet, with an increased width in certain specified parts. Its general location is the same as that adopted by the old company. The dimensions of the lock chambers are 738 feet in length, 82 feet in width, and 32 feet 10 inches in depth in the clear; the lifts to vary from 26 feet to 33 feet, according to location and stage of water. The cost was estimated at $101,850,000 for the works, which does not include administration or financing. While this is the plan recommended by the French engineers, they worked out in detail a second plan, which is an extension or modification of the foregoing, which they seemed to prefer in itself, but which they feared would require more time to execute. The limits of their concession and the heavy cost of financing led them to attach very great weight to the consideration of time. Under this second plan the upper level was omitted, the cut through the continental divide being deepened until its bottom was 32 feet above the sea; Lake Bohio was made the summit level and was fed directly by the Chagres; one flight of locks on the Atlantic side and one lock on the Pacific were omitted; the feeder from Alhajuela was omitted, but the dam at that place was retained. The estimated cost of completing the canal under this plan was not much greater than that for the other, being about $105,500,000. All work done for several years under the first plan would be equally available under the second plan, and the company contemplates reverting to the second plan if the experience of the first few years shows that time will permit. In both plans the dam at Bohio converted the river between that point and Obispo into a lake of such dimensions as not to be seriously affected by the partial floods admitted to it, while diversion channels were to be constructed on both sides of the canal from this lake to the sea. With a carefully designed system of sluices and controlling works the violence of the floods was to be checked by impounding the water both above the Alhajuela dam and Lake Bohio, so as to keep the flow below the Bohio dam within the capacity of the two diversion channels.

Physical data available.

The old Panama Canal Company began its work without adequate knowledge of the physical conditions at the Isthmus. It inaugurated at an early day some of the surveys and examinations required to supply the deficiency, and some of these it maintained as long as it continued to exist. Additional surveys were made by the liquidator, and very extended additional surveys and observations have been made by the new company. The information relating to the topography, hydrography, and geology of the Isthmus is now much more complete than is usual before the inauguration of an engineering enterprise in a new country. The canal company spared no trouble or expense in laying it all before the Commission. The most important maps, drawings, and documents were lithographed or printed and systematically arranged for the use of the Commission, copies being furnished for each member. Many other documents were supplied in manuscript. In all some 340 documents, many of them elaborate studies, were furnished. A list of them will be found in Appendix C. These supplied essentially all the data required for the preparation of plans and estimates, though further information was desired as to the foundation upon which the great dam at Bohio must be built, and as to the area of the Chagres River drainage basin. This additional information was obtained by the field parties of this Commission. It was necessary also for the purpose of this investigation to verify the French data. Independent lines of levels, measurements of distances, borings, soundings, and hydrographic observations made by its own parties, supplemented by personal observation, enable this Commission to state that the data furnished by the canal company are essentially correct.

Plan for the United States differs from that for a commercial corporation.

The circumstances under which the Commission approaches the study of a plan for the canal differ from those of the French engineers in two important particulars. The question of the time required for completion is of less vital importance, since a new concession from the Colombian Government must be obtained in any event, and since the cost of financing would be much diminished if the United States should provide the funds, that question would not be decisive against a plan which is otherwise preferable. In a plan prepared for a government seeking the permanent development of its possessions, and content to receive its returns in an indirect way and at a future time, the canal must have dimensions which will permit the passage of the largest ships now afloat or likely to be constructed. For a time such ships may be exceptional and the canal revenue derived from them may be small. A plan prepared for a commercial corporation investing capital from which an immediate and direct revenue is desired would probably exclude such exceptional ships, and the dimensions given the canal—at least in the beginning—would be less than in the former case.

Chagres River a natural obstacle.

One of the greatest natural difficulties to be encountered in the construction of a ship canal on the Panama route lies in the control of the Chagres River. That stream is about 145 miles long and has a drainage area above Bohio of about 875 square miles. Above Obispo it is in general a clear-water stream flowing over a bed of coarse gravel; but sand, clay, and silt in moderate quantities appear in the lower portions of its course. It flows through a mountainous country, in which the average annual rainfall is about 130 inches. A maximum rainfall has been observed of over 6 inches in twelve hours. Its discharge at Bohio varies from a minimum of about 350 cubic feet to a possible maximum of 136,000 cubic feet per second. The excessive rainfall and the precipitous slopes of the valley give to the river a torrential character. On December 1, 1890, it rose at Gamboa 23 feet in sixteen hours, its discharge, which was about 9,000 cubic feet per second at the beginning of the rise, increasing in the same time to six or seven times that volume. This is the most violent change of which there is definite record, but similar changes of somewhat less violence are not uncommon. The admission of a stream of this character to the canal would create conditions intolerable to navigation unless sufficient section of prism be provided to reduce the current to an unobjectionable velocity.

Sea-level plan rejected.

If a sea-level canal be constructed, either the canal itself must be made of such dimensions that maximum floods, modified to some extent by a reservoir in the Upper Chagres, could pass down its channel without injury, or independent channels must be provided to carry off these floods. As the canal lies in the lowest part of the valley, the construction of such channels would be a matter of serious difficulty, and the simplest solution would be to make the canal prism large enough to take the full discharge itself. This would have the advantage, also, of furnishing a very large canal, in which navigation under ordinary circumstances would be exceptionally easy. It would involve a cross section from Obispo to the Atlantic, having an area of at least 15,000 square feet below the water line, which would give a bottom width of about 400 feet. The quantity of excavation required for such a canal has been roughly computed, and is found to be about 266,228,000 cubic yards. The cost of such a canal, including a dam at Alhajuela and a tide lock at Miraflores, near the Pacific end, is estimated at not less than $240,000,000. Its construction would probably take at least twenty years. This Commission concurs with the various French commissions which have preceded it since the failure of the old company in rejecting the sea-level plan. While such a plan would be physically practicable, and might be adopted if no other solution were available, the difficulties of all kinds, and especially those of time and cost, would be so great that a canal with a summit level reached by locks is to be preferred.

Water supply for canal with locks.

In the case of a canal with locks the problem of controlling the floods is very much simplified, but a new one is introduced—that of supplying the summit level with water. The quantity of water required for the operation of the canal will vary with the amount of traffic and the size of the vessels carrying it. Assuming 10 lockages per day for vessels of about 3,000 tons each, an annual traffic of about 10,000,000 tons will be accommodated, which is greater than the amount to be expected at the opening of the canal. Ten lockages will require 35,127,960 cubic feet per day, or 406 cubic feet per second, assuming that four of these lockages are for the full-size lock and six of them for the reduced size, using the intermediate gates. The loss from evaporation is assumed to be 6 inches per month. The area of the lake to be proposed hereafter is 38.5 square miles, or 1,073,318,400 square feet. The loss from evaporation over this area is 536,659,200 cubic feet in a month, or 207 cubic feet per second. The loss from leakage at the lock gates is estimated at 250 cubic feet per second. To this has been added 200 cubic feet per second for power and other contingencies. Adding these amounts together, the total amount required to operate the canal for a traffic of 10,000,000 tons per annum is found to be 1,063, or, in round numbers, 1,070, cubic feet per second. The average annual discharge of the Chagres is far in excess of this, being about 3,200 cubic feet per second, but there is a well-defined dry season when the daily discharge is often less. A deficiency during the months of February, March, and April is to be apprehended and must be provided for, though it does not always occur. For use during these months some of the surplus waters of the other months must be stored. The minimum average discharge at Bohio for any month covered by the records is that for March, 1891, when it was 600 cubic feet per second, or 470 cubic feet less than the amount required. If water enough be stored to supply this deficiency, supposing it to exist continuously for three months, provision will be made against a state of affairs worse than any that has ever been known or is likely to occur. A deficiency of 470 cubic feet per second for ninety days gives an aggregate deficiency of 3,654,720,000 cubic feet, for which storage room must be provided. In a lake having an area of 38.5 square miles it corresponds to a depth of 3.4 feet.

Flood discharge of the Chagres.

The greatest flood which has occurred since the occupation of the isthmus by the Panama Railroad (which covers a period of fifty years), and so far as known the greatest which ever occurred, was that of November 18, 1879. No measurement was made of its volume, but the height which it reached at Bohio is stated upon the authority of Mr. Sosa, a Colombian engineer, to have been 39.3 feet above low water. A comparison of this height with that reached by floods of which the volume was measured (see Appendix D) leads to the conclusion that the maximum discharge at Bohio at the highest point of the flood in 1879 might have been as much as 136,000 cubic feet per second. In reaching this conclusion one of the assumptions is that there was no change in the size of the waterway between 1879 and the dates of the later floods, and that if the same quantity of water nad been flowing at the later dates as in 1879, it would have reached the same height. Inasmuch as the size of the waterway was much increased subsequently to 1879 by the excavations of the old company, this assumption gives a result which is certainly not too low. In this, as in all other cases of doubt, the assumptions have been made such as to err on the safe side, if at all. The other greatest floods of which there are records are those of 1885, with a height at Bohio 33.8 feet; 1888 with height 34.7 feet; 1890 with height 32.1 feet, and 1893 with height 28.5 feet. The last two were measured, the maximum discharge in 1890 being 74,998 cubic feet per second, and in 1893, 48,975 cubic feet. Thus it appears that the floods in which the discharge exceeds 75,000 cubic feet per second are of rare occurrence. If the works be so designed that such a flood would produce no currents which would interfere with navigation, and that a flood of 140,000 cubic feet per second, while it might temporarily suspend navigation, would not injure the structure of the canal, ample provision will be made for the flood control of the Chagres.

Lake Bohio.

No location suitable for a dam exists on the Chagres River below Bohio, and while this location is not without difficulties it has the great advantage that about 3 miles southwest of the dam, near the head of the Rio Gigante, a tributary of the Chagres, there exists an excellent site for a spillway, by which the discharge from the lake can be kept well away from the dam and accessory works, and may be made extremely large without inconvenience either to the canal itself or to the country below the lake. The height of this spillway would regulate the height and area of the lake. After careful consideration of the requirements for flood control and for storage against deficiency in the dry season, and also of the effect upon the amount of excavation required for the canal through the continental divide, the Commission has decided to fix this height at 85 feet above mean tide, and to make the spillway a fixed weir 2,000 feet long. The area of the lake at this height is 38.5 square miles, or 1,073,318,400 square feet. Using coefficient 3.5 in the weir formula, it is computed that with a depth of 5 feet over its crest the weir will discharge 78,260 cubic feet per second. In reaching elevation 90 the area of the lake will be enlarged to about 43 square miles and it will impound over 5,680,000,000 cubic feet of water. The quantity of water discharged over the weir while the lake is rising from elevation 85 to elevation 90, assuming circumstances of flow similar to those observed in the flood of 1893, is computed to be about 4,000,000,000 cubic feet. (See Appendix E.) The total quantity of water impounded and discharged before the lake will rise above elevation 90 is therefore nearly 10,000,000,000 cubic feet. It provides for unimpeded navigation during all floods not exceeding 75,000 cubic feet per second. The velocity of the currents in the narrowest part of the lake would not exceed 2 feet per second. Floods may occur, however, which will cause the lake to rise above elevation 90. From the data available it is not possible to compute with precision the exact height which a flood may hereafter attain, but the extreme possible effect of a flood discharging 140,000 cubic feet per second for a prolonged period would be to raise the water over the spillway to 92.5 feet. All great floods are of short duration, and such a flood is absolutely without precedent, being as improbable as any other convulsion of nature. The crest of the dam has, however, been placed at 100 and the top of the lock walls and gates at 94, to make them entirely safe from overflow by even such a flood, the ill effect of which would be limited to the temporary obstruction of navigation by swift currents in the narrowest part of the lake, where the velocity might reach 5 feet per second. Under extreme conditions the lake might be lowered to 82 to provide water for operating the canal during the dry months. The excavations will be so adjusted as to give a depth of 35 feet at that level.

Future increase of water supply.

This provision for the storage of water for use in the dry season is ample for a traffic of 10,000,000 tons per annum in vessels of the size now in common use. It will be equally ample for a much larger tonnage if, as seems probable, the size of vessels continues to increase. For example, the number of vessels which passed the Suez Canal in 1900 was 3,441, against 3,389 in 1890, while the gross tonnage in 1900 was 13,699,238, against 9,749,129 in 1890. The number of vessels in 1900 was less than in 1898, while the total tonnage was greater. The annual flow of the Chagres and the topography of the country are favorable, however, to a very large increase of the supply, if that be found desirable in the future. A reservoir can be constructed at Alhajuela with a capacity for storing an additional volume of water four times that now provided for daily consumption.

Disposal of overflow.

The overflow of Lake Bohio will discharge through the Gigante spillway into Pena Blanca Swamp, thence through natural and artificial channels to the Chagres River below Gatun, and thence through that river to the sea, being kept out of the canal in the lowlands by levees where necessary.

Detailed description.

The canal, as thus projected, may be described as follows (see pls. 21, 22, 23):

Beginning at the 6 fathom line in Limon Bay, a channel 500 feet wide at bottom, and with side slopes 1 on 3, is excavated, curving gently to the left upon a radius of 6,560 feet, until it reaches a point just inside the jetty constructed by the old Panama Canal Company. Here it changes direction to the right upon a curve of 3,280 feet radius, and is then conducted upon a straight line for a distance of 2,000 feet

Entrance and harbor at Colon.

to a point 2.39 miles from deep water in the bay. For about a mile this wide channel is inside the shore line, forming a narrow but well-protected harbor. Near the apex of the second curve the bottom width is increased to 800 feet for a length of 800 feet, to provide a turning basin. The estimated cost of this entrance and harbor is $8,057,707, of which $1,936,991 is for work outside the jetty. The annual cost of maintenance is estimated at $30,000.

Colon to Bohio.

From the inner end of the harbor the bottom width of the canal is 150 feet, the side slopes of 1 on 3 being retained for 1.86 miles through the swamp, after which they are reduced to the standard used in firm earth, and are kept at that standard for a distance of 12.56 miles farther to the Bohio locks. The length of this level measured from the inner end of the harbor is 14.42 miles. Its estimated cost is $11,099,839, including $151,347 for levees to exclude flood waters and $299,000 for the lower approach, 1,200 feet long, to the lock.

Bohio locks.

At Bohio is located a double flight of locks, having a total lift varying from 82 feet at the minimum level of the lake to 90 feet at the maximum, 41 to 45 to each lock, the normal lift being 85 feet. These locks are on the location adopted by the French company. They are shown on Pl. 24 and are of the type adopted for both the Nicaragua and Panama canals and described elsewhere in this report. The estimated cost of this flight of double locks, four lock chambers in all, is $11,567,275, including excavation.

Lake Bohio.

Above the locks the canal enters the artificial lake formed by the Bohio dam and known as Lake Bohio. For the first 7 miles it is a broad, deep body of water, affording room for anchorage, as well as navigation. Beyond this some light excavations are necessary. At the upper end the channel will be enlarged to provide for the flood discharge of the Chagres, being given a minimum section of 42,000 square feet. The length of the channel in Lake Bohio is 12.68 miles from the locks to the point where the canal leaves the Chagres. The section extends ninety-three hundredths of a mile farther, to the point where it enters the cut through the divide. The estimated cost of this section is $2,952,154, including $434,400 for the upper approach to the Bohio locks.

Obispo guard gates.

Near the entrance to the summit cut will be placed a pair of gates 100 feet wide, so that if it should become necessary to draw off the water from the summit cut the level of Lake Bohio would not be affected. These gates will be at the site of a lock proposed by the French company near Obispo, with a foundation on hard rock. The estimated cost of these gates, including masonry and excavation, is $295,434.

The summit cut is 7.91 miles long from the Obispo gates to the Pedro Miguel locks. The highest point is about 5 miles from the Obispo gates, where the bottom of the canal at the axis is 286 feet below the natural surface of the ground. This is the famous Culebra cut, though the name has often been applied only to the mile of heaviest work. There is a little very hard rock at the eastern end of this section, and the western two miles are in ordinary materials. The remainder consists of a hard indurated clay, with some softer material at the top and some strata and dikes of hard rock. In fixing the price it has been rated as soft rock, but it must be given slopes equivalent to those in earth. This cut has been estimated on the basis of a bottom width of 150 feet, with side slopes of 1 on 1. While the cut would probably not be finished with this uniform slope, this furnishes as correct a basis of estimate as can now be arrived at. The entire cut will be lined with masonry walls, finishing at elevation 92, 2 feet above high water, these walls having nearly vertical faces and furnishing benches 38 feet wide on either side of the canal, on one of which the Panama Railroad will be laid, while it is probable that a service track will be placed on the other.

Culebra cut.

Much has been said about the instability of the Culebra cut; in point of fact, there is a clay in the upper portion of the deep cut which flows readily when saturated, but which will give little trouble if thoroughly drained; probably nine-tenths of the material would naturally be classed as hard clay of stable character; it would weather somewhat, and the surface might require some repairing with concrete in bad places, a practice common in deep cuttings in Europe. This clay disintegrates rapidly in water, and for this reason the canal prism should be confined between masonry walls. With the provision made for broad benches on each side, on which any slight slides would be arrested, it is believed that no trouble will be experienced. The estimated cost of the 6.02 miles of heavy work is $41,940,480, and of the entire 7.91 miles between the Obispo gates and the Pedro Miguel locks, $44,414,460, including the upper approach to these locks. It would probably take eight years to excavate this section of the canal.

The amount of excavation in this section is 43,237,200 cubic yards. The concentration of so large an amount of excavation in so small a space is without precedent. The engineer will recognize at once that thorough organization and tools specially adapted to the work are here required. Fortunately there is ample ground on which to deposit the spoil both north and south of the divide. The method of conducting the work in general principles and in detail should be thoroughly worked out before actual execution is begun. No work has ever been undertaken on which the highest class of practical engineering talent could produce so great economies as in this great concentrated excavation. Its cost has been estimated at 80 cents per cubic yard; bad management might easily increase this to a dollar, and it is not impossible that with a carefully considered equipment the cost might be reduced to 60 cents.

Pedro Miguel locks.

The Pedro Miguel locks (see pl. 25) will be similar to the Bohio locks, the aggregate lift varying from 54 to 62 feet. There is an excellent rock foundation here. The estimated cost of these locks, including an adjacent dam, is $9,081,321.

Pedro Miguel level.

A level 1.33 miles long extends from the Pedro Miguel locks to the last lock, which is at Miraflores. The normal elevation of the surface of the water is 28. The estimated cost of this section is $1,192,286 including $388,880 for lock approaches at each end.

Miraflores lock.

At the end of this level will be located the Miraflores lock (see pl. 25), with a lift varying from 18 feet at high tide to 38 feet at mean low tide. There is a good rock foundation for this lock. A spillway will be required to regulate the height of this level. The estimated cost of this lock and spillway is $5,781,401.

Pacific maritime section.

For 4.12 miles beyond the Miraflores lock the canal extends through a low swamp country through which the Rio Grande runs. Occasional rock is found here, but the material is generally very soft and the canal has been estimated for a bottom width of 150 feet with slopes of 1 on 3. This brings the canal to a point known as La Boca where the Panama Railroad Company has constructed a large and substantial wharf. A dredged channel 200 feet wide with slopes of 1 on 3 will extend from this point 4.41 miles to the 6-fathom line in Panama Bay. The first 2 miles of this dredged channel are through flats which are bare at low water, where there is a considerable amount of submerged rock. The total cost of this section from the lock to deep water is estimated at $12,427,971, of which $1,464,513 is for work outside of La Boca. The cost of maintenance of this channel is included in that of the canal. No separate estimate for maintaining a harbor at Panama is submitted, because it is a natural roadstead, not requiring expenditure.

Bohio dam.

The Bohio dam is the most important structure on the line, being of great magnitude, of vital necessity to the scheme, and offering many difficulties of construction. The Commission has devoted much time to the procurement of full and reliable information concerning the foundation upon which this dam must rest, and to a study of the various types of structures which might be adopted.

The borings made by the French engineers upon and near the line of the dam as furnished to the Commission were 21 in number. In the central part of the valley they did not go down to rock. In this case the Commission decided to do more than verify the data furnished to it, and caused a large number (86) additional borings to be made. With the exception of seven, which were abandoned before completion on account of accidents to the apparatus or unusual difficulties of soil, all of these borings reached rock. They show a variety of materials—hard clay, soft clay, sand, gravel, and some mixtures of sand, clay and gravel in varying proportions. These materials are found in beds of varying shape and thickness, not distributed with uniformity and not arranged according to any general law from which can be deduced the character of the soil at points other than those actually examined. In every section constructed from the borings, strata of greater or less dimensions are found, which are permeable by water. How far these extend and whether or not they communicate with the surface of the ground above the site of the dam are points about which information can not be obtained in advance with certainty. If a dam be built with permeable strata under it there will probably be leakage, but what the amount of this will be is a question about which there is room for much difference of opinion. It would seem probable to many that the leakage will not be sufficient to endanger the water supply, and that an earthen dam is therefore feasible, but it is evident that here is a danger to be avoided if possible. A masonry dam founded throughout upon the rock, or an earth dam with a masonry core going down everywhere to rock, would close the valley completely and would leave no question open as to its future efficiency. In its preliminary report the Commission based its estimates on a masonry dam. The examinations of the ground had not at that time been completed. So far as they had progressed they showed a site where a masonry dam seemed the most suitable, but it was subsequently found that the depth to rock upon that site was at least 143 feet below sea level at the deepest part. It was considered best to avoid, if possible, so great a depth of foundation. A site was found a few hundred feet farther downstream where the length of the dam would be considerably greater than at the former site, but the greatest depth to rock revealed by the borings was only 128 feet below sea level. The line runs from a point near the railroad station at Bohio, on the east side of the river, straight across to the rocky hill on the west side. (See pl. 26.) On the east side the rock is at the surface practically from the water in the river to the end of the dam. On the west side the bank above low water is composed either of pure clay or of clay mixed with sand, while below low water are found irregular beds of sand and sandy clay. The physical features of the location admit of the construction of an earth embankment with a heavy masonry core carried down to bed rock throughout the length of the structure. For reasons of economy that type of dam is preferable to one wholly of masonry upon the new site, and is now adopted.

It is proposed to sink the foundation of the core wall by the pneumatic process at all points where the foundation bed is lower than about 30 feet below mean sea level. This requires the pneumatic process to be used through a length of 1,314 feet, of which about 310 feet is at the maximum depth of 128 feet below the sea level. Where the foundation bed is above elevation —30, cofferdams are to be used. This involves the use of cofferdams through a length of 324 feet, the foundation at sea level being extended 78 feet at the easterly end and 246 feet at the westerly end of the pneumatic work. The cofferdams extend to a height 8 feet above sea level. Above elevation 8 all operations would be carried on by the ordinary methods of dry work.

The width of the dam at the top is 20 feet, and its total length is 2,546 feet. The elevation of the top is 100 feet above mean sea level, affording a superelevation of the dam of 8 feet above the highest possible water in the lake and 10 feet above the usual high water. Its total height above the lowest part of the foundation is 228 feet. The earth faces of the dam are designed to have mean slopes of one vertical to three horizontal, and to be broken by three terraces, each 6 feet wide. It is necessary to pave only the upstream face, but it is probable that both faces would be heavily riprapped with the rock spoil from the lock excavation near the westerly end. The masonry core is 30 feet thick at and below elevation —30. From that level it tapers to a thickness of 8 feet at top.

Material for the heavy fill required is found in the immediate neighborhood. The local conditions are such that not less than seven-eighths of the work could be completed without interfering with the natural flow of the Chagres. When it becomes necessary for the completion of the dam to divert the river, the unfinished Gigante spillway and, later on, the finished locks at Bohio may be employed as diversion channels. A temporary dam would be required to turn the water through these outlets at suitable stages. This temporary dam may be placed either at the site of the permanent dam and finally be buried in it, or at some suitable point higher upstream. The cost of the Bohio dam is estimated at $6,369,640. This estimate is higher than any which has hitherto been made for this dam. It is possible that before actual construction a better location can be found and the cost reduced. A dam on the French location, with masonry core carried to rock, would contain less than half the material in the dam for which estimates have been made, but for a length of 170 feet the foundation would be deeper than anywhere on the adopted location, the maximum being 146 feet below mean tide.

The Gigante spillway, which is a structure of considerable magnitude, is very simple. There is a good rock foundation at or above tide level for the entire length of this spillway. It will consist of a dam entirely of concrete with a crest at elevation 85, terminating in an apron at elevation 65, with a

Gigante spillway.

solid foundation below this level, the apron being everywhere below the present surface of the ground. The foundation, below elevation 65, will be put in first and before the flow of water through the present river at the site of the Bohio dam is checked. Plans for this spillway are shown on plate 27. The estimated cost, including the channel ways immediately above and below it, is $1,209,419.

Peña Blanca swamp.

The water after passing over the spillway will flow across country about a mile to the Peña Blanca swamp. The elevation of the surface of this swamp is now 22.3, so that the water will have a fall of 62.7 feet in this mile. The swamp is separated from the line of the canal by a ridge, of which the lowest part is at elevation 33. It can be filled to elevation 31 without inconvenience to the canal. Its outlet will be placed at elevation 11. Its area at that level is 0.447 square mile and at elevation 31 it is 1.186 square miles. Its storage capacity between those two levels is 455,000,000 cubic feet.

Peña Blanca outlet.

From the Peña Blanca the water will be discharged into the Agua Clara swamp by an artificial channel, located about a mile from the canal, cut through the ridge which separates the two swamps. This channel will have a bottom width of 500 feet and a depth of 20 feet when the water in Peña Blanca swamp stands at elevation 31. Its length measured on the bottom is 5,676 feet and the maximum depth of cutting is 63 feet, much of it rock. The bottom has a fall of 2.2 feet from one swamp to the other. This channel will discharge 75,000 cubic feet per second with a mean velocity of 7.5 feet per second, or 5 miles per hour, and this it can attain if the difference of level between the two swamps be 2.1 feet. With a head of 7.3 feet it can discharge over 140,000 cubic feet per second, at a velocity of about 9.55 miles per hour. Its cost is estimated at $2,448,076.

The present surface of the Agua Clara swamp is at elevation 11.5, and its area at that level is about 2.9 square miles. Farther on are other swamps—the Vino Tinto and the Bruja. The ground separating them from each other and from the line of the canal is low, affording a wide area for the spread of flood waters, until the neighborhood of Gatun is reached. Here the width of the valley contracts and its direction changes, so that an artificial channel becomes necessary to

Chagres diversion.

divert the Chagres. A channel was cut here by the old canal company, but it is of inadequate dimensions, and in order to avoid some rock excavation it was given an awkward shape. A new channel will be cut on a straight line, part of which will be an enlargement of the present one. It will have a width at bottom of 650 feet, and will be excavated to a depth of 8.5 feet below the datum plane, which will give it an area of cross section of about 10,000 square feet when the surface of the water is at elevation 7. Its length measured on the bottom is 6,955 feet, and the maximum depth of cutting is 25 feet, much of it rock. With a head of 11 feet it can discharge 140,000 cubic feet per second at a velocity of about 9.55 miles per hour. Its cost is estimated at $1,929,982.

Levees.

The canal in the low region above and below Gatum must be protected from overflow by levees, their total length aggregating about 5.4 miles. The height to which these levees should be carried can not be determined with accuracy from the present data, and must be fixed from observations of floods hereafter. As in all other cases of doubt, a height has been adopted which will err, if at all, upon the safe side. For the purpose of estimate the height has been placed at elevation 25. The width on top is 13 feet and the side slopes 1 on 2. It is probable, however, that the levees will be used as spoil banks for the material dredged from the canal, and that their dimensions, except as to height, will much exceed those here given.

From Gatum the overflow from Lake Bohio and all tributaries below the lake on the west side of the canal will find its way to the sea through the Chagres River, which the canal here leaves.

Gatun diversion.

The only tributary on the east side for which any special provision need be made is the Gatun. A diversion channel intended to take a portion of the water of the Chagres was constructed by the old company along the east side of the canal to Boca Grande back of Colon. It cuts across the Gatun near the town of the same name, and while no longer required for the Chagres, it is available as a new channel for the Gatun. It was designed to carry a discharge of 17,600 cubic feet per second, which is much in excess of the maximum discharge of the Gatun. Some work must be done on it, especially at the crossing of the Panama Railroad, where the piers for a new bridge have been built. The cost of putting this channel into service is estimated at $100,000.

Panama Railroad diversion.

From Bohio to the Obispo gates the Panama Railroad must be rebuilt for 15.5 miles on a new location, with a bridge across the Chagres below Gamboa. An estimate made from approximate profiles indicates that the cost of this diversion will not exceed $75,000 a mile, or $1,162,500. From the Obispo gates the railroad will be carried for 6 miles on the bench formed by the retaining wall on the east side of the Culebra Cut, these 6 miles being estimated to cost $10,000 a mile, which includes only track laying, ties, and ballasting. Beyond this will be a mile of light work estimated at $25,000, while the main track will have to be raised for 2 miles farther at a cost of $20,000. Combining these figures, the total cost of the diversion of the Panama Railroad becomes $1,267,500.

Suming up the several figures already given, the total estimated cost of completing the Panama Canal is as follows:

Total estimated cost.

	Miles.	Cost.
Colon entrance and harbor	2.39	$8,057,707
Harbor to Bohio locks, including levees	14.42	11,099,839
Bohio locks, including excavation	.35	11,567,275
Lake Bohio	13.61	2,952,154
Obispo gates	....	295,434
Culebra section	7.91	44,414,460
Pedro Miguel locks, including excavation and dam	.35	9,081,321
Pedro Miguel level	1.33	1,192,286
Miraflores locks, including excavation and spillway	.20	5,781,401
Pacific level	8.53	12,427,971
Bohio dam	....	6,369,640
Gigante spillway	....	1,209,419
Peña Blanca outlet	....	2,448,076
Chagres diversion	....	1,929,982
Gatun diversion	....	100,000
Panama Railroad diversion	....	1,267,500
Total	49.09	120,194,465
Engineering, police, sanitation, and general contingencies, 20 per cent	....	24,038,893
Aggregate	....	144,233,358

The total amount of excavation is 94,863,703 cubic yards, exclusive of excavation for the Bohio dam, and the Gigante spillway.

The location of the canal is, in general, the same as that proposed by the French company. Its total length, from 36 feet deep in the Atlantic to 36 feet deep in the Pacific, is 49.09 miles. The distance from the inner end of the harbor enlargement at Colon to the shore end of the bay channel at La Boca is 42.3 miles, of which 11 miles is the broad channel of Lake Bohio. The alignment is exceptionally good, the sharpest curve having a radius of 6,232 feet, except one at the entrance to Colon Harbor, which has a radius of 3,280 feet, but where the bottom width is from 500 to 800 feet. The total curvature in the entire length of the canal is 771° 39′, distributed as follows:

Length and curvature.

Number of curves.	Length.	Radius.	Total curvature.	
	Miles.	*Feet.*	°	′
1	0.88	19,629	14	17
1	.48	13,123	11	04
4	4.22	11,483	111	32
15	11.61	9,842	355	50
4	2.44	8,202	90	20
2	1.67	6,562	77	00
1	.73	6,234	35	45
1	.82	3,281	75	51
Total	22.85	....	771	39

Alternative location.

An examination has been made of a different location on a more direct line between Gatun and Bohio by which the distance will be shortened 1.25 miles. As this line shows no material saving in cost from that described in this report, it has been thought best, for purposes of estimate, to adhere to the French location. A description of this line will be found in Appendix F.

Time of transit.

The time required to pass through the canal after completion will vary with the size of the vessel and with the number of other vessels. For the purpose of comparison the time has been carefully computed for a ship 400 feet long, 50 feet beam, and 24.5 feet draft, or what may be called an average-sized ship. The open sea speed is taken at 12.5 statute miles, or about 11 knots, per hour. The reduced speed in various parts of the canal and the delays caused by lockages and by passing other vessels have been obtained from observation of the practical working of the Sault Ste. Marie and the Manchester canals. They are as follows: In canal sections having a bottom width 150 feet, speed on tangents 8 miles per hour, on curves 7 miles per hour; in Panama Bay channel, speed 9 miles per hour; in Lake Bohio, speed on tangents 10 miles per hour, on curves 9 miles per hour; in harbors and harbor entrances, speed on tangents 10 miles per hour, on curves 8½ miles per hour; all statute miles. The delay caused by lockages is 3 hours and 58 minutes, and that caused by meeting other vessels 1 hour and 14 minutes. From these data the time of transit through the canal is computed to be 11 hours and 14 minutes. A full discussion of this subject will be found in Appendix G.

The plan recommended by the Commission is, in its general outlines, the same as the second plan of the French engineers, the one preferred by them, except for the time required for construction. The principal difference is in the height given to the Bohio dam and the important consequences which result therefrom. A marked feature of the Commission's plan is its simplicity. The increase in the depth and area of Lake Bohio renders it possible to receive the full flood discharge of the Chagres directly into it without impeding navigation and at the same time to take full advantage of favorable topographical features of the country in the subsequent discharge of the surplus waters. The Alhajuela dam becomes unnecessary for flood control, and its construction may be deferred until additional storage capacity is required as the result of a large increase in the traffic of the canal in the future. The outlet of Lake Bohio becomes a single fixed weir instead of two weirs with regulating gates and with two separate channels to the sea. A great reduction also results in the amount of excavation required to cut through the continental divide. There is a material reduction of cost.

Advantages of the Commission's plan.

The quantities given in the foregoing estimate are based upon the present condition of the Isthmus, utilizing the excavations already made where they are useful. The new company has excavated about 5,000,000 cubic yards, which, added to the 72,000,000 cubic yards excavated prior to its organization, make a total of 77,000,000 cubic yards excavated by the two companies. Much of it is of no value because of the various changes of plan. For example, sites for locks have been excavated and then abandoned; the spoil banks on the Atlantic maritime section frequently come within the limits of the canal prism now projected and must be rehandled. The amount of work done which will be of value under the plan recommended by the Commission has been carefully computed for the main canal line, and is found to be 36,689,965 cubic yards. The amount of excavation which can be utilized in the Chagres diversion is 210,873 cubic yards and in the Gatun diversion 2,685,494 cubic yards. Adding these together the total quantity of excavation which will be of value in the new plan is 39,586,332 cubic yards. A temporary diversion of the Panama Railroad has been made at the Culebra cut which also must be considered. Using the same classification of materials and the same unit prices as in the other estimates, with the 20 per cent added for contingencies, the value of the work done is found to be:

Value of excavation already done.

Canal excavation	$21,020,386
Chagres diversion	178,186
Gatun diversion	1,396,456
Railroad diversion (4 miles)	300,000
	22,895,028
Contingencies, 20 per cent	4,579,005
Aggregate	27,474,033

There is on hand an immense amount of plant, consisting of locomotives, excavators, dredges, cars, rails, and machines, implements, tools, spare parts, and supplies of various kinds, besides buildings used for offices, quarters, storehouses, hospitals, and miscellaneous purposes, and some 30,000 acres of land. The inventory furnished to the Commission includes many thousands of items, classified as follows:

Plant on hand.

1. Lands not built on.
2. Buildings, 2,431 in number, divided among 47 subclassifications.
3. Furniture and stable outfit, with 17 subclassifications.
4. Floating plant and spare parts, with 24 subclassifications.
5. Rolling plant and spare parts, with 17 subclassifications.
6. Plant, stationary and semistationary, and spare parts, with 25 subclassifications.
7. Small material and spare parts, with 4 subclassifications.
8. Surgical and medical outfit.
9. Medical stores.
10. Office supplies, stationery.
11. Miscellaneous supplies, with 740 subclassifications.

As a general rule, this property shows signs of attention, and the evidence seems satisfactory that it has been well cared for since the liquidator took charge of it in 1889. It would manifestly be imprudent, however, to fix a value upon any important machine which has been idle that length of time without first actually testing it at work, however neatly painted and sheltered it may now be. Much of the property is ill adapted to American methods, and all of it is now from thirteen to twenty years old, during which period the improvements in this class of machinery have been such that contractors would generally find it to their advantage to buy entirely new machinery of modern pattern rather than attempt to use this of an older class, even if given to them free and in good order. The locomotives, rails, and cars may be of some service, but their value is doubtful; the locomotives are much lighter than is desirable for economical service, the rails are of a pattern ill fitted to rough use, and the cars have narrow-tread wheels. The cars are probably the best part of the whole outfit. It has seemed to the Commission that in acquiring the Panama Canal the United States should not buy this plant as a whole, and that no special allowance should be made for it in estimating the total value of the property. Its owners may realize something by the sale of portions of it to contractors if the latter find that they can use it to advantage. This valuation is all that the Commission can put upon the plant; it has already appeared in the estimates, since the unit prices have been fixed upon the condition that contractors furnish their own plant.

Value of plant.

The same is true of the great majority of the buildings, including all barracks, storehouses, shops, stables, and miscellaneous buildings, and excepting only the hospitals and principal administration buildings. The latter would be the subject of special negotiation. They have appeared in the estimates under the head of contingencies; no special allowance is made for them here.

Value of buildings.

The concession is of no value to the United States, since a new one must be obtained from the Colombian Government in any event. It is the same with the lands, title to which is dependent upon the completion of the canal, and is still to be earned.

Value of concession and lands.

The existence of the Panama Railroad is, however, a very important factor, as it supplies a service railroad for the entire length of the canal. On the basis of $75,000 a mile, this railroad would be worth $3,500,000, which is half the face value of its capital stock. In view of its good condition and its valuable termini, it should not be estimated for purposes of canal construction at less than $6,850,000, the par value of the 68,500 shares

Value of Panama Railroad.

of its stock held by the canal company. The exceptional gauge—5 feet—somewhat reduces its value, as it adds to the cost of rolling stock.

Value of maps and records.

The maps, drawings, and records are unusually complete, and their value is great, though not capable of accurate estimate. In the judgment of the Commission, a fair allowance for these would be $2,000,000.

Total value of the Panama Canal.

Summing up the foregoing items, the total value of the property is found to be:

Excavation already done	$27,474,033
Panama Railroad stock at par	6,850,000
Maps, drawings, and records	2,000,000
Total	36,324,033

to which add 10 per cent to cover omissions, making the total valuation of the Panama Canal $40,000,000.

Chapter VI.

THE NICARAGUA ROUTE.

Attractive features.

The Nicaragua route attracted the attention of explorers in the early days of interoceanic canal discussion, and was regarded by many as a most favorable one. Water communication by means of a large river and lake from the Atlantic to within a short distance of the Pacific accentuates the natural advantages of this route and at the same time tends to exaggerate them and to obscure the attendant difficulties.

Lake Nicaragua.

Lake Nicaragua is about 103 miles long. It has a maximum width of about 45 miles and an area of about 3,000 square miles. It is fairly regular in outline, with its longer axis nearly parallel to the Pacific coast, which in this vicinity has a northwesterly direction. It resembles Lake Erie somewhat in shape, but has only about one-third the area of the latter. Notwithstanding the fact that the existence of this lake had long been known, it appears that the first instrumental survey was made by the Nicaragua Canal Commission in 1898. It was then found that the bottom of the lake is above sea level over the greater part of its area, a comparatively small depression being below that level. The maximum depth is about 200 feet, and is found just south of the island of Ometepe, which has an elevation of 5,000 feet.

Lake Managua.

About 18 miles to the northwest of Lake Nicaragua, and on the prolongation of its axis, lies Lake Managua, extending a distance of 37 miles toward the Gulf of Fonseca, a large natural harbor opening to the Pacific Ocean. The drainage of Lake Managua is through the river Tipitapa, which, however, is frequently without water in the dry seasons. This lake is 65 miles from the Gulf of Fonseca. A somewhat shorter route from Lake Managua to the Pacific crosses the plain of Leon to the bay of Corinto, a distance of about 35 miles in an air line.

Fluctuations of Lake Nicaragua.

The surface of Lake Nicaragua is generally a little more than 100 feet above sea level. Its extreme fluctuation is not definitely known. Its annual fluctuation varies with the annual rainfall and the discharge of the streams that empty into it. These are small, and in the dry season they discharge very little. Mr. Menocal in his report for 1885 states that the lake was as high as 110.63 feet above mean sea level at the end of the wet season of 1878. This is perhaps founded on the observations of the residents of Granada, who are reported to have seen the water of the lake up to the top of the steamboat wharf at that place. This may be regarded as an approximate determination of highest lake level. The data for fixing the minimum level of the lake are equally uncertain; but it is stated on the authority of what are believed to be competent witnesses that it has been as low as 97 or less. These extremes have only been reached at long intervals. The fluctuations in the last three years, during which time regular observations have been taken, have amounted to only 6.09 feet.

Characteristics of drainage basin.

The drainage basin of the lake is in great part mountainous. This is particularly the case on the east side, where it is separated (except in the immediate vicinity of its outlet) from the district draining into the Atlantic by a mountain range. There is reason to believe that this range was formerly the continental divide. At the present time the divide is between the lake and the Pacific. Until the surveys of Colonel Childs, made in 1850–1852, the lowest passes known across this divide were supposed to be those from Lake Managua to the Gulf of Fonseca and the Bay of Corinto, and canal lines from the lakes to the Pacific were projected to those points. Colonel Childs developed a far better route, crossing the divide at an elevation of only 153 feet above mean tide and following the valley of a small stream called the Rio Grande to the Pacific at Brito. The entire region between the lakes and the Pacific is now well enough known to establish beyond doubt that this is the lowest crossing of the divide, and is in every respect the best canal route.

The San Juan River.

The San Juan River, through which the lake discharges at Fort San Carlos, follows a tortuous course in a southeasterly direction and empties through several mouths into the Caribbean Sea near Greytown. The distance from the lake outlet to the mouth of the river is about 80 miles in an air line, but about 120 miles following the windings of the river, the greater portion of the valley drained being on the right bank, where the divide, a lofty mountain range, is about 50 miles distant. On the left bank the divide is only 10 to 20 miles from the river, and the crest is much lower. The Indio, which empties into the Caribbean Sea some 6 miles northwest of Greytown, runs generally parallel to the San Juan, the headwaters of some of its tributaries being only about 15 to 20 miles distant from that river.

Tributaries of the San Juan River on left bank.

The principal tributaries of the San Juan on the left bank are the Melchora, Sabalos, Santa Cruz, Bartola, Machuca, Danta, and San Francisco, but none of them are of great size. The most important in their relation to the canal project are the Danta and San Francisco. They are in a region of heavy rainfall, but it is impossible to measure their greatest flood discharges because they overflow their banks and intercommunicate, and also because backwater from the San Juan extends for a considerable distance up their valleys. The soil in their beds and banks is of a soft, alluvial character, generally free from grit, and contains quantities of decayed or decaying vegetation. When drained it stands well on steep slopes, as is shown by the banks, which are often vertical. At a short distance from the banks, where the drainage is imperfect, the material is very soft to a great depth. Their drainage basins are covered with a dense tropical growth which protects the soil, so that water finds its way into the streams with comparatively little solid matter in suspension. The Sabalos, while not a large stream, attains considerable size at times. Gaugings taken by this Commission show that the discharge often reaches as much as 2,000 cubic feet per second. The maximum measured was on September 23, 1899, when it reached 12,000 cubic feet per second. The minimum discharge is as low as 23 cubic feet per second. The Santa Cruz is of similar character, while the Melchora, Bartola, and Machuca are much smaller streams.

On the right bank are the Frio, the Poco Sol, the San Carlos, and the Serapiqui, besides several smaller streams. The Frio is treated as a river discharging into the lake. Its mouth, however, is close alongside the outlet of the San Juan. It is a river of some importance when in flood, though it is small in the dry season. A discharge of nearly 12,000 cubic feet per second was observed by the Nicaragua Canal Commission. The Poco Sol is a much smaller stream. There is little known of its watershed, though the maps show its source in the mountainous region of Costa Rica. The river has been gauged and its discharge determined in a series of 18 gaugings extending over a period of one year, viz, from October, 1899, to the latter part of September, 1900. On April 20, 1900, the discharge was only 34 cubic feet per second. On July 15, 1900, the discharge was 2,651 cubic feet per second; this was the maximum observed. No appreciable amount of sediment has been brought into the San Juan by any of these tributaries during the continuance of the surveys extending over the last four years, and there is no indication in the San Juan itself that any of its tributaries above the San Carlos contributes an amount of sediment that is appreciable in connection with the maintenance of a navigable channel.

Tributaries of San Juan River on right bank.

The largest and most important tributary of the San Juan is the San Carlos. It rises in the monutains of Costa Rica, flows northeasterly and empties into the San Juan about 57 miles (measured along the windings of the river) from the lake. It is a wide, swift stream, having a drainage area of about 1,500 square miles, as determined from the best maps available. This esti-

San Carlos River.

mate may be too great or too small, as the region has never been surveyed. The discharge varies within wide limits. It is known to have been as low as 3,000 cubic feet per second, and as high as 66,820 cubic feet per second. The estimated possible maximum is 100,000 cubic feet per second. Its banks as far as they have been explored are of clay and withstand well the action of the river current. It is proper to remark, however, that information on the physics of this river is mainly limited to what is obtainable near its mouth. The bed of the river in the lower part is sand which is easily put in motion. It is supposed that the sources of this sand are the volcanoes in the Costa Rican mountains. That found in the delta of the San Juan River is similar in character. The floods of this stream are of great violence and frequency.

Serapiqui River.

The Serapiqui is a river of similar character to the San Carlos, but it is not so large. It is a sand-bearing stream and adds a large quota of this material to the main river. Its measured discharge varies from about 3,000 cubic feet to about 26,000 cubic feet per second. Its maximum is doubtless much greater.

Negro River.

There is another river still farther to the eastward called the Negro, which, according to the maps, drains a large area of Costa Rican territory, and discharges into the Colorado outlet of the San Juan. Very little is known of the characteristics of this stream and no effort was made to secure any information, as it does not affect the question before the Commission.

Fall in San Juan River.

The fall of the San Juan River from the lake to the sea is about 100 feet. About one-half of this occurs above the mouth of the San Carlos, and is mainly concentrated at several rapids. At each of the principal rapids the bed of the river is rock. The most important of these is at Castillo. The fall in the river is here 6 feet in a distance of little more than one-third of a mile. The existing navigation of the river is very much obstructed here and boats can only pass when the river is high. Ordinarily freight and passengers are carried around the rapids on a tramway.

Between the Machuca Rapids and the mouth of the San Carlos the river is deep and the current moderate. In low stages it is almost imperceptible. When the San Carlos is in flood the San Juan current may even set upstream. This part of the river is called the Agua Muerte (dead water). The bottom of the channel in places is below the sea level. The amount of sediment delivered to the river by its upper tributaries has evidently been no greater than its waters have been able to transport, notwithstanding the moderate current. Below the mouth of the San Carlos the fall is quite uniformly distributed.

The following table gives approximately the fall in feet for the various reaches of the San Juan River from the lake to the sea, with the lake at elevation 104:

Slopes in various reaches of San Juan.

Reach.	Distance in miles.	Fall in feet.
From the lake to head of Toro Rapids	27.16	5.4
In Toro Rapids	1.70	7.3
From foot of Toro Rapids to head of Castillo Rapids	7.98	1.2
In Castillo Rapids	.38	6.0
From foot of Castillo Rapids to head of Machuca Rapids	11.17	24.5
In Machuca Rapids	.95	4.0
From foot of Machuca Rapids to mouth of the San Carlos (Agua Muerte)	15.37	1.0
From mouth of San Carlos to head of the San Juanillo	33.02	30.0
From head of San Juanillo to the head of the Colorado	5.28	4.0
From head of Colorado to sea (via Lower San Juan)	18.65	20.6
Total, from lake to sea	121.66	104.0

The slopes above given are approximate only, and result from the lake being at elevation 104 and the river under normal conditions. They will vary with the stage of the lake and with the rainfall in the drainage basin of the river.

Bed of Upper San Juan. The bed of the Upper San Juan (and by this is meant the San Juan from the lake to the mouth of the San Carlos River) consists chiefly of silt, clay, or rock. The river banks generally resist the erosive action of the currents, even where the velocities are great. This is due in a measure to the protection afforded by growing vegetation, which reaches to the water's edge and sometimes extends below it, but mainly to the cohesive character of the material. Below the mouth of the San Carlos the bed of the San Juan consists mostly of sand, which forms shifting bars.

San Juan in freshets. Freshets in the rivers of the United States are usually characterized by quantities of logs and other drift floating on the surface. As a rule fallen timber in the San Juan River remains where it falls, or at least is not moved any great distance, as the most of it is too heavy to float. This is an important fact in connection with the construction of the canal. Where the line passes through old swamps, doubtless considerable heavy timber will be encountered below the surface of the ground.

San Juanillo River. About 8 miles below the mouth of the Serapiqui the San Juanillo branches off, following a tortuous course until it again joins the Lower San Juan, a short distance southeast of Grey Town. The indications point to this stream as having been in remote times an important outlet of the main river.

Coastal plain. A short distance below the mouth of the Serapiqui the San Juan River enters the coastal plain, a region of swamps, bayous, and lagoons. About 20 miles from the sea it divides into two outlet branches—the Lower San Juan, which discharges through Harbor Head Lagoon near Grey Town, and the Colorado, which discharges directly into the Caribbean Sea, about 15 miles to the southward. The latter is the principal outlet and may be enlarging at the expense of the Lower San Juan, although as long ago as 1851 the gaugings made by Colonel Childs showed that the Colorado was carrying nearly four-fifths of the total amount at a mean stage. Each of these outlets is subdivided and the entire system intercommunicates.

Subsidence.

There are indications of a general subsidence of the Atlantic coast in this region. The former rocky bed of the San Juan appears to have been depressed. At Machuca Rapids rock appears near the water surface. At the dam site adopted by this Commission at Conchuda the distance from the low-water surface to the lowest point in the rock cross section is about 80 feet. At the dam site suggested by the Nicaragua Canal Commission the distance is about 110 feet. At Tambor Grande, 18 miles farther downstream, it is not less than 140 feet, and is doubtless considerably more in the lowest depression. From the mouth of the San Carlos down is a deep rocky trough, which is filled with sand. Some sand has also been carried a short distance above the San Carlos by floods from that stream when the San Juan was low.

In the coastal plain, which consists mainly of swamps, vegetable matter intermixed with silt is found to a considerable depth, but within 5 or 6 miles of the coast sand is found extending to a great depth under a light covering of mud.

Along the Atlantic coast in the vicinity of Grey Town and for some distance inland the rainfall is the greatest known on the continent. There is no definite dry season. Rain may be expected almost any day in the year. On the other hand, the entire drainage basin of Lake Nicaragua lies in a region having a well-defined dry season. The annual rainfall near Grey Town sometimes amounts to nearly 300 inches. The average is probably 260 to 270 inches, while at Bluefields, 75 miles to the north, and at Port Limon, 70 miles to the southeast, it is less than half as much. There is a perceptible diminution in the annual rainfall as one proceeds westward to the lake.

Rainfall.

The total for the year 1899, at Grey Town was 285.93 inches, while that for the same period at Ochoa was 177.91 inches, and at Fort San Carlos 77.20 inches. For the year 1900 the annual rainfalls were for Grey Town, 266.10 inches, for Ochoa, 158.83 inches, and for Fort San Carlos, 89.34 inches. The heaviest observed rainfall in a short period was that at Silico station on Lake Silico, November 4, 1899, when 10.5 inches fell in six hours, an average of 1¾ inches per hour. On the same date a fall of 12.48 inches in twenty-four hours was observed at Grey Town. A rainfall of 4 inches or more in one day is not a rare occurrence in that vicinity. In the drainage basin of Lake Nicaragua the average annual rainfall is about 65 inches.

Winds.

The trade winds blow almost constantly, but they are not strong enough to sensibly affect canal navigation. At rare intervals violent northers occur, which are felt to a less degree in the interior. It is not believed that the winds would seriously interfere with canal navigation at any time.

It can be readily understood that the Nicaragua route, affording water transportation from the Atlantic to within a few miles of the Pacific, was very attractive when navigation was carried on by means of small ships. It became a favorite transisthmian route immediately after the discovery of gold in California. Passengers arriving by sea at the port of Grey Town, at that time an excellent harbor, were transported by steamboats to the west shore of the lake; whence the Pacific was reached by a short stage line, which terminated at the port of San Juan del Sur. This was a busy traffic route for some years. Successive projects for interoceanic communication have had to provide for the increasing dimensions of ships, and as channel dimensions have thus been enlarged the difficulties of providing for a safe navigation have become greater. The serious difficulties, however, are nearly all found between Machuca Rapids and the Caribbean.

Transit route.

The region of practicable canal routes is limited to the north side of the San Juan River, by the existence of the San Carlos and Serapiqui rivers on the south side. Financially it would be impracticable to divert these streams, and it would be equally impracticable to take them into the canal. Hence all the surveys and examinations for a canal route have been confined to the north side of the river.

Region of practicable canal routes.

The topography of the country in the vicinity of the route adopted is generally rough. The hills as a rule do not attain a great height, but they are usually steep and bunched together, with areas of swamp or low flats about them. The surface is covered with a dense growth of tropical vegetation which renders exploration or surveys extremely difficult and expensive. There are few places where a transit line can be run 50 feet without cutting out a line of sight. This difficulty accounts for the paucity of existing topographical information, notwithstanding the fact that the country has long been known and studied for a canal route.

Topography.

From Grey Town to Castillo the boundary between the republics of Costa Rica and Nicaragua follows the right bank of the San Juan River. Thence to the lake, the boundary is a line on the right bank, generally about 2 miles from the river. Both shores from Castillo to the lake are therefore in Nicaraguan territory. When the level of the water of the river is

Boundary.

raised by the construction of the proposed dam at Conchuda, some of the lands in Costa Rican territory will be submerged, although the canal line from Castillo westward to the Pacific will lie wholly in Nicaraguan territory.

Childs's project, 1852.

While many propositions more or less indefinite had previously been made for a canal across the isthmus in Nicaragua, the first actual survey made and definite project proposed were those of Col. O. W. Childs, a civil engineer of high standing, in 1850–52. The survey made by him was for a private corporation known as "The American Atlantic and Pacific Ship Canal Company." His project has been the basis for all subsequent ones, and the route followed by him does not differ greatly from that which is now recommended by this Commission. He reached the conclusion that a ship canal through Nicaragua from the Atlantic to the Pacific could not be considered practicable upon any other route than that through the valley of the San Juan to Lake Nicaragua, and from that lake either southwesterly upon a line through some valley extending across the dividing ridge, or northwesterly up the river Tipitapa to Lake Managua, thence through the valley extending from the head of that lake to some feasible point for a connection with the Pacific. In view of the greater length of a canal by the latter route, the greater amount of lockage, and uncertainty of obtaining a full supply of water upon the higher summit, it was deemed best to begin by exploring the country lying directly between the west side of Lake Nicaragua and the Pacific.

Routes examined by Colonel Childs.

He then examined different routes from Lake Nicaragua to the Pacific, beginning with that via the Sapoa and terminating in Salinas Bay. The conclusion was reached that the line leading from the lake at the mouth of the River Las Lajas up the eastern slope of the divide and down the valley of the Rio Grande on the western slope to the Pacific at Brito presented more favorable conditions than any other between Lake Nicaragua and the Pacific, and was superior to any route by way of Lake Managua. He thus disposed of the routes terminating at the Gulf of Fonseca, Port Realejo, and Tamorinda River. The divide on this line was crossed at an elevation of about 46 feet above the level of the lake. The plan adopted made the lake the summit level; its surface was to be maintained at about 108 feet above sea level by means of a dam 1,050 feet long and 16.21 feet high at Castillo Rapids, and another on the west side at Buen Retiro, about 10 miles west of the lake. The latter dam was to be 290 feet long and 33 feet high. The summit level made by these dams, as given by Colonel Childs in his report, was to be 103.43 miles. It would have been longer, as the distance across the lake was underestimated. The fall from high lake to low tide on the Atlantic side was to be 108.73 feet and on the Pacific side 111.47 feet. On the eastern side the summit was to be reached by 12 locks of 8 feet lift each, 1 of 6.5, and 1 of 6.23 feet; on the western side by 13 locks of 8 feet each and 1 of 7.47 feet.

The water in the canal was to have a depth of 17 feet and a bottom width of 50 feet. In earth, the side slopes were to be 1 on 2 for a height of 9 feet from the bottom, then a berme of 6 feet followed by a slope of 1 on 1¼, paved with stone. In rock the bottom width was to be the same, but for a height of 9 feet above the bottom each side had a slope of 1 on 1½; from there to a height of 15 feet above the water in the canal the slope was to be 24 on 1. At this level there was a berme 9 feet wide for towing purposes, and from the back of this berme the side slope was 4 on 1 until earth was reached, when the slope was changed to 1 on 1½. A passing place was to be made at the head of each lock and at least one in every mile of length of the canal. At these passing places the bottom width of the canal in earth was to be increased to 90 feet, and in rock to 105 feet. The bottom width of that portion of the canal occupying the Rio Las Lajas was to be 100 feet; at all of the cuts through bars in the river the width at bottom was to be 150 feet. The locks were to be 60 by 250 feet, with 17 feet depth of water on their miter sills. Slack water navigation was to be made in the San Juan from the lake to about one-half mile below the mouth of the Serapiqui River by a series of 7 dams. These were to be passed by means of locks on short canals. Below this point the canal left the river on the north side and was to be excavated for a distance of 28.50 miles to 17 feet depth of water in the harbor of Grey Town. The line crossed the Rio San Jaunillo about three-fourths of a mile from its junction with the San Juan. The San Juanillo was to be diverted to the north.

Dimensions and side slopes.

The project included the formation of a harbor at Brito and the improvement and enlargement of the one at Grey Town by jetties and by excavation. A light-house was provided for at each harbor. Grey Town, at the time of the examination made by Colonel Childs, was connected with the sea by a channel 24 feet deep and 1,300 feet wide. In the lake the channel from near Fort San Carlos to near Boccas (Solentiname) Islands, which was to be 150 feet wide, was to be protected by a row of piles driven on each side. On the western side, near the mouth of the Las Lajas, the cut in the lake was to be protected by a pier constructed on either side and extended to deep water. The total length of the route was given as follows:

Length and cost of the canal.

	Miles.
From the 17-foot curve in the Pacific to dam at Buen Retiro	8.809
From dam at Buen Retiro to Lake Nicaragua	9.779
Total western division	18.588

		Miles.
Across Lake Nicaragua (now known to be 70.51 miles)		56.500
From Lake Nicaragua to dam near Castillo	37,151	
From dam near Castillo to dam near Serapiqui	53,874	
From San Juan River to 17-foot curve in Caribbean Sea	28,280	
Total eastern division		119.305
Total		194.393

Summit level:

West of lake	9.779
Lake	56.500
East of lake	37.151
Total	103.430

The total cost of the canal was estimated at $31,538,319.55, which included 15 per cent for contingencies, and the work was to be completed within six years from the time of breaking ground.

Depth of canal not as great as contract required.

The contract between Nicaragua and the company required that the canal should be large enough to accommodate vessels of all sizes, and Colonel Childs had been instructed by the company to make surveys and estimates for a work of such dimensions as would comply with this requirement. He recognized that the dimensions proposed would not meet it. His reasons for limiting the depth to 17 feet were that the ratio of increase of the expense of a deeper canal would be very great, and that the construction of a canal of the dimensions required for vessels of the largest size would be an injudicious application of means that the company would scarcely favor or the interests of commerce require. He stated also that no vessels were plying between the Atlantic States and the eastern coast of the Pacific with a draft as great as 17 feet, and that of 261 steam vessels, mostly English, as given in Murray's Treatise on Marine Engines and Steam Vessels, only 15 drew over 17 feet, 21 drew 17 feet, and 225 less than 17 feet each at the load line. He had therefore made his plans and estimates with due consideration of the disparity in cost and general utility of a canal of larger dimensions.

Report referred to Colonel Abert and Major Turnbull.

At the request of the company this report of the survey and location was submitted by President Fillmore to Col. J. J. Abert and Maj. W. Turnbull, Corps of Topographical Engineers, for their inspection and opinion, and on the 20th of March, 1852, they reported that the plan proposed by Colonel Childs was practicable, but they expressed the opinion that the jetties at Grey Town Harbor and one or both at Brito could be dispensed with; also the pile work in the lake near Fort San Carlos; and that one row of guide piles about 100 feet apart to mark the channel from there to Boccas (Solentiname) Islands would be sufficient. It was also recommended that additional surveys be made between the San Juan River and Grey Town Harbor to determine whether a more direct line could be found. These modifications, it was suggested, would materially diminish the cost of the canal, also the time in passing it. Colonel Childs subsequently proposed a project for a canal 12 feet deep with a smaller prism and smaller locks.

Lull's project, 1873.

Nothing further was done by either the American Atlantic and Pacific Ship Canal Company or anyone else looking to the construction of this canal for about twenty years, when an expedition was fitted out by the United States Government, under the charge of Commander A. F. Crossman, U. S. N., for the purpose of surveying an interoceanic canal route. The expedition sailed from Key West, and arrived off Grey Town on April 7, 1872. On April 12, while attempting to make a landing at Grey Town, the boat containing Commander Crossman capsized, and he with a number of his party was drowned. The command of the expedition then devolved upon Commander Hatfield, U. S. N., who proceeded with the surveying parties to Lake Nicaragua and began operations on the west side of the lake, securing some valuable information respecting the routes between the lake and the Pacific. His investigations showed that Colonel Childs's survey of the western portion of his line was correct. Commander Hatfield's party made reconnoissances, with the object of finding another line by which the route could be shortened and the Rio Grande avoided, the upper part of the valley of the latter being practically a gorge and liable to give trouble in time of flood.

Expedition under Commander Crossman, U. S. N.

Parties under Commander Hatfield.

The parties under the charge of Commander Hatfield, with the exception of a few men, left to do some hydrographic work in the lake, for which the calmer weather of the rainy season is more favorable, were withdrawn from the Isthmus in July. In November of the same year an expedition was fitted out under the command of Commander E. P. Lull, U. S. N., who arrived off Grey Town December, 1872, and took up the work begun by Commander Hatfield. Commander Lull made an examination of a number of routes between the lake and the Pacific, and finally adopted the one known as the Medio route.

Lull succeeds Hatfield.

From the Pacific Ocean to a place called Las Serdas, near the outlet of the Rio Grande gorge, the line is practically the same as that adopted by Colonel Childs. From thence it swings to the northward on a radius of 2,200 feet, following the valley of a small stream then called the Chocolata (called Gua-

West Division.

chipilin on recent maps) for a short distance, and crosses the divide into the valley of the Medio, which it follows to the lake. The total length of the line from Brito to the lake was 16.33 miles, being about a mile and a half shorter than the Childs route. The summit of the divide was 134 feet above the level of the lake, or about 241 feet above sea level, giving a maximum depth of cutting of 160 feet. There were to be 11 locks in this section, including a tide lock at Brito, to admit ships at any stage of the tide. The tide lock was to have a lift of 9 feet, the others of 10.31 feet each. The brook Chocolata, which the route crossed, was to be taken into the canal, but the Tola, as well as several smaller streams, was to be passed under the canal by means of culverts to the Rio Grande. The waters of the latter stream were conducted to the Pacific on the south side of the canal, diversion channels being provided where necessary. By this departure from the Childs route the Rio Grande was excluded from the canal, a feature then deemed important.

Brito.

A small harbor at Brito was to be formed by the construction of a breakwater extending easterly from Brito Head and a short jetty from the beach on the opposite side of the entrance. The mouth of the river was to be utilized for harbor purposes, and the diversion of the stream to the eastward of the entrance was provided for. The harbor as designed was well protected.

Eastern division.

From the lake eastward it was proposed to canalize the San Juan River by the construction of dams and locks and short sections of canal at Castillo, Balas, and Machuca Rapids, and at a place about 2 miles below the mouth of the San Carlos. All the dams were to be comparatively low, and the waters of the river were to be discharged over them. It was estimated that the fall at the first three dams would be 10.28 feet each. The fall over dam No. 4 was expected to be 23.87 feet.

Lake Nicaragua.

The lake was to be held at a minimum of 107 above sea level, but no provision was made for holding it close to that level against a rise, except that which was afforded by the discharge through the river; and no effort whatever was made to provide for the deficiencies of the dry season, when the lake would naturally fall below 107 from evaporation. The danger of taking the San Carlos into the canalized part of the river above dam No. 4 seems to have been fully realized by Commander Lull, for we find that he proposed to divert the waters of the San Carlos by a cut-off and discharge them into the San Juan below the dam, but it is evident that the difficulties of this work were not fully appreciated.

From near the mouth of the San Carlos to Grey Town the canal was to be carried in excavation a distance of 41.9 miles. The least radius of curvature was 2,500 feet. The line was to follow the general course of the main river bank, cutting off bends wherever the conformation of the ground would permit, until the head of the San Juanillo was reached. From there to Grey Town Harbor it was nearly a straight course. Seven locks, in addition to those abreast of the dams, were proposed, making ten in all. The last two locks were to be placed together and sea level reached just before the canal entered the Silico Lagoon. From there to Grey Town it was expected to dredge a channel, embankments not being thought necessary. The seven locks were to have each a lift of 10.87 feet.

Canal from near San Carlos River to Grey Town.

Dimensions.

The depth throughout the canal was to be 26 feet and the locks were to be 400 feet long by 75 feet wide. A number of the streams which are crossed by the canal were to be passed under it by means of culverts. The bottom width of the canal varied from 50 feet in the deep earth cuttings to 60 feet in the rock cuttings and 72 feet in the shallow cuttings. The harbor that existed at the time the Childs project was made had since been inclosed by the sand spit, which had moved westerly until it united with the mainland, converting the harbor into a lagoon. It therefore became necessary to construct a harbor at this entrance. All communication was to be cut off between the harbor and the San Juan River, so as to cause the entire waters of the San Juan to be discharged by the Colorado branch, but the San Juanillo was to be discharged into the harbor and a jetty extending from the shore to 35 feet of water was to be built. A channel into the harbor was to be dredged under the lee of this breakwater, which had a direction of NNW. The total estimated cost of this project, allowing 25 per cent for contingencies, was $65,722,137.

From 1873 to 1884, a period of eleven years, no surveys were made by the Government or by individuals in this connection. In 1884 the Frelinghuysen-Zavala treaty was negotiated with Nicaragua, giving to the United States the right to build a canal across the isthmus from ocean to ocean within the territory of that Republic, following the most available route. Another survey was then ordered. This expedition was under the command of Mr. A. G. Menocal, civil engineer, U. S. N., who had been the principal assistant to Commander Lull in 1872 and 1873. The object of this survey appears to have been chiefly to determine the advisability of any changes in the route for shortening the canal and diminishing the cost.

Menocal survey.

Menocal project, 1885.

As a result of Mr. Menocal's work a new project was submitted in a report to the Secretary of the Navy November, 1885, in which very radical changes were made in the Lull project. On the west side, between the lake and the Pacific, the changes were confined to that part of the route between Las Serdas and the lake. Instead of following the valley of the Medio from the lake across the divide to the valley of the Rio Grande, he adopted the Las Lajas route, several miles to the southward, which was the one originally surveyed by Colonel Childs. This made it necessary either to receive the waters of the upper Rio Grande into the canal or to divert them to Lake Nicaragua through a new channel, the Rio Grande gorge being too narrow to take the canal and river separately. The maximum discharge of this stream was estimated by Colonel Childs at 5,670 cubic feet per second, but it was thought by Mr. Menocal that it might sometimes, for short periods, be as great as 10,000 cubic feet per second. He thought the taking of so large an amount of water into the canal would be dangerous to navigation and the stability of the work; hence he sought to find some method of diverting it. This he found could be done by building a dam across the river several thousand feet from the canal and excavating an artificial channel through the ridge which separated the valley of the Grande from that of the Juan Davila, a branch of the Las Lajas. The proposed channel was to have a width of 75 feet at the bottom, to be 15 feet deep, with proper slopes, and a fall of 2.53 feet per mile. The length from the dam to the Juan Davila was 3.88 miles. The waters of the Rio Grande being thus diverted, the valley of that river was practically dry as far as the Tola, and this enabled a better alignment to be made. The Tola was to be passed under the canal by means of a culvert, as in Lull's project. The sailing line across the lake was changed back to the old route, which started from the mouth of the Las Lajas instead of from that of the Medio.

Changes in Lull project on west side suggested by Menocal.

On the section from the lake eastward radical changes were introduced which rendered the project for this section entirely unlike any that had yet been suggested. Instead of a succession of comparatively low dams as far down as the San Carlos, a single dam was proposed at Ochoa, about 3½ miles below the mouth of that river. This dam was to create slackwater navigation in the river, raising the lake to 110. It practically converted the river from the lake to the dam into an arm of the lake. It was expected that a slope of 4 feet from Fort San Carlos to the dam, which was provided for, would discharge the surplus waters from the lake and the drainage of the river basin. The Ochoa dam was to be built of concrete masonry, with a large amount of loose stone on the upstream side and an apron on a pile and grillage foundation on the lower side to prevent undermining. The entire surplus waters of the San Juan River were to be discharged over the crest of the dam. No borings had been made to determine the nature of the foundations, but it was supposed from the outcropping bowlders on the side hills and on the banks, that rock underlaid the gravel and sandy bottom at no great depth.

Ochoa dam.

It was supposed that the hills south of the San Juan formed a continuous range which would hold up the sumit level on that side. It was discovered some years later by the Maritime Canal Company that this was not the case, but that embankments of considerable magnitude would be required between the hills. The project now being considered did not contemplate such embankments, and no estimate was made for them.

Embankments south of the San Juan.

Starting from a point a short distance above the dam on the north side of the river, the canal was to be carried in excavation through the broken country at the headwaters of the Danta, crossing the latter stream into the valley of the San Francisco, which it also crossed and followed to its confluence with the Chanchos; it then ascended the latter and a tributary thereof to the divide which separates this drainage system from that of the Deseado, a tributary of the San Juanillo. After crossing the divide the line entered the valley of the Deseado, which it followed to the coastal plain, whence it took a direct course to Grey Town lagoon. The summit level was to be maintained across the Danta, San Francisco and Chanchos, and through the "east divide" by a small embankment not far from the Ochoa dam and a large one 6,500 feet long and 51 feet high across the valley of the San Francisco below the mouth of the Chanchos. The subsequent surveys of the Maritime Canal Company showed that a large number of embankments was necessary.

Line from Ochoa dam eastward.

Divide cut.

The "divide cut" was an important feature in this project. It was stated to be a little less than 3 miles long and was nearly all in curvature. Mr. Menocal states that the elevation of the divide between the eastern and western flowing waters was 280 feet, but it being impossible to locate the canal so as to follow the turns of the valley, the line would cut several spurs where the excavation was still deeper. The maximum cutting would have been about 350 feet.

The saving in distance from the Pacific to the Atlantic over the Lull route is stated in Mr. Menocal's report to be 10.96 miles. The project contemplated a depth of 28 feet, increased in places to 30. The summit level was to be reached by three locks on the east side and four on the west. The locks proposed were to have a uniform length of 650 feet between the gates and a least width of 65 feet. Locks 1, 2, and 3 on the east side had lifts of 26, 27, and 53 feet, respectively. The locks on the west side, counting from the lake to the sea, had lifts as follows: 26.4 feet for the first, 29.7 feet each for the second and third, and for the last, being a tide lock, the lift was to vary between 24.2 and 33.18 feet, depending upon the state of the tide. The lock with 53 feet lift was proposed to be

Locks.

cut out of solid rock on the eastern slope of the divide, concrete to be used only to the extent required to fill cavities, to give proper dimensions to the various parts and a surface to the blasted rock. All the other locks were to be built of concrete, and all were to have a heavy timber lining in the chambers and bays extending from the tops of the walls to 15 feet below low-water level.

Railroad.

A narrow-gauge railroad was to be built from Grey Town to the dam across the San Juan River and another between the lake and Brito.

The total estimated cost was $64,036,197. This included 25 per cent for contingencies, but nothing for surveys, hospitals, shops, management, and other necessary expenses in addition to the construction contingencies proper.

Maritime Canal Company's project, 1889.

The Frelinghuysen-Zavala treaty was withdrawn from the United States Senate by the President before ratification, and became inoperative. But a concession, known as the Menocal concession, was granted by Nicaragua to the Nicagagua Canal Association, in 1887, to construct a canal connecting the two oceans. A similar concession was granted by Costa Rica in 1888. The Maritime Canal Company, of Nicaragua, was organized under the terms of these concessions in February, 1889, and a charter was granted by Congress to enable the company to execute the work. (See act approved February 20, 1889.)

Organization of company.

Project essentially the same as Menocal's.

The project of the canal company was essentially the same as that of Menocal, of 1885, modified in respect to the summit level. This was to be extended on the west side to within 3½ miles of Brito by the construction of a dam across the Rio Grande at La Flor.

Surveys had shown that a continuous ridge, with a single break at the crossing of the San Francisco from the north end of the Ochoa dam to the "east divide," did not exist, and that in addition to the embankment or dam across that stream, a great number were necessary in other places. The supposed ridge proved to be a series of hills of greater or less height, with saddles or low valleys between them. The total number of embankments, great and small, required between the Ochoa dam and the divide, as stated in the report on final location in 1889, was 67, having a total crest length of about 6 miles. Most of them were small, but four of them were very large, and their construction constituted a most difficult engineering problem on account of the great depth and the soft and yielding nature of the soil at the sites.

San Francisco embankment line.

It was also found that the ridge from the south end of the dam was not continuous to the hills in Costa Rica, and that a number of embankments to connect these hills would be required. The total number was

21, with an aggregate length of 5,540 feet on their crests. These embankments were to be entirely of clay. This embankment line was not only shorter than the San Francisco line, but the construction of the dams in the saddles of the ridge presented no special engineering difficulties. It was proposed to build a waste weir in the ridge about $2\frac{2}{3}$ miles from the Ochoa dam, having its crest at 106 feet above mean sea level, to discharge the flood waters of the San Carlos into the valley of Cureña Creek, which empties into the San Juan below the Ochoa dam.

San Carlos embankments.

Embankments or dams were also required east of the divide in the valley of the Deseado, one of which was to be 70 feet high and 1,050 feet long. Weirs and sluices were provided in the San Francisco and Deseado valleys for the control of floods. Some of the largest of the embankments or dams on the San Francisco line were first designed as rock fills backed with earth, their crests to be 107 feet above mean sea level, and the top and outer slopes so shaped and paved with large stones as to admit the free flow of water over their surfaces. These were to be, in fact, so many waste weirs for the discharge of the surplus waters from the summit level.

Other embankments.

The Ochoa dam, which was originally to be of masonry with a timber apron, was modified to a rock fill backed with earth. The crest of the dam was fixed at 105 feet above mean sea level. Its width across the top was to be 25 feet. As the water of the San Juan was to be held at 106 in the vicinity of the dam, a constant discharge due to a head of 1 foot over the dam was expected. This, however, would not have been the case, for the lake would have fallen to 106 or lower in the dry season and the level at the dam could not have been maintained. It was estimated that the discharge over the crest of the dam might sometimes reach 42,500 cubic feet per second, and the combined discharges with the lake at 111 over the dams, weirs, and through sluices were estimated at a maximum of 147,800 cubic feet per second. The dam was to be built of rock taken from the east divide cut and deposited by means of cables stretched across the river. On the upstream side of the rock pile thus formed clay was to be deposited to render it watertight.

Maximum discharge of San Juan at Ochoa.

La Flor dam.

On the west side of the lake the summit level was to be continued through the west divide and down the valley of the Rio Grande to a point called La Flor, about $3\frac{1}{2}$ miles from the Pacific, where the valley narrowed to about 1,600 feet. At this place the valley was to be closed and the summit level maintained by a large dam. For several miles above this site the valley is about a mile or more wide, and a large, deep basin would thus be formed into which the floods of the Rio Grande, Tola, and other smaller streams would be received. It was held that the creation of this large pool would render unnecessary the proposed diversion of the Upper Rio Grande into Lake Nicaragua, and thus save about $1,500,000, which the proposed diversion would cost. It was at first intended to build the La Flor dam as a rock fill backed with earth, in the same manner as proposed for the Ochoa dam, but finding the underlying strata of earth unsatisfactory, the plan was changed to an earthen dam with a masonry core extending down to rock. A waste weir 300 feet long was to be provided east of the dam to discharge the surplus waters into the bed of the Rio Grande.

Locks.

With the adoption of a dam at La Flor, the location of the locks was fixed near its western end, the combined lift of two being 85 feet. A third, which would be the tide lock, was to be located a short distance from the harbor and have a variable lift according to the stage of the tide of from 21 to 29 feet.

Cost.

The total cost of the canal was estimated at $65,000,000, inclusive of 25 per cent for contingencies, but exclusive of interest, commissions, and other charges not coming under the cognizance of the engineers, and on the basis that the work would be prosecuted with vigor along the whole line and without intermission.

In the early part of the year, 1899, the project was submitted to a board of consulting engineers for examination, report, etc. This

Report of Board of Consulting Engineers.

board made a report on May 9 of that year, giving the opinion that from the information furnished by the maps, profiles, borings, samples, and statements of the chief engineer and other employees, the project was "unquestionably feasible." The board stated, however, that there was a possible hazard in respect to the San Francisco and other basins that they might not prove sufficiently retentive, owing either to the leakage around the ends or under the bases of the dams and embankments from concealed permeable strata beneath the natural surface. They deemed "this a remote danger, since both the surface and subterranean formations, as far as revealed by the borings and by the reports of observations of reliable men familiar with the locality, are favorable." The estimate of cost as determined by this board, inclusive of 20 per cent for contingencies, was $87,799,570.

Nicaragua Canal Board, 1895.

On March 2, 1895, Congress passed an act providing for the appointment of a board of engineers to make a survey and examination for the purpose of ascertaining the feasibility, permanence, and cost of the construction and completion of the Nicaragua Canal by the route contemplated and provided for by an act which passed the Senate January

28, 1895, entitled "An act to incorporate the Maritime Canal Company of Nicaragua, approved February 20, 1889." The report of this Board was published in House Doc. No. 279, Fifty-fourth Congress, first session. It was stated therein that more specific information was necessary before a satisfactory final estimate of the company's project could be prepared, and recommended additional examinations and surveys. The Board submitted a tentative approximate estimate based on the company's plans and data amounting to about $133,000,000.

Report of Nicaragua Canal Board and estimate of cost.

Project of Nicaragua Canal Commission, 1899.

On June 4, 1897, Congress passed an act for the appointment of the Nicaragua Canal Commission to "continue the surveys and examinations authorized by the act approved March 2, 1895. * * * into the proper route, feasibility, and cost of construction of the Nicaragua Canal, with a view of making complete plans of the entire work of construction of such canal as therein provided." The results of the surveys and examinations of the Nicaragua Canal Commission are contained in the report to the President of the United States, May 9, 1899.

Act March 2, 1895.

Project of Nicaragua Canal Commission.

As the project of the Nicaragua Canal Commission is essentially the same as that of the existing Isthmian Canal Commission, with slight modifications, and as a description of the latter is given in full, a brief description of the former is all that seems necessary. The route adopted by the Nicaragua Canal Commission was practically that suggested by Colonel Childs, in 1852, but his project was modified in some important respects and greatly enlarged. The project provided for a canal with a depth of 30 feet, a bottom width of 150 feet, and with locks 665 feet long between quoins, and 80 feet wide. A single high dam across the San Juan, above the mouth of the San Carlos River, was provided for, and the canal carried thence on the left bank of the San Juan River to the Caribbean Sea. Provision was made for the regulation of the lake level, a subject which no prior project had adequately dealt with.

Safety of prime importance.

The Nicaragua Canal Commission determined that in a work of the magnitude and importance of a canal connecting the two oceans, and of the disastrous consequences that would result from a failure to maintain its integrity after it was once opened, it was of far more importance that it should be safe than that it should be cheap. Plans that seemed to the Commission to possess advantages in certain respects, but were coupled with dangerous engineering works, were rejected for other plans reasonably free from risk. The short and comparatively straight cut across the country from the neighborhood of Ochoa and the extension of the summit level nearly to the Atlantic were attractive features of the Menocal project, but necessitated dealing with some hazardous problems. The safer alternative of terminating the summit level at the San Juan River dam and then following the left bank of the San Juan was chosen.

The large embankments across the Danta, the San Francisco, and at other places would have proved not only far more expensive than was anticipated, but hazardous to maintain. The adoption of the longer line with lower level does not eliminate all the difficult constructions, for some will be found in any project for a canal across the American isthmus, but it reduces their number and brings them within the limits of safety. The Commission thought also that the proposed rock fill dam across the San Juan River involved such serious risks in construction and maintenance that this form of structure should be avoided.

Discharge of San Juan greatly underestimated.

This course seemed the more imperative from the fact that the discharge of the San Juan River had always been very much underestimated. Gaugings at Ochoa made by the Nicaragua Canal Commission in November, 1898, gave 104,928 cubic feet per second as the discharge on that day, and at the time the San Carlos was only discharging 32,265 cubic feet per second, whereas it is now estimated that the latter stream alone may discharge as much as 100,000 cubic feet per second. A possible discharge of 200,000 cubic feet per second at Ochoa might reasonably be anticipated when both rivers were in high flood at the same time.

The construction of a high dam at Ochoa, or at any point below the junction of the San Carlos, was regarded as a work of such difficulty that a search was instituted for a site higher up the river, suitable for a masonry structure. Such a site was found about 3 miles above the mouth of the San Carlos. The first borings, which were few in number, indicated hard rock at a maximum depth of about 14 feet below sea level, but the more extensive system made subsequently by the Isthmian Canal Commission disclosed a very irregular bottom with a maximum depression 46 feet lower. Nevertheless, the site of the dam was far more favorable than the one at Ochoa, as the floods of the San Carlos could do it no harm.

Dam at Boca San Carlos.

The La Flor dam was a large and difficult work, on account of the unsatisfactory foundations. The western end of the summit level was brought so near the sea that the space available for locks was much restricted. The ridge near the north abutment rises abruptly to a height of 300 feet and over, which would have necessitated the location of the locks on the side of a steep hill. Near the south abutment the ground was also unfavorable. The project of the Nicaragua Canal Commission did not call for locks in duplicate, but the desirability of so locating them that an additional lock could be added in case of future demands was not lost sight of. It would have been very expensive to build locks in duplicate on either side of the La Flor dam. On the other hand, there were no serious engineering difficulties in the way of constructing a canal in excavation from the lake to the sea, and the slight advantage of the Tola basin as against a canal pure and simple did not, in the opinion of the Commission, compensate for the extra risks.

With La Flor dam, duplicate locks expensive.

Project of Isthmian Canal Commission, 1901.

The project of this Commission follows the general route of that proposed by the Nicaragua Canal Commission, but the depth of water in the canal has been increased, the locks duplicated and enlarged, and a new and better site for a dam in the San Juan found. The project is as follows:

Grey Town Harbor and entrance.

Beginning at the 6-fathom curve the entrance to the canal will lie between two jetties running nearly north and south, about $1\frac{3}{4}$ miles northeast of Grey Town and passing close to the most westerly bend of the lower San Juan, near its entrance to Harbor Head Lagoon. The entrance to the harbor is to be 500 feet wide and not less than 35 feet deep at low water. At the shore end of the jetties the line swings to the right on a curve of 4,175 feet radius and then passes into a tangent across the existing Grey Town Lagoon. For a distance of 2,500 feet from the inner end of this curve the width is continued at 500 feet. It is then widened to 800 feet for a further distance of 1,000 feet, in order to furnish a turning basin. It is then gradually reduced to 150 feet, the regular width of canal at the bottom. This width is reached 2.15 miles from the 6-fathom curve in the Caribbean. The head of the east jetty is to extend to this curve and is the zero point to which distances along the canal are referred. The harbor thus formed is well protected. The estimated cost of the entrance and harbor is $2,198,860.

Section from harbor to Lock No. 1.

From the harbor the line runs in a southwesterly direction, crossing the San Juanillo to the low, swampy ground along the Rio Misterioso. At a distance of 7.56 miles from the entrance the line swings to the left on a curve of 11,459 feet radius, and then follows a straight line in a direction a little west of south through the first lock, which is located 9.59 miles from the entrance.

Swamp section.

From Grey Town to the Misterioso the line passes through a region covered in places with coarse swamp grass or silico palms, in other places heavily timbered. The surface is but little above sea level. The soil is generally mud to a depth of 3 or 4 feet, underlaid with sand or sandy silt to below the grade of canal bottom. The borings made in this section extend from 50 to 112 feet below sea level without reaching other material.

From the first crossing of the Misterioso to lock No. 1 the canal line traverses a country in which low hills are interspersed in the coastal plain, and skirts the northwestern edge of the mass of hills about Silico Lake. The hills are heavily timbered, but between them the ground is flat and swampy, the surface being composed of soft mud mixed with decaying vegetable matter, which in places extends to a depth of 30 feet or more. This material is generally underlaid with firm clay. After the first crossing of the Misterioso the line follows the general course of that stream for several miles, the swampy surface being from 5 to 10 feet above tide. Lock No. 1 is located in a hill on the southwest side of the stream, and will have a lift of 36½ feet above mean low tide. This lock, as well as all others, will be in duplicate and founded on rock. The swamps communicate freely with the San Juan River through the San Juanillo and other streams, and the flood level rises at lock No. 1 to about 11 feet above sea level.

Material in other places.

It is proposed to exclude flood water from the canal on this section. This will require embankments on both sides. They are to have a minimum top width of 15 feet, with side slopes of 1 on 3. The crest of the embankments will be 5 feet above the highest flood levels. These dimensions apply to all sections of the canal where embankments are required. On the south side the embankment will be formed of spoil from the canal prism from Grey Town to the Misterioso, where it connects with the Silico hills, the remaining distance to lock No. 1 requiring only one short embankment across a small stream. On the north side the embankment will be formed in the same way from Grey Town to the crossing of the San Juanillo. From this point to lock No. 1 the embankment line follows first the right bank of the San Juanillo to a point about 1 mile above the mouth of the Deseado and then crosses a region of low hills and swamps to the canal line. This embankment line is circuitous, and a better one may possibly be found; but it is perfectly practicable and the construction will not be difficult or costly.

Embankments.

Diversion of San Juanillo.

The canal embankment will cut off the San Juanillo. The latter has another connection with the Caribbean Sea through the Benard Lagoon and the Indio, but the route is long and it is deemed better to provide a shorter one. A diversion is therefore to be made by a channel dredged from a point on the San Juanillo about five-eighths mile north of the canal crossing to the excavation made by the Maritime Canal Company, and through this to Grey Town Lagoon. The length of the channel to be dredged is about 1½ miles.

The length of this section is 7.44 miles. For a distance of 6.20 miles the side slopes of the canal prism will be 1 on 3. For the remaining distance the material is generally firm and the cross section will be that provided for firm earth.

Cost.

The estimated cost of this section, including approach wall to lock No. 1, embankments, and diversions of the lower San Juan and San Juanillo, is $5,056,747; lock No. 1, including excavation, $5,719,686.

Section from Lock No. 1 to Lock No. 2.

From lock No. 1 the line continues in the general direction of the Misterioso for about 2 miles. It then crosses the Pescado, which drains a swampy region to the southward, and enters the region drained directly into the San Juanillo. It crosses this stream about 2 miles from the place where the San Juanillo leaves the San Juan, and then traverses about a mile of swamps and low hills, passing into the valley of the Rio Negro, a tributary of the San Juanillo, behind the hills at Punta Petaca, where it is about 1 mile distant from the San Juan. It then continues in the valley of the Rio Negro, crossing it about a mile east of the Negro hills in which lock No. 2 is located. There are two curves on this section, each of 8,594 feet radius. The section is generally swampy, but in the Rio Negro Valley the line cuts through some hills.

The canal surface in this section is to be maintained at a minimum elevation of 36 feet above mean tide. The flood levels immediately above lock No. 1 appear to be about 31 feet above the same reference and immediately below lock No. 2 about 43 feet above it. The region communicates freely with the San Juan during high water in the latter, whence most of the flood water comes, and also receives considerable drainage from the mass of hills north of the line. The embankments have not only to maintain the canal level, but are also required to exclude floods from the San Juan on the upper portion of the section. On the north side of the canal hills form the greater part of the line of protection, although a few swamps have to be crossed by embankments. On the south side the Silico hills protect the level for several miles, but to the westward of them are long stretches of swamp with soft bottom where embankments are required. These embankments constitute one of the difficulties of this section. The estimates provide for the removal of the soft material for a width of 30 feet at bottom to make the embankments safe when built. They are located

Embankments.

in most places so far from the canal line that the material excavated would not be available even if suitable, which it seldom is. They will be formed from clay borrowed from the hills.

The swamp level near lock No. 1 is at about elevation 16, and at lock No. 2 about elevation 38. Almost the entire area within the embankment lines (some 12 or 13 square miles) will be below the level of water in the canal. The total drainage tributary to the

Waste way and lock.

section is probably about 25 square miles. A waste way is required which will be located at or near the Silico hills where the flood level in the San Juan is below the canal level. It is to be a simple overflow weir with crest at elevation 36, the minimum canal level, and to have a length of 600 feet, which will prevent the canal level rising above elevation 37.5. The assumed maximum rainfall is 12 inches in twelve hours, all reaching the pool within twenty-four hours. No site with rock foundations has been found for this waste way. It will be built in the clay hills. Lock No. 2 will have a hard rock foundation. The lift will be 18½ feet, from elevation 36 to elevation 54.5.

Length and cost.

The length of this section is 10.96 miles. A part is through swamps, requiring side slopes of 1 on 3. In the remaining portion the cross section is reduced to the standard adopted for firm earth. The estimated cost of this section, including approach walls to locks, embankments, and waste ways, is $6,296,632; lock No. 2, including excavation, $4,050,270.

Section from lock No. 2 to lock No. 3.

The general direction of the line in this section is a little north of west. It leaves the Rio Negro Valley near lock No. 2, and passes behind the Serapiqui hills, which were formerly supposed to be connected with the high range to the northward. At this point the line is more than a mile from the San Juan. A short distance farther west the route crosses the Tamborcito ridge, after which at short intervals it crosses the Tambor Grande and San Francisco ridges. A line located around the ends of these ridges near the river would have inadmissibly sharp curvature, and would be liable to injury during river floods. If carried across them far from the river the cuttings would be very heavy. The line projected by this Commission is at a safe distance from the river, and although involving heavy work, avoids the much heavier work that a location farther from the river would require. The deepest cut on the center line of the canal is 297 feet, in the Tamborcito ridge.

Protection against floods in San Juan.

Riprap protection against river floods will be required in the swamp levels of those localities where the line approaches close to the river. After crossing the San Francisco River the line follows a westerly direction to the Danta, which it first crosses about 2 miles from the San Francisco. It then follows the valley of the Danta, which it crosses several times, to lock No. 3. This portion of the line passes through a swampy region with occasional low hills.

Tamborcito cut.

The cut in the Tamborcito ridge is the deepest on the route, and will consist largely of hard, basaltic rock. It is, however, only about 3,000 feet from the foot of the ridge on the east side to the foot on the west, and the crest is narrow.

Curves.

There are eight curves on this section of the canal, of which one has a radius of 4,911 feet, four of 5,730 feet, one of 6,876 feet, one of 8,594 feet, and one of 11,459 feet.

Since the line was laid out borings have shown that deep sand exists under a part of that portion of it lying between the Tambor Grande and the San Francisco, its upper surface being near the canal bottom. It is probably a former bed of the San Juan River.

Recent examinations.

Recent surveys and borings have shown that this material can be avoided by a location farther inland, but as it has not been practicable to take new borings across the ridges on the new lines, the estimates are made on the line that is laid down, and include an allowance for puddling the bottom of the canal where needed. A small amount of permeable material is also shown by the borings in a hill crossed by the canal line near the Florida Lagoon, and the estimates provide for puddling at this locality.

The surface of the swamp near lock No. 2 has an elevation of about 38 feet above sea level, and gradually rises to elevation 45 in the Florida Lagoon, near lock No. 3. The line intercepts the drainage from about 75 square miles lying to the northward, and crosses the Guasimo, San Geronimo, Tambor Grande, San Francisco, and Danta, as well as a number of small creeks. The beds of the larger streams are from 15 to 20 feet below swamp level. The swamp bottoms are of clay silt, which may settle under the embankments, but should not offer serious difficulties to good construction. The level of the canal is to be maintained at the minimum elevation of 54.5 feet, submerging all the swamps. The flood levels appear to be about 53 feet at the Serapiqui and 56 feet in the San Francisco region, the latter being 1½ feet above the minimum stage in the canal. In order to diminish the currents through the narrow connecting channels, three waste ways are provided, one in the Serapiqui Hills, 500 feet long, one of the same length in the west flank of Tamborcito, and one of 1,000 feet near the Danta. With these waste ways it is estimated that the water in the canal will never rise more than 2½ feet above the normal stage.

Drainage.

Wasteways.

The wasteways are designed to be plain overflow weirs built of concrete, with the crests at elevation 54.5, the minimum canal level. At rare intervals the crest of the Danta wasteway may be submerged by the San Juan floods, but the amount of water taken into the canal over it will be so small that no trouble is apprehended. The borings made at the site of the Danta wasteway show unfavorable material for foundations, involving an additional expense for safe construction, for which provision has been made in the estimates. Lock No. 3, which terminates this section, is located on a rock foundation, having a lift of 18½ feet, viz, from elevation 54.5 to elevation 73 at minimum canal level.

Length and cost.

The length of this section is 16.75 miles, and the estimated cost, including approach walls, embankments and wasteways, is $19,330,654; lock No. 3, including excavation, $3,832,745.

Section from lock No. 3 to lock No. 4.

Curves and drainage.

Westward from lock No. 3 the line follows down the valley of Embankment Creek to within about 1,700 feet of its mouth, and then crosses some hills and the Machado to lock No. 4. There are two curves on the section having radii of 11,459 feet each. The excavation will be mainly in firm earth with standard slopes to correspond. Some rock will be found near the site of lock No. 4, and soft mud in crossing the valley of the Machado. The drainage area tributary to this section has not been well determined, but is taken at about 9 square miles, about 1 square mile of which will be submerged. It is proposed to control the surface of the pool, between elevations of 73 and 76 feet, by a weir 300 feet long, located in a hill a short distance east of the Machado.

Embankments.

Two embankments will be needed between the canal and the San Juan River, one across Embankment Creek, the other across the Machado, where the crest will be about 31 feet above the bottom of the stream and about 24 feet above the swamp level. The borings show the surface material in this swamp to be soft, and some of it will have to be excavated, so that the embankment may rest on firm material. Lock No. 4 is located in a hill immediately west of the Machado. It is proposed to control the surface of the summit level of the canal between the elevations of 104 and 110 feet, hence this lock is designed to have a variable lift, the maximum being 37 feet and the minimum 31 feet.

Length and cost.

The length of this section is 2.77 miles. The estimated cost, including approach walls, embank ments, and waste way, is $4,310,580; lock No. 4, including excavation, $5,655,871.

Section from lock No. 4 to the San Juan River.

Westward of lock No. 4 the line passes through a rough, hilly region where deep cutting is encountered. About three-fourths of a mile west of the lock the depth to the bottom of the canal on the center line is 218 feet below the surface. The borings show a stratum of clay 10 feet thick, from elevation 65 to elevation 55, the top being about 4 feet below the bottom of the excavation. About 1 mile farther westward is another cut 170 feet deep on the center line, with a clay stratum 10 feet thick, the upper surface being at elevation 89. In the latter case the clay stratum is in the wetted prism of the canal. In both cases there is rock overlying the clay. It is supposed that the rock is a volcanic overflow. Where the clay shows in the wetted prism, slopes of one on one are provided for both rock and clay.

Special slopes.

Summit level.

The section forms a part of the summit level, and has two curves, each of 5,730 feet radius. The point where it enters the San Juan River is 46.17 miles by the canal line from the 6-fathom curve in the Caribbean Sea. The upper end of this section is 3.3 miles by the river from the dam site at Conchuda. This dam will maintain the summit level, regulated by wasteways at the dam and in the hills a short distance southwest on the Costa Rica side. The dam, wasteways, and system of regulation are fully described elsewhere.

Length and cost.

The length of this section is 5.30 miles. The estimated cost, including approach wall to lock, is $8,579,431.

San Juan River section.

This section embraces that portion of the river from the point where the canal enters it above the dam to Lake Nicaragua. As already stated, the San Juan River above the mouth of the San Carlos is practically free from sediment, and in this respect is well adapted for slack-water navigation. It is very crooked, however, the curves being so sharp in places that the natural channel, even if deep enough, would be difficult for large ships to navigate. Cut-offs have been located in such places, improving the course of the channel and reducing the sailing distance. These improvements leave 54 per cent of the total distance from the dam to the lake in curvature. Except in a few cases the radius exceeds 5,000 feet, but in the section between the Machuca and Castillo Rapids the limit was reduced to 4,045 feet. In the present project the curves are of larger radius than in any previous one. They could be improved, but the cost would be increased. It has been the governing motive to preserve a judicious balance between curvature and cost.

Curvature and cost.

In this section there are four curves of 4,045 feet radius, one of 4,297, two of 4,911, three of 5,289, six of 5,730, two of 5,927, four of 6,876, one of 8,385, five of 11,459, and one of 17,189. The bottom of the excavated channel is established at elevation 69, giving a depth of 35 feet when the lake is at 104, its lowest stage. From the dam to the Machuca Rapids the general direction of the channel is northwesterly. The dam raises the water so as to permit a material straightening of the line on this part of the section with but little excavation. At the Patricia Rapids (in the fifty-ninth mile) the bed of the river rises above the grade of the channel bottom, and excavation is required thence to deep water in the lake.

Curves.

The necessary straightening of the channel past the Machuca and Diamante Rapids, which are nearly continuous, and the Pilares Rapids immediately above them, requires two small cut-offs and slight widenings at two other places. There is also a cut-off between the Patricia Rapids and the mouth of the Rio Bartola. At several places between the Bartola and Castillo, points of bends are cut off to reduce curvature. The line passes

Principal cut-offs.

through two small cut-offs between Castillo and the mouth of the Santa Cruz. At the first, a short distance west of Castillo, the borings show that considerable rock will have to be excavated. At the second there is comparatively little. The Santa Cruz cut-off, a short distance above the mouth of the Santa Cruz River, saves nearly 4 miles of distance. The line then crosses Sombrero de Cuero Island and enters the Toro Rapids. There will be a large amount of rock excavation under water between Castillo and the head of the Toro Rapids. The line then follows the river, impinging slightly on the banks in several places, bisects Isla Grande, and one-half mile above the latter enters the Palo de Arco cut-off, which effects a saving of 1.36 miles. It then follows the river, cutting off one small point just above the Rio Palo de Arco to the mouth of the Rio Medio Queso, where it enters the San Francisco cut-off. This is the longest cut-off on the route, and saves 1¾ miles. Beyond this the line continues in the river to the Isla del Padre, and then cuts across the marsh on the right bank of the river. It again enters the river nearly opposite Fort San Carlos, after passing which it enters the lake. Opposite Fort San Carlos there is some rock to be excavated. The bottom width of the channel in the river and in the shorter cut-offs is fixed at 250 feet on tangents, but increased on the curves according to the rule given elsewhere. The longer cut-offs have the standard canal width of 150 feet at the bottom on tangents, with corresponding widenings on curves.

In the vicinity of Rio Sabalos, Isla Grande, and Fort San Carlos, it was found, after the line described above had been laid down, that a material reduction in the estimated cost of the canal could be made by slight changes in alignment at these places. These changes in alignment have been adopted by the Commission, and are indicated on plates 30, 31, 42, 43, 44, 45, and 63 by broken lines, and on profile, plate 49a. The estimates are based on the new alignment. The changes are as follows:

First, that near Rio Sabalos begins in the Santa Cruz cut-off at mile 69.41, follows a westerly course, cutting off a small portion of Isla Sombrero de Cuero, and passes through Toro Rapids a little north of the line first adopted. It then crosses the latter, passes through the point of land opposite the mouth of Rio Sabalos, crosses the San Juan into Sabalos cut-off, and rejoins the line first adapted to mile 75.64.

The second, near Isla Grande, begins near the middle of the long curve east of Isla Grande, mile 79.72, continues on a curve following approximately the old channel north of the island, and joins the line first adopted at mile 82.51.

The third begins about 1¾ miles below Fort San Carlos, mile 93.94, follows close to, but north of, the line first adopted, crosses the latter at mile 94.85, and enters the lake about 400 feet to the southward of the first line.

These changes add 479 feet to the total distance from the Atlantic to the Pacific, and change slightly the curvature given in a preceding paragraph.

Length and cost.

The total length of the river section on the adopted alignment is 49.64 miles, and the estimated cost is $23,155.670.

Lake Nicaragua section.

The line enters the lake on a curve of 11,459 feet radius, and then continues on a tangent, passing southward of the Balsillas Islands and northward of the Solentiname group. Near the latter it crosses a submerged channel, where for a short distance no excavation will be required, and, passing around a short curve in deep water, enters a second tangent, where some excavation is required for a distance of 10.77 miles. This tangent continues to the vicinity of the mouth of the Las Lajas on the west side of the lake. The lake bottom on the sailing line lies below the grade of the canal bottom for a distance of 41.78 miles; the remainder, 28.73 miles, will require excavation. On approaching the mouth of the Las Lajas, the line swings to the westward in deep water to the long tangent at the east end of the western division of the canal.

Dredged channel in lake.

The bottom from Fort San Carlos to deep water in the lake consists of soft mud 6 to 17 feet deep, underlaid by hard clay and sand. The mud is so soft in places that it is difficult to determine its surface. The steamboat navigating the lake pushes its way through several feet of it when the lake is low. This material will take a flat slope, and after a channel is excavated through it there will be some expense for maintenance.

Channel on west side of lake.

On the west side the excavation in the lake commences 1.52 miles from the shore. It will consist chiefly of rock, and, as it is submerged, is estimated at the price for rock excavation under water. The material excavated from the west side of the lake can be wasted where it will form jetties for the protection of this entrance. The bottom width of the channel in excavation in the lake, both on the east and west sides, will be 300 feet.

The total length of the lake division is 70.51 miles, and the estimated cost is $7,877,611.

Lake Nicaragua to lock No. 5.

The entrance to the canal from Lake Nicaragua is about 1,100 feet north of the mouth of the Rio Las Lajas. The line extends in a southwesterly direction, following first the Las Lajas, which it crosses four times in a distance of 1½ miles, then following the general course of a small tributary, called the Guiscoyol, to the continental divide. The surface of the ground from the lake rises gradually until the divide is reached at elevation 153, a distance of about 5 miles from the lake shore. The highest point on this section is a small projecting hill three-fourths of a mile east of the divide, at elevation 156 on the center line.

From the divide the line follows the valley of the Espinal to the Rio Grande, and then continues in the valley of the latter to the Pacific. From the mouth of the Espinal to Lock No. 5 the valley of the Rio Grande is narrow and crooked, with hills on either side rising to elevations of 150 feet and upward. Here the line passes through several spurs, with rather deep but short cuts. The most important feature of this section is the cut through the west divide. Its maximum depth on the center line of the canal is 87 feet; for a distance of about 3 miles the average cut is about 75 feet. The rock is of all degrees of hardness from partially disintegrated sandstone to hard trap. Lock No. 5 is located in a hill on the north side of the Rio Grande at Buen Retiro, and will have an excellent rock foundation. On the southside of the lock a small dam will be required across the river to the adjacent hills to maintain the summit level. This dam is designed to be of earth with a masonry core wall extending to rock. The lock will have a variable lift from 22½ to 28½ feet, depending on the height of the lake. The section contains four curves with radii of 17,189, 5,730, 5,209, and 5,056 feet, respectively. Three of these are between the divide and the lock.

West Divide Cut.

Streams taken into canal.

The estimates provide for diverting the Las Lajas into the lake and for receiving basins at the points where the waters of the Rio Grande and the Chocolata enter the canal. These consist simply of enlargements of the river channels sufficient to pass the estimated maximum floods with velocities that will not interfere with navigation. At the head of each receiving basin there will be an overflow weir to act as a sand catcher. Other small streams that are crossed will be taken into the canal, but they will be relatively unimportant, and are provided for in the estimates only in the item of contingencies. A ferry will be needed for the highway traffic between Rivas and San Juan del Sur. The canal prism will be almost wholly in rock, and will have a bottom width of 150 feet, with vertical sides.

Length and cost.

The length of this section is 9.09 miles. The estimated cost, including approach wall to lock, diversion of the Las Lajas, and receiving basins for the Rio Grande and Chocolata, is $19,765,957; lock No. 5, including excavation, $4,913,512; dam near Buen Retiro, $125,591.

Lock No. 5 to lock No. 6.

The valley or gorge of the Rio Grande gradually widens in this section, opening into the so-called Tola Basin. The soil of the Rio Grande Valley is a light, sandy loam, readily acted upon by currents. The grade of the canal is established so low that the prism will be almost wholly in excavation, and the embankments will not be heavy and can easily be protected. This section contains a single curve of 4,982 feet radius. A by-pass in lock No. 5 will provide water for this level. A small wasteway will discharge surplus waters into the Rio Grande. The excavation will consist mainly of sandstone much disintegrated near the surface, but less so farther down.

Lock.

Lock No. 6 is located in a small hill on the south side of the Rio Grande about one-half mile above the mouth of the Rio Tola. The foundation is on rock. The lift is 28½ feet.

Length and cost.

The length of this section is 2.04 miles. The estimated cost, including approach walls and wasteway, is $3,259,283; lock No. 6, including excavation, $4,368,667.

Lock No. 6 to lock No. 7.

In this section the line crosses the bed of the Rio Grande several times, and short embankments 20 to 30 feet in height will be required; elsewhere the embankments will be unimportant, the grade line being low, as in the preceding section. This section contains a single short curve of 5,056 feet radius. The excavation will be mostly in sandy earth, except in the vicinity of the lock sites. While the excavation is sandy, it contains enough earthy material to form water-tight embankments. A new channel will have to be provided for the Rio Grande for nearly the entire distance. This will receive the drainage from the north side of the valley, including that of the Tola. On the south side the drainage will be received into the abandoned bed of the Rio Grande, and thence discharged into the canal. A wasteway located near the upper end of the section will discharge surplus water from the canal into the new channel of the river.

New channel for Rio Grande needed.

Lock.

Lock No. 7 is located in a hill at the site formerly proposed for the south abutment of the La Flor dam. The lift will be 28½ feet. The prism of the canal will be mostly in sandy silt with side slopes of 1 on 3.

Length and cost.

The length of this section is 1.83 miles. The estimated cost, including wasteway, river diversion, embankments, and approach walls, is $2,485,890; lock No. 7, including excavation, $4,709,502.

Lock No. 7 to lock No. 8.

The conditions in this section are almost exactly the same as in the preceding one. The material consists chiefly of light sand mixed with loam, which can be dredged by machines taken through lock No. 8 after the latter is built. It contains two short curves of 5,730 feet radius. A small wasteway is located near the upper end of the section where the canal is entirely in excavation. It will not have a rock foundation, and will be merely a depressed section of canal bank with protected surface.

Material, wasteway, and lock.

Lock No. 8, which connects with tide water, is located in a projecting spur, and will have a rock foundation. Its lift will vary with the tide from 28½ feet at mean low water to 20½ feet at mean high water.

Length and cost.

The length of this section is 2.43 miles, and the estimated cost, including approach walls, river diversion, embankments, and waste way, is $1,905,076; lock No. 8, including excavation, $4,920,899.

Lock No. 8 to the Pacific.

This includes a short section of the canal proper and an artificial harbor at Brito. A description of this harbor is given elsewhere. The excavation in this section consists mostly of sand. Some rock will be encountered near the lock site. The entrance to the harbor will be straight and have a width of 500 feet on the bottom.

The length of this section to the 6-fathom curve in the Pacific is 1.15 miles. The prism, except near the lock, will have side slopes of 1 on 3. The estimated cost is as follows:

Lock No. 8 to Brito Harbor, including approach wall to lock	$553,476
Brito Harbor and entrance, including jetty	1,509,470

The total distance from Lake Nicaragua to the 6-fathom curve in the Pacific is 17.34 miles.

The following table shows the amount and length of curvature for the entire line:

Number of curves.	Radius.	Length.	Total degrees of curve.		
	Feet.	*Miles.*	°	′	″
2	17,189	1.53	26	51	10
8	11,459	6.80	179	31	50
4	8,594	4.31	151	40	50
1	8,385	1.43	51	44	30
2	7,814	1.90	73	28	30
1	7,759	1.73	67	16	50
5	6,876	4.64	204	34	40
2	5,927	2.40	122	41	20
16	5,730	11.08	584	47	40
2	5,289	2.27	129	45	50
1	5,209	1.15	66	38	30
2	5,056	1.22	73	17	40
1	4,982	.82	49	49	00
3	4,911	.75	169	36	00
1	4,297	.63	44	19	50
1	4,175	.81	58	20	40
4	4,045	3.82	285	25	40
56	....	49.29	2,339	50	30

There are two curves of 11,459 feet radius having a combined length of 1.89 miles and a combined angle of 49° 58′ 50″ located in deep water in Lake Nicaragua, which for obvious reasons are not included in the above table.

Harbors.

Lack of harbor facilities.

As there is no natural harbor at either end of the proposed canal artificial harbors will have to be constructed. This lack of harbor facilities will be seriously felt on the east side in the early stages of the work, as the difficulties and expense of landing material before the harbor can be constructed are great.

Grey Town Harbor.

A fine harbor once existed at Grey Town, with about 30 feet of water at the anchorage and in the entrance. This was not such as is often found at the outlet of a large river like the San Juan, where the current scours an entrance, but rather a bight or protected area formed on the lee side of a sand spit which was itself built by the action of the waves and sea currents acting under conditions which favored such formation.

Destruction of Grey Town Harbor caused by moving sands.

A study of the various maps of Grey Town from the earliest to the latest reveals, it is believed, the processes by which natural forces acting on the movable sands composing the delta of the San Juan River have formed successively in ages past harbors which were afterwards converted into lagoons or lakes. The process seems still to be going on, and Grey Town lagoon is the latest development. Ibo, Barco, Sucio, and Shepherds lagoons were probably formed in the same way and by the same agencies.

Region unexplored.

There is a large area of low flat country lying to the eastward of a north and south line through the westerly end of Grey Town Lagoon, which, except for a fringe of the coast and the various outlets of the river, is practically unexplored. What there is in this region can not be stated with certainty, but it is probable that there are other lagoons similar to those just enumerated, or to the Parada and Agua Dulce, which connect with the Colorado branch of the river.

Sand brought down by San Juan River.

The sand composing the delta of the San Juan is volcanic, like that now brought down by the San Carlos and Serapiqui, which take their rise in the mountains of Costa Rica. This sand being deposited in front of the mouth of the river would form, if it were not acted on by other agencies, a bar approximating more or less the form of a crescent. The winds and waves of the sea, however, tend to give it an irregular shape, depending on the direction from which they come, while the currents of the river tend to cut out the channels. As the sand deposit increases the bar rises until finally the outlet of the river is in part cut off, and then it cuts out other channels. The San Juan River has no less than three outlets at the present time and perhaps has had more. Each outlet carries its load of sediment, and each has doubtless been an active agent in building up the existing delta. This delta forms a low area projecting into the sea from the general coast line between the Indio and the Tortuquero, some miles south of the Colorado.

There are some old maps of Grey Town Harbor, which have appeared in publications from time to time, that afford data of more or less value in studying the operations of nature that converted this once excellent harbor into a lagoon. The absence of definite common points and uncertainties as to compass bearing, however, render it impossible to make accurate comparison of the maps of earlier date, but they contain much information tending to throw light on the subject under consideration. The oldest of these maps is that bearing the title "Puerto y Boca del Rio de San Juan de Nicaragua," and is published in Sullivan's "Problem of interoceanic communication by way of the American Isthmus." It is not known what value attaches to this map. The only authority for it is given in a note. The name of the surveyor is not given, and it seems to have been a sketch rather than a chart from an instrumental survey. The map has no date, but the note referred to would indicate that it was about 1809. The soundings would seem to be fairly correct so far as they go, but they are few in number and cover only a limited area at the anchorage and the mouth of the San Juan. There are no offshore soundings shown. This map shows a sand spit that had formed to the northeast of Grey Town, connecting with the mainland and extending westerly, covering an area of deep water which was thus protected from the sea. The westerly end is bent in toward the shore, giving a good anchorage with deep water under its lee. The depth of water in the protected area is somewhat greater than is shown on later maps, and this tends to verify it, as a greater depth would naturally be expected at first. The westerly point of the spit was at that time almost due north of the mouth of the river.

The next map in order of date is that derived from the Peacock survey, which was made in 1832 by G. Peacock, master of H. B. M. ship *Hyacinth*. This map having been made by an officer of the British navy, may be presumed to be reasonably accurate. Besides the soundings in the harbor, it shows soundings off the coast a distance of 2 nautical miles and more. This map, as published in the work of Felipe Molina, entitled "Bosquejo de la Republica de Costa Rica," and republished in other works, shows accretions to the spit during the period from 1832 to 1848. It is not known on what data these indicated accretions are founded; neither is it certain whether the soundings in the harbor are those of 1832 or later. One would naturally suppose that they belong to the earlier date, but those inside the spit would seem to indicate the contrary. This map was used by a committee of the National Academy of Sciences in making a report, in 1866, on the restoration of Grey Town Harbor, and as that committee was composed of the most eminent men in their respective professions, it is believed that the map can be taken as essentially correct.

Map of 1832.

Subsequent to 1848 frequent surveys were made by officers of the British navy and published by the British hydrographic office. The accretions to the sand spit indicated on the map of 1832 are probably founded on similar data. It is not a matter of vital importance, however, whether this be so or not, for a study of the subsequent surveys without reference to these leads to the same conclusions. If they be correct, they enable the progress of the sand movement to be traced from an earlier date than otherwise could be done. These early surveys were made with a view to giving information to mariners as to the depth of the water at the entrance to and within the harbor of Greytown and the protection afforded at the anchorage. They do not contain all the information desirable in studying the problem of the restoration of the harbor, but they show unmistakably how the harbor was originally formed and subsequently destroyed.

Hydrographic charts of Great Britain.

From the mouth of the Indio southward a distance of about 3½ miles, the shore line now has a direction nearly south-southeast. It then bends to the eastward and follows this course for a farther distance of about 4 miles, when it curves gradually toward the south, and after passing the Tauro outlet it follows a nearly straight course for a distance of more than 40 miles. If a straight line be drawn from a point a little north of the mouth of the Indio to the mouth of the Tortuquero, about 27 miles south of the Colorado, it would pass through the western edge of the Ibo Lagoon. It is probable that this was once the general trend of the coast. The area to the eastward is low and sandy, and has in all probability been formed from the more recent deposits from the San Juan River.

Trend of coast.

The various outlets of this river lie to the eastward of Greytown Lagoon and all are sediment bearing. The quantity of material carried depends in a great measure on the amount of water being discharged. When the river is swollen the currents are swift and the amount of material is great. When the river is in its normal condition the amount is not so great, though it is seldom small.

Outlets of San Juan.

This sediment being deposited from the various outlets of the river first builds up a bar or shoal; as the accretions continue, some is pushed out to sea, some driven shoreward, and some to the right or left, according to the direction of the prevailing winds and waves. The material in suspension may be wafted far out to sea, but the sand which is moved along the bottom, and not held in suspension, is deposited near the outlet. When the accretions are sufficient to raise the shoal above sea level the waves drive it up still higher and the wind carries some of it still farther inland. In this way the sandy deposit widens out and in time is covered by a vegetable growth that protects it. In a moist, warm climate like that at Greytown, the silt or loam mixed with the sand, and that derived from decaying vegetable matter, will, in the course of a few years, support the growth of a forest.

Sedimentary deposits.

The coast line directly in front of Greytown has now nearly an east and west direction; the waves produced by the northeast trade winds break diagonally on the shore. Even when the wind is from the north the breakers come from an easterly direction. The longest fetch of the sea is nearly due east. The breakers are persistent for the greater part of the year, and as they roll in on the beach they stir up great quantities of sand and drive it westward on a zigzag course that is plainly visible to an observer on the shore. This westerly movement of the sand first formed a spit or hook, behind which was an area of comparatively still water. This area is the incipient harbor found on pl. 52. It is there shown as comparatively small, but the spit rising above the level of the sea acts like a breakwater and gives good anchorage behind it.

The effect of wave action on coast.

Pl. 54 shows a steady movement of the sand spit westward and a gradual shoaling of the harbor up to and including the year 1848. The shoaling in the harbor is due doubtless to the lighter deposits from the San Juan that have been carried down the stream in suspension and deposited where the water has become comparatively quiet and to the light sand that is blown into the harbor by the winds. The later charts show the progressive movement of the sand spit until that of 1865 which shows that the entrance was completely closed. It has remained practically closed ever since. On one occasion an opening was made by cutting a ditch across the spit to release the pent up waters of the river which had risen so as to flood the town. When the jetty was constructed by the Maritime Canal Company in 1891, an opening having a depth of about 7 feet formed to the leeward of the jetty by natural forces. In both cases the opening was only temporary. The outlet by way of Harbor Head is the shorter one and comparatively little water from the river in its normal stages finds its way to the Greytown Lagoon, but when it is in flood, water comes into the lagoon by way of all the small channels connecting with the river. At such time the amount of water may be sufficient to maintain a small but temporary outlet.

Movement of sand spit.

The surveys made in 1898 and 1900 show that the shore line at a point about 1 mile eastward of the jetty built by the Maritime Canal Company has been eroded to the extent of 1,200 feet from January, 1898, to July, 1900. During the same period the shore line about 1,200 feet west of the jetty receded 700 feet. There was no erosion in close vicinity to the old jetty. The erosion on the east and west sides, however, would seem to indicate that the normal supply of sand from the eastward had been reduced, or perhaps temporarily cut off, or that a change had taken place in the direction of the prevailing wind and waves. A change in the direction of the waves that impinge on the coast, or a diminution or increase of the sand supply, will modify the existing conditions and may temporarily produce abnormal results. The resultant movement, however, of the sand between the angle west of the old jetty and Harbor Head is westward and has been for years. This is attested by a comparison of the maps. What it is eastward of Harbor Head is more a matter of conjecture, as few of the maps cover that region. The Commission, when it was in Nicaragua, inspected the mouth of the Colorado River and the beach at a point about 4 miles to the northward. At the latter place there was no evidence of recent erosion or accretion. The shore seemed to be fairly permanent. A heavy growth of timber extended almost to high water, but the usual evidence of recent erosion, such as stumps or trees standing out in shoal water, was lacking. There was a house not far from the shore which was occupied, and the occupants, who had been living there several years, stated that the seashore had not changed materially since they had been there. At the time of the visit the wind came from about east-northeast and the waves broke nearly normal to the shore.

Erosion or accretion dependent on direction of waves and sand supply.

Reentrant angle.

One of the marked results shown by a comparison of the charts is the filling of the reentrant angle of the shore west of the old jetty. This doubtless comes in greater part from the eastward, but there are also some indications that a part comes from the northward and may possibly be contributed by the Indio. An examination of the chart of 1832 shows that a considerable reentrant angle once existed in the vicinity of the entrance to the canal of the Maritime Canal Company. The later surveys show that this has filled out several hundred feet.

Apparent recession of 8-fathom curve.

From a comparison of the chart of 1832 with the more recent surveys, it appears that the distance from the shore line to the 8-fathom curve, measured from a point near the site of the buildings of the Maritime Canal Company, has changed considerably. In 1832 the distance was about 13,000 feet, while now it is only about 9,000 feet. This indicates that the contour must have moved in or the shore line moved out, or that the change was due in a measure to both. It is known that the shore line in the neighborhood referred to has moved out, but it hardly seems possible that it could have moved out 4,000 feet; a part of the difference in distance may be accounted for by errors of sounding. The old charts do not record fractional parts of fathoms beyond the 6-fathom curve.

Apparent recession of 6-fathom curve.

There has been an apparent recession of the 6-fathom curve also, but the difference between the relative distances of the shore line and that curve are not so great. The sand that forms the beach extends gradually to about the 7-fathom curve, beyond which soundings show mud. There is an easterly current in front of Grey Town out in the deep water, while that close to the shore is westerly; but enough is not known of the velocity of the outer current on which to base an expression of opinion as to its effects on the bottom. The seaward advance of the shore line is confirmed by the existence at the present time of wrecks now visible nearly buried in the sand; one near the Maritime Company's hospital, one about 1,800 feet northwest, and one near the headquarter buildings.

While, therefore, we may not be in possession of all the facts touching the formation and subsequent destruction of Grey Town Harbor, sufficient is known to indicate unmistakably that the harbor was first formed by the westerly drift of sand which formed the spit or hook shown on the maps as Punta Arena or Punta Castillo, and that by the gradual extension of this spit westward the harbor was shut in from the sea and thereby destroyed. If, then, the westerly drift of sand can be stopped by interposing some obstacle, such as a jetty extending into the sea, there need be no difficulty in keeping open a channel on the lee side of it by dredging. This method of improving the entrances to harbors is one in common use, and is applied notably to the Mediterranean entrance of the Suez Canal, which is a similar case in many respects to that under consideration.

How to stop westerly drift of sand.

The feasibility, moreover, of constructing a harbor at Grey Town has been practically demonstrated by the work done by the Maritime Canal Company. About 1,000 linear feet of jetty was constructed by that company at a place a short distance west of the location proposed by this Commission, and where the conditions of sand movement are identical. This was quickly followed by the scouring out of a channel on the lee side to a depth of about 7 feet. This channel was made through the sand spit which converted Grey Town Harbor into a lagoon. The channel was increased in depth to 12 or 14 feet by dredging. No difficulty would have been experienced in deepening this channel still more and in maintaining the increased depth by the further extension of the jetty seaward aided by dredging and the possible construction of another jetty on the west side.

Construction of harbor feasible.

The harbor which this Commission proposes at Grey Town will have a length of 2,500 feet and a width of 500 feet, widened at the inner end to 800 feet in order to provide a turning basin. The depth throughout the harbor and entrance will be 35 feet. The entrance will be located about one mile east of the old jetty of the Maritime Canal Company. A jetty is proposed on the east side of the entrance, having a direction a little west of north. It is to be built of loose stone of irregular shape and size, resting on a suitable

Jetties.

foundation, the hearting of the jetty to be composed of small stone intermixed with large so as to form a compact mass, and this to be covered by stone not less than 10 to 15 tons in weight irregularly deposited to break the force of the waves. It is confidently expected that the partial construction of the east jetty will be followed by the scouring out of a channel of moderate depth on the lee side of it, as was the case when the Maritime Canal Company's jetty was constructed; but as it is not expected that the depth will be sufficient for navigation, dredging will be required to obtain the desired depth. The east jetty should be extended to the 6-fathom curve. It is believed that a second jetty will be necessary on the west side to catch the sand that may at certain times come from the westward. It will be shorter than the one on the east side and its cost is included in the estimates. The jetties are to be built not less than 6 feet above high water with a width on top of 20 feet, and, for purposes of estimate, side slopes of 1 on 2 and 2 on 3 have been assumed.

Dredging.

After a navigable entrance has been made, dredging will be required for its maintenance, and probably some extension of the jetties may in time be needed. The cost of maintenance is not susceptible of accurate determination, as it is impossible to predict how much sand will accumulate on the east side of the jetty or pass around it into the dredged channel. Some have estimated the total sand drift along the shore at 750,000 cubic yards per annum, but reliable data for an estimate are not available. It is believed that this westward drift is diminishing and may in time become quite small. A dredge could be worked on the east side of the jetty to remove the sand that will accumulate there, but much time would be lost on account of the rough seas. A better method of operation would be that practiced at the Mediterranean entrance of the Suez Canal, where the shore end of the jetty is kept low for some distance out, so that the sand is washed over it by the waves and is easily removed by a dredge working in the comparatively quiet water under its lee. The conditions in the two cases are very similar. The jetty is given a direction a little west of north, the purpose being to provide an area in which this sand may be allowed to accumulate.

Maintenance of harbor.

Time required to secure 18 feet of water.

It is estimated that about two years will be required to make the necessary preparations and to construct an entrance and working harbor at Grey Town having a depth of 18 feet, which is regarded as the least that would afford reasonable facilities for the landing of material needed to construct the canal. The prompt construction of this entrance is therefore of the utmost importance.

Cost of construction and maintenance.

The estimated cost of constructing a harbor, which includes the cost of the jetties, is $2,198,860, and this sum is included in the total estimated cost of the canal as given. The cost of maintenance is estimated at $100,000 annually, which includes everything needful to maintain a depth of 35 feet in the harbor and entrance.

Brito Harbor.

The Rio Grande empties into the Pacific Ocean at Brito, close under the rocky headland of that name. At low water in the dry season there is about 3 feet depth at the entrance, but as the tide rises and falls from 8 to 10 feet the depth is much increased at the high stage.

Depth of water at mouth of Rio Grande.

The entrance to the canal will be through a low sandy beach and a harbor excavated in a swamp extending a considerable distance inland. Little is known of the physical changes that have taken place on this part of the coast, but the indications are that it is much more permanent in character than the coast near the eastern entrance. Brito Head forms a projecting jetty on the northerly side. Much of the coast in this vicinity is of a rocky character, sand being found in the indentations. As the Rio Grande and other rivers which discharge into the Pacific along this part of the coast drain only limited areas, the amount of sediment brought down by them is insignificant. Another favorable feature is that the winds blow offshore almost invariably. The waves break normally on the beach and have little tendency to drive the sand along the coast in either direction. The depth of water offshore increases rapidly, the 10-fathom curve being found at about 2,200 feet from low-water mark. The entrance to the harbor will be 500 feet wide, protected by a single jetty on the southeasterly side. The harbor itself will be 2,200 feet long and 800 feet wide. From the easterly end of the harbor this width is narrowed gradually to the approach to lock No. 8. The jetty will have a southwesterly direction and will reach the 6-fathom curve at a distance of 1,200 feet from the shore line. The difficulties of landing material on this side in the early stages of the work before a harbor can be constructed are less than at Grey Town. The sea is comparatively smooth most of the time. Material for construction purposes could be landed on a pier reaching to deep water, similar to those on the coast of California, or a temporary entrance to the Rio Grande could be made within a short time and at comparatively little cost.

How harbor can be constructed.

Cost of construction and maintenance.

The estimated cost of the harbor, including the entrance and protecting jetty, as stated elsewhere, is $1,509,470. The annual cost of maintenance is estimated at $50,000.

Regulation of level of Lake Nicaragua.

The summit level of the canal is the surface of the water in the lake. A dam across the San Juan River at Conchuda, 52.9 miles from the lake, extends the summit level to that point. In other words, if a dam be built at the Conchuda site an arm of the lake will reach to it, carrying the lake level during a period of no discharge to the same point. The canal will leave this arm of the lake at a point 3.3 miles up stream from the dam. These are the general conditions which must be preserved, and the problem of the regulation of the lake level involves the control of the latter within such limits, more or less exact, as will never permit the navigable depth of the summit level to be anywhere less than 35 feet on the one hand, nor permit the lake to rise materially beyond a determinate elevation on the other. This regulation can be accomplished by the construction of dams across the Rio Grande west of the lake and across the San Juan on the east side, both being designed with suitable waste ways for the discharge of surplus water, or all the surplus water may be wasted through the San Juan. As wasteweirs at or near the Conchuda dam may be given sufficient capacity to discharge all the wastage, and as the latter may readily be discharged through the lower San Juan, the entire regulation works are designed to be located at or in the immediate vicinity of the Conchuda dam.

Conditions of the problem.

Obviously, after any given dry season has begun, with the lake surface no higher than the maximum permitted elevation, only the remaining surplus run-off, if there be any, will be allowed to escape over the dam or wasteway, the lake acting as a reservoir of sufficient capacity to hold available at least all the water that may be needed for navigation until the beginning of the next season. On the other hand, the wet season must be utilized in restoring the depleted lake, but if the amount of rainfall during that season is more than sufficient to raise the lake surface above the desired maximum level, the surplus inflow must be allowed to waste with sufficient rapidity to prevent the lake rising high enough to produce serious inconvenience or damage. The precise minimum elevation of the surface of the depleted lake, and the maximum height to which the water in the lake may be allowed to rise, may not be determinable, but it is not difficult to prescribe such a control of the lake surface by available means as to fix those limits near enough for the certain and safe operation of the canal or for the preservation of the usual industrial operations about the shores of the lake.

Maximum and minimum elevations not precisely determinable.

The storing of a sufficient supply to meet the demands of dry seasons is a simple matter of computation of reservoir capacity, and can readily be prescribed. The determination of the maximum elevation of the water surface to be permitted in the lake involves the discharging capacity of the canalized San Juan River from Fort San Carlos to the Conchuda dam after it has become practically an arm of the lake. The first part of

Discharging capacity of San Juan.

the problem will, therefore, consist of the determination of the discharging capacity of the San Juan River for 52.88 miles of its length from the lake to the Conchuda dam, corresponding to various elevations of the lake surface.

The total available length of the wasteweir or dam must be such as to give the maximum discharge with a head on the crest of the weir that shall not in general trench upon the navigable depth of 35 feet in the summit level of the canal. The minimum elevation of that summit level has been fixed at 104 feet above the sea level. It will be necessary, therefore, so to proportion the regulating facilities at the dam as to attain the maximum discharge of the canalized river with an elevation of water surface at the same point of 104 feet. Evidently the maximum discharge will be required when heavy rainfalls cause the lake to be at or near its maximum elevation; or it may be desirable to determine the discharge of the canalized river with the lake surface at almost any elevation between the minimum and the maximum, while the elevation of the water surface at the dam has its minimum value of 104 feet. It may therefore be necessary to know not only the discharge of the lake at any elevation with any less elevation of surface at the dam above the minimum, but also what will be of greater practical consequence—the discharge of the lake at any given stage with prescribed elevations of the water surface at the dam.

Discharge of lake at any given stage.

This part of the investigation has been made by finding the continuous slopes of water surface from the lake to the dam, corresponding to discharges of 20,000, 30,000, 40,000, 50,000, 60,000, and 70,000 cubic feet per second for each elevation of the lake surface 104, 106, 108, 110, and 112. These slopes are shown in fig. 3 of Appendix H. After having determined these slopes, the curves shown on the right-hand side of fig. 3 will give the varying discharges for a given elevation of lake surface and corresponding to different elevations of the water surface at the Conchuda dam. The curves shown in fig. 4 of Appendix H are then at once so drawn as to exhibit the discharge for a given elevation of water surface at the dam with any elevation of the lake surface. These results afford all the information regarding the discharge of the canalized river required for the complete treatment of the regulation of the lake surface.

Slopes of canalized river corresponding to various discharges.

Obviously, at the end of the dry season the gates at the dam will always be found closed, and there will be no water escaping from the lake except by evaporation and to supply the needs for canal uses. It is equally evident that the gates will also remain closed, so as to permit no wastage during the early part of the wet season, starting from its beginning. As the wet season proceeds, the surface of the lake will rise toward and generally quite to its maximum elevation, and then the operation of wasting over the weirs will commence. The time of beginning of this wastage will depend upon the amount and distribution of the rainfall during the wet period. Indeed, no wastage whatever would be permitted during such a low water wet season as that of 1890. The rainfall from the entire drainage basin would be impounded in the lake, and it would then fall short of restoring the depletion resulting from evaporation and requirements of the canal. On the other hand, during such a wet season as that of 1897, wastage would begin at an early date. In general it may be said that neither the rate nor the law of the rise of water surface in the lake can be predicted. There may be years when no wastage will be permitted, but generally considerable wastage will be necessary in order to prevent the lake rising above the permissible stage.

Regulation of gates.

An examination of the rainfall statistics and diagrams furnished in the report of Mr. Arthur P. Davis, hydrographer to the Commission, and found in Appendix 1, shows, as would be anticipated, that even a high monthly rainfall in the early part of the wet season falling on parched ground will have a comparatively small effect upon the elevation of the lake surface. The same amount of precipitation, on the other hand, falling later in the wet season, when the ground is saturated, has a much more marked effect upon the elevation of the lake surface, both in rapidity and amount.

Precipitation in wet season.

A careful study of the results of Mr. Davis's observations shows that the maximum rate of rise of the lake during the three years, 1898 to 1900, inclusive, is 19.5 inches in twenty-two days. This took place between the 2d and 24th of October, in the year 1900. The total amount of rainfall at Granada in October of that year was 16.7 inches. The total rise of the lake for the entire month of October was practically 24 inches. In the month of June, 1897, a year of maximum rainfall, the precipitation at Granada was 31 inches. Unfortunately, no observations on lake elevation were made during the latter year, and hence the corresponding movements of the lake surface can not be given. It is most important to observe, in connection with this matter of lake regulation, that the effect of a heavy rainfall is not felt immediately, except for that portion of the precipitation which falls directly upon the lake surface. While no precise statement can be made as to the time which elapses between the beginning of a month's heavy rainfall and the resulting material effect upon the elevation of lake surface, due to run-off, it would appear from the consideration of the data available to the Commission that from two to three weeks may be taken for that purpose. This is an important feature in the problem of lake regulation, because it is essentially a warning given from two

Effect of rainfall not felt immediately.

to three weeks in advance of a considerable rise in the elevation of the lake surface. This period may consequently be utilized for the maximum discharge over the waste weir, if deemed advisable, in anticipation of the ultimate effects of a heavy rainfall.

During the early portion of a wet season, therefore, while the gates are closed, the lake will be permitted to rise until it reaches nearly its maximum surface elevation. As an illustration, this may occur during the month of August or September. The rainfall records show that generally there may be expected a relatively heavy rainfall during the month of October. That month would be approached, then, with the lake surface elevation at perhaps 109.5, leaving 0.5 foot margin below the desired maximum of 110. If but a small rainfall should occur during October and November, the waste gates might remain closed, impounding, if necessary, all the precipitation, and thus reaching a full lake. If, on the other hand, October should prove to yield a heavy rainfall, as is frequent, the maximum rate of wastage could be at once afforded at the beginning of the month, or as near that time as might be deemed advisable.

October rainfalls.

The discussion of this part of the general problem of lake regulation must necessarily be involved in some doubt until more data concerning concurrent heavy rainfalls and variations of the elevation of the lake surface are available. With the exception of the year 1897, the year 1900 afforded the greatest total annual rainfall during the fifteen years from the beginning of 1886 to the end of 1900. Fortunately, during the latter year observations of the lake level were taken, as well as rainfall records at Granada and other points. Furthermore, there was a rather heavy rainfall, 16.7 inches, during the month of October, with more precipitation than usual during the four months preceding October. From October 2, 1900, to October 24, a period of twenty-two days, the elevation of the lake increased from 105.7 to 107.32 feet, giving an actual rise of the lake surface of 1.62 feet. This was a net rise in excess of the evaporation and outflow through the San Juan River. According to Mr. Davis's observations at Fort San Carlos, as shown in his rating table in Appendix I, the discharge out of the lake at Fort San Carlos on the first day mentioned was 21,815 cubic feet per second, and on the latter date, October 24, 29,555 cubic feet per second, giving an average discharge per second out from the lake during the twenty-two days under consideration of 25,685 cubic feet per second; or, again, a total outflow for the twenty-two days of 48,822,048,000 cubic feet. The total area of the lake surface is 82,938,240,000 square feet. This latter area multiplied by 1.62 feet gives a total storage in the lake, during the period under consideration, of 134,359,948,800 cubic feet, which, added to the above determined outflow, gives a total of 183,181,996,800 cubic feet as the total supply to the lake during the twenty-two day period

Satisfactory control.

in excess of evaporation. While this total quantity of water would be flowing into the lake, were the dam and waste way in operation at Conchuda in connection with the canalized river, a maximum wastage could be afforded of about 61,600 cubic feet per second, that being the average discharge over the waste way for the lake surface elevation at 109.75, with the water surface at the dam at 104. That rate of waste for twenty-two days would give a total outflow of 117,089,280,000 cubic feet. The difference between this amount of outflow and the total amount of supply, in excess of evaporation given above, is 66,092,716,800 cubic feet, which, divided by the area of the lake in square feet, as stated above, will give 0.797 foot. In other words, under the conditions named, in spite of the maximum outflow over the wasteweir, the surface of the lake would rise practically 0.8 foot, or 9.6 inches; or, finally, 3.6 inches over the maximum elevation 110 feet desired. This result may be considered essentially a satisfactory control or regulation of the lake surface.

During the first thirty days of the same month of October, 1900, the surface of the lake actually rose 1.96 feet, which, for the purposes of this computation, will be taken as 2 feet. The results will, therefore, be slightly in error on the safe side. The rating table already used for the discharge of the San Juan River at Fort San Carlos shows that the average discharge during that month of October was 25,200 cubic feet per second. Hence, during that month, except the last day, the total outflow through the river was 65,318,400,000 cubic feet. To this must be added the number of cubic feet in the volume of the area of the lake surface, multiplied by 2, since the increase in elevation was 2 feet. As the lake area in square feet is 82,938,240,000, the total volume of outflow through the river, added to the actual storage in the lake, all in excess of evaporation, will be 231,194,880,000 cubic feet. It will be essentially correct to take the discharge of the canalized river, available for relieving this supply to the lake, as that which exists with the lake surface at 110, and the surface of the water at the dam at 104. That discharge is 63,200 cubic feet per second, or a total of 163,814,400,000 cubic feet. This last volume of wasteage, deducted from the sum of the thirty days' outflow of the natural river added to the 2 feet of storage, gives a volume remaining in the lake in its regulated condition of 67,380,480,000 cubic feet, which, divided by the area of the lake surface in square feet, gives a net rise of 0.813 foot, or practically 10 inches; or, finally, a lake surface 4 inches above the maximum limit desired. This also may be considered a satisfactory regulation of the lake. Any small excess of net storage in the lake at the end of October above that which might be deemed desirable, either in the two preceding or other cases, could be quickly run out after the end of the month by making use of the maximum discharge of the canalized river for a short time only.

Concurrent rainfall and lake stage records not sufficiently extended.

The preceding results obviously can not be considered finally conclusive as to what may happen in regulating the lake in the manner desired, for the reason that a larger monthly rainfall than that corresponding to 16.7 inches at Granada may occur in October of any year, or in any other month following preceding rainy months which have left the ground in a saturated condition. Concurrent rainfall and lake stage records are not sufficiently extended to afford a demonstrative treatment of this part of the question.

Maximum rainfall anticipated.

The largest monthly rainfall by far recorded at Granada is 31 inches for the month of June, 1897, the wettest year in all the rainfall records available for the lake basin. It has already been observed that a heavy rainfall so soon following the dry season will in general produce a less variation in the elevation of the lake surface than if that monthly amount should fall at a time approaching the end of the wet season, as in the month of October. Since, however, that amount of rain has fallen in one month, it should be taken as a possible precipitation for the month of October. In that case, if the ground were saturated to the same extent as at the beginning of October of 1897, a comparison may be made with the 1897 conditions in order to determine what would happen under such phenomenally great precipitation. It might be inferred at first sight that the amount of inflow from the basin to the lake under such conditions would be proportionate to the total monthly precipitation. Although this is not far wrong, it is not quite correct. A certain minimum amount of rainfall, possibly 1½ inches per month, would be held by the earth and would produce no inflow at all. Again, in such a tropical country as that of Nicaragua, there is a sensible evaporation from the earth's surface during a month, although its amount is unknown. If this latter quantity be neglected, and if 1½ inches be deducted from the monthly rainfall, in order to determine a suitable ratio for the inflow, that amount should be deducted from the 16.7 for October, 1900, leaving 15.2, and from the 31 inches of 1900, leaving 29.5 inches. The latter divided by the former will yield a ratio by which the total inflow into the lake for 1897 should be multiplied, in order to obtain the inflow which would have resulted from 31 inches of rainfall at Granada for the month of October, 1897, under the assumed conditions. This ratio is $29.5 \div 15.2 = 1.94$.

Rise due to maximum rainfall.

It has been shown that the total supply to the lake in excess of evaporation during the month of October, 1900, was 231,194,800,000 cubic feet. In addition to this, the evaporation from the surface of the lake for that month may be taken at 5 inches in depth. The amount of discharge through the San Juan River in its natural condition has also been shown to be 65,318,400,000 cubic feet, which is equivalent to a depth of

0.788 foot over the lake surface. The elements of the total supply for October, 1900, are therefore as follows:

Evaporation	5″ =	0.41667 feet
Rise of lake surface	24″ =	2 feet
Discharge of natural river	9.456″ =	0.788 feet
Total supply		3.20467 feet
Less the rainfall on lake surface	16.7″ =	1.39167 feet
Total inflow		1.813 feet

This depth of 1.813 feet is to be multiplied by 1.94 to obtain the corresponding depth of total inflow (including that to be evaporated) for the assumed October; and to that result must be added the 31 inches of precipitation which would fall directly on the lake surface. Finally, from the quantity thus derived must be subtracted 5 inches or 0.41667 feet for evaporation. The statement will, therefore, stand as follows:

	Feet.
1.813 × 1.94	=3.51722
Rainfall on lake surface	=2.58333
Total supply	6.10055
Less evaporation	.41667
Total rise of lake, all water impounded	5.68388
Discharge of canalized river for thirty days at the rate of 68,000 cubic feet per second reduced to uniform depth over lake surface	=2.125
Actual rise of surface in thirty days	=3.559

The average rate of discharge of the canalized river is taken at 68,000 cubic feet per second, as that corresponds closely to the mean stage of the lake during the assumed October.

The thirty-day rise of 3.559 feet, added to 109.5, would give an elevation of lake surface of practically 113 feet. In reality, the lake would not rise so high, since such an elevation would give a small increase to its surface area, and the available minimum cross-section of the canalized river would be somewhat greater than assumed. Yet, under such conditions, the surface of the lake might rise above the elevation of 112. If this were liable to happen frequently, it could not be considered satisfactory lake regulation. No such October precipitation, however, has yet been observed, and it may be said that the existing records do not afford a basis of expectation for such a rise in the lake as often as once in fifteen years. It is even possible that such a rise may never occur. If such an extraordinary precipitation should occur in October, it does not necessarily follow that the lake surface would reach an elevation much over 110, for the reason that it might be materially below 109.5 at the beginning of the month.

The possibility of such a phenomenal rise in the lake surface as that just considered at long intervals of years is indicated by the rainfall record at Masaya in the year 1887. In fig. 15 of Appendix I it is shown that in October, 1887, there was a rainfall of 23.56 inches following preceding months of sufficient precipitation to leave the soil in a saturated condition. Mr. Davis shows by a comparison of records for Masaya and Granada that the rainfall at Granada may be one-fifth to one-fourth more than that at Masaya. Hence it may be assumed that if there was a precipitation of 23.56 inches at Masaya in the month of October there may have been 22½ per cent more than that amount, i. e., 28.86 inches, at Granada at the same time. The increase of elevation or lake surface for that amount of rainfall at Granada may be compared directly with the increase of elevation of lake surface for the same month at the same place for the year 1900, which has already been considered, when the monthly precipitation was 16.7 inches. Subtracting, for the reasons already stated, 1½ inches from both 16.7 and 28.86 and dividing the latter result by the former the ratio of 1.8 will be found. The total inflow following a thirty-day rainfall of 16.7 inches in October, 1900, was equal to a depth of 1.813 feet over the entire lake surface, as was shown in the preceding computations. A statement applicable to the present case and similar to that already given will therefore be as follows:

	Feet.
	1. 813×1. 8=3. 2634
Rainfall on lake surface, 28.86 inches	=2. 405
	5. 6684
Less evaporation of 5 inches	. 4167
	5. 2517
Less discharge of canalized river at a mean rate of 68,000 cubic feet per second during thirty days, reduced to the uniform depth over lake surface of	2. 125
Actual rise of lake surface	3. 127

If the above rise of 3.127 feet be added to the assumed elevation of lake surface, on October 1, of 109.5, there will be found an elevation of 112.63 feet. As a matter of fact, for the reasons already stated, the lake surface would probably not reach 112 feet in elevation, but the results of both these latter computations show that, since the month of October must be approached by a nearly full lake, there is a possibility at long intervals of probably more than fifteen years of reaching a high lake surface elevation between 111 and 112. As the thirty-day discharge of the canalized river, at an elevation of about 111, is but little less than 180,000,000,000 cubic feet, it is further seen that the elevation of the lake surface under these phenomenal conditions would remain above 110 for possibly a little more than one month.

Results based on assumption that rainfall in basin is proportioned to that at Granada.

The preceding results are based essentially on the assumption that the rainfall on the entire lake basin is in direct proportion to that at Granada, while in fact the average rainfall over the whole basin should be used. There are not sufficient data of observation to establish such a relation, and the assumption is provisional only. It leads to the best method of procedure available, but the conclusions reached may obviously need modification in either direction as the rainfall record and observations of the lake elevations are extended. It is a generally recognized feature of rainfall conditions that an extremely high local precipitation for a short period, as one month, in any large basin, is almost invariably considerably higher than the simultaneous average for the entire basin; and there is reason to suppose that this is particularly true of the watershed of Lake Nicaragua.

The use of the rainfall record for one point, or possibly two, instead of the average for the whole basin, is liable to lead to conclusions extreme or possibly erratic in character. It is believed in this case that this unavoidable feature of treatment has created conditions too severe, and hence the resulting estimated extreme lake elevations are probably too high.

It is not believed to be necessary to include in the estimates of cost any items covering additional regulating facilities of such magnitude as to meet these phenomenal conditions. It is not probable that such facilities will ever be needed.

Salient features.

The preceding considerations indicate the salient features of the contemplated control of the greatest lake elevations in seasons of maximum precipitation. At the other extreme there must be considered such provisions as are necessary to meet the requirements of the dryest years on record. Of all the observations at the present time available, those which show the lowest annual rainfall belong to the year 1890, and are found in the Masaya record in Appendix I. That year was immediately preceded and followed by years of at least the average precipitation, the records showing 78.78 inches for 1889, 20.52 inches for 1890, and 49.98 inches for 1891. It will be obvious, therefore, that the two dry seasons, with the exceedingly low rainfall between, make the nineteen months from November, 1889, to June, 1891, a period of unusually small precipitation, the lowest indeed so far known. It may be assumed that the lake would be full at the end of the wet season immediately preceding such a dry period of nineteen months. The elevation of that full lake has been taken by Mr. Davis in Appendix I at 110.2, which is essentially what it should be. It then becomes necessary to know what should be the movement of the lake surface during the period in question. Evidently the sluices at the wasteway would remain closed and no outflow of the lake would be permitted during the first dry season, or from November until the succeeding May. Indeed the sluices would be closed during the succeeding wet season, as there would not be sufficient rainfall to restore fully the depletion already accomplished.

In considering the movement of the lake surface from the end of May it is necessary to keep in view the concurrent rainfall. The record available is for Masaya, hence it is necessary to compare the rainfall record at that place for some years, covering observations on the variation of lake-surface elevations with that for 1890. Observations for 1899 and 1900 are available for the purpose, but as shown in Appendix I those for the latter year are preferable. The observed precipitations for the months of 1900 are compared directly with those for the same months of 1890, and the variations of lake surface produced by the corresponding rainfalls for the latter year are made protional to those of the former year, which were actually observed.

Method of discussion not free from error.

As indicated by Mr. Davis, this method is not free from error, but these errors to some extent compensate each other, and there is no reason to believe that they are great enough seriously to militate against the conclusions reached. The portion A K, of the line in fig. 6, of Appendix H, shows the result of these operations. Starting from elevation 110.2 at H on the 1st day of November, a full lake is assumed to be maintained, as would be the case, up to the 1st of December, when the wet season closes, and consequently the sluices at the wasteway are also closed. Evaporation and consumption of 1,000 cubic feet per second for the use of the canal operate to deplete the lake until on the 1st day of June the point A is reached, at elevation 107.03. At that point the dry-wet season, so to call it, begins. The sluices at the wasteway still remain closed and the consumption of water in the canal continues, as well as evaporation from the lake surface. The small rainfall only partially restores this depletion, so that at the end of November the water surface in the lake has fallen to K, at an elevation of 106.9. No further supply is available until the beginning of the next wet season. The sluices are therefore kept closed and the lake surface at the end of the second dry season, on the 1st day of June, has fallen to the point L, at an elevation of 104. In other words, in spite of all storage of available water during the nineteen months, evaporation from the lake and the use of the canal have run the elevation of the lake surface down from 110.2 to 104, representing the net depletion of 6.2 feet in depth of lake water. At the point L the supply from the next wet season would be available to relieve the situation and cause the lake surface to rise.

These computations show that the net available storage in the lake must be 6.2 feet, if the requirements for evaporation and navigation for two dry seasons and an intermediate dry-wet season are to be met.

Storage.

The line H A K L is a minimum line of lake surface elevations, below which it should never fall at the dates indicated. In no dry season following an ordinary rainy season should it fall below H A, because there would then be a shortage, and possibly a serious one, if a dry-wet season should follow it. Nor should the lake surface, under any circumstances whatever, fall below the line K L for the dry months indicated, for in that event at the end of the dry season there would not be the desired navigable depth in the summit level.

The complete consideration of the effect of years of low rainfall on the regulation of the lake requires an examination into their possible frequency so far as existing data will permit. The entire record for fifteen years, from 1886 to 1900, at Granada and Masaya, shows but one year, 1890, with insufficient precipitation during the rainy season to fill the lake and restore the amount evaporated. Had the proposed regulating works been in existence there would have been a full lake on the 1st of every December, except for 1890, of the fifteen-year period. So far as the existing records indicate, therefore, there is no reason to expect the continued depletion of the water supply to an elevation below 104 by a succession of low rainfall years, each with an insufficient precipitation to fill the lake during the wet season.

As has already been indicated in connection with the discussion of months of maixmum rainfall, it is not possible to predict elevations of the lake surface during the early months of the rainy season, such as June and September. Knowing the discharging capacity of the canalized river, it is quite simple, after knowing the rainfall record of a season, so to lay out a programme of wasteway discharge as to control the lake surface in any desired manner within a considerable range of limits. It is quite another matter, however, to predict what lake elevation must be reached on a given date within those months in advance of the rainfall. Indeed it is not possible to make such a prediction as will agree with a season's development. It has been shown, however, within what limits the elevations of lake surface may be controlled for certain maximum monthly precipitations and for what less monthly rainfalls closer approximations to the desired maximum elevation of 110 may be reached.

Not possible to predict elevation of lake.

Although a definite line showing the elevations of lake surface for a specified period may be drawn for a given season of known supply to the lake, like H A K L of fig. 6 of Appendix H for the nineteen low water months, such a line can not be continuously drawn for an ordinary year. The portion H A may be prescribed, and perhaps

A O, but the part O P Q M, shown as a broken line, can not be laid down for the reason that it will depend entirely upon the record of rainfall which is not completely known until the season is past. It can only be stated that the line of lake surface elevations for the wet season will probably be similar in general character to O P Q M, fig. 6 of Appendix H, M being at the elevation of 110.2, which is shown as a broken line on account of the uncertainty attached to its location. Ordinarily the line for the succeeding dry season would be M S, which is the same as H A.

Certain general principles of control procedure may be set forth in view of the results of the preceding computations. In general, it may be stated that at the end of the dry season, on the 1st day of June, the elevation of lake surface will be at 107.3, or at about that elevation. The sluices at the wasteway having been closed during the dry season are still maintained in that condition, so that during the first part of the wet season all supply to the lake will be impounded. If there be a phenomenally heavy rainfall, as in June, 1897, it will be necessary, as soon as the amount of precipitation is realized, to open the sluices to their full capacity. Even under such circumstances the rise which would take place in the lake surface is shown by the line A D, in fig. 6 of Appendix H, and they would have to remain open until the 1st of August in order to bring the elevation of the lake surface down to 110, as shown at B, the maximum elevation of lake surface at D having been 110.6. From that time on the manipulation of the sluices would necessarily depend upon the subsequent rainfall, the effort being to keep the lake level at, or a little below, 110 until October.

Principles of control.

Instead of the phenomenal rainfall of June, 1897, should there be a moderate or ordinary precipitation, the sluices at the waterway might be maintained closed for a number of weeks, or until some date in August or September, depending upon the amount of rainfall, it being in this case as in all others the effort during this period of the year to keep the lake surface elevation as near to 110 as practicable, or possibly a little below it.

October, month of heavy rainfall.

The rainfall records show that ordinarily the month of October may be expected to be one of comparatively heavy precipitation, and there would seldom be years when it would not be necessary to discharge considerable water over the waste ways during that month. In the years of specially heavy rainfall, or possibly in others of ordinary rainfall, it would be necessary to open the sluices to their full capacity for the entire month, or a little longer. The month of October is practically the last opportunity of the wet season to secure a full lake, and that should certainly be attained, even if the effort to do it should run the lake somewhat above the maximum desired limit of 110 feet, so that on the 1st of December a full lake would exist as a necessary preparation for the succeeding dry season.

Instructions for regulation.

While, therefore, no detailed instructions can be set forth regarding the condition of the sluices at the waste way on specified dates, the general lines of their operations should be as stated below, viz:

1. A full lake with surface probably a little above 110 on December 1.

2. Waste-way sluices closed at least from about December 1 to some date in the early portion of the succeeding rainy season, or throughout that season if it be one of unusually low precipitation.

3. A variable opening of waste-way sluices, if necessary, during the intermediate portion of the rainy season, so as to maintain the lake-surface elevation but little, if any, below 110 at the beginning of October.

4. The operation of waste-way sluices during October and November so as to reach the 1st of December with a full lake, or lake elevation probably a little above 110.

The mean velocities in the minimum sections of the canalized river corresponding to the greatest discharges required in the regulation of the lake are as follows:

Elevation of lake.	Elevation of water at dam.			
	103 feet.		104 feet.	
	Ft. per sec.	*Mi. per hr.*	*Ft. per sec.*	*Mi. per hr.*
110 feet	4.16	2.8	3.9	2.7
111 feet	4.51	3.1	4.2	2.9
112 feet	4.85	3.3	4.5	3.1

Velocities.

The discharge of the river corresponding to the velocity of 2.7 miles per hour is 63,200 cubic feet per second; while that corresponding to 3.3 miles per hour is 77,000 cubic feet per second. These estimated high velocities will occur but rarely, and they will not sensibly inconvenience navigation. In reality they are too high, for the reason that while the overflow at the minimum river section materially increases the areas of those sections, it has been neglected in this discussion.

It is probable that at some periods of heavy rainfall when the lake is at or near its maximum elevation, the Sabalos and other smaller rivers tributary to the San Juan between Fort San Carlos and the Conchuda dam may be discharging at their greatest capacity also under the influence of heavy rainfalls on their respective drainage areas. It is even possible that the concurrent flood inflow of these streams may reach as high as 50,000 cubic feet per second. The effect of these aggregate discharges on the elevation of the lake surface has been ignored for two reasons. In the first place, their points of discharge are mostly

Effect of tributaries of San Juan.

far removed from the lake and largely below the steepest portion of the river slope. Hence their effect upon the lake elevation would not be great even if these tributary flood discharges continued for a considerable period of time. In the second place, these tributary flood discharges continue for a short time only; in fact, in nearly or quite all cases for less than twenty-four hours. Under such circumstances they can have no material influence upon the maximum elevations reached by the lake. The drainage areas from which they flow are all small and the total flood volume contributed by them for short periods of a few hours only is insignificant when compared with the volume required to raise to any sensible extent the surface of the lake.

Again, in all the preceding computations the volume of water required for the uses of the canal has been ignored. Should this volume be equal to a rate of consumption of 1,000 cubic feet per second, a depth of only 0.4 inch per month would be required to supply it, and that is an amount too small for consideration in connection with the question of lake control.

Conchuda dam and Wasteway.

The regulation will be effected by wasteways at the east end of the summit level. It being necessary to have control of the discharge, a movable dam of some form is essential. The form adopted consists of vertically moving gates of the Stoney type, each giving an opening of 30 feet in the crest of the wasteway.

Stoney gates.

The discharge through the upper section of the canalized San Juan will be 63,000 cubic feet per second, with the lake at 110 and the pool immediately above the dam at 104. This will be reached nearly every year, but, as before shown, the lakes may rise, in exceptional circumstances, possibly to 112, increasing the discharge of the river to 76,000 cubic feet per second, with the water at the dam at 104.

To produce such a discharge from the lake the rainfall would have to be extremely heavy over the entire basin draining into it. There would probably be a simultaneous heavy rainfall over the San Juan basin from the lake to the dam, most of which would reach the river below the constricted section which limits the discharging capacity from the lake, and would increase considerably the required discharging capacity of the waterway. This structure is therefore designed to discharge 100,000 cubic feet per second, with the water in the pool immediately above it at 104.

Capacity, 100,000 cubic feet per second.

It is deemed judicious to limit the depth of water on the crest, under normal conditions, to 7 feet, fixing the crest of the wasteway at elevation 97. With a high lake and heavy rainfall in the district near the dam the pool might, for a short time, rise a little above 104. The discharge of 100,000 cubic feet per second, with 7 feet on the crest, requires a weir 1,590 feet long.

Depth on crest, 7 feet.

This is provided by placing on the dam 21 sluice gates, each of 30 feet opening, and 32 similar ones at a site about 2,500 feet from the dam in Costa Rica.

Plan.

The latter structure is designated "Conchuda wasteway" on the map. Its sluices will be placed on a concrete structure, which will have a foundation on hard rock. Small ravines head near the site on both sides, and will require enlargement to permit the water to reach the wasteway and flow away from it with moderate velocities. The plan of the wasteway and approaches is shown on pl. 68.

Conchuda dam.

The most important structure on the route is the Conchuda dam. Before deciding on its location a large number of borings were made to ascertain the depth to suitable hard rock for the foundation, both at the Conchuda site and at the one near Boca San Carlos suggested by the Nicaragua Canal Commission. At the latter site the greatest depth to hard rock is 120 feet below the surface of the river at low stage. At the Conchuda site the greatest depth to hard rock is 82 feet, which is very important, because the foundations will probably have to be placed by the compressed-air process, and the depth is well within that at which the foundations of many bridge piers have been built by the same method.

A plan of the Conchuda dam is shown on pl. 69.

The portion of the dam across the river and the swamp on the Costa Rica side, for a total distance of 731 feet, will consist, below low water, of caissons placed close together with the joints between them sealed. Upon the platform thus made the part above low water will be built as a continuous monolithic structure and will support the sluices already mentioned. From each end of this portion the dam will be built for a further distance of 100 feet into the hillsides in open excavations and with cross section designed to sustain the full head of water. Core walls extend 100 feet farther on the Costa Rica side and 240 feet on the Nicaragua side. The total length of the dam, including core walls, will be 1,271 feet. The foundation is on hard rock for the entire length.

In its preliminary report this Commission estimated the time for completing the entire work on the Nicaragua route at about ten years. This was based on the expectation that two years would be required for preparatory work and eight years to construct the dam at Boca San Carlos, which would be begun only after a temporary harbor at Grey Town was constructed and other work done. A more favorable site for the dam having been found at Conchuda, its construction is no longer the controlling feature. It is estimated that this dam can be built in four years.

Cost.

The estimated cost of the dam and auxiliary wasteway is as follows:

Dam at Conchuda, including sluices and machinery	$4,017,650
Auxiliary wasteway, including sluices, machinery, and approach channels	2,045,322
Total for dam and wasteway	6,062,972

Wasteways for regulation of levels in pools.

The wasteways for the disposal of floods in the several levels or pools of the canal (the summit level excepted) are simple overfall weirs, with the crests at the elevation of lowest water surface in the pool. The areas of the watersheds which drain into the several pools, and the areas permanently submerged, are for the eastern division approximately as follows:

Overflow weirs.

Level.	Area to be submerged.	Total area of watershed.
	Sq. miles.	*Sq. miles.*
Lock No. 1 to lock No. 2	13.4	24.9
Lock No. 2 to lock No. 3	7.5	73.1
Lock No. 3 to lock No. 4	1.1	9.3

The areas for the division west of the lake, while not accurately determined, are known to be small.

The eastern division is the region of heaviest rainfall. The ground is generally saturated, the slopes steep, and the basins small in area, so that the run-off is rapid and its ratio to rainfall unusually large. The greatest observed rainfall in twenty-four hours, as already stated, occurred at Grey Town in November, 1899, and amounted to 12.48 inches, of which 8 inches fell in six hours. During the same storm at Lake Silico 10.50 inches fell in six hours. The wasteways provide for a rainfall of 12 inches in twelve hours, the total amount falling on the areas not submerged reaching the pool within twenty-four hours.

Freeboard.

The embankments are given a freeboard of 5 feet above the level to which the assumed floods would rise, increased where the floods in the San Juan rise above the flood levels in the canal.

The data concerning the flood levels of the San Juan are necessarily not exact.

These assumed rainfalls and run-offs are greater than are likely to occur; but if they should be exceeded the works would not be endangered. If, for example, there should be a continuous rainfall of 1 inch per hour, extending indefinitely, the freeboard would be reduced in the lower end of the pool between lock No. 1 and lock No. 2 to 3.5 feet. Such a rainfall continued for twenty-four hours is without precedent on this continent, so far as known. Plans of wasteways for the eastern division are shown on pl. 67.

A small wasteway is provided in each of the levels between the summit level and the Pacific. Each of these is to be 100 feet in length. In the level between lock No. 5 and lock No. 6 the wasteway and channel leading therefrom will consist simply of a cut through sound rock to the Rio Grande, the bed being at the minimum canal level at the canal bank, and sloping thence toward the river. The wasteway in the level between lock No. 6 and lock No. 7 is to be similar in every way. In the next level toward the Pacific, which ends at the tide lock, there is no site for a wasteway with a rock foundation, but the water in the canal will be 12 or 15 feet below the surface of the valley at the upper end of the level, and but little below it at the lower end. It is proposed here to form a wasteway by excavating a channel in the earth from the canal to the river and to pave this for a distance of about 500 feet from the canal. The amount of water to be discharged here is small, and as the canal will be below valley level, a break in the canal bank will be impossible.

Wasteways on Pacific side.

Retaining walls.

Some of the rock which will be found in the cuts is much disintegrated. Rock from which no core, or only small pieces, can be obtained by the diamond drill is classified in the estimates as soft rock. The rock thus classified is usually very soft on top, gradually becoming harder farther down and passing into the material classified as hard rock, where cores nearly continuous are obtained. For the purpose of making the estimate, it is assumed that the soft rock for half its depth will require facing with a retaining wall. The top of the wall, 5 feet above the water surface in the canal, will be 5 feet wide. The face will be vertical. The back will also be vertical for 10 feet from the top and below that point will have a batter of 2 on 1.

Alternative surveys.

The project now presented is based upon a careful and detailed examination of the physical conditions of the entire route. The line has been marked out on the ground, improvements have been made in location, and the subsurface materials have been explored by means of borings, many of which have been made with diamond drills. Samples of all materials have been obtained, and the classification is based on a careful study of them. The completeness of the system of borings will be evident on an examination of the maps and profiles. The alternative dam sites at Boca San Carlos and Conchuda have received special attention. At each place three lines of borings, 100 feet apart, were made from bluff to bluff, the borings generally being 100 feet apart on each line, reduced to 50 feet where marked depressions in the rock surface had been revealed or indicated by the earlier borings.

Examinations and borings.

With these data at hand, it is believed the difficulties of the route are fully disclosed. Should construction be decided on, doubtless minor improvements in location could be made, particularly in the section between the Conchuda dam and Grey Town where, on account of the dense vegetation, one can see but a short distance from any point.

A few explorations of considerable magnitude were made to avoid special difficulties on this section. The first one to be made was to ascertain whether there existed a practicable route from the valley of the San Juan to that of the Indio. For years vague but persistent rumors of the existence of a low pass in the divide between the headwaters of the Machuca River and the Indio have been current. These reports were made chiefly by rubber hunters, the pioneers of this region, and considerable credence was given to them by many persons. If such a pass could be found, and the canal led into another valley, avoiding the difficulties of the Lower San Juan, the change would be of great importance. A dam across the San Juan River at Machuca Rapids could be built more quickly, and would cost much less than at Conchuda or any other point below Machuca; but a canal in the San Juan Valley between Conchuda and Machuca would be very expensive on account of the hilly character of the country.

Route from Upper San Juan to headwaters of the Indio.

Explorations.

Under the direction of this Commission a search for such a route, extending over several months, was made by a well-equipped party. Surveys were made up the Bartola and Machuca rivers, with a view of utilizing the Machuca site for the San Juan River dam. The survey was carried up the Bartola to a point 638 feet above sea level without reaching the summit, and the route being manifestly impracticable, the survey was stopped. A survey was also made up the Machuca River, connecting with a survey of the Indio and its tributary, the Negro. The divide is 544 feet above sea level, and it would require a summit cut 24½ miles long and 475 feet deep at the maximum to carry Lake Nicaragua level across it. The cost of this work alone would be greater than that of the entire canal from Machuca to the sea by the adopted route.

It was decided also to examine the La Cruz del Norte, which discharges into the San Juan between Machuca Rapids and Conchuda. If this route had proved practicable, the Conchuda dam would still be required. The survey was carried over the divide to the Salvador, a branch of the Negro. The summit was 469 feet above sea level, and a summit cut 15½ miles long would have to be made. The cost of the canal by this route would be much greater than by the one adopted.

In the district between the San Francisco hills and lock No. 2 borings along the center line of the canal revealed two sand deposits—one west of Tambor Grande ridge, extending about a mile along the canal line, with sand a little below the grade of canal bottom, and the other east of Tamborcito ridge, where the prism of the canal would be partly in sand. Borings were made to ascertain the limits of the sand deposits, as well as surveys for a location farther inland. It was ascertained that such a location, avoiding the sand deposits, was practicable, but the cost of the canal would be greater than by the adopted route.

Sand deposits on canal route.

Silico route.

A survey was also made of a line which leaves the adopted one 15½ miles from the Caribbean, passes through Lake Silico, and continues to Grey Town. The line would be more direct, and the existing navigation from Grey Town to Lake Silico, which could easily be improved, and the narrow-gauge railroad recently built from Lake Silico to the San Juan River might be useful in the earlier period of construction. Lock No. 1 was located in the hills on the west side of Lake Silico, and the site was bored. The surface material, which was clay, was over the greater part underlaid by rock. This proved to be a volcanic overflow, underlaid by mud and sand. At the upper end of the lock site the lock foundation would have been in the sand. A good lock site having been found on the adopted line, the one through Lake Silico was abandoned. It is still possible that a better location may be found in this vicinity.

As already stated, the movement of the sand along the coast, which at Grey Town seems to be at the maximum, decreases as the mouth of the Indio is approached. This stream doubtless brings down some sand and silt during floods. The amount is unknown, but is probably small. Immediately north of its mouth a forest growth, fringing the ocean front, indicates that the shore line is not now being subjected to much change. In view of the small sand movement in the neighborhood of the mouth of the Indio and the apparent stability of the shore line there, it was thought advisable to locate an alternative route from lock No. 1 to a harbor site at that place. The line was a continuation of the tangent through lock No. 1 to a point near the sea, where it curved slightly to the harbor and entered the sea on another tangent. It crosses the San Juanillo and Deseado near their junction. These streams would be diverted through a channel northwest of and practically parallel to the canal line and at a safe distance from it, and discharged into the sea to the northward of the harbor.

Indio route.

This alternative route is of about the same length as the adopted one to Grey Town, but has a little less curvature. The fore shore of the coast is flatter than in the vicinity of Grey Town, requiring longer jetties to secure a harbor. The jetties should converge seaward to give a large area outside the shore line in which the force of the waves may expend themselves, as at Ymuiden. The first cost of this alternative route, both for excavation and harbor jetties, would be greater than that of the adopted one. There is reason to believe, however, that the cost of maintaining the harbor would be less, and possibly the saving in this respect would be sufficient to warrant the greater expenditure for construction.

The harbor site at Grey Town, on the other hand, has one important advantage, that a harbor for light-draft vessels can be formed in less time. Protection to the entrance to such a harbor would be afforded by the east jetty before its construction was far advanced. An entrance with about 18 feet of water, opening into Grey Town lagoon, would be of great value for the landing of materials to be used in the construction of the railroad and canal. Moreover, an entrance at Grey Town would make it practicable to transfer materials to the river steamers, which in the earlier stages of the work would be of considerable value. The Commission estimates that such a harbor could be opened at Grey Town in about two years.

A working harbor could also be constructed at the Indio site, but as the entrance there opens more directly seaward, both jetties would have to be commenced and built farther out to give adequate protection and would require considerable more time. Since the formation of the working harbor is preliminary to the beginning of canal construction proper, this additional period required at the Indio site would delay by a like mount the opening of the canal itself.

The data concerning the Indio route are not so well ascertained as those relating to the adopted route terminating at Grey Town, but its advantage in respect to maintenance of the harbor can hardly be doubted. The Commission believes, however, that it is practicable to maintain a harbor at Grey Town which will be fully as serviceable in every way, and regards its advantages as a working harbor as of such importance that its estimates are based on that location.

Sea levels.

Mean sea levels of the Pacific at Brito and of the Atlantic at Grey Town were determined by the Nicaragua Canal Commission in 1898 and 1899 by a series of tide observations at each place and by a line of precise levels from Grey Town to Lake Nicaragua, and from Lake Nicaragua to Brito. The levels across the lake were transferred by water level in the lake, a series of observations extending over a period of twenty-nine days being taken for this purpose. As thus determined, mean sea level in the Caribbean Sea at Grey Town was apparently 0.99 of a foot above that at Brito in the Pacific, but during this period the Pacific Ocean at Panama, as determined by the tide tables of the United States Coast and Geodetic Survey, was one foot below the normal. Assuming this to be true at Brito, and there seems to be no reason for doubting it, the mean level of the two oceans would be the same.

Good sand for construction purposes can be had in large quantities in the bed of the lower San Juan, as well as on the seashores. There are ample quantities of good stone for rubble and concrete. Cement is not now manufactured in Nicaragua, and it will probably be necessary to import it. There are now in Nicaragua small dams, cisterns, indigo vats, and other constructions built of concrete, which are quite old and in excellent state of preservation. Concrete ought to last indefinitely in the mild climate of Central America. There is an ample supply of stone on both sides of the lake suitable for jetty construction.

Railroad.

A railroad for construction purposes will be necessary, and provision has been made for building one from Grey Town to the mouth of the Sabalos River, and from the west shore of the lake to Brito. The intervening space can be traversed by boats, the river between Fort San Carlos and the Sabalos being deep enough to accommodate, without improvement, such vessels as can reach the deep water of the lake from the San Juan. It is possible that the portion of the railroad between the Conchuda dam and Sabalos might be dispensed with, as the work between those points is almost entirely in the river, but it was thought best to provide convenient communication between the two oceans, as a transfer of material and men from the east to the west side of the lake, or from the west to the east side, might become important. The portion of the river between the dam and Sabalos is navigable only for small steamers.

The railroad has been located on the south side of the canal, with the grade not exceeding 0.5 per cent. It is to be of standard gauge, supplied with sidings, stations, and water tanks, and fully equipped with the necessary rolling stock. The estimate is made on the basis of $75,000 per mile for the railroad completed and ready for operation.

Summing up the various items, the total estimated cost of constructing the Nicaragua Canal is as follows:

	Miles.	Cost.
Grey Town Harbor and entrance	2.15	$2,198,860
Section from Grey Town Harbor to lock No. 1, including approach wall to lock	7.44	4,899,887
Diversion of Lower San Juan		40,100
Diversion of San Juanillo		116,760
Lock No. 1, including excavation	.20	5,719,686
Section from lock No. 1 to lock No. 2, including approach walls, embankments, and wasteway	10.96	6,296,632
Lock No. 2, including excavation	.20	4,050,270
Section from lock No. 2 to lock No. 3, including approach walls, embankments, and wasteway	16.75	19,330,654
Lock No. 3, including excavation	.20	3,832,745
Section from lock No. 3 to lock No. 4, including approach walls, embankments, and wasteway	2.77	4,310,580
Lock No. 4, including excavation	.20	5,655,871
Section from lock No. 4 to San Juan River, including approach wall and embankments	5.30	8,579,431
Conchuda dam, including sluices and machinery		4,017,650
Auxiliary wasteway, including sluices, machinery, and approach channels		2,045,322
San Juan River section	49.64	23,155,670
Lake Nicaragua section	70.51	7,877,611
Lake Nicaragua to lock 5, including approach wall to lock and receiving basins for the Rio Grande and Chocolata	9.09	19,566,575
Diversion of the Las Lajas		199,382
Lock 5, including excavation	.20	4,913,512
Dam near Buen Retiro		125,591
Section from lock No. 5 to lock No. 6, including approach walls and wasteway	2.04	3,259,283
Lock 6, including excavation	.20	4,368,667

	Miles.	Cost.
Section from lock No. 6 to lock No. 7, including approach walls, embankments, and wasteway	1.83	$2,309,710
Diversion of Rio Grande	....	176,180
Lock No. 7, including excavation	.20	4,709,502
Section from lock No. 7 to lock No. 8, including approach walls, embankments, and wasteway	2.43	1,787,496
Diversion of Rio Grande	....	117,580
Lock No. 8, including excavation	.20	4,920,899
Section from lock No. 8 to Brito Harbor, including approach wall	.23	553,476
Brito Harbor and entrance, including jetty	.92	1,509,470
Railroad, including branch line to Conchuda dam site, at $75,000 per mile	....	7,575,000
Total	183.66	158,220,052
Engineering, police, sanitation, and general contingencies, 20 per cent	....	31,644,010
Aggregate	....	189,864,062

An estimate has been made of the time required to pass through the canal by ships of several types, the details of which are given in Appendix G. The estimated time is thirty hours for a ship of average size, 400 feet long, 50 feet beam, and 24.5 feet draft, and thirty-seven and six-tenths hours for a ship 650 feet long, 70 feet beam, and 32 feet draft, which corresponds closely with the largest ships afloat.

Work done by the Maritime Canal Company of Nicaragua.

The following is a brief summary of the work that has been done by the corporation known as the Maritime Canal Company of Nicaragua in the construction of a canal on the Nicaragua route:

The annual reports of the Maritime Canal Company for the year 1889 and subsequent thereto, made in pursuance of the requirements of the act of Congress incorporating the company, show that actual work of construction was begun October 8, 1889, and was suspended some time in 1893. During this period of over three years comparatively little work was accomplished. In 1893 the Nicaragua Canal Construction Company, with which a contract was made by the Maritime Canal Company for construction, suspended payments and work ceased.

The reports of the company show that during this period a telegraph line was built from Grey Town to Castillo, where it connected with the lines belonging to the Nicaraguan Government. Other telegraph and telephone lines were established to connect headquarters with some of the camps or stations.

A single-track standard-guage railroad was built, 11⅓ miles in length, from Grey Town to a point between the sites of the first two locks, and is reported to have been equipped with 4 locomotives, 50 cars, and other requisites. Much of this railroad was built across a swamp, requiring timber cribbing, on which a temporary track was laid, and the permanent embankment was formed of sand hauled by trains from the canal spoil banks near Grey Town. A number of buildings, workshops, quarters, hospitals, and storehouses were also constructed. In all, 39 buildings, having a floor space of 75,902 square feet, sheds, water tanks, and other smaller structures are reported as having been constructed, in addition to wharves equipped for unloading heavy freight.

A jetty or pier was constructed for securing an entrance into Grey Town Lagoon from the sea. It was built 42 feet wide, of creosoted piles and timber, and filled with brush, stone, and concrete blocks. It extended about 937 feet into the sea. The pier was intended to intercept the westward drift of the beach sand and cause an opening to be formed into the lagoon, which it did. The current soon deepened it to about 7 feet, permitting the dredges which had been purchased by the canal company to be floated in. Afterwards the entrance was still further deepened by dredging to a depth reported as about 15 feet. The channel has since been closed by sand, the jetty is much decayed, and some of it washed into the sea.

The company brought to Grey Town six dredges which had previously worked on the Panama Canal. In the reports to the Secretary of the Interior it is stated that seven were purchased. One was said to have been lost at sea between Colon and Grey Town. Besides the dredging done in the sea entrance to the lagoon, some was done to provide anchorage and access to the company's buildings and shops and also on the canal proper. This latter work was done by an elevator dredge, making a single cut for a distance inland of about 4,350 feet, with a width of 167 feet and depth of 16½ feet. This was followed by another cut of about 3,000 feet in length, the width of the double cut being 279 feet. There has been no apparent deterioration in this excavated portion of the canal.

The canal company's reports state that important work had been done on the Machuca Rapids and quantities of rock removed from the bed of the San Juan at that point. The canal line was reported cleared of timber for a distance of 20 miles from the Atlantic coast. The company also reported that 8 miles of the route of the canal on the west side of the lake was cleared of timber and undergrowth and that the line of the railroad which was to extend from the lake to the Pacific was carefully surveyed and located.

Nearly all the property of the Maritime Canal Company, including dredges, boats, tugs, etc., has gone to ruin, except the railroad and the 4,350 feet of partially constructed canal. The buildings now standing are in bad condition. Some of them in 1897 were capable of being repaired and were used by the employees of the Nicaragua Canal Commission and later by the employees of the Isthmian Canal Commission.

Practically none of the property would have any value to-day in the construction of the canal, except, possibly, the canal excavation made from Grey Town Lagoon inland, and this would be of value only as part of a channel for the diversion of the San Juanillo River. It is now understood that the failure of the Maritime Canal Company to complete the canal within the time required by the concession has worked the forfeiture of the latter, and that all the property of the company in Nicaragua has been taken possession of by the Nicaraguan Government.

CHAPTER VII.

EARTHQUAKES, VOLCANOES, CLIMATE, HEALTH.

Earthquakes.

So much has been written upon the liability of an isthmian canal to injury or destruction by earthquakes, that a brief discussion of the subject seems desirable.

Obscurity of subject.

The cause of earthquakes is not well understood, but amid the obscurity surrounding the subject there are a few salient facts which seem to be generally accepted.

The first is that the geographical distribution of volcanoes corresponds with the areas most subject to earthquakes. One of the most celebrated and destructive earthquakes known to history—that of Lisbon in 1755—occurred far from any volcano; and so with that of New Madrid, Mo., in 1812, and that of Charleston, S. C., in 1886; but the general statement is correct, that they are more frequent in volcanic countries than elsewhere, though there is probably no part of the earth's surface which is entirely exempt from these disturbances. It does not follow that volcanoes and earthquakes bear to each other the relation of cause and effect, but it is highly probable that they represent different manifestations of the same subterranean forces.[1]

Volcanic regions most subject to earthquakes.

Volcanoes safety valves.

The doctrine that volcanoes are safety valves which diminish the violence of earthquakes in their vicinity is accepted by such writers as Baron von Humboldt, Sir Charles Lyell, Prof. Charles Daubeny, and J. Le Conte.[2]

In general terms, then, the region of volcanoes is the region of earthquakes, but the immediate vicinity of the volcanoes is not necessarily the most dangerous part of the region.

Entire isthmus in volcanic region.

The location of the principal volcanoes in the part of the world where lies the isthmus is shown on plate 70. From a glance at this map it is evident that the entire isthmus between North and South America is a volcanic region. Humboldt thus speaks of it: "The grandest example of a continental volcanic 'chain' is offered by the great rampart of

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[1] "Earthquakes," by John Milne. D. Appleton & Co., N. Y., 1899.

[2] Humboldt's "Cosmos," Sabine's translation, eighth edition, Vol. I, p. 202; "Principles of Geology," by Sir Charles Lyell, first American edition, Vol. I, p. 32; "Volcanoes," by Charles Daubeny, second edition, p. 691; "Elements of Geology," by J. Le Conte, fourth edition, p. 105.

the Andes extending from the southern part of Chile to the northwest coast of America."[1] No portion of it is exempt from earthquakes.

Records available.

The record of those which have occurred is meager, being as a rule confined to those severe enough to inflict damage upon buildings or otherwise attract general attention. The most complete catalogue to which the Commission has had access is that prepared by Mr. F. de Montessus de Ballore,[2] published in 1888. It covers the entire period from the time of the Spanish conquest to the year 1886. No very important earthquake has occurred upon either the Nicaragua or Panama lines since the latter date.

Earthquakes on Nicaragua line.

The record for points upon the line of the Nicaragua Canal shows 14 earthquakes. Two of these were felt at Grey Town, which has been supposed by some writers to be exempt. The only one which is reported to have caused serious injury was that of 1844—Rivas was almost destroyed, and great damage was done at Grey Town. Rivas is 4 miles from the canal line, and is the only town of consequence in that part of Nicaragua. It has had a continuous existence since a period antedating the conquest, when it was known as Nicarao. It was subsequently known as Nicaragua.

Earthquakes on Panama line.

For Panama the records show 28 earthquakes. Of these, 12 occurred in the three years 1882, 1883, and 1884, which illustrates the incompleteness of the record as a whole. The only one that could be called destructive was that of 1621, which destroyed nearly all the houses in Panama. The next most severe was that of September 7, 1882. During this earthquake a part of the front of the cathedral in Panama was thrown down and the headquarters building of the canal company was cracked; the railroad had its track and roadbed in places thrown out of line, and the masonry of three or four bridges and culverts was damaged; at Las Cruces the church was thrown down; at Colon some lives were lost and crevasses were opened, and the Jamaica telegraph cable was broken.

No difference between the two lines.

It is evident that this list is not complete enough to justify a comparison between the Nicaragua and Panama routes as to either the number of earthquakes or their severity. They are on precisely the same footing historically as they are geographically. In neither case is there recorded any great disasters such as have occurred in neighboring countries. The earthquake of Caracas to the eastward in 1812, and

[1] Cosmos, Vol. I, p. 228.

[2] Tremblements de Terre et Eruptions. Volcaniques au Centre-Amerique, by F. de Montessus de Ballore, p. 61. Societe des Sciences Naturelles de Saone-et-Loire, Dijon, 1888.

that of Jamaica to the northward in 1692, are well known as among the most destructive in history. To the northwestward the town of San Salvador has been ruined ten times and that of Guatemala seven times. To the southward, the earthquake of Riobamba, in the province of Quito, in 1779, was one of the most terrible phenomena in the history of the globe.[1] With the exception of the injury to Panama in 1621 and to Rivas in 1844, the worst that has ever happened at the isthmus upon either line was to throw down or crack a few walls; and even in those cases it is to be remembered that comparatively few of the houses were substantially built.

Mechanical action of earthquakes.

The internal disturbance which results in an earthquake is transmitted to any given point of the earth's surface in the form of an elastic wave of compression, and its effects may be of infinite variety, depending upon the varying elasticity of the different media through which it passes, and their shape, as well as the strength and distance of the original impulse. The resulting motion may be vertical, horizontal, or oblique, and a circular or twisting effect may be produced if the direction of the force be not in a vertical plane passing through the center of gravity of the object acted upon. Twisting motion would also be produced by two waves crossing each other. The ground may be elevated or depressed, and fissures may be opened, these effects being sometimes temporary and sometimes permanent. The effect of the undulations of the earth's surface upon any structure increases with the height of the structure above the ground. A force which would leave the foundation intact might throw down a high wall.

Power of canal works to resist.

The works of the canal will nearly all of them be underground. Even the dams are low compared with the general surface of the country and with their broad and massive foundations may be said to form part of the ground itself as they are intended to do. The locks will all be founded upon rock. It does not seem probable that works of this kind are in any serious danger of destruction by earthquakes in a country where lofty churches of masonry have escaped with a few minor injuries.

Tidal wave.

When an earthquake originates beneath the sea, one of its attendant phenomena is often a tidal wave, and this is sometimes of enormous height and destructive character. At Lisbon the sea rose to a height of 50 feet above its ordinary level.[2] With a given force of impulse, the dimensions of such a wave must bear some relation to the depth and area of the water disturbed. A lake like that of Nicaragua is insignificant compared with the ocean. It is not probable that a tidal wave of great proportions could be generated therein. The probability is still less for Lake Bohio.

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[1] Cosmos, Vol. 1, p. 194. [2] Keith Johnston's Physical Atlas, p. 40.

It is possible and even probable that the more accurately fitting portions of the canal, such as the lock gates, may at times be distorted by earth quakes, and some inconvenience may result therefrom. That contingency may be classed with the accidental collision of ships with the gates, and is to be provided for in the same way, by duplicate gates.

Injury to be expected.

It is possible also that a fissure might open which would drain the canal, and if it remained open, might destroy it. This possibility should not be erected by the fancy into a threatening danger. If a timorous imagination is to be the guide, no great work can be undertaken anywhere. This risk may be classed with that of a great conflagration in a city like that of Chicago in 1871, or Boston in 1872.

Danger from a fissure.

It is the opinion of the Commission that such danger as exists from earthquakes is essentially the same for both the Nicaragua and Panama routes, and that in neither case is it sufficient to prevent the construction of the canal.

Climate.

The climate of the Isthmian Canal regions is generally damp and enervating. The temperature is not extreme, rarely rising as high as 95° or falling below 70°, but the excessive humidity greatly restricts the capacity for physical exertion. The lowlands near the coast have long been known as insalubrious, and the seaports are subject to fevers. Perhaps the greatest difficulty to be encountered in the construction of the canal will be the procurement of an adequate force of laborers and the preservation of their health and efficiency.

Health.

In this respect the Panama route has a lugubrious history from which the Nicaragua route is free. The notorious mortality which attended the construction of the Panama Railroad and later the operations of the Panama Canal Company has taught a lesson which will not soon be forgotten for that route. Among the white employees of this Commission sent to Nicaragua there were fewer cases of sickness than there would probably have been among the same number of men employed in some parts of the United States. Among those sent to Panama the proportion of sick was greater. On the Nicaragua line during the operations of the Maritime Canal Company the health of the force was reported to be good. These operations, however, were of a preliminary character, employing but a limited number of men. It is probable that when ten or twenty thousand men are assembled and the rank soil is being turned up over a widely developed line of works the experience will be different.

Experience at Panama and Nicaragua.

There are some slight differences of climate. In Nicaragua the trade winds are more regular than at Panama, tempering the heat and removing miasma more effectively; but, on the other hand, the rainfall is greater at Nicaragua, at least for the east side, and the resulting humidity is greater. Both are covered with the rank vegetation peculiar to the Tropics, and swamps abound in both. The lessons taught at Panama should be heeded for Nicaragua also.

Lessons from Panama.

It is stated by Mr. Bunau-Varilla, at one time chief engineer of the old Panama Canal Company, that out of one hundred individuals sent to the Isthmus not more than twenty, as an average, could remain there, and even these lost a part of their value. The negro alone could perform manual labor; the white man must supervise and direct. After costly and fatal experiments with other races the company ceased sending to the Isthmus as laborers any but native Colombians and negroes from the British Antilles, particularly Jamaica. The Panama Railroad Company grants to its white employees from the United States two months' leave of absence each year, with transportation to their homes.

Precautions for preservation of health.

Careful selection, including physical examination, of persons sent to the Isthmus, a well-organized hospital service, an efficient sanitary supervision of camps and barracks, a rigid quarantine service, a liberal water supply and sewerage system, with the authority and the police force necessary to enforce the rules, and regular leaves of absence to white employees, are among the requirements for a successful prosecution of the work, and will probably be found necessary at either place.

Chapter VIII.

RIGHTS, PRIVILEGES, AND FRANCHISES.

Requirements of law as to investigation.

The act of Congress under which the Commission was appointed and the instructions of the Chief Executive thereunder require a full and complete investigation of the Isthmus of Panama with a view to determining the most feasible and practicable route across said Isthmus for a canal, together with the cost of constructing and placing the same under the control, management, and ownership of the United States.

The right to own and manage the canal when constructed can not be exercised without control of the territory through which its line actually passes and that immediately contiguous thereto and the ports or harbors at either end, also that occupied by the auxiliary works; and in order that the duties of the Commission may be clearly understood, it is important to consider and determine how far it was contemplated by the law-making power that this control should extend.

The proposition before Congress up i which this legislation was based was that the United States should, in a governmental capacity, construct, maintain, and operate a navigable waterway through the territory of foreign states.

This can not be done under the laws of nations without their consent, and no treaties then existed or have since been concluded giving such consent.

Treaties have been heretofore made by the United States and by the Governments through whose territory the different canal routes mentioned in the law extend relating to this subject of an interoceanic communication, and in all of them these States have expressly reserved the right of sovereignty and it has been respected by our Government. Thev have made a like reservation in all the contracts made with corporations, associations, and individuals granting privileges to enable them to construct a canal by these different routes.

The organic laws that the people of these different States have made for themselves give no authority to relinquish sovereignty over any part of their territory to a foreign power for this or any other purpose. If the government and people were willing to make such changes in them as would authorize the cession of any part of their territory, these changes could be effected only after long delays, that would seriously hinder and delay the inauguration of this great undertaking.

It must also be remembered that this subject of constructing a maritime canal had been before Congress many times before the law under consideration was enacted, and that no proposition to obtain the entire and absolute control that sovereignty gives was ever adopted by either House. If a departure from the line of action which had been followed up to that time was intended, it would doubtless have been clearly expressed.

Sovereignty of United States over canal route not requisite.

The acquisition of the territory to be occupied and the extension over it of the sovereignty of the United States, desirable and advantageous as it might be, is not essential to the success of such a project as the statute contemplates. The Republics owning the proposed routes are all friendly to an interoceanic communication, and there are no constitutional or other legal obstructions in the way of an agreement, in harmony with existing treaty obligations between any of them and the United States, authorizing the latter to enter its territory and excavate a canal there with such additional authority as may be necessary to make and enforce police and quarantine regulations, establish and collect tolls and other proper charges, and protect the canal and those engaged in its construction and operation and the persons and property using and passing through it when completed, such powers and privileges to be exercised subject to the sovereignty of the Republics in which the property is situated.

Strip of territory required.

In order to exercise these rights and perform these functions the United States will require the control of a strip of territory from sea to sea, including the canal and auxiliary works, with sufficient space at each terminus for all port and harbor accommodations, including offices, warehouses, residences for officials and workmen, docks, light-houses, and quarantine stations. Within this area those charged with the direction of the canal project during the period of construction, and with the management and operation of the work and its auxiliaries after completion, should have power to protect the entire line from intrusion by evil-disposed persons, prevent smuggling, regulate the kinds of business that ordinarily require control, and enforce police, sanitary, and other appropriate rules and regulations, as well as contracts relating to the construction and operation of the canal.

Breadth of strip.

The strip should be of sufficient width to prevent wrongdoers from easily withdrawing beyond the limits of police jurisdiction and thus avoid arrest and escape punishment. It should be not less than 10 miles in width; that is, 5 miles on each side of the center line of the canal throughout its entire length and including its terminal harbors.

If rights, privileges, and franchises exist, they should be removed.

Any rights, privileges, and franchises still in force which may have been granted by the States owning the territory to corporations, associations, or individuals at any of these canal routes are in the way of negotiations to secure the desired privileges and powers, and the Commission is charged with the duty of ascertaining what rights of this nature exist and upon what terms they can be purchased and removed.

Treaties to be examined.

Such rights, privileges, and franchises depend largely upon the international relations and obligations which exist between the Governments whose territory is to be occupied and the United States and other Governments claiming an interest in the subject of an interoceanic communication; so this investigation properly begins with an examination of the treaties between these different Governments in order to ascertain upon what basis such grants and concessions have rested, and also to determine whether any definite policy has been developed by the negotiations which have resulted in these conventions with reference to opening a communication for the commerce of the world across the American isthmus and its future control and ownership. If any other obstacles exist in the way of obtaining the necessary authority to occupy and use the territory required, such an investigation will develop them, and this is the first step toward their removal.

Treaties relating to Nicaragua route.

The treaties relating to the Nicaragua route will first be considered, and these include not only those concluded with the Republic of Nicaragua, but also those in which the Republic of Costa Rica was one of the contracting parties, as the geographical situation requires the consent of both these Governments before a canal can be constructed on this route, for though but little of the territory of the latter will be used in any of the proposed plans, much of it will be affected thereby.

Costa Rica also interested in this route.

Whatever doubt may have existed upon this point was removed by the award made by President Cleveland on the 22d day of March, 1888, in the arbitration for the settlement of the differences which had arisen between the two Republics as to their respective boundary rights, in which it was expressly determined that in cases where the construction of an interoceanic canal across Nicaragua will involve an injury to the natural rights of Costa Rica, her consent to its construction is necessary, and she may demand compensation for the concessions she is asked to make.

Treaty between United States and Nicaragua, 1867.

On the 21st day of June, 1867, a treaty was negotiated between the United States and the Republic of Nicaragua for the purpose of maintaining and improving the friendly relations then existing between them, of promoting the commerce of their citizens, and, last and chiefly, of making some mutual arrangement with respect to a communication between the two oceans by the river San Juan and either or both the lakes of Nicaragua and Managua, or by any other route through the territories of Nicaragua.

The two Republics agreed upon a reciprocal freedom of commerce, opened their ports, rivers, and harbors to the ships and cargoes of each other, and assured to the merchants and traders of each nation, respectively, complete protection and security to their commerce, subject always to the laws of the two countries. The respective ships of war and post-office packets of each Government were granted the same liberty to enter the ports of the other, anchor and refit there, as the war ships and packets of other nations enjoyed. And generally they declared their intention to treat each other on the footing of the most favored nations and any favor, privilege, or immunity in matters of commerce and navigation already granted, or that might thereafter be granted, to the citizens or subjects of any other State was extended on equal terms to the citizens or subjects of the other contracting party.

The Republic of Nicaragua also granted to the United States and to their citizens and property the right of transit between the Atlantic and Pacific oceans through its territory on any route of communication, natural or artificial, by land or water, then existing or to be thereafter constructed under the authority of Nicaragua, the same to be used on equal terms by both Republics and their citizens, Nicaragua, however, reserving its sovereignty over the same.

The United States agreed to protect all such routes of communication and to guarantee their neutrality and innocent use; also to influence other nations, as far as possible, to guarantee such neutrality and protection.

Liberty was granted to the United States, on giving notice to the authorities of Nicaragua, to carry troops and munitions of war from one free port to the other to be established at each extremity of the line of communication between the two oceans without charges or tolls for their transportation, provided such troops and munitions were not to be employed against Central American nations friendly to Nicaragua.

Nicaragua agreed to employ military forces when necessary for the security and protection of persons and property passing over any such route of communication. But upon failure to do so authority was given to the United States, in certain specified contingencies, to employ such force, but only for the purpose of protection, the force to be immediately withdrawn when the necessity should cease.

Nicaragua agreed to protect and preserve the rights and privileges, with reference to the establishment of an interoceanic communication, granted to the United States by this treaty in any grants or contracts thereafter entered into by the Government. And the assurance of protection to such routes, given by the United States, was declared inoperative, so far as prior grants were concerned, unless their holders should agree to observe the concessions granted by the treaty as fully as if they had been embraced in the original grants or contracts.

This treaty was ratified in June, 1868, and was to remain in force for fifteen years thereafter, or longer, unless one of the parties should give notice to the other of its intention to terminate it at least twelve months before the expiration of that time. If such notice were not given, it could at any time thereafter be terminated, in twelve months, in the same way.

The Government of Nicaragua exercised this privilege on the 27th of September last, and the notice was received by the Secretary of State on the 24th day of October, so that in twelve months from that date the treaty will be abrogated.

It is thoroughly understood that this action has been taken in a friendly spirit and with a desire to remove all obstructions in the way of a new treaty, in harmony with the cordial relations of friendship which happily exist between the two Governments.

A copy of this treaty is attached to this report marked Appendix K.

Frelinghuysen-Zavala treaty.

Subsequently, on the 1st day of December, 1884, another treaty was negotiated between the United States and Nicaragua. It is generally known as the Frelinghuysen-Zavala treaty and its purpose was to provide for the construction of a navigable canal across the territory of Nicaragua by the United States, to be owned by the two contracting Republics.

It provided for a perpetual alliance between the United States and Nicaragua, and the former agreed to protect the integrity of the territory of the latter and disavowed any intention to seek in any way to impair its independent sovereignty.

The canal was to be constructed by the United States upon the most available route from ocean to ocean and was to be commenced within two years from the ratification of the treaty and completed within ten years, or as soon thereafter as circumstances would permit. It was to be large enough to accommodate vessels of the greatest size in use and when completed was to be managed by a board of six directors; three of these were to be appointed by Nicaragua, the other three, including the chairman, were to be appointed by the President of the United States, and the chairman was to have a casting vote, in addition to his vote as a member of the board, whenever the members were equally divided. Costa Rica was not a party to this arrangement and the treaty included no provision for the protection of any rights that Republic might have upon or near the line of the canal.

Nicaragua permitted the free use of its territory, so far as might be necessary, for the construction, maintenance, and operation of the canal, and granted valuable concessions and privileges in aid of the enterprise, but all the money needed for the construction was to be furnished by the United States. A strip of territory 2½ miles in width, the center line to coincide with the center line of the canal, and a strip of the same width around the south end of the lake and along the river, where used a part of the canal, were to be set apart for the work. This was to be owned by the contracting parties, but Nicaragua was to exercise civil jurisdiction within it, and was to provide a police system to keep the peace and prevent smuggling into her territory; the cost of this service was to be a charge upon the revenues of the canal.

The net earnings of the work when in operation were to be divided quarterly between the two contracting parties, one-third to belong to Nicaragua, two-thirds to the United States.

The United States agreed also to advance to Nicaragua $4,000,000, to be repaid with 3 per cent interest from its share of the dividends or from the general revenues of the Republic, as might be most convenient, but the repayment was not to be exacted till ten years after the opening of the canal to commerce.

If the terms of the treaty were not compatible with other treaties made by the Republic with other Governments, Nicaragua agreed to terminate such incompatible treaties without unnecessary delay.

Each party agreed not to dispose or suffer itself to be deprived of its interest in the canal property without the consent of the other manifested by legislative enactment.

This treaty was submitted to the Senate and was there rejected, but a motion was made to reconsider the rejection, and Congress adjourned before final action was taken upon this motion. At the beginning of the next Congress and before any further action had been taken the treaty was withdrawn by President Cleveland for the reason, given in his message of December, 1885, that the engagement to form a perpetual alliance with Nicaragua and protect the territorial integrity of that State was inconsistent with the declared policy of the United States.

A copy of this treaty is attached to this report, marked Appendix L.

Treaty between Nicaragua and Great Britain, February, 1860.

Prior to these treaties with the United States Nicaragua, on the 11th day of February, 1860, entered into a treaty with Great Britain very similar in its terms to the first-named treaty with the United States. It, however, gave either party the right to terminate it after the expiration of twenty years, upon giving due notice to the other, and Nicaragua exercised this right by giving such notice on the 7th day of May, 1887, in response to which Great Britain announced

Terminated.

that the treaty would expire on the 11th day of June, 1888.

A copy of this treaty is attached to this report, marked Appendix M.

Treaty between Nicaragua and Great Britain, January, 1860.

Another treaty had been made by these powers with one another on the 28th day of January, 1860, which is still in force. In one of its articles Nicaragua agreed to declare the port of Grey Town a free port under its own sovereignty. It was agreed that no dues or charges should be imposed upon vessels using this port other than such as should be sufficient for the maintenance and safety of navigation and providing the expense of police, and no charges or duties were to be levied upon goods in transit through this port from sea to sea.

A copy of this treaty is attached to this report, marked Appendix N.

Treaty between Nicaragua and France, 1859.

A treaty was also made by Nicaragua with France on the 11th day of April, 1859, and it was confirmed early in the following year. It extended to France the right of transit across the territory of the Republic by all natural or artificial routes on land or sea then existing or thereafter constructed, to be used and enjoyed in the same manner and on equal terms by both of the contracting parties and their citizens and subjects. France consented to extend protection to all such routes of communication, to guarantee their neutrality and inoffensive use, and to use whatever influence the Government might have with other nations to persuade them also to guarantee this neutrality and protection. It contains a like agreement on the part of Nicaragua to employ military force when necessary for the security and protection of persons and property passing over any such route of communication, and to permit the other contracting party to employ its own military force for such protection under certain circumstances to that found in the treaties already referred to with the United States and Great Britain.

A copy of this treaty is attached to this report, marked Appendix O.

After this treaty had been in force for twenty years, either party was by its terms authorized, by giving twelve months' notice to the other, to terminate its provisions relating to commerce and navigation; but if such action were taken, the articles concerning the relations of peace and amity were to remain binding on the two powers.

Nicaragua gave such notice on the 9th day of May, 1897, and France accepted the action in the following year.

Other treaties made by Nicaragua.

Other treaties were made by Nicaragua—with Spain in 1850, with Belgium in 1858, with Italy in 1868, two with Costa Rica in 1869, and one with Germany in 1896. Some of these mention the canal project and grant the privilege of transit, and the contracting parties generally treat with each other on the footing of the most favored nations. They all aid in ascertaining the views which the commercial nations and people of the world have held, and still hold, with reference to the establishment of an interoceanic waterway, and the policy that should be maintained in its management. A list of these treaties made by Nicaragua, and the publication in which each can be found, is attached to this report, marked "Appendix P."

Clayton-Bulwer treaty.

The Clayton-Bulwer treaty, made between Great Britain and the United States on the 19th day of June, 1850, also has an important bearing upon this subject, although neither Nicaragua nor Costa Rica was a party to it; for in its preamble it is stated that it was entered into for the purpose of setting forth and fixing the views and intentions of the two contracting parties with reference to any means of communication between the Atlantic and Pacific oceans, by the way of the river San Juan and either or both of the lakes of Nicaragua and Managua to the Pacific Ocean.

In this treaty the two Governments declared that neither would ever obtain or maintain for itself any exclusive control over the proposed communication by canal; that neither would ever erect or maintain any fortifications commanding the same or in the vicinity thereof, or occupy, fortify, or exercise any dominion over Nicaragua, Costa Rica, or any part of Central America; and that neither would use any alliance or influence it might possess with any state or government through whose territory the said canal might pass for the purpose of acquiring for the citizens or subjects of the one any rights or advantages in regard to commerce or navigation through the said canal which should not be offered on the same terms to the citizens or subjects of the other.

In case of war between the contracting parties, it was agreed that the vessels of each country should be exempt from blockade or capture by either of the belligerents while traversing the canal or near either of its ends.

The contracting parties further engaged to protect the canal when completed and guarantee its neutrality, so that it might be forever open and free and the capital invested in it be secure; and they agreed to invite every State to enter into similar stipulations, so that all might share in the honor and advantage of having contributed to a work of such general interest and importance.

They also declared that they entered into this convention not only to accomplish a particular object, but also to establish a general principle, and agreed that they would, by further treaty stipulations, extend their protection to any other practicable communications across the isthmus, whether by canal or railway, particularly to the interoceanic communications by the way of Tehauntepec or Panama.

A copy of this treaty is attached to this report, marked "Appendix Q."

Treaty between United States and Great Britain of February 5, 1900.

A subsequent treaty was negotiated between the contracting parties at Washington on the 5th day of February, 1900, for the purpose of modifying the Clayton-Bulwer treaty, which was amended by the Senate before ratification, but the amendments were not accepted by Great Britain.

Policy with reference to interoceanic canal.

An examination of all these treaties shows that Nicaragua has for a long period favored the establishment of a communication for commerce and travel and governmental operations through its territory between the Atlantic and Pacific oceans, with a free port at each extremity, and that the contracting Governments are in harmony upon the following points with reference to the construction and operation of any such route through Nicaraguan territory, if a maritime canal is there located. These points of agreement indicate a well-defined policy with reference to this subject, which is acceptable to the nations and people of the world that have manifested an interest in an interoceanic communication.

1. The recognition of the right of sovereignty of Nicaragua over the territory of the Republic to be occupied in making and maintaining the proposed communication between the two oceans.

2. The right of transit by this route and its innocent use to be enjoyed upon equal terms by other governments, their citizens and subjects.

3. The neutrality of the route guarantied by the contracting parties, with an agreement to use their influence to induce other nations to make a like guaranty.

4. Military force to be supplied by Nicaragua when needed for the security and protection of the canal and auxiliary works, the officers and workmen engaged in its construction and operation, and the vessels passing through it, with their officers, crews, passengers, and cargoes.

5. If Nicaragua fails at any time to employ a force adequate for this purpose, other contracting parties may furnish such force with the consent of Nicaragua, and, in exceptional cases of imminent danger, without such consent.

6. Grants relating to interoceanic communications are to be subject to the privileges conceded by these treaties.

7. Each contracting party in these treaties stands toward the other on the footing of the most favored nation.

These treaties relate to projects to be undertaken by companies or individuals, with the exception of the Frelinghuysen-Zavala treaty, negotiated between Nicaragua and the United States in December, 1884; this is the only one in which the consent of any of these Governments has been given for the construction and operation of a canal through its territory, to be owned and operated in whole or in part by the United States.

The withdrawal of the Frelinghuysen-Zavala treaty was followed by negotiations between Aniceto G. Menocal, a member and representative of the Nicaragua Canal Association of New York, and the Government of Nicaragua, which resulted in a certain concession from the Republic, granting to the association the exclusive privilege of excavating and operating a maritime canal across the territory of Nicaragua between the Atlantic and Pacific oceans, with grants of lands, exemption from taxation, and other valuable rights and franchises, to aid in the construction, maintenance, and operation of the work.

Concession to Nicaragua Canal Association.

The concession was to be exercised by a company of execution to be called the Maritime Canal Company of Nicaragua, and was to continue for ninety-nine years from the day the canal should be opened to universal traffic. The association was allowed two and a half years from the date of the ratification of the contract, on the 24th day of April, 1887, to make the preliminary arrangements and commence the work of construction, and the company of execution was required to complete the canal and open it for maritime navigation within ten years thereafter; but it was agreed that in case of unavoidable delays impeding the progress of the work the time should be extended.

In case of failure to complete the canal within the time designated in the contract or within the period of extension, if an extension should be granted, the concession was to be forfeited; and at the close of the term of ninety-nine years, or in the event of a forfeiture, the Republic was to enter upon possession of the entire work and all the establishments used in its administration in perpetuity, but the grantees were to have the right to lease the property for another period of ninety-nine years, on the condition of paying to the Republic 25 per cent of the annual net profits, in addition to the dividends due upon its shares in the capital stock. At the close of this second term the rights and privileges of the Maritime Canal Company were to expire and the canal was to belong to the Republic in perpetuity.

In consideration of the rights, privileges, and franchises conceded to the company the Republic was to receive in shares, bonds, certificates, or other securities issued to raise the corporate capital 6 per cent of the total amount of the issue, such amount in no event to be less than $4,000,000—that is, 40,000 shares or obligations of $100,000 each—the same to be subject to no charges, assessments, or payments. The interest of the Republic was to be represented in the board of directors of the company by one member to be appointed by the Government with the same powers, privileges, and rights that other members might be entitled to under the act of incorporation and the rules made thereunder. As a further compensation it was stipulated that no tolls or charges should be exacted from Nicaraguan ships of war, and that merchant vessels belonging wholly to citizens of the Republic and sailing under the Nicaraguan flag should pay only one-half of the usual tolls for the use of the canal while engaged in the coasting trade or in reciprocal trade with other Republics of Central America or when beginning a foreign voyage with a cargo composed wholly of home products. Under certain circumstances like privileges were to be extended to the other Republics of Central America.

A copy of this contract is attached to this report, marked "Appendix R."

Maritime Canal Company of Nicaragua Incorporated.

In accordance with the terms of the concession from Nicaragua and one of like terms from Costa Rica, which will be referred to more at length later on in this report, a company of execution was organized under the name of "The Maritime Canal Company of Nicaragua" and was incorporated by an act of Congress approved on the 20th day of February, 1889.

A copy of this act is attached to this report, marked "Appendix S."

The company was required by this act to make an annual report on the first Monday of December to the Secretary of the Interior, giving under oath a detailed statement of its affairs, its assets and liabilities. This requirement has been complied with, and the report has been printed as a Senate executive document each year since 1889.

From these reports it appears that the surveys and plans for the canal were completed within the time required by the concession and duly approved by the Nicaraguan Government, and that the work of actual construction had been begun within this limit and officially recognized on the 8th day of October, 1889. The work proceeded under a contract with the Nicaragua Canal Construction Company, and some progress was made, but the construction company met with financial embarrassment, the work was stopped, and the company was obliged to suspend payment. This resulted in the appointment of a receiver for the company on the 30th day of August, 1893, by the circuit court of the United States for the southern district of New York, and the work of construction has not been since resumed.

Concession of Maritime Canal Company declared forfeited.

The President of Nicaragua, in a message to the Congress of the Republic dated on the 27th day of October, 1898, announced that the contract had become null and void, owing to the lack of fulfillment of its most essential clauses and the abandonment of the work; but an official declaration of forfeiture was delayed until after the time fixed for the completion of the work, the 8th day of October, 1899. Since then such declaration has been made, and by the terms of the contract a forfeiture authorizes Nicaragua to enter upon possession in perpetuity of all the property of the company within the territory of the Republic without being required to pay any indemnity.

Concession to Interoceanic Canal Company.

Before the time limited for the construction and completion of the canal the Government of Nicaragua, on the 31st day of August, 1898, entered into another contract, or "promise of contract," as it was officially designated, for the construction of an interoceanic canal through the territory of the Republic. The other contracting parties were Edward Eyre and Edward F. Cragin, who agreed to organize a company of execution to be called "The Interoceanic Canal Company," which should perform the obligations entered into with the State.

It was declared that the concession to the Maritime Company would expire by its terms on the 9th day of October, 1899, and that the new concession to Messrs. Eyre and Cragin should take effect on the following day without further action. Messrs. Eyre and Cragin were, however, permitted to negotiate with the Maritime Company, so as to secure the recision of its contract at an earlier day, in which event the Interoceanic Canal Company was to be permitted to enter upon its privileges from the date of the recision.

This contract gave to the Interoceanic Canal Company many valuable prerogatives and franchises, in addition to the grants, exemptions, and other privileges connected with the canal project, authorizing the corporation to embark in business enterprises of many different kinds throughout the entire Republic.

Messrs. Eyre and Cragin obligated themselves to effect the organization of the company of execution within six months from the recision of the Maritime Canal Company's contract, or from the day when the Government declared it would cease to have legal existence. The Maritime Company did not consent to a recision, so the six months commenced at the latter date, which was declared to be the 9th day of October, 1899.

The Interoceanic Canal Company when organized was obligated to commence the excavation of the canal within two years from the date of its organization and to complete the work during the ten years following. At the end of this period it was to be open to universal traffic.

In consideration of the privileges granted, the Government of Nicaragua was to receive 8 per cent of the total amount of the stock issued by the company, to be considered as full paid and nonassessable, and in no event to be less in par value than $8,000,000 in American gold.

This stock was to be represented in the management and control of the property by one member of the board of directors of the company, to be named by the Government of Nicaragua.

During a first period of one hundred and ninety-nine years after the opening of the canal to universal traffic the net profits were to belong to the stockholders. During a second period of ninety-nine years the stockholders were to receive an annual dividend of 10 per cent from the net profits and if any balance of profits should remain one-half thereof was to be paid to the Government of Nicaragua and one-half to the stockholders of the company; After this second period one-half of the net annual profits were to belong to the Government and one-half to the stockholders.

As a guaranty that the company would be organized in accordance with the contract, Messrs. Eyre and Cragin agreed to deposit in the treasury of the Republic the sum of $100,000 in American gold within three days following the ratification of the contract, and this condition was complied with. They also agreed to deposit the further sum of $400,000 in American gold within four months after the organization of the company. These sums were to be held by the Government to respond for any fines the company might incur according to the agreement.

It was declared that the rights of the Maritime Canal Company would expire on the 9th day of October, 1899, and the limit of time for the organization of the Interoceanic Canal Company was six months thereafter, that is, on the 9th day of April, 1900. The second payment was therefore due by the 9th day of August, 1900, but the company failed to meet it or to secure an extension of time. and the contract was declared annulled according to its terms, as in article 38 the failure to make these deposits was one of the causes of forfeiture.

Concession declared forfeited.

A copy of this contract is attached to this report, marked Appendix T.

During the long period that the subject of establishing an interoceanic communication across the territory of Nicaragua has been before the commercial nations of the world that Republic has made other and earlier grants and concessions than those mentioned to individuals and companies proposing to undertake the work; but none of these projects thus authorized was ever actually commenced, and these contracts have long since expired. It has not, therefore, been deemed necessary to mention them specially in this connection, and this investigation has been limited to concessions under which the contracting persons or companies have commenced actual work and those in which it is claimed, or has within a recent period been claimed, that the concessionaires have rights, privileges, or franchises still in force and entitled to recognition.

Previous concessions.

There have, however, been other contracts made by the Government of Nicaragua with different companies, giving them privileges on some of the navigable waters of the Republic which will necessarily be used in the construction and operation of a canal along this route, and it is proper that attention should be directed to them, so that it may be determined whether these privileges will give to the concessionaires the power to obstruct or hinder in any way the successful prosecution of the canal enterprise.

Contract with F. A. Pellas.

It appears that the Government of Nicaragua had, prior to the concession to the Nicaragua Canal Association, granted the exclusive privilege for the navigation of Lake Nicaragua and San Juan River by steam. This privilege was transferred to Mr. F. A. Pellas, and a contract with him was ratified on the 16th day of March, 1877. In the concession to the association the company was given the right of expropriation against Mr. Pellas on just assessments by experts, after making a corresponding compensation according to the laws of the Republic.

Contract with Nicaragua Mail Steam Navigation and Trading Company.

A company organized under the name of the Nicaragua Mail Steam Navigation and Trading Company had acquired this contract, and it became necessary for the Maritime Canal Company to control it, so that it might have the right to navigate the lake and river for transporting materials and carrying workmen and supplies from point to point while the canal was being constructed. The Maritime Canal Company stated that this was accomplished by purchasing the concession and plant for $300,000, and the purchase is mentioned in its annual report to the Secretary of the Interior of December, 1891. Soon after this, owing to the failure of the Nicaragua Canal Construction Company in August, 1893, the Maritime Canal Company was unable to continue its operations. A new arrangement became necessary, and as the contract was about to expire the Nicaragua Mail Steam Navigation and Trading Company was reorganized and obtained an extension from the Republic for ten years from November 3, 1894. It was, however, stipulated that the new contract should not interfere with the rights of the canal company.

Transfer of contract to Maritime Canal Company.

Purchase by Atlas Steamship Company.

Subsequently the Atlas Steamship Company, a British company then running a line of steamers from New York to Grey Town and other ports in the Caribbean Sea, bought the steamers, plant, and concession of the Nicaragua Mail Steam Navigation and Trading Company and applied for an extension and enlargement of the contract. This was granted by Nicaragua in June, 1897, for the purpose of securing the improvement of the lower San Juan, facilitating the communication between the lake and the ocean, and thus promoting the internal commerce of the country. Both of these contracts were transferred to the Caribbean and Pacific Transit Company, an auxiliary of the Atlas Company.

Caribbean and Pacific Transit Company.

Contract of Atlas Company.

The contract gave to the Atlas Steamship Company the exclusive right of steam navigation in the Silico Lagoon for thirty years, dating from the approval of the contract on the 30th day of September, 1897, and the exclusive right for the same time of constructing tramways and railways along the line to avoid the obstacles in the lower part of the San Juan River, making the transit to San Juan del Norte or Grey Town more rapid during the dry season. The company obligated itself within three years to construct a narrow-gauge railroad, about 5 miles long, from a point on the Silico Lagoon to a point on the San Juan River near the Colorado junction, and suitable warehouses and wharves at the terminals for passenger, freight, and other service. This road was subsequently constructed and is now in operation.

The company is required by the terms of the contract to make with its steamers at least three trips a month each way between Granada, on Lake Nicaragua, and Grey Town, and has the right to cut in the natural forests on the lake and river all the wood required for the use of its steamers, tramways, railroads, wharves, and shops; also to occupy in the ports and places of transit the national lots of land necessary for the establishment of warehouses, offices, and other buildings.

It is, however, provided that the concession shall not be an obstacle in the way of the contracts which the Government of Nicaragua then had, or might thereafter make, relative to the opening of the interoceanic canal along the same line.

A copy of this contract is attached to this report, marked Appendix U.

Boundary between Nicaragua and Costa Rica.

As was stated in the earlier part of this chapter, the consent of Costa Rica, as well as that of Nicaragua, is necessary in order to place a navigable canal by this route under the control, management, and ownership of the United States. The award of 1888, already referred to, settled the disputed boundary and was accepted by the two Republics, and the line between them has since been actually located and marked. Along the route of the canal it follows the right bank of the San Juan River from near its mouth to a point 3 English miles from the outer fortifications of Castillo Viejo; thence in a curve, of which the said fortifications are the center, from which it is 3 English miles distant throughout its course, until it reaches a point 2 English miles from the river bank above Castillo Viejo; thence it continues in a direction toward the River Sapoa, which falls into Lake Nicaragua, always 2 English miles from the right bank of the river with its circumvolutions and from the south shore of the lake until it reaches the River Sapoa. Though the line of the canal, according to the latest approved project, does not actually pass through Costa Rican soil, it is manifest that it affects the natural rights of that State, for it includes a part of the San Juan

River below Castillo Viejo, in which the Republic has, according to this award, the right of navigation, and the construction of the proposed waterway will necessarily submerge portions of its lowlands contiguous to it and to the lake and diminish the flow of water in the Lower San Juan and Colorado rivers. Hence the attitude and policy of this Government, as far as they have been developed by its diplomatic negotiations and contracts, also require examination and consideration.

Treaty between United States and Costa Rica, 1852.

The United States and Costa Rica have never entered into a convention relating directly to an interoceanic communication or to a transit through the territory of the latter. The only treaty affecting the friendly and commercial relations between the two countries was concluded on the 10th day of July, 1851, and the ratifications were exchanged on the 26th day of May, 1852.

It was agreed that there should be perpetual amity between the two Governments and their citizens and a reciprocal freedom of commerce between the territories of each. Their ships of war and post-office packets were to have liberty freely and securely to enter all harbors, rivers, and places in the country of the other to which other foreign ships of war and packets were or should be permitted to come, and to anchor, remain, and refit there subject to the laws of the country.

The intention of the high contracting parties being to treat each other on the footing of the most favored nation, it was agreed that any favor, privilege, or immunity in matters of commerce and navigation which either party had granted or might thereafter grant to the subjects or citizens of any other state should be extended to the citizens of the other contracting party upon like terms.

A copy of this treaty is attached to this report, marked Appendix V.

Treaty between Costa Rica and Spain, 1850.

In May, 1850, a treaty was entered into between Costa Rica and Spain in one of the articles of which it was agreed that in case of either the total or partial accomplishment through the territory of the former of the proposed interoceanic communication, whether by means of canals or railroads or by a combination of these or of other means, the Spanish flag and Spanish merchandise should enjoy free transit upon the same terms as other nations, and without other or greater dues than those levied upon the vessels, merchandise, and citizens of Costa Rica.

A copy of this treaty is attached to this report, marked Appendix W.

Treaty between Costa Rica and Nicaragua, 1869.

There was also diplomatic negotiation between Costa Rica and Nicaragua upon the subject, as will be seen by reference to a treaty made by them in June, 1869. By the terms of this treaty Costa Rica agreed, on due notice from and in conjunction with Nicaragua, to take the necessary steps with the Governments of France, England, and the United States, in order that the neutrality of the proposed communication, individually guaranteed by those powers, might become the subject of a general convention on the basis of the Clayton-Bulwer treaty, in accordance with the promises made by them in the former treaties referred to. The treaty in which this agreement appears was entered into to authorize the construction of an interoceanic canal through the territory of the two Republics in accordance with a contract made on the 6th day of October, 1868, by the Government of Nicaragua with M. Michel Chevalier, a citizen of France. The project was never carried out, and the treaty failed in its purpose, but its engagements are important because they indicate the attitude of the two Governments with reference to the establishment of a transisthmian communication, and the policy that should be pursued with reference to its management.

A copy of the articles of the treaty relating to this subject is attached to this report, marked Appendix X.

Other treaties.

Other treaties were made with the Hanse Towns and France, both in 1848, with Great Britain in 1849, with Netherlands in 1852, with Belgium in 1858, with Italy in 1863, with Germany in 1875, with Guatemala in 1895, and with Honduras in 1896. The purpose of the contracting parties was to strengthen their friendly relations and to place their international intercourse upon a liberal basis, but they contain no direct mention of the proposed interoceanic communication.

Policy with reference to interoceanic canal.

An examination and consideration of all these treaties made by Costa Rica show nothing inconsistent with the general policy that was developed in the case of Nicaragua, and it is manifest that Costa Rica stands fully committed to the establishment of a communication from ocean to ocean, partly or wholly through its territory, and the Republic and the Governments it has contracted with, so far as they have given expression to their views, are in harmony with the policy already outlined.

A list of these treaties made by Costa Rica and the publication in which each can be found is attached to this report, marked Appendix Y.

Concession to Nicaragua Canal Association.

On the 31st day of July, 1888, the Government of Costa Rica concluded an agreement and contract with the Nicaragua Canal Association, granting to it the exclusive privilege of excavating and operating a maritime canal between the Atlantic and Pacific oceans for a period of ninety-nine years, wholly or in part through the territory of the Republic or along the whole or a part of the border line between it and the territory of Nicaragua, and it was duly ratified by the Costa Rican Congress on the 9th day of August, 1888.

This contract was negotiated to supplement the one already obtained from Nicaragua, hereinbefore mentioned and designated as Appendix R, it being manifest that the project generally known as the Nicaragua

Canal could not be carried into execution without the consent and authority of Costa Rica. It conferred upon the association and a company to be organized to construct and operate the proposed canal substantially the same rights, privileges, and franchises in Costa Rican territory as had already been conferred upon them in Nicaragua.

A period of two years and a half from the ratification of the contract was granted to make the final surveys, organize the company of execution, and begin the work of construction. A further term of ten years was granted for the construction and completion of the canal and opening it for maritime navigation. This required the work to be commenced by the 10th day of February, 1891, and to be completed by the 9th day of February, 1901. It was, however, provided that in case the company should fail to complete the work within the prescribed time, because of unavoidable delays or unforeseen difficulties, extensions should be granted according to the length of the necessary delays.

It was agreed that the failure to begin or to complete the work within and by the time specified should each be a cause of forfeiture of the concession and in case of such forfeiture that the Republic should take possession of the canal property within its jurisdiction and hold it in perpetuity.

In consideration of the privileges granted, it was agreed that the Republic should receive in shares, certificates, or other values, representing the capital stock of the company, an amount equal to 1½ per cent of such capital stock in shares or certificates of $100 each, the same to be regarded as full paid and nonassessable. The amount of such shares was in no event to be less than $1,500,000; they entitled the Republic to all the benefits and privileges to which other shareholders should be entitled, and the same privilege of appointing a member of the board of directors that had been granted to Nicaragua.

In further compensation for the privileges granted, the company consented that Costa Rican ships of war and merchant vessels under the flag of the Republic should be entitled to use the canal upon like terms as were agreed to in the contract with Nicaragua with reference to the vessels of that Republic.

A copy of this contract is attached to this report, marked Appendix Z.

No obligations now in force to prevent an agreement with the United States relative to a canal.

The time for the completion of the canal under this contract expired in February, 1901, and it has not been extended, and the contract of the Maritime Canal Company with Nicaragua having been declared forfeited by that Government, as already stated, there are now in force no obligations of either Republic with any Government, corporation, or individual to prevent either of them from entering into an agreement with the United States that will authorize our Government to construct, control, and manage a maritime canal along this route and exercise all the privileges of ownership over it, provided the negotiations and action proceed upon the lines indicated by the treaty relations by which the different Governments are bound.

The contracts made by Nicaragua and Costa Rica giving special privileges to individuals, associations, or companies for the use of their territory and navigable waters for the construction of a canal or for other purposes contain no authority to transfer these rights to foreign Governments, and in most of them such transfer is absolutely prohibited. This indicates that each of these Governments at one time was unwilling to have its territory occupied by another nationality even for the purpose of promoting the commercial and industrial development of the State.

The Commission has reason, however, to believe that this feeling does not now exist. The sentiment in both countries is strongly in favor of opening a navigable connection between the two oceans, and the failure of every private effort to construct such a work has brought thinking men to the conclusion that it can only be successfully accomplished with the large resources and abundant means of a willing Government.

During the visit the Commission made to Central America early in the year 1900, its members had favorable opportunities to meet and confer with the Chief Executive and other leading and influential men in public life at the capital of each of the two Republics. They received a most cordial welcome both at Managua and San Jose, and were assured at each place that the Government and people were ready to listen favorably to propositions that might be made by the United States for the arrangement of terms upon which our Government might occupy their territory for the construction of a canal along this route, and control, manage, and own it when completed, with the understanding, however, that the rights of sovereignty of the present Government must be maintained.

Protocols with Nicaragua and Costa Rica.

This sentiment has since been expressed officially by both of these Governments in agreements made with the United States in December, 1900. The protocols of these agreements provide that when the President of the United States is authorized by law to acquire control of such territory of these Republics as may be desirable and necessary, on which to construct a navigable canal for vessels of the largest size from a point near San Juan del Norte or Greytown, by Lake Nicaragua to Brito on the Pacific, they will enter into negotiations with each other to settle the plan and the agreements in detail, which may be found necessary to accomplish the construction and to provide for the ownership and control of the proposed canal.

It was also agreed that the course and terminals of such canal should be the same as those stated in the treaty of February 5, 1900, negotiated between the United States and Great Britain, which has already been mentioned. The failure of this treaty terminated the negotiations for the time, but they clearly indicate the willingness of these Republics to permit the United States to use their territory for canal purposes on such terms as may be agreed upon. A copy of the protocol entered into with Costa Rica is attached to this report marked Appendix AA. The one entered into with Nicaragua is substantially in the same language.

Treaties with Colombia or New Granada.

The legislation and instructions under which the Commission is acting require also an examination of the treaties made by the Republic of Colombia or New Grenada, as it was designated prior to 1862 with other governments affecting the Panama route and any contracts made with corporations, associations, or individuals authorizing them to open a communication there for travel and commerce.

The waters of the Atlantic and Pacific oceans are only about 30 miles apart at the narrowest part of the isthmus which connects North and South America, and this advantage has naturally attracted the attention of those who have interested themselves in the subject of an interoceanic communication during the centuries that have elapsed since the first conception of such an undertaking. But no action was taken by the United States to secure any special advantages or privileges there until 1846, during the controversy with Great Britain over the Oregon boundary, which was settled by the Buchanan-Pakenham treaty of that year, and while the country was engaged in the war with Mexico, when, as one of its results, an extension of our territory on the Pacific coast seemed probable.

Treaty negotiated in 1846 securing transit rights.

During this period a treaty was negotiated with New Granada by which, among other things, the United States secured the right of way or transit across the Isthmus upon any modes of communication then existing or that might thereafter be constructed. This transit was to be open and free to the Government and its citizens, and for the transportation of any articles of produce, manufactures, or merchandise of lawful commerce, subject to no other tolls or charges than those levied or collected, under like circumstances, from citizens of New Granada.

In return for the advantages and favors acquired, and in order to secure their tranquil enjoyment, the United States guaranteed to New Granada the perfect neutrality of the Isthmus, so that the free transit from the one to the other sea might not be interrupted during the existence of the treaty; the United States further guaranteed the rights of sovereignty and property which New Granada had and possessed over the said territory.

In addition to these stipulations, the two Republics engaged with each other not to grant to other nations any particular favor in respect to commerce and navigation which should not immediately become common to the other party and on like terms. They also agreed that whatever favors, immunities, or privileges either Republic might find it proper to give to the ministers and public agents of any other power, should by the same act be extended to those of the other contracting party.

Ratified in 1848.

This treaty was concluded on the 12th day of December, 1846, but the ratifications were not exchanged until the 10th day of June, 1848, and it was proclaimed two days later.

A copy of the treaty is attached to this report, marked Appendix BB.

During President Johnson's Administration, in 1869, and again during the first Administration of President Grant, in 1870, other treaties were negotiated between the two Governments to promote the construction of a ship canal across the isthmus, but none of them was ever ratified, and the relations between the United States and the Republic of Colombia upon the subject are still defined by this convention.

Treaty with France, 1856.

Colombia has entered into treaties with other governments bearing upon this subject. One with France in 1856 permits her ships to enter all places, harbors, or rivers open to foreign commerce. A copy of this treaty and a later one, negotiated in 1892, are hereto attached, marked Appendix CC.

Treaty with Spain, 1881.

A treaty was made with Spain in 1881 providing that that Government should enjoy the canals and ports of the Republic and all advantages given to the most favored nations. A copy of this treaty is attached to this report, marked Appendix DD.

Other treaties.

Conventions, with the Hanse Towns in 1854, with Portugal in 1857, with Great Britain in 1866, with Italy in 1892, and with other governments are upon the footing of the most favored nations, but none of them contains the obligations of neutrality which were assumed by the United States. A list of the treaties made by New Granada or Colombia and the publication in which each can be found is attached to this report, marked Appendix EE.

Before the treaty concluded in 1846 had been ratified the increasing value of the communication across the isthmus of Panama attracted the attention of enterprising men in Europe as well as in our own land.

Contract with Panama Company for railroad.

The first movement to establish such a communication was made by a number of individuals in Paris, who formed an association under the name of the Panama Company for the purpose of connecting the two oceans by a railroad across the isthmus. Through their agent and attorney, Mateo Klein, they negotiated a contract with the Government of New Granada, which secured to the company, for a period of ninety-nine years, the exclusive privilege of constructing and maintaining a railroad at Panama, to be completed within six years, to be counted from the expiration of four months after the approval of the concession by the Congress of the Republic. The agreement was executed at Bogota on the 10th day of May, 1847, and was approved on the 8th day of the following month.

Transferred to Panama Railroad Company of New York.

The French company was unable to control the capital necessary for the proposed enterprise, and in June, 1848, its privileges lapsed. Subsequently, on the 28th day of December, 1848, the grant was revived in a modified form in favor of William Henry Aspinwall, John Lloyd Stephens, Henry Chauncey, and their associates, under the name of the Panama Railroad Company, an organization which was afterwards, in 1849, incorporated by the legislature of New York. All former concessions of a like character were declared null and void and the grant as modified gave the company the same exclusive privilege of establishing a railroad between the two oceans across the Isthmus of Panama as was contained in the contract with Klein, to continue for forty-nine years from the day of its completion and its being opened to public use. Six years were allowed for the construction of the road, with the assurance that an extension of two years would be granted, without the enforcement of any penalty, if it were found impracticable to finish it within the required time.

Panama Railroad completed in 1850.

Under this grant the company constructed the road and on the 27th day of January, 1855, it was completed and the first passenger train passed over the track, and ever since then it has continued in operation.

Present form of contract.

On the 16th day of April, 1850, the contract was put in a new form, so as to render it unnecessary to refer to the original contract with Klein in order to understand the rights of the contracting parties. Subsequently there were other modifications and changes. In its present amended form the company is entitled to the use and possession of the railroad, the telegraph between Colon and Panama, the buildings, warehouses, and wharves belonging to the road, and in general all the dependencies and other works now in its possession necessary to the service and development of the enterprise for a period of ninety-nine years from the 16th day of August, 1867. At the expiration of this term the Government is to be substituted in all the rights of the company and is entitled to the immediate possession of the entire property. The Republic is bound to grant no privilege, during this term, to any other company or person to open any other railroad on the isthmus, nor without the consent of the company to open or work any maritime canal there to the west of a line drawn from Cape Tiburon on the Atlantic to Point Garachiné on the Pacific, nor to establish any such communication itself. But the company can not oppose the construction of a canal except directly along the route of its road, and the consent required is only to enable it to exact an equitable price for the privilege and as indemnification for the damages it may suffer by the competition of the canal. It is also stipulated that the company shall forfeit its privilege should it cede or transfer its rights to any foreign government.

A copy of this agreement in its latest amended form is attached to this report, marked Appendix F F.

But this communication by rail was inadequate to supply the growing demands of commerce and the subject of connecting the two oceans at the isthmus by a navigable waterway still engaged the public mind. From time to time it was considered by Congress, and explorations and surveys were authorized and made under governmental authority. But the reports with reference to the routes across the Panama and Darien isthmus were unfavorable and no further concessions or grants were obtained by American companies or citizens with a view to construct a canal there.

Contract with Wyse for canal.

Meanwhile, in May, 1876, Lucien N. B. Wyse obtained from the Government of Colombia a right of way for this purpose across the isthmus, south and east of an imaginary straight line drawn from Cape Tiburon on the Atlantic side to Garachiné Point, on the Pacific. This restriction was to avoid any conflict with the privileges of the Panama Railroad Company.

Modification of Wyse contract in 1878.

In 1878, in behalf of the International Interoceanic Canal Association of France, he sought an enlargement of the privileges granted in 1876 and a new contract was entered into on the 20th of March, 1878, which gave the association authority to locate a canal across the territory, in which the Panama Railroad Company had exclusive privileges, provided the grantees could make some amicable arrangement with the last-named company. This new contract, with some modifications introduced by a decree of the Colombian Congress, became a law of the Republic on the 18th day of May, 1878, and in its modified form was on the same day accepted by Mr. Wyse.

The amended contract thus accepted gave to the association represented by the negotiator the exclusive privilege of constructing and operating a maritime canal across the territory of the United States of Colombia between the Atlantic and Pacific oceans for ninety-nine years, to be computed from the day on which it should be wholly or partly opened to public service or when the grantees should commence to collect tolls or dues on transit and navigation.

The general route of the canal was to be determined by an international commission of individuals and competent engineers not later than 1881, unless unavoidable circumstances should prevent their doing so by that time. After the settlement of the route the grantees were allowed two years to organize a joint stock company to take charge of the enterprise and of the construction of the work and the company when organized was required to finish the canal and place at the public service within the subsequent twelve years after its formation.

All public lands required for the route of the canal, the ports, stations, wharves, moorings, and warehouses, and for its construction and service, were ceded gratis to the grantees including a belt of land 200 meters, or 656 feet, wide on each side of its banks throughout its entire length.

There are other provisions and grants to aid the association in the successful prosecution of its work, and the port at each end of the canal and the waterway itself are declared neutral for all time, so that in case of war among other nations the merchant vessels and individuals of all countries may enjoy its use and advantages without being molested or detained.

In consideration of the rights, privileges, and exemptions contained in the contract, the Government of Colombia is declared entitled to a share in the gross income of the canal from all sources on an increasing scale of 5 per cent at first to 8 per cent from the seventy-sixth year after its opening to the termination of the privileges. Four-fifths of these amounts are to go to the Republic and one-fifth to the State through whose territory the canal may pass, and the company controlling the canal expressly guarantees that the share of the Republic shall in no year be less than $250,000.

The right to transfer these privileges to other capitalists or financial companies is given, but there is an absolute prohibition against ceding or morgaging them to any foreign government.

A copy of the grant is attached to this report, marked Appendix GG.

International Scientific Congress at Paris in 1879.

The agreement that the route of the canal should be determined by an international commission of individuals and competent engineers was complied with by calling an "International Scientific Congress" at Paris, which met on the 15th day of May, 1879. There were 135 delegates, a majority of whom were French; 11 were from the United States. Great Britain, Germany, and other European nations were also represented. The convention was called to order by Ferdinand de Lesseps, already famous by reason of his connection with the Suez Canal, and after a session of two weeks a decision was reached that the best location for the proposed waterway was from the Gulf of Limon, or Navy Bay as it was called in earlier days, to the Bay of Panama, and the construction of a sea-level canal was recommended.

Panama Canal Company organized.

Subsequently a company, chartered under the laws of France, was organized in the early part of 1881 to construct the canal under the grant from the United States of Colombia and De Lesseps became the leading spirit in the enterprise. The company was designated in the law as the "Compagnie Universelle du Canal Interoceanique de Panama," but it is more commonly known in this country as the Panama Canal Company.

The location of the canal in the part of the isthmus where the Panama Railroad Company had exclusive privileges in the construction of artificial waterways as well as railroads, made it necessary to enter into some arrangements with that company before the work could be commenced, and this was accomplished by obtaining the control of the railroad company through a purchase of its stock, or the larger part of it, which remained among the assets of the canal company when it subsequently went into liquidation.

Company goes into liquidation in 1888.

All obstructions being removed, the company entered upon its work; but after the expenditure of vast sums of money the effort failed, and in December, 1888, payments were suspended. The company went into liquidation and in February, 1889, a liquidator or receiver was appointed by the civil tribunal of the Seine and was given authority to transfer to any new company all or any portion of the company's assets.

New agreement with Colombia, 1890.

This failure and the change in the situation made it important to have a new agreement with Colombia, and Mr. Wyse was authorized to enter into further negotiations to obtain a modification and extension of the contract in favor of the receiver, whom he represented. He succeeded in his efforts, and another contract was entered into at Bogota on the 10th day of December, 1890, granting an extension of ten years within which the canal was to be finished and put in public operation by a new company to be organized with a capital sufficient for the purpose. This company was to resume the work of excavation not later than the 28th day of February, 1893. The contract was confirmed by the Congress of the Republic, and a copy of it is attached to this report, marked Appendix HH.

Contract extended to 1904.

It being found impracticable to complete the arrangements contemplated by the modified contract within the specified time, a further extension was applied for and obtained on the 4th day of April, 1893. This required the formation of the new company and the resumption of the work in a serious and permanent manner by the 31st day of October, 1894. The time for its completion was extended for ten years from that date.

A copy of this contract is attached to this report, marked Appendix II.

Extension to 1910.

A further extension until the 31st day of October, 1910, was granted on the 23d day of April, 1900. A copy of the contract granting this new extension is attached to this report, marked Appendix JJ.

In October, 1894, the new company was organized under the general corporation laws of France under the name of the New Panama Canal Company. Its capital was fixed at 65,000,000 francs, divided into 650,000 shares of 100 francs each; 50,000 of these, full paid and non-assessable, were to be set apart for the Republic of Colombia. A memorandum showing the legal status of the company, including copies of the French laws and the decrees of court which govern it, and of its charter, is attached to this report, marked Appendix KK.

The receiver of the old company became a party to this new organization, and transferred and contributed to it all the property and assets of the Panama Canal Company, real and personal, whether in France or Colombia, including the grants from the Colombian Government under which it had been operating, and also the rights of every nature in the Panama Railroad which had been obtained by the arrangements made and entered into with the company or its stockholders. He also subscribed, in his official capacity, for about one-fourth of the stock of the new company. This sale and transfer was made upon the express condition that the property and rights thus transferred should revert to the estate in liquidation upon default in the completion of the canal within the time fixed in the concession under which the work was to be constructed, and special conditions were made as to the Panama Railroad, which are set forth in the charter.

During the progress of the work the receiver has the right under the terms of the transfer to appoint a commission of three engineers to inspect the progress that is made, the condition and maintenance of the buildings and plant, and the accounts relating to these different objects. The expense of this commission is to be borne by the new company.

Under the terms of the transfer the New Panama Canal Company has a title to the whole property, but the rights of those interested in the old company have not been entirely extinguished. They are under no further obligations to contribute toward the construction of the canal or the auxiliary works, but its successful completion and operation will to some extent be to their pecuniary advantage, for under the terms of the sale 60 per cent of the surplus income, after paying all expenses, charges, and stipulated dividends, is to be appropriated to the liquidator, to be properly distributed. While there may be little left for the proposed distribution, the existence of this right in favor of the old company will apparently require its concurrence in case of a sale of the property and the concession and charter under which the company is acting.

No treaties exist giving United States the right to occupy Nicaragua, Costa Rica, or Colombia for canal purposes.

It appears from the foregoing that no existing treaties with Nicaragua, Costa Rica, or Colombia give to the United States the right to occupy the territory of any of these Republics for the purpose of constructing and operating a maritime canal.

Terms must be arranged by diplomatic negotiations.

The concessions and grants heretofore made by these Republics to and with corporations, associations, and individuals authorizing them to establish and maintain a communication across their territory from ocean to ocean, whether by land or water, in terms exclude the right of the concessionaires and grantees to transfer them to a foreign government. The purchase, therefore, by the United States of any such concession or grant would be ineffectual unless it were accomplished with the consent of the Republic by which the privileges were granted, and the terms upon which such consent will be given must be arranged by diplomatic negotiations.

Concessions from Nicaragua and Costa Rica declared forfeited.

It also appears that the only prior obligations to corporations, associations, or individuals, in the way of a direct agreement, under which the United States may acquire authority from Nicaragua and Costa Rica to use their territory for the construction of a canal, to be under its control, management, and ownership, have been eliminated by the forfeiture and termination of the contracts with the Maritime Canal Company of Nicaragua and the Interoceanic Canal Company, and if these forfeitures are final there are no private rights in the way of continuing at an appropriate time negotiations with these two Republics to acquire the consent and authority necessary for the accomplishment of this purpose.

Cost of acquiring privileges to be considered.

One of the purposes of the investigation mentioned in the law was to determine the cost of constructing a canal and placing the same "under the control, management, and ownership of the United States." Under this head the Commission may perhaps be expected to consider the cost of acquiring the privilege of entering and occupying the territory of the States through which the different routes extend.

Nature of title required.

Preliminary to this a question arises as to the nature of the title by which the United States is to hold the proposed canal, and the words of the law already quoted clearly indicate the legislative intent. Propositions have been before Congress in former years by which the United States was to be a part owner in such an enterprise, or a shareholder in a company organized to construct a maritime canal, and the projects which were considered contemplated ownership for a term of years, after which the property was to revert to the Republic that had permitted the use of its territory. But

Plans formerly before Congress.

there is no such suggestion in the law under which this Commission is acting. The United States is to control, manage, and own the canal; the period of ownership is not limited; it is to be in perpetuity. No divided control of management is proposed, whether effected by some arrangement between the United States and the government contracting with it, or by the formation of a company, with stocks and shares, or by any other method. Such divided ownership would give some voice in the management of the enterprise, even to minority holders, whose interests might and probably would require a policy different from that deemed best by the Government and people of the United States. This right of complete ownership and control in perpetuity, which is clearly indicated, is to be exercised under the sovereignty of the State in which the canal is located, according to the view presented in the early part of this chapter.

Unlimited control now required.

It naturally follows that the compensation to be paid by the United States in consideration of the privileges to be granted should be definitely fixed, whether included in a single amount to be agreed upon during the progress of negotiations, or in payments to be made annually or at other regular intervals, or in a combination of these two methods. A compensation to be dependent upon the earnings and profits of the enterprise would be subject to the objections which make a divided ownership undesirable. Other interests than those of the United States would be involved in the management, and accountings would have to be made from time to time to another government.

Compensation for privileges should be definite in amount.

The amount of the compensation that these Republics would require for the occupation and use of their territory remains to be considered, but the Commission had no power under the law to enter into negotiations with them, and the treaties and concessions relating to this question supply the only information from which any deductions or conclusions can be drawn. This may be of little value, but what has been done in the past with reference to a subject is often suggestive, and it is presented so that it may be available for future use and reference.

Amount of compensation.

A treaty negotiated by Mr. Elijah Hise on the part of the United States with Nicaragua in June, 1849, conferred upon the former, or to a company of its citizens, the exclusive right to construct and build within the territories of the latter a canal or road for the purpose of opening a passage or communication between the Caribbean Sea and the Pacific Ocean. No pecuniary consideration was required for this privilege, but the United States, by the twelfth article of this treaty, solemnly agreed and undertook to protect and defend Nicaragua in the possession of the exercise of its sovereignty and dominion over all its terri-

Hise treaty with Nicaragua.

tory and coasts within its just and true boundaries. Mr. Hise acted without authority in negotiating this treaty, and it was never submitted to the Senate for confirmation. The purpose of Nicaragua in agreeing to its terms was doubtless to secure a powerful ally in the disturbed and threatening relations which then existed between her and Great Britain.

A copy of this treaty is attached to this report marked "Appendix LL."

In August, 1849, Nicaragua entered into a contract for a ship canal across its territory with the American Atlantic and Pacific Ship Canal Company.

Contract between Nicaragua and American Atlantic and Pacific Ship Canal Company.

The company was to pay to the State $10,000 on the ratification of its charter, and the same sum each year thereafter during the period of construction. The State was to receive stock of the company to the value of $200,000. The total amount of stock intended to be issued is not stated.

After the completion of the canal the State was to receive annually, for a period of twenty years, 20 per cent of the net profits of the work after deducting interest at the rate of 7 per cent per annum on the capital invested, and after this period of twenty years its share in the net profits was to be increased to 25 per cent annually until the termination of the contract, which was to be in force for eighty-five years from the day the canal was completed and put in use. The company was to present a report and account yearly to the State as a basis for these payments, which was to be subject to examination and comparison with the company's books by commissioners to be appointed by the State. At the end of the period of eighty-five years the entire property and the rights and privileges granted were to be surrendered to the State without indemnity or compensation, but the company was to be allowed 15 per cent from the net profits of the canal for ten years after the surrender if the cost of the work should be less than $20,000,000, and for twenty years if the cost was greater than that amount.

A copy of this contract is attached to this report, marked "Appendix MM."

Frelinghuysen-Zavala treaty.

The next contract relating to this subject was the Frelinghuysen-Zavala treaty between the United States and Nicaragua, signed in December, 1884, already mentioned in this chapter and designated as Appendix L. By the terms of this treaty the canal was to be built by the United States and owned by the two signatory powers, without any limitation as to time. The proceeds of the canal and its accessories were to be applied to the maintenance and necessary improvement of the works, including the salaries of the board of managers and all officers and others employed, and the balance remaining was to be divided between the two Governments, one-third of which was to be paid to Nicaragua and two-thirds to the United States. The United States also agreed to loan to Nicaragua $4,000,000, which was to be expended in making internal improvements and was to be repaid with interest at 3 per cent per annum out of its share in the net revenues of the canal. As stated in another part of this chapter, this treaty was rejected by the Senate, and at a subsequent session, while a motion for reconsideration was still pending, it was withdrawn by the President.

Contract between Nicaragua and Maritime Canal Company.

The contract which the Maritime Canal Company of Nicaragua was incorporated to execute was made by Nicaragua with the Nicaragua Canal Association of New York in March, 1887. The pecuniary consideration promised for the privileges granted was to be received by the Republic in shares, bonds, certificates, or other securities which the company might issue to raise the corporate capital, and was to be 6 per cent of the total amount of the issue, and in no event less than $4,000,000 in face value, to be represented by 40,000 shares or obligations of $100 each, full paid and nonassessable.

The privileges were to last for ninety-nine years from the opening of the canal to universal traffic, at the end of which period the Republic was to become the owner of the entire property in perpetuity. The company, however, was to have the privilege of renting the canal for ninety-nine years longer on condition of paying 25 per cent of the annual net profits to the Government of Nicaragua. This contract has been stated more fully in an earlier part of this chapter and is there designated as Appendix R.

Contract between Nicaragua and Interoceanic Canal Company.

The latest contract made by Nicaragua for the construction of a maritime canal through its territory was entered into with Messrs. Edward Eyre and Edward F. Cragin, representing the Interoceanic Canal Company, in October, 1898. The terms of this contract are set forth in an earlier part of this chapter, but the part relating to the consideration promised by the company will be briefly restated in this connection for more ready comparison with the terms of the other contracts. The Republic was to be entitled to 8 per cent of the company's stock, full paid and nonassessable, not less than $8,000,000 in par value. For one hundred and ninety-nine years from the day on which the canal was opened to universal traffic the net profits were to belong to the stockholders; during a period of ninety-nine years following the stockholders were to receive a cumulative annual dividend of 10 per cent, and of any balance that remained the company was to pay half to the Republic and the other half to the stockholders; after this period the net annual profits were to be divided equally between the Government and the stockholders. While the grant was nominally in perpetuity, it is evident that the company after the first period would not be entitled to the rights of undivided ownership.

The Republic in this contract granted to the Interoceanic Canal Company some important privileges which do not appear in any of the other contracts.

It conferred authority to make and modify police regulations, subject to the approval of the government of the State, for guaranteeing order, safety, and health within a zone 5 miles in width on each side of the canal. A police force, to be appointed and paid by the company, was to enforce these regulations and also the general police regulations and laws of the State within this zone, with all the corrective powers exercised by the police force of the Republic. This provision is found in Article XVII of the contract.

In another article it was provided that all contracts made by the company relating to the canal and its accessories should be governed by the principle of "lex loci contractu."

In addition to the privileges contained in other contracts relating to canal construction, the Republic granted to this company many mercantile, banking, and other business prerogatives, varied in character, which would have been of great value to private owners. These are enumerated in Article XVI of the contract.

In addition to liberal grants of land, such as were contained in the contract with the Nicaragua Canal Association, the company was given an option to select and purchase, within two years from the date of its organization, a million hectares (nearly 2,500,000 acres) of national land, at $1 per hectare in American gold.

Taking all these privileges into consideration this is by far the most liberal contract that has been made by Nicaragua in connection with this subject, and it is of special significance, because it is the most recent in date and is the latest expression and act of the Government from which an inference can be drawn as to the value that would be set upon such a concession or grant as would authorize the United States to construct, manage, and operate a maritime canal through the territory of the Republic.

A copy of this contract is attached to this report, marked "Appendix T."

Contract between Costa Rica and Maritime Canal Company.

Only one of these parties that contracted with Nicaragua with reference to the route known by the name of that State entered into a contract with Costa Rica so as to secure the consent of that Republic for the use of its territory as far as might be necessary in executing the project. This was the Maritime Canal Company of Nicaragua. Its contract was entered into in July, 1888, and Costa Rica granted to the company privileges as to the use of its territory similar to those it had already obtained from Nicaragua, but the amount of capital stock in the company was to be 1½ per cent, instead of 4, in shares or certificates of $100 each; the total value to be in no event less than $1,500,000. This contract has been referred to in an earlier part of this chapter, and is designated as "Appendix Z."

While the way is open for direct negotiations with Nicaragua and Costa Rica for the occupation and use of their territory for canal purposes, the situation is different at Panama. The Republic of Colombia first granted a concession to the Panama Railroad Company, giving it exclusive privileges on the isthmus, which will continue, according to modifications afterwards made, for ninety-nine years from August 16, 1867. A later concession to the Panama Canal Company required it to enter into some amicable arrangement with the railroad company under which the former might occupy the territory along or near its line. The canal company acquired by purchase a majority of the railroad stock, and the necessary arrangements were made. This stock is now under the control of the New Panama Canal Company, which gives it a directing influence in both organizations. The canal concession is to continue, according to its latest extension, for ninety nine years from the day on which the canal shall be wholly or partially opened to public service, and the date fixed for this in the contract is October 31, 1910. Should it fail, and the concession be forfeited, the company will still have exclusive control of the territory through which its line extends till 1966, under the railroad concession.

Privileges of Panama Railroad Company continue to 1966.

Privileges of canal company continue to 2009.

The canal company is absolutely prohibited to cede or mortgage its rights, under any consideration whatever, to any nation or foreign government, under penalty of forfeiture. The contract with the railroad company contains a like prohibition, and declares further that the pain of forfeiture will be incurred by the mere act of attempting to cede or transfer its privilege to a foreign government, and such an act is declared absolutely null and of no value or effect.

Both companies prohibited from ceding privileges to foreign government.

These concessions, if acquired by the United States, would not give to the Government the control and ownership evidently contemplated by the law—that is, an absolute ownership in perpetuity. The right under the contract with the railroad company is designated as "the use and possession" of the property for ninety-nine years, and it is provided that "at the expiration of the term of the privilege," and by the sole fact of the expiration, the Government of Colombia shall be substituted in all the rights of the company, and shall immediately enter into the enjoyment of the line of communication, its fixtures, dependencies, and all its products. The right of the canal company is substantially of the same character. Its concession expressly provides that five years previous to the expiration of the ninety-nine

Nature of right under concessions.

years of "the privileges," the executive power shall appoint a commissioner to examine the condition of the canal and annexes, and make an official report describing the condition of the property in every detail. This report is to establish the condition in which the canal and its dependencies are to be delivered to the National Government on the day of the expiration of the privilege. There is no provision for an extension of either concession beyond the period mentioned, and the entire property in each case passes from the company without compensation.

Privileges subject to annual charges.

The privileges granted by these concessions are subject to certain annual charges in the nature of rentals, and to other obligations. The railroad company is bound during the continuance of its concession to pay to the Colombian Government "an annual revenue" of $250,000 in American gold, in quarterly payments. The failure to make any of the quarterly payments, after being one year overdue, subjects the company to a forfeiture of its privilege. It is also bound to transport over its road the Colombian mails without charge, and the troops, chiefs, and officers, and their equipage, ammunition, armament, clothing, and all similar effects belonging to or destined for the service of the Republic, and emigrants to the country up to the number of 2,000 annually. The canal company is bound to pay to the Government, in half-yearly installments, during the first twenty-five years after the opening of the canal to the public service a share amounting to 5 per cent on its gross income from all sources, without any deductions whatever. For a second period of twenty-five years the share of the Government is increased to 6 per cent; for a third to 7 per cent; and for a fourth, to the termination of its privilege, to 8 per cent. The company guarantees that this share shall in no case be less than $250,000 in any year. The Colombian Government also owns, in accordance with the extension law of December 26, 1890, and by the terms of the company's charter, 50,000 full-paid shares of its stock, of the par value of 100 francs each, the total number of shares issued by the company being 650,000. The Government of the Republic has the power under the concession to protect these interests by appointing a commissioner or agent to intervene in the collection, and examine the accounts of the company.

This being the situation, it was manifest that, even if the privileges of the companies could be purchased by and transferred to the United States, they were encumbered with charges and conditions that would not permit this Government to exercise all the rights of complete ownership over a canal constructed by it at the Panama route.

New arrangement necessary if United States undertakes work.

A new arrangement is necessary if the United States is to undertake the work. The relinquishment by the canal company, with the consent of Colombia, of the privileges it has under existing concessions, for a consideration to be agreed upon with the United States, would leave the way open for treaty negotiations between the two Governments to ascertain whether Colombia will consent to the occupation of its territory by the United States for the construction of a canal to be under Government control, management, and ownership, and, if so, whether they can agree upon terms mutually satisfactory. The situation is peculiar, as there are three parties in interest. The United States can obtain from Colombia no concession that does not have the approval of the company, and its concessions do not permit the company to transfer or attempt to transfer its rights to a foreign government.

As the Commission was specially authorized and instructed to ascertain the cost of purchasing all the rights, privileges, and franchises held and owned by corporations, associations, and individuals in the different canal routes, so as to determine the cost of constructing an isthmian canal at each of them and placing it under the control, management, and ownership of the United States, it attempted at the first favorable opportunity, after its organization, to ascertain the views of the New Panama Canal Company with reference to a disposition and transfer of its property and rights.

While the Commission was in Paris in September, 1899, interviews were held with the president and other officers of the company, during which their attention was directed to the scope of the investigation in which it was engaged, and their views were sought upon this subject of sale and transfer. They were not prepared to make a definite reply, and responded only with some general remarks, which did not give the information that was sought.

Mr. Maurice Hutin was afterwards chosen president of the New Panama Canal Company and came to the United States early in 1900, during the absence of the Commission in Central and South America. Soon after its return, on the 4th day of April, 1900, he addressed a letter to the president of the Commission, stating that the principal object of his visit was to give to the Commission any additional information it might desire with reference to the company and the canal project, and that he was ready to do so, either upon technical points or others that might be indicated to him.

In response to this letter the president of the Commission reminded him of the discussions at Paris with reference to a transfer of the canal property to the United States which had then led to no result, and submitted three inquiries to which he solicited replies as full and as clear as he might find it convenient to make. They were substantially as follows:

1. Whether the company was willing to sell its rights, property, and unfinished work to the United States.

2. Whether the company had the legal power to make such sale and

give to the purchaser a perfect title, free from all incumbrances and the claims of the stockholders and creditors of the old company.

3. For what sum, in cash, would the company sell its rights, privileges, franchises, and its property of every description connected with the construction of a canal across the isthmus of Panama?

He stated that the Commission was well aware that the concession under which the company was acting prohibited a sale or transfer of its privileges to any foreign Government, and suggested that, in the discussion of the subject, the consent of the Colombian Government might be assumed. He also called attention to the terms of the law under which the Commission was acting, which authorized it to collect information to be submitted to the President of the United States, but conferred no power to accept or reject any terms which might be offered.

There was no early response to this communication. President Hutin returned to Paris, and on the 20th of July addressed a letter to the president of the Commission, in which he said that on account of the importance of the questions asked him it would be well to have interviews with him and other members of the Commission, with a view of making the reply precise and including in it everything which might be needed. Before closing he asked to be informed by what date a reply to the letter of April 10, 1900, was desired. In acknowledging this letter, on the 13th of August, the president of the Commission stated that it was desirable to have the reply at as early a date as practicable, and not later than the 1st day of October following.

A few weeks later, President Hutin visited Washington again, and the Commission and its committee on rights, privileges, and franchises held conferences with him from time to time, at which the subject of these inquiries was freely discussed, but no formal reply to the letter was received until November 16, just before the Commission closed its preliminary report.

During these conferences the question of title was fully discussed, and the Commission was furnished with copies of the concession from Colombia to the old company; the different contracts by which it was extended; the laws under which the old and new companies were organized; the legislative acts relating to the old company and the liquidation of its affairs; the decrees of the court relating to the liquidation and to the formation of the new company; the charter of the new company, and other documents bearing upon its legal history. These have been made use of by the Commission in its investigation of the legal status of the new company, and its conclusions will be given further on in this report.

No result was reached with reference to the other questions. There was no offer to dispose of the property and privileges of the company to the United States upon any terms, even with the consent of the

Colombian Government, nor was any desire expressed to enter into any negotiations with the United States with reference to such a disposition of its property and rights, and it was manifest that the company preferred some other arrangement than an absolute sale. President Hutin during these conferences suggested that the United States might obtain control of the rights, privileges, and property of the canal company as a majority stockholder of a new organization, to which the company might contribute its concession, plant, unfinished work, and other property, at a valuation to be determined by arbitration, and he expressed the opinion that such an arrangement could be made without violating the concessions. But this must include some plan for the protection of the minority stockholders in the financial management, for they would favor a policy that would realize liberal dividends in proportion to the commercial value of the canal, while the policy of the United States might be to reduce tolls and charges to the cost of maintenance, or even below it, if its interests would be thereby advanced.

The letter contained no answers to the first and third questions of the communication of April 10, 1900, but submitted a plan substantially the same as that outlined in the letter of the company of February 28, 1899, addressed to the President of the United States, which was published in Senate Doc. No. 188, Fifty-sixth Congress, first session, pages 41 and 42.

This was to reincorporate under the laws of New York or some other State, and accord to the United States such representation in its board of directors and such opportunity to acquire an interest in its securities as its concessions permitted.

This plan was subject to all the objections of a divided ownership, and would not give to the United States the control, management, and ownership contemplated by the law. An assurance was added to the effect that if the United States should desire to perpetuate or enlarge its existing rights and privileges acquired under the treaty of 1846, the company would conform to such supplemental treaty as might be entered into between the United States and Colombia.

It was further stated in the letter of November 26, 1900, that there were other plans by which the United States could acquire a preponderating influence in the company without violating the spirit of the concessions, but they were not disclosed either in the letter or during the discussions.

In the spring of 1901, the preliminary report of the Commission having been published during the previous winter, there were some communications between the Colombian Government and the canal company, which caused the latter to somewhat change its attitude. The Commission was informed that the company, through its president, had expressed a desire to sell and transfer its rights, property, and interests to the United States, with the necessary authorization of the Colombian Government, that the Government would give its consent to the company to make such sale and transfer, if satisfactory arrangements and conditions could be agreed upon, and that the company was authorized to enter into negotiations with that end in view.

This apparently removed all obstacles to a full and frank expression of the views of the company upon the subject, and in a letter, dated May 8, 1901, addressed to President Hutin, the president of the Commission expressed the hope that he would take up the question once more, now that he was relieved of the embarrassments under which he had formerly labored, and give such additional information as he felt at liberty to do, particularly in reply to the first and third questions contained in the former letter of April 10, 1900, so that the Commission might make a full representation of the subject in its forthcoming report for the information of the President of the United States.

In his reply, on the 15th of the same month, President Hutin responded to the first question by stating that the company would consent if authorization therefor should be given by the Colombian Government to transfer its concessions to the Government of the United States, the conditions of the transfer to be fixed independent of any particular arrangements which might be made between the Governments of Colombia and the United States.

A reply to the third question was deferred until his return to Paris, because, as he stated personally to the president of the Commission, no price could be fixed until he could consult with the directors of the company and have free access to its books and accounts.

He referred again to the question of a divided control of the canal property, and the conditions under which the United States might obtain a share in it, and suggested that it might be of interest to examine it afresh.

The president of the Commission acknowledged the receipt of this letter on the day following. He urged that the first step for the company to take was to express its views as to the value of its property, and that this could be done in no better way than by a specific reply to the question asked in the letter of April 10, 1900, and expressed the hope that this would be done with the least possible loss of time. He discouraged the proposal to examine afresh the question of divided control. The law under which the Commission was appointed contemplated nothing less than a complete ownership of the property, and, as the company was then in a position to make a direct sale to the United States, he said that it need no longer be considered.

The summer passed without making any material progress, although letters and cablegrams upon the subject were exchanged. On the 28th of June the president of the Commission was assured that a detailed valuation of the company's property would be sent in about a fortnight. On the 25th of July it was to be sent by next mail, and the statement was added that the preparation had required more time than contemplated. The formal reply, dated Paris, October 4, 1901, was finally presented in Washington by President Hutin in person, on the 17th of the same month, together with a paper containing the estimated values of the property of the company. These valuations are given in the following table in francs and also in dollars, the franc being valued at 19.3 cents:

	Francs.	Dollars.
Stock of the Panama Railroad Company	55,000,000	10,615,000
Buildings, lands, etc., on Panama Isthmus, constituting the company's private estate	9,000,000	1,737,000
Hospitals at Colon and at Panama	4,500,000	868,500
Amounts expended for concessions, with interest	24,000,000	4,632,000
Work done by the old company	415,000,000	80,095,000
Work done by the new company to January 1, 1902	40,000,000	7,720,000
Technical surveys	18,000,000	3,474,000
Total	565,500,000	109,141,500

These figures were intended by the company to represent the intrinsic, or real and absolute, value of the work already done and the other property it owns upon the isthmus. In addition to this a compensation was proposed for the possible profits that might result from the operation of the canal after its completion. The plan proposed for estimating these profits was to allow a certain amount per ton on the actual annual tonnage that might pass through the canal whenever it amounted to 7,000,000 tons or more, at an increasing rate, without reference to the toll charge or actual receipts. The proposed rates of compensation were as follows:

	Francs per ton.
7,000,000 tons per annum	.50
8,000,000 tons per annum	1.00
8,000,000 to 11,000,000 tons per annum	1.50
11,000,000 to 16,000,000 tons per annum	2.00
16,000,000 to 19,000,000 tons per annum	2.50
20,000,000 and more tons per annum	3.00

It being the desire of President Hutin to enter upon a discussion of these items, so that objections might be made and considered, members of the committee on rights, privileges, and franchises met for a conference with him and his counsel, and the greater part of three days was spent in an examination of the paper containing the estimated value of the property.

The total valuation is largely in excess of that fixed by the Commission, the greatest variance being in the amounts for the excavation and work already done that can be utilized in the completion of the canal.

This resulted from different views as to prices and methods of calculation and partly to a difference in plans. The company's estimate also included, in addition to the work, the value of the plant upon the isthmus, consisting of locomotives, cars, dredging and other machines, tools and implements of various kinds, stored in sheds and warehouses, which originally cost many millions of dollars, but would be of no value to the United States; most of these machines and implements are old, and even if in good order are not adapted to present methods.

The members of the Commission could not agree to the proposition that the company would have any just claim to share in the profits of the canal enterprise after selling it to the United States at its real and absolute value. The element of probable future profits may fairly be considered in fixing the price, but if the United States should become a purchaser, it will be upon the condition of acquiring a complete title and the absolute control of the property. As a result of the discussion, this proposition was withdrawn, but in other respects the views and opinions of each party remained unchanged.

It was then proposed by President Hutin that there should be a thorough examination of the data and estimates made by the Commission and the company, so that by proper comparison the differences might be developed, and if possible, adjusted, so that a result could be reached that would be acceptable to the two interests that were represented. It was further proposed that if the differences could not be thus adjusted, there should be an arbitration to settle them. As the reasons for the existing differences had been developed during the conferences already held, and as the efforts to reconcile them had been fruitless, the further examination proposed did not appear to be desirable, and besides it was then impracticable.

After all the obstructions in the way of a sale had been removed, it took several months for the company to go over its books, accounts, and other data in preparation of the paper then under consideration. The Commission had devoted many months to this part of its investigations and studies. It was therefore manifestly impossible to go over the details of the results reached by the company and the Commission in the brief time that remained for the preparation and presentation of the report of the latter to the President of the United States.

A resort to arbitration in case of disagreement would require a presentation of the two sets of details to a new body of men, who would have to examine the entire subject for themselves, and their work could not be completed for many months, perhaps years.

If an adjustment by this method were practicable and desirable, it was not within the scope of the duties of the Commission. Its duty was to obtain information, and it was ready to entertain any proposition or agreement that the company might offer, submit it to the president, and to continue the discussions as far as practicable during the brief time that remained; but it was clothed with no power to accept or reject, as the company had been informed at the beginning of these conferences. An arbitration under such circumstances would be a useless waste of time and effort, would lead to no practical result, and would only serve to further delay action upon the canal question.

The proposition for a more extended discussion and comparison of the details of the estimates made by the company and by the Commission was therefore declined, and President Hutin was informed that the Commission would be obliged to complete its report at an early day, and that any proposal from the company would be received until the 5th day of November, when the question would be considered as closed, and it was hoped that by that time he would be ready to present his final conclusions.

Before that time a letter was received from President Hutin, stating that the board of directors of his company had fixed a price for the sale of the canal property and interests, according to calculations and estimates "which it considers exact and justified until the contrary is proven." This price is the aggregate of the items contained in the paper submitted with his letter of October 4, and he states that he confirms this letter and the accompanying paper or memorandum, except the part of the latter relating to a share in the profits of the canal enterprise, which claim is relinquished "as an act of conciliation."

This statement was somewhat indefinite, but in the reply to the letter the president of the Commission stated that he understood that the company withdrew the proposition with regard to sharing in the possible profits accruing from the canal, after completion, and with that exception that the company confirmed and stood upon the figures submitted with the letter of the 4th of October last, which aggregated 565,500,000 francs, or $109,141,500, and that these figures, with his views, would be presented to the President in the report of the Commission. There has been no dissent to this interpretation of the meaning and purport of the letter.

The Commission submits this as the result of its efforts to ascertain upon what terms the rights and privileges of the new Panama Canal Company can be obtained.

It is proper to add that the examination of the title of the present company to the canal property under the laws of France and Colombia has satisfied this Commission that the new Panama Canal Company has the entire control and management of the canal property. It appears, further, that the liquidator appointed by the French court to settle the affairs of the old company contributed under the charter all the privileges and property of that company to the new organization, and in consideration of this contribution he will be entitled to receive 60 per cent of the net income after paying all expenses, charges, and stipulated dividends, to be distributed by him among the parties in interest. This right to a share in the profits gives no right to the old stockholders to take any part in the acts or administration of the new company, but the charter recognizes a continued interest of the old company in the affairs of its successor by conferring upon the liquidator until the completion of the canal the power to appoint a commission of three members to inspect the progress of the work, the condition and maintenance of the plant and buildings, as well as the accounts relating to these different objects, the expense of the commission to be borne by the new company. It will thus be manifest that if an agreement be made for the purchase of the company's concession and property by the United States, it must include some settlement of this right which the French court has placed under the control of the liquidator, and if a sale is effected the liquidator must unite in it under the authority of the court from which he received his appointment.

The correspondence between the company and the Commission is as follows:

THE NEW CANAL COMPANY OF PANAMA,
Washington, D. C., April 4, 1900.

Admiral J. G. WALKER,
President of the Isthmian Canal Commission, Washington, D. C.

MR. PRESIDENT: In pursuance of the intentions expressed and the assurances given by the New Canal Company of Panama to the President of the United States and the committees of Congress before the creation of the Commission over which you preside, and also because of similar intentions and assurances which we had the honor of addressing to yourself, we were very glad to be able in the beginning to confer with the Commission in Paris. Indeed, that gave us the opportunity of presenting to you in a most complete and satisfactory manner our detailed technical plans, with all the data and documents which had been used in their formation. We have also made known to you the results of our statistical and economical investigations and have exhibited the general organization and the present situation of our company.

Following your studies in Paris, we were much pleased to receive you in the Isthmus of Panama, where we submitted for your examination the entire scheme of our project and the work on the canal in process of execution.

Since your departure from Paris I was elected president as well as director-general of the New Canal Company of Panama, and soon after I left France with the intention of joining you on the isthmus. Upon my arrival at New York I cabled you and received from you the reply that the Commission would probably leave Colon on the 19th of March, which left me no opportunity of an interview with the Commission during its stay in Panama.

As the principal object of my visit was to give the Commission any additional information which it might desire, I have remained in the United States to await its return. It is possible that your profound study of the project of our company, made during your visit to the isthmus and illustrated by the actual condition of the work which is now in process of execution upon the line of the canal, may have suggested the desire to obtain new information; and because of that possibility I have been desirous of holding myself at your disposition in order to supply you upon technical points, as well as upon others that you may be good enough to indicate to me, such complementary information and explanations as you may judge necessary.

I shall remain in Washington or in New York as long as you consider my presence useful. I beg that you will accept, Mr. President, the assurances of my high consideration and my devoted sentiments.

M. HUTIN.

My address at Washington is Hotel Raleigh, and in New York to the care of Messrs. Sullivan & Cromwell, 45 Wall street.

DEPARTMENT OF STATE, ISTHMIAN CANAL COMMISSION,
Washington, D. C., April 10, 1900.

MAURICE HUTIN, Esq.,
President of New Panama Canal Company,
Care of Messrs. Sullivan & Cromwell, 45 Wall street, New York, N. Y.

DEAR SIR: During the conferences which this Commission had the honor to hold with you in Paris, and in the sessions of September 7 and 8 last, your attention was invited to that portion of the law of Congress which created the Commission, requiring it "to ascertain the cost of purchasing all the rights, privileges, and franchises held and owned" by the association of which you are the head. Your attention was also invited to the scope of the investigation in which the Commission is engaged, as defined in the last sentence of section 3, which is as follows, viz: "To make such full and complete investigation as to determine the most feasible and practicable route across said Isthmus for a canal, together with the cost of constructing the same and placing the same under the control, management, and ownership of the United States."

The subject was opened without any expectation that it could be fully discussed at that time, it being well understood that questions so important and so difficult must require time for consideration. You were pleased to make certain general statements, which were all that could be expected by the Commission for the moment. They did not, however, convey the information which the Commission is seeking, viz: How much will it cost the United States to acquire complete ownership and control of all the rights, privileges, franchises, and property belonging to the New Panama Canal Company? I beg, therefore, to revert to the subject with a view to reaching, if possible, a clearer understanding upon that subject.

You understand, of course, that the Commission has no authority to accept or reject any terms which may be offered, but is collecting information to be submitted to the President.

I may remark at the outset that the Commission is familiar with the clause in your concession which prohibits the sale or transfer of your rights to any nation or foreign Government. In the discussion of this question it may be assumed that the consent of the Colombian Government has been obtained for a sale to the United States. It is with that assumption that the following questions are respectfully submitted, and that replies as full and as clear as you may find it convenient to make are solicited.

1. Is the New Panama Canal Company willing to sell to the United States all of the rights, privileges, and franchises, together with all the works, railways (including the Panama Railway), telegraph or telephone lines, buildings, lands, plant, material, drawings, and documents of every description which it owns or controls in connection with the construction of a canal across the Isthmus of Panama?

2. Is the company able—that is, has it the legal power—to give a clear title to such rights, privileges, franchises, property, etc., of every description, free of all encumbrance or claim of any nature, from any person whatsoever, and particularly from the stockholders or creditors of the old Panama Canal Company?

3. For what sum of money, in cash, will the company transfer to the United States all of the rights, privileges, franchises, property, etc., of every description, which it owns or controls in connection with the construction of a canal across the isthmus of Panama?

The law under which the Commission is acting contemplates only the complete "control, management, and ownership" of the canal by the United States, and not a partial or joint control with private corporations or individuals. Nevertheless, should your reply to the first or the second questions be in the negative, it would no doubt be of great interest to the President to know what degree of control could be obtained by the United States in the Panama Canal, and upon what terms.

In the contingency referred to, viz, a negative reply to the first or second questions, you are invited to state how far the company will be able and willing to go in the direction of yielding control to the United States, and what compensation it will expect therefor.

Thanking you again, my dear Mr. Hutin, for the great assistance and many kindnesses extended to the members of this Commission, both in Paris and upon the isthmus of Panama, I am, with great respect,

Your obedient servant,

J. G. Walker,
President of Commission.

Paris, *July 20, 1900.*

Mr. President: Our council of administration is preparing to reply to your letter of April 11 (10) last.

On account of the importance of the questions asked, we think it possible that before determining precisely the terms of our reply, and with a view of making it precise and including therein everything which you may need, it might be well that I should have at Washington interviews with yourself and with the members of the Commission.

Whether you are of this same opinion or not, we would be much obliged, Mr. President, to be informed by what date you wish to have our reply to your abovementioned letter.

I beg that you will accept, Mr. President, the renewed assurance of my devoted sentiments.

The president of the council of administration:

M. Hutin.

Rear-Admiral Walker,
President Isthmian Canal Commission,
Corcoran Building,
Washington, D. C., United States.

Department of State, Isthmian Canal Commission,
Washington, D. C., August 13, 1900.

Mr. Maurice Hutin,
President New Panama Canal Company, Paris, France.

Mr. President: I have to acknowledge the receipt of your letter of July 20, received during my absence from town, informing me that the council of administration of your company is preparing a reply to my letter of April 10 last, and also asking to be informed by what date we desire your reply to the above-mentioned letter.

In response to your inquiry I have to say that I will be glad to have your reply at as early a date as practicable, but I think it should not be later than the 1st of next October.

With great respect, believe me, very sincerely, yours,

J. G. WALKER,
President of Commission.

WASHINGTON, D. C., *November 26, 1900.*

Rear-Admiral JOHN G. WALKER,
President Isthmian Canal Commission.

DEAR SIR: We have taken pleasure in being able at various times to confer with you and your associates of the Commission upon the numerous and complex questions involved in the problem of the interoceanic canal, and particularly the inquiries presented by your letter of April 10 last.

Referring to that communication we note your statement "that the Commission has no authority to accept or reject any terms which may be offered, but is collecting information to submit to the President."

It is manifest, therefore, that nothing decisive at this time could result from a categorical answer to certain of your inquiries. Nevertheless we wish now, as we have from the beginning, to manifest our sincere desire to assist you in accomplishing the high duties with which you have been charged by the President.

We beg leave, first, to renew and confirm our proposal of February 27–28, 1899.

In that proposition the company declared that if the Government of the United States adopted the Panama route it would transform its organization and reincorporate under American law, and while providing for the completion of the canal with its own resources would grant to the Government (without pecuniary contribution upon the latter's part) representation in the directorate of the company; and it also thereby offered to the Government the opportunity of acquiring securities of the company to the extent permitted by the concessions without being made a condition of our proposal; and it further thereby pledged itself to conform to such supplemental treaty as might be entered into between the United States and the Republic of Colombia in perpetuation or enlargement of the existing rights and privileges of the United States under the treaty of 1846, and to accept such modifications of the concessions as might result therefrom.

We would prefer to carry out this plan, which is embodied in the communication of February 27–28, 1899, but we recognize the present desire of the Government to acquire preponderating interest and influence in any interoceanic canal, and we are prepared to further that desire as far as lies in our power.

There are several plans by which the United States could acquire such preponderating interest and influence without violation of the provisions of the concessions prohibiting the transfer of the concessionary rights to any foreign government. As the Commission is acquainted with the terms of such prohibition, we are quite sure that it will agree that should the arrangement arrived at (whatever it might be) take a form requiring the concurrence of Colombia, we could not in that contingency bind ourselves until such concurrence be obtained. You will surely appreciate that under no circumstances must any act be done by us which might imperil our concessionary rights.

As concerns all legal questions, we reiterate our unequivocal declaration, justified by the title deeds and documents submitted to you and supported by the highest legal authorities, that our titles and concessions are absolute and indisputable, and that any agreement which might be reached between the United States and the company would be indubitably legal.

I beg leave to say, therefore, that I am prepared and fully authorized to continue the consideration of the subject and to reach a conclusion with any representatives of the Government authorized, as I am, to come to a final determination.

I am, dear sir, with great respect, your obedient servant,

M. HUTIN,
President et Directeur-General.

LEGACION DE COLOMBIA,
Washington, April 29, 1901.

M. M. HUTIN,
President and General Director of the Panama Canal Company, Washington.

DEAR SIR: In reply to your favor of yesterday I have the honor to inform you that the honorable Secretary of State, Mr. Hay, has told me that, not being duly authorized by the Senate, he can not for the present enter into direct negotiations in the matter of the Panama Canal.

Besides, I understand that the Government of the United States wishes to come to an understanding with Great Britain on the proposed modifications of the Clayton-Bulwer treaty before entering into negotiations relative to either the Nicaragua or the Panama Canal.

Under present circumstances, and pending the reunion of Congress, the labor of the Commission over which Admiral Walker presides will be merely informatory; and so I have been given to understand by the Secretary of State.

The final report that the Commission is to present will be absolutely impartial, and it will cover all questions, whether technical, political, economic, or commercial, that are to be taken into account to secure a correct result, leaving no room either for undue haste or for the influence of private interests.

In order to facilitate the preparation of a complete report by the Commission, I would beg of you to inform me, at least in a general way, what would be the conditions under which your company would be disposed to cede its franchise to the Government of the United States, of course with the necessary authorization from the Colombian Government.

I believe that it is important to make this matter clear in order to dispel doubts and misunderstandings that have given rise to malignant insinuations, in spite of the prudent reserve that you have observed before being informed of the attitude of the Colombian Government in the matter.

I avail myself of this opportunity to renew the assurance of my high regard.

CARLOS MARTINEZ SILVA.

WASHINGTON, D. C., *May 1, 1901.*

His Excellency Mr. MARTINEZ SILVA,
Minister of Foreign Affairs, Minister Plenipotentiary of the Republic of Colombia to the Republic of the United States at Washington.

MR. MINISTER: Since your arrival in this country I have had the honor of having with you numerous conferences, in the course of which I have stated to you the purpose, the development, and present state of the relations established between the Government of the United States and our company since the end of the year 1898.

At your suggestion and in agreement with you I have abstained from all other proceedings. It was proper, in fact, to wait until the situation of the interoceanic cana question in the United States, regarded from the double point of view—legislative and diplomatic—should be, if it were possible, better defined. The events which occurred in the course of the months of February and March last permitted me to write you my letter of March 20, in which I asked you to kindly inform me how your Government, under the present circumstances, meant to interpret and apply the provisions of articles 21 and 22 of the law granting the concession for the Panama Canal.

You were good enough to answer me on March 28, by a letter from which I quote the following passage:

"The reserve maintained by you with regard to the propositions which have been made by the Commission appointed by the President of the United States, in conformity with the act of Congress of March 3, 1899, with a view to obtaining a sale to the Government of the United States of the Panama Canal concession, has been prudent; because any offer on your part would have been baseless without the previous knowledge and authorization of Colombia, in accordance with articles 21 and 22 of the concession law.

"In order to define clearly the respective positions of Colombia and the United States on the subject of the Panama Canal, I presented yesterday to the Secretary of State, Mr. Hay, a memorandum on the general points which might serve as a basis for negotiations for the purpose of harmonizing the interests of Colombia, those of the Panama Canal Company, and those of the United States, so far as the latter are not in conflict with the traditional principles of Colombian policy which are expressed in the concession law.

"In this memorandum it was stated that the Government of Colombia would give the canal company its consent to transfer the latter's concession to the Government of the United States, provided always that the latter would accept the conditions which have been submitted to it.

"The Secretary of State told me that he would study the question with care and that he would advise me when we could discuss it at another conference.

"I will give you timely advices of what may result from it."

In view of the announcement of the departure and the intended long absence of the Secretary of State, referring to the foregoing letter I wrote you on April 28, to ask you to let me know whether any decision had been reached or any determination arrived at.

You were good enough in reply to write me on the next day as follows:

"In reply to your letter of yesterday, I have the honor of informing you that the Secretary of State, Mr. Hay, has told me that not being authorized by the Senate he can not at present enter into any direct negotiations concerning the Panama Canal.

"I understood also that the Government of the United States desired, before undertaking any arrangement relative to the Nicaragua or Panama Canal, to come to an understanding with the English cabinet to endeavor to modify the Clayton-Bulwer treaty.

"For these reasons the Secretary of State informed me that until the meeting of the next Congress the work to be done will consist in collecting further information, with which the Commission of which Admiral Walker is president will be charged.

"The final report which it is to present will be inspired by the loftiest impartiality, and will comprehend all the technical, political, economic, and commercial questions which should be taken into account to give the problem the best solution, closing the way to any hasty action and to the operation of private interests.

"To facilitate this Commission in obtaining the means of presenting a complete report it would be proper that you, as representing the New Panama Canal Company, should tell me, at least in general terms, what are the bases, given the previous consent of the Government of Colombia, upon which the company would be disposed to transfer its concession to the Government of the United States.

"I think it important to settle this point in order to avoid the doubts and misunderstandings which have given rise to unfriendly interpretations, notwithstanding the proper reserve of the course which you have followed, so long as you were not informed of the attitude of the Government of Colombia."

I hasten, Mr. Minister, to comply with your wish. I shall thus, moreover, only be continuing to follow the invariable line of conduct adopted by the New Panama Canal Company since its organization in 1894. In fact, in each of its annual reports to the shareholders' meetings. our board of directors has shown itself disposed to grant to American interests the satisfaction which they might legitimately desire, subject to the sole condition of an understanding which should be equitable to all parties in interest.

You are also aware, Mr. Minister, from the documents which I have handed you, that we have the right to express regret that the preliminary report of the Isthmian Canal Commission, dated November 30, 1900, while furnishing arguments which fully justify the attitude of our company, contains conclusions which have caused our declarations and intentions to be judged incorrectly.

Our company ought not and would not infringe the express requirements of its concession laws. It could not, without the previous consent of Colombia, answer the questions which were put to it, nor the propositions which were made to it. By every means in our power we have sought to bring about the necessary intervention of your Government. Your presence and your action, as authorized representative of the Colombian Government at Washington, establish the proper situation in which our company should be placed in order to discuss the questions presented by the Government of the United States.

I shall not dwell further upon this subject, of which I have made a complete statement in the memorandum which I hand you and in which I shall note also some inaccuracies which the preliminary report contains on the subject of the situation and legal powers of our company.

Nor is it my intention to discuss here the technical part of the preliminary report of the Isthmian Canal Commission. This would be premature, and I should be compelled at present to confine myself within the limits of a general discussion. It is proper to await the detailed statements which the final report of the Commission must necessarily furnish to be able to make in a complete manner a critical comparison of the two routes of Panama and Nicaragua. I will limit myself to observing that the preliminary report as it stands proves incontestably the superiority of the Panama project, and, furthermore, I must make all reservations as to the comparative estimates of expenses which it contains.

I must further protest against the conclusions of the report which relate to the time of passage. We are ready to prove irrefutably that the difference of twenty-one hours shown in favor of Panama is much too small; that the real difference is at least three times greater, thus favoring the Panama project for each of the routes from San Francisco to New York, or to New Orleans, or to Liverpool. Now, in addition to this the Commission itself admits that the time for maritime voyages from the Atlantic ports of the United States to the west coast of South America is less by way of Panama than by Nicaragua.

Having stated all this and to reply, Mr. Minister, to the request contained in your letter of April 29, quoted above, I have the honor of informing you that our company will consent, if authorization therefor is given by the Colombian Government, to transfer its concession to the Government of the United States. All the conditions of this transfer will be fixed, of course, for the company outside of and independently of the particular arrangements which may be made between the Governments of Colombia and the United States.

The price of sale of the concession itself, of the works executed, material and installations, shares of the Panama Railroad Company, etc.—in short, of all the property of the New Panama Canal Company—would be fixed, so far as possible, by amicable valuations and agreement; but it would be understood, however, that if a considerable difference of opinion should arise, recourse would be had, as is just and equitable, to arbitration in the usual form.

It will also be necessary to determine, either by amicable agreement, or, if need be, by arbitration, the compensation which should be awarded to the company for the eventual profits which its concession would have enabled it to make; a compensation which may be represented either by an annuity, or by capitalized sum, to be proportioned in either case, of course, to the value of the property transferred by the company at the time when the transfer shall be made.

Everybody will understand, finally, that the promise to transfer its concessions can not bind our company for an indefinite time without danger of compromising the progress of its works and its general interests. We shall, therefore, ask to limit the effect of this promise to March 1, 1902, it being understood that all preliminary agreements shall be made before December 1, 1901, in order to be submitted, after approval by the shareholders' meeting of the company, for ratification by Congress at its next session.

Finally, Mr. Minister, I should remind you of the question which was also put to us by the Isthmian Canal Commission for the purpose of learning what share of control could be assigned to the Government of the United States, failing a complete transfer of the concession. Later the Commission refuses to enter into negotiation on its own propositions. At various times I had made various suggestions which are finally summed up in a letter of November 30, 1900. We are still ready to consider combinations of this character.

Kindly accept, Mr. Minister, with the assurances of my high consideration, the renewed expression of my devoted sentiments.

M. Hutin.

Legacio de Colombia,
Washington, May 3, 1901.

Rear-Admiral John G. Walker,
President of the Isthmian Canal Commission.

My Dear Sir: In consequence of the interview that I had the honor of having with you last month, I addressed a letter to Mr. M. Hutin, president and general director of the New Panama Canal Company, a translation of which I inclose, together with a copy of Mr. Hutin's answer.

I believe that these documents will be of importance to the Commission over which you so worthily preside.

In conformity with the wishes of the honorable Secretary of State, I would inform you that I am ready to answer, on behalf of the Colombian Government, the questions that the Commission may be pleased to present relative to the manner of bringing about an understanding between the two Governments for the construction of the Panama Canal.

I trust that the steps that have been taken will render manifest to the Commission the good will that animates both the Colombian Government and the Panama Canal Company to remove obstacles in the pending negotiations, and to dissipate any doubts that may have been entertained respecting their attitude toward the Government of the United States.

I remain, sir, yours, very respectfully,

Carlos Martinez Silva.

Department of State, Isthmian Canal Commission,
Washington, D. C., May 8, 1901.

Maurice Hutin, Esq.,
President of the New Panama Canal Company, Washington, D. C.

My Dear Sir: I have to inform you that I have received a letter from Señor Don Carlos Martinez Silva, minister of foreign affairs and minister to the United States from the Republic of Colombia, under date of May 3, inclosing for the information of this Commisson a copy of your letter to Mr. Silva of May 1, in which you state that your company will, if so authorized by the Colombian Government, sell and transfer its rights, concessions, and property to the United States, upon terms to be hereafter arranged. It appears also from this correspondence that the Colombian minister, acting for his Government, has authorized you to enter into negotiations, in behalf of your company, with this purpose in view.

Under these circumstances I desire to call your attention to a letter addressed to you by myself on April 10, 1900, in which certain questions were asked with regard to the sale and transfer of the property of your company, so that the Commission might obtain information which it required, in order to discharge its duties intelligently. You were not then in a position to reply fully and definitely to that letter, because of the terms of your concessions; but now that you have been relieved of the embarrassments under which you then labored, I am encouraged to hope that you will take the subject up once more, and give me such additional information as you feel at liberty to do, particularly in reply to the first and third questions contained in my letter of April 10, a copy of which letter I inclose, so that the Commission may be able to make a full representation of the subject in its forthcoming report for the information of the President of the United States.

I fully appreciate the courtesy that you have always manifested in your delicate and difficult position between the Colombian Government and the work of this Commission, and with an earnest hope that the way is now open to a satisfactory solution of the many perplexing problems which have been committed to you, believe me, my dear Mr. Hutin,

With great respect, always, your obedient servant,

J. G. Walker,
President of Commission.

Washington, D. C., *May 10, 1901.*

Admiral John Walker.

My Dear Admiral: I have never regretted so much as during these days, particularly to-day, being unable to speak English, in order to be able to inform you directly concerning our business. But I wish to tell you, now, that I shall send you an answer to your letter of the 8th instant as soon as I shall have had the necessary time to consider it; and since you will be absent for a few days, I shall send you the answer and hold myself at your disposal upon your return.

I beg that you will accept, my dear Admiral, the renewed assurance of my devoted sentiments,

M. Hutin.

Washington, D. C., *May 15, 1901.*

Admiral J. G. Walker,

President Isthmian Canal Commission, Washington, D. C.

My Dear Mr. President: I beg leave to acknowledge receipt of your favor of the 8th instant, by which you inform me that Señor Don Carlos Martinez Silva, minister of foreign affairs and minister to the United States from the Republic of Colombia, transmitted to you on the 3d instant a copy of the letter which I addressed to him upon his request on the 1st of the month.

I am obliged to you, Mr. President, for recognizing in your above-mentioned letter of May 8 that our company has not been until the present time in a position to answer certain questions presented by the Commission over which you preside.

Under the new conditions now actually existing it will be sufficient for the response which you desire to the first and third questions contained in your letter of April 10, 1900, to now confirm what I had the honor to write to Minister Martinez Silva on the 1st of the present month.

Therefore I beg to inform you that our company will consent, if authorization therefor is given by the Colombian Government, to transfer its concession to the Government of the United States. All the conditions of this transfer will be fixed, of course, for the company outside of and independently of the particular arrangements which may be made between the Governments of Colombia and the United States.

The price of sale of the concession itself, of the works executed, material and installations, shares of the Panama Railroad Company, etc., in short, of all the property of the New Panama Canal Company, will be fixed, so far as possible, by amicable valuation and agreement; but it will be understood, however, that if an important difference of opinion should arise recourse will be had, as is just and equitable, to arbitration in the usual form.

It also will be necessary to determine, either by amicable agreement or, if need be, by arbitration, the compensation which should be awarded to the company for the eventual profits which its concession would have enabled it to make—a compensation which should be represented either by an annuity or by a capitalized sum, to be proportioned in either case, of course, to the value of the property transferred by the company at the time when the transfer shall be made.

This being said, I must call your attention, Mr. President, to the necessity which we jointly have (according to my understanding) of examining afresh the second question of your letter of April 10, 1900, which refers to the legal powers of our company. It will be proper, in consequence, to correct certain statements on that subject contained in the preliminary report of the Isthmian Canal Commission.

Independent, however, of the foregoing, will you permit me, Mr. President, to say, as you have suggested in your letter of April 10, 1900, that it may be of interest to examine afresh the proposition contained in said letter, viz:

"What share of control could be assigned to the Government of the United States in the New Panama Canal and under what conditions."

In conclusion, I beg leave to say, Mr. President, that the promise made by the New Panama Canal Company to transfer its concession can not continue for an indefinite period of time. We shall therefore limit the effect of this promise to March 1, 1902, it being understood that all preliminary agreements shall be made before December 1, 1901, in order to be submitted, after approval by the shareholders' meeting of the company, for ratification by Congress at its next session.

I have the honor, my dear Mr. President, to express my high esteem and to be,

Your obedient servant,

M. Hutin,
President and Director-General.

Department of State, Isthmian Canal Commission,
Washington, D. C., May 16, 1901.

Maurice Hutin, Esq.,
President of New Panama Canal Company, Washington, D. C.

My Dear Sir: I have to acknowledge the receipt of your letter of yesterday in response to mine of the 8th instant.

You inform me that your company, with the consent of the Colombian Government, will transfer its concessions and property to the Government of the United States, the conditions of this transfer to be determined by negotiations outside of and independently of the particular arrangements which may be made between the Governments of Colombia and the United States.

This being the case, the next step will be to determine the price to be paid for the property of the New Panama Canal Company, which you suggest shall be fixed, so far as possible, by amicable valuation and agreement, with the understanding that if an important difference of opinion should arise recourse should be had to a just and equitable arbitration in the usual form.

As a basis for these negotiations there should be some expression of the views of the company as to the value of its property, and perhaps this can be done in no better way than by a specific reply to the questions asked you in my letter of April 10, 1900.

At the informal conference of yesterday you stated that no price could be fixed by you until after your return to Paris, where you could consult with the directors of your company and have free access to its books and accounts; and I presume, therefore, that no progress can be made in that direction until your return to Washington, which I trust may be at an early date, as it is important that this matter be fully negotiated with the least possible loss of time.

With regard to the question of compensation for the possible profits from the enterprise when completed, I would suggest the extreme difficulty, if not impossibility, of arriving at a correct estimate of such profits, and my present opinion is that this question should be considered in fixing the price for the property when sold, as the law under which this Commission is acting contemplates absolute ownership on the part of the United States.

Regarding the legal question—that is, of the ability of your company to give the United States a clear title to the property—I did not, in my recent letter, touch upon that matter because it is one which will in the end necessarily be determined by the law officers of the company and those of the United States, and no transfer of the property can be made until a clear title is obtainable. Your company has already given us much information upon this subject, but we shall be pleased to receive and consider any further facts or information that you may be able to furnish us.

Referring to my letter of April 10, 1900, in which I say that in the case of a negative reply to the first and second questions contained in that letter, you are invited to state how far the company will be able and willing to go in the direction of yielding control to the United States, and what compensation it will expect therefor, I have to say that this Commission being directed to furnish the President of the United States with complete information upon the question of a canal across the American isthmus, I made this inquiry with that end in view; but the law contemplates nothing less than a complete ownership and control of the canal by the United States, and as the New Panama Canal Company is now in a position to make a direct sale to the United States, that question need no longer be considered.

In the conclusion of your letter you state that you limit your promise to sell, etc., to March 1, 1902, it being understood that all preliminary agreements shall be made before December 1, 1901, in order to be submitted for approval at the stockholders' meeting of your company at its next session.

To this I have to say that, while there is no objection to December 1, 1901, being named as the date at which all preliminary agreements shall be completed, I suggest that the promise to sell shall stand until the end of the next session of Congress, in order that that body may have its entire session for a full and careful consideration of the whole subject.

Hoping that you may soon return to Washington prepared to carry this important matter to a satisfactory conclusion, believe me, my dear Mr. Hutin,

With great respect, your obedient servant,

J. G. WALKER,
President of Commission.

PARIS, *June 21, 1901.*

MR. PRESIDENT: By your letter of May 16 last you kindly asked us to extend, until the end of the next session of the Congress of the United States, the time during which would remain binding the promise made, subject to the reserves and under the conditions mentioned in your letter of May 15th, to transfer our concession to the Government of the United States.

I have the honor to inform you that after examination with my colleagues of the board of directors it has been decided to accede to your desire.

Our board of directors (council of administration) is undertaking a careful study of all the questions which are brought up by the project to transfer our concession to the Government of the United States, and I will inform you, in the shortest possible time, of the resolutions (decisions) which may have been adopted.

I beg that you will accept, Mr. President, the assurances of my high consideration.

M. HUTIN,
The President of the Council of Administration.

Admiral JOHN G. WALKER,
President Isthmian Canal Commission,
Corcoran Building, Washington, D. C., United States.

[Cablegram.]

PARIS, *June 28, 1901.*

ADMIRAL WALKER,
Corcoran Building, Washington:

We confirm our letter dated June 21. We will send you in about a fortnight, in accordance with letters exchanged May 8, 15, 16, detailed valuation company property. Please advise us at what date you shall have examined results, that we shall send and gather elements of your own valuation, so that on either side we may be able to discuss contradictorily.

HUTIN.

DEPARTMENT OF STATE, ISTHMIAN CANAL COMMISSION,
Washington, D. C., July 3, 1901.

MAURICE HUTIN, Esq.,
President, New Panama Canal Company, 7 Rue Louis le Grand, Paris, France.

MY DEAR MR. HUTIN: I have the honor to acknowledge the receipt, on the 28th of June, of your cablegram of the same date confirming your letter of June 21, which reached me on July 1.

I shall await the receipt of the detailed valuation of your company's property, which I shall hope to receive at an early date.

Believe me, my dear Mr. Hutin, with great respect,

Very sincerely yours,

. G. WALKER,
President of Commission.

[Cablegram.]

PARIS, *July 25, 1901.*

Admiral WALKER,
Corcoran Building, Washington:

We intend sending you by next mail detailed valuation company's property, but preparation has required much more time than contemplated. Can you tell us by cable up to what date you will remain in Washington, or whether will be absent on account of season, and whether we might examine together contradictorily our valuation as early as beginning September, or can you name a date at your convenience?

HUTIN.

[Cablegram.]

WASHINGTON, *July 26, 1901.*

PANANOVO, *Paris:*

Will give valuation prompt attention when received. Will take up discussion here upon your arrival.

WALKER.

[Cablegram.]

PARIS, *September 14, 1901.*

Admiral WALKER,

Corcoran Building, Washington:

Under sad present circumstances, do you still think I should meet you in Washington about October 1?

HUTIN.

[Cablegram.]

WASHINGTON, *September 14, 1901.*

PANANOVO, *Paris:*

If you intend naming price for property and concessions there should be no delay.

WALKER.

[Cablegram.]

PARIS, *September 25, 1901.*

Admiral WALKER,

Corcoran Building, Washington:

Boyard has sailed Saturday last on *Champagne*, carrying document which he will hand you. Myself will sail Saturday next on *Savoie* and join you Washington.

HUTIN.

[Telegram.]

NEW YORK, *September 30, 1901.*

Admiral J. G. WALKER,

President Isthmian Canal Commission, Washington, D. C.:

Steamer delayed. Arrived only this morning. Will go Washington to-morrow afternoon, Tuesday, and call at your office Wednesday morning to deliver you documents as per cable Mr. Hutin. If not convenient to you, kindly wire my office to-morrow morning early.

X. BOYARD.

NEW YORK, N. Y., *October 10, 1901.*

Admiral J. G. WALKER,

President Isthmian Canal Commission, Washington, D. C.

DEAR SIR: By a cable received yesterday from my company in Paris I am requested to respectfully inform you that Mr. Hutin sailed yesterday from Cherbourg on the steamer *Kaiser Wilhelm.*

I believe Mr. Hutin will be in New York on or about the 15th of October, and will at once communicate with you.

Yours, very respectfully,

X. BOYARD.

DEPARTMENT OF STATE, ISTHMIAN CANAL COMMISSION,
Washington, D. C., October 11, 1901.

X. BOYARD, Esq.
24 State street, New York, N. Y.

MY DEAR MR. BOYARD: Your letter of yesterday reached me this morning. I am glad to know that Mr. Hutin has sailed for New York. Trust he will have a speedy and pleasant passage.

Time is becoming an important element with this Commission. Its report has been delayed pending a conference with Mr. Hutin, but it will soon be called for by the President and it is of importance that Mr. Hutin should come here as promptly as possible, that our conference with him should be expedited in every practicable way.

Will you please say to him that I trust he will lose no time in coming to Washington?

With best wishes, believe me, my dear Mr. Boyard,

Very truly, yours,
J. G. WALKER,
President of Commission.

PARIS, *October 4, 1901.*
(Received in Washington October 17, 1901.)

MR. PRESIDENT: In the letter I had the honor to address to you from Washington on May 15 last, in answer to yours dated 8th of same month, and in consequence of the communications from Señor Martinez Silva, I stated that this company would agree to transfer its concession and property to the United States Government if it was so authorized by the Government of Colombia, and I defined the general conditions under which such a transfer might be effected, as follows:

"The selling price of the concession itself, work done, plant and machinery, Panama Railroad stock, etc., and all the property of the New Panama Canal Company, should be determined, wherever possible, on valuations and by an amicable understanding. It shall be understood, however, that in case a serious difference of opinion should arise, arbitration, in its customary form, as it is just and fair, should be resorted to.

"It shall also be necessary to determine, either by an amicable understanding, or if needed by arbitration, what compensation shall be allowed to the company for the possible profits it would have derived from its concession, which compensation might be represented either by an installment or by a capitalized amount, the one and the other corresponding both to the value of the property transferred by the company at the time of effecting the transfer."

In your letter of May 16, acknowledging receipt of my previous letter, you were kind enough to suggest that:

"This being the case, the next step will be to determine the price to be paid for the property of the New Panama Canal Company, which you suggest should be fixed, so far as possible, by amicable valuation and agreement, with the understanding that if an important difference of opinion should arise recourse should be had to a just and equitable arbitration in the usual form.

"As a basis for these negotiations there should be some expression of the views of the company as to the value of its property, and perhaps this can be done in no better way than by a specific reply to the questions asked you in my letter of April 10, 1900."

You added, Mr. President, that, as to the question of compensation for the possible profits to be derived from the undertaking when completed, it seemed to you that there was an "extreme difficulty, if not impossibility, of arriving at a correct estimate of such profits, and my present opinion is that this question should be considered in fixing the price of the property when sold, as the law under which this

Commission is acting contemplates absolute ownership on the part of the United States."

On my return to Paris I brought to the knowledge of the board of our company the letters exchanged with your good self on May 15 and 16 last, and of which the above quotations are the essential paragraphs. I pointed out the necessity of answering to our mutual views and of giving satisfaction to the ideas expressed in our above letters, by effecting, on our part, a complete work, with the object of determining the pecuniary value we thought it fair to put on the whole of rights, privileges, and property we would have to transfer to the United States Government when transferring our concession. The board appointed a commission of three of its members to accomplish the said investigation, which required long and difficult researches in the engineering records of both the old and the new company.

This Commission has submitted the result of its investigations and estimations both of the value it deemed fair to put on the property we should have to transfer of the kind of compensation to be applied, accounting, in the fairest way possible, for the possible profits we would have derived from our concession, in a very elaborate note, the general ideas of which were approved by the board, and which I beg to inclose herewith as a document for discussion.

This note shows for every portion of our contribution the amounts which, according to the constitutive elements of property included, appear to represent a fair estimate of the value of each, as it would result from the actual advantages to accrue to the United States from the acquisition.

You will kindly note that we have viewed these values in their intrinsic consistence, in what they really are in themselves, without any reference to their relation with the comparative expenses of either canal; in short, for the portion of usefulness they actually represent in the Panama Canal undertaking, supposed to be completed and regarded solely in itself. They represent what might be called the real and absolute value of our contribution.

We might have followed another course, showing the relative advantages to be derived from the completion of the Panama Canal as compared to the construction of the Nicaragua Canal. But if the latter became necessary, we think it would be useful to proceed to make such an estimation of the relative value of our contribution only when a more perfect knowledge will be reached of the conditions of a possible project of a canal through Nicaragua.

I hasten to add, Mr. President, that these are but the amounts to which we have come from a personal estimation of the elements to be discussed contradictorily in our negotiations and which, as a result of such contradictory discussion, themselves might be altered to a more or less important degree. Such is therefore, properly speaking, the first expression of views of our company, to which you have referred in your letter of May 16, last, as being to form the basis of discussion on our side in the proposed negotiation, which negotiations we shall take up, as you may be sure, with the most earnest wish to reach an amicable understanding. With that object in view, we are willing to follow a sincere course of conciliation and concessions, with the hope that we may be met from the other side with the same spirit and the same desire to conciliate, in an equitable manner, the weighty interests which are confronted in the subject.

I further beg to state, Mr. President, that, in view of the above-shown good will and in consideration of the large amount of French money invested in the Panama Canal undertaking from the beginning, we think we are justified in asking, without any purpose on our part to interfere with matters relating to the future control of the proposed isthmian waterway, that the French merchant ships may be treated on a foot of absolute equality with the merchant ships of the United States.

Believe me, Mr. President, respectfully and devotedly yours,

M. Hutin,

The President of the Council of Administration.

A STUDY CONCERNING THE ESTIMATED VALUE OF THE FRENCH COMPANY'S CONTRIBUTION TO THE CANAL UNDERTAKING IN CASE OF A TRANSFER OF OUR CONCESSION TO THE UNITED STATES GOVERNMENT.

From whatever standpoint, a priori, we may consider the principles which must be taken as a rule for the determination of the pecuniary compensation that would be due to the Panama Company for the transfer of its concession and property to the United States Government, whether those principles be based on the consideration of the commercial value of the property and the possible profits expected to be derived therefrom, or on the simple consideration of its intrinsic value, as resulting from the expenses involved in its construction, it is plain that the first and vital element to be considered and, therefore, determined in the discussion, is the actual value of the advantages represented by the cession of all that has been already accomplished in the interoceanic canal undertaking supposed to be brought to conclusion. We think it is fair to estimate the various elements as follows:

Elements Concerning the Real Value Proper of our Contribution.

Our contribution consists in two portions of an essentially different character—

FIRST PORTION.

A first portion is represented by property having in itself an immediate marketable value independent from the possible results of operation, and not forming a necessary part of the canal undertaking itself. This property, which has properly the character of private property, is as follows:

First. The stock of the Panama Railroad Company, which is held by the canal company.

Second. The buildings, lands, and real property, constituting the company's private estate, which by reason of their destination itself are not given an ephemeral existence only, dependent on the time of canal construction; such are the company's buildings at Panama, the various inhabitations constituting the block of houses of Christopher Columbus, the inhabitations erected along the canal line, as lodgings for the officers of the company, and which are to be maintained after the conclusion of the work.

Third. The important property as represented by the Panama and Colon hospitals, and the price of which, as admitted by the isthmian Commission, is not to be included in the estimated value of the work done by the old company on the canal. We are not referring here to the landed property granted to the concessory company under article 4 of the concessions, besides the canal itself, and which there is no reason to transfer together with what concerns the canal itself.

We will now state the values which we think must be given to these various elements:

Stock of the Panama Railroad Company.—The old company had bought 68,534 shares of this stock. The new company bought 329, making a total of 68,863 shares.

The amount paid for this total quantity is 93,411,834.60 francs.

The Isthmian Commission found that it would be fair to pay for this stock the par value thereof, which is $100 a share, or a total amount of 36,000,000 francs.

Neither of these figures do we think fair. In fact, the Panama railroad stock has an intrinsic value, to be estimated according to the chances of profits it may yield in the future and under circumstances that may be anticipated. The United States Government should pay for it to the company on same terms as it would pay for the stock to a private individual who would be holder thereof and willing to transfer, with neither gain nor loss as to profits he expected to derive therefrom, which profit would, after transfer, accrue to the party who would hold the stock. In short, the company by transferring the stock is entitled to claim a compensation equal to the profits it would derive from the stock if kept.

Besides the results of normal operation, which it is impossible to foretell and appreciate, the Panama Railroad Company is expected to derive, during the period of canal construction and from the construction itself, in view of the large transportation traffic that will be occasioned thereby, very important profits, an idea of which may be formed from the experience of the past and which are such as to constitute for the stock a value which should fairly be accounted for when selling it, since it is sold precisely in anticipation of the canal being completed.

In the years from 1881 to 1889, a period during which the operations of the old company gave rise for the railroad to an active local traffic, the stock of the Panama Railroad Company yielded an average dividend of 13.75 per cent a year. It is but reasonable to expect that during the eight-year period assigned for the completion of the work to come, the Panama Railroad shall, by the sole fact of these operations, derive profits which will allow, during that period, of an average annual dividend of 13 or 14 per cent. The mere discount of such an exceptional income would justify by itself an allowance to the Panama Railroad stock, at the time of resuming work, of a selling value of about 500 francs per share. On the other hand, it is certain that after the construction of the canal the railroad will remain most valuable as a means of transportation by reason of the increase in local population and production, which shall not fail to take place on the canal territory. The Panama Railroad stock may therefore expect profits after the canal is completed, and it should also be allowed a certain selling value at that time, which value we think may be regarded as equal to a compensation of 300 francs to be paid at present.

It is useful here to call attention to the improvements made from time to time on the railroad, and which help to add to its value, such as the recently constructed La Boca terminal.

In this connection consideration should be given to the large interest which the constructor of the canal has in owning the bulk of the stock, which empowers him to exercise a controlling influence for the use of the railroad in the execution of the work on most favorable terms, and will enable him later on to reach an amicable understanding with the Panama Railroad as to the possible rights conferred upon it by the concession in case a canal should be constructed through the part of the isthmus crossed by the railroad. From the above considerations, which were amid the motives that have induced Count de Lesseps to put in possession of the canal company nearly the whole of the stock, we may infer, with the best chances to be on the safe side, that the selling value to be given to the Panama Railroad stock if the company chooses to dispose of it to the United States Government, which it is willing to do, without it being absolutely necessary for the completion of the canal, must not fairly be estimated below 800 francs. The number of shares owned by the company being 68,863, that would make a capital of 55,000,000 francs in round figures to be allowed to the company as a consideration for this transfer.

Buildings and property constituting the private estate.—The estimation of this special property is not an easy task, because the expenses they represent are partly mixed up with the expenses included in the estimation of work of canal construction.

Under our estimates, based in part on the investigations into the accounts of the old company and in part on direct estimate, we are induced to fix the value of this property at 9,000,000 francs.

Hospitals at Panama and Colon and dependencies.—The cost of this property was about 4,500,000 francs, and could not be put to-day at a lower figure. There is even ground for contending that, by the further improvements effected thereon, and by the cultivation of important depending lands, this property acquired additional value.

This portion of our contribution, the elements of which we have just shown—that is to say, the portion of the company's property which has the character of private property and represents a capital to be due to it at the time of the transfer—might be made the object of either an immediate payment of that amount or of installments to be determined according to a method of division to be agreed upon.

We deem it useful to point out here that the possession of this property by the constructor of the canal, whoever he may be, is not an absolute necessity, although the company be willing to dispose thereof to him, if he finds therein a serious interest. There is no obligation inherent to the circumstances, and we think the company would prefer to keep it rather than transfer it on too unfavorable terms.

SECOND PORTION.

The second portion of our contribution is represented by property which derives essentially its value from the use that may be made of it in the work of completion of the canal. It consists in all that has been usefully done or prepared for the execution of the canal by both the old and the new companies. It is composed of various elements, which we shall now estimate in turn:

The first element is composed of the amounts actually expended for the payment of the concession as now defined.

The whole of the amounts paid, either in cash or by fully paid stock, amounts to 32,000,000 francs. As, however, the fully paid stock, which has been transferred for this special object, does not represent an actually expended capital—although it is entitled to share with the other stock the right to participate in the price of the proposed transfer, and on that account ought to be considered as expended capital—we shall not take it into consideration, but will only retain on the above figure the amount paid in cash, 22,000,000 francs, to which must be added for accrued interest on a portion of this capital (5,000,000 during 8 years) 2,000,000 francs, bringing the figure to 24,000,000 francs.

The second element is of a different determination, and necessarily dubious to a certain degree. The total amount of excavation done by the old company and the new company must first be established, and then the amount which is now without object as to the realization of the proposed lock canal must be deducted therefrom, in order to retain the real amount only that is useful for the final construction of the canal. Then the average cost to be credited to that amount of excavation is to be determined, by taking into consideration every element that plays a part therein, such as the first cost of organization, establishment of works necessitated by the excavation of that amount and regarded as redeemed in its cost, amortization of the plant employed for the excavation, as well as the establishment of workshops and laborers' quarters which it has necessitated. We shall consider separately what has been done by the old company and what has been done by the new company.

The old company, as regards work proper concerning the canal and the diversion of streams which formed a completing portion, has done excavation only. The total amount it has excavated, according to statements rendered on different occasions, and particularly in the reports of legal experts appointed after the failure of the company, is in round figures 50,500,000 m. c., divided as follows for the different sections:

	m. c.
Section from Colon to Bohio, Colon (kilometer 23. 5) Harbor, canal, and diversions	20, 500, 000
Section from Bohio to Obispo (kilometers 23. 5 to 45)	9, 500, 000
Section from Obispo to Paraiso (kilometers 45 to 57), the diversion included	11, 500, 000
Section from Paraiso to end of canal	9, 000, 000

Of these amounts, a portion executed for a tide-level canal will be useless for the lock canal. Certain portions of diversions executed in order to meet the provisions of the tide-level plans are also now without object, in view of the lock-canal plan.

Such amounts as have become without object should be deducted as erroneous operations, since it is proposed to determine the real value of useful cooperation of the old company in the final canal work as now proposed. The corrected amounts, after the necessary deductions, are as follows:

Section from—	m. c.
Colon to Bohio	17,000,000
Bohio to Obispo	4,700,000
Obispo to Paraiso	10,500,000
Paraiso to end	9,000,000
Total of available excavation by the old company	41,200,000

To which must be added the amount excavated by the new company in the big cut and in the Pacific tide-level section, which amount on the 1st of January, 1902, should be fixed at 8,500,000 m. c.

But it must be stated that of the amount of excavation done by the old company in the level from Colon to Bohio, and the left side diversion corresponding to that level, an important portion has been filled in by the silt from the Chagres and other streams that invaded that portion of already deepened river beds. The amount of that silt is about 5,000,000 m. c.

A similar fact is to be noted in the section from Paraiso to end of canal; an amount of silt of about 2,000,000 m. c. has partially filled up the excavations of the old company.

It would be quite unfair to deduct these amounts from the amounts originally excavated, crediting the company with the surplus only. The removing of this silt will be, in fact, a great deal easier and less costly, especially at present, than the removal of original river bed it has filled up. With the removal of this silt the work done by the old company would be wholly restored. The only deduction that ought fairly to be made on this account from the value of the work of the old company is that resulting from the expenses now to be incurred for the removal of the silt.

We have now to figure out the value to be given to the work of the old company, determined by quantities, according to what has been said. With that object in view, we must find out the average unit prices that we fairly may apply to the usefully excavated amounts, taking into consideration all circumstances and difficulties that would affect those prices if the work were to be done under the same general conditions as in the past; the expenses that would be represented by the preliminary work; the organizations of the beginning and the establishment of the works for an undertaking of such magnitude. Of course, it must be supposed that all that would have been accomplished with the same competence and prudence as those supposed to be used in the execution of future operations. It would be obviously unfair to apply to the estimation of such original work, as was done by the Isthmian Commission in its preliminary report, the unit prices the Commission took as a basis for the work remaining to be done. For not only will the latter benefit by all the installations and by the organization realized at great cost for the former, as well as by the improvement in the sanitary conditions resulting from the original work, but also all the expenses of preliminary work and organization, expenses which are always important, are covered by the work already done. The same remark applies to the enormous quantity of machinery that was to be provided for their execution, and part of which may be used for the execution of the others free of cost, if we include the value of the useful machinery in the cost of the work already done. Such is also the case as to installations on labor places which we shall suppose as having been paid by this original work, and which will be useful for the execution of the others. Finally, we must not lose sight of the fact that the work done derives for the greater part the advantage it represents precisely from the fact that it is now accomplished, thus reducing the time required for the opening of the canal by this route. It must therefore be estimated at the cost required for its execution in the past when the unskilled labor, the unit of which was and remains the Colombiam silver dollar, was worth, all things being equal, nearly twice what it is worth now.

Supposing that the unit prices adopted by the Commission (which, it says, are the same as for the Nicaragua Canal) are a fair average for the whole of the Panama Canal work, if everything was still to be done, it would be quite contrary to equity and experience to hold that, under similar conditions as to the nature of the soil, the original work done under the pressure of all the difficulties and indirect expenses of the beginning, should be estimated at the same unit prices as the last work to be done that is to follow and will benefit by all the facilities of execution created and paid for by the original operations at great cost, as if it was to be added to the latter as an additional bulk to be executed under the same conditions. In short, the work remaining to be done ought to cost a great deal less than the average of the whole, and the original work a great deal more than that average. We think that, whereas we include in the cost of the original work all of the preliminary and indirect expenses, all the expenses of establishments on the canal works, workshops, storehouses, etc., all the expenses of machinery used up or yet valuable as apt to be employed in the future, all the expenses for installations affecting the laborers' quarters, by which the future work will also be benefited; whereas, finally, the labor price at the time of construction of that work was about the double of what it has been supposed it shall be for the execution of the remaining work, we are conservative in admitting on a principle, and as a general proposition, that the estimate of work done should be established by adding an average increase of 3.50 francs per cubic meter to the result that would be obtained if to that work were to be applied the unit prices we took as a basis for the estimate of the work remaining to be done, in which estimate it was supposed that everything that had to come from the old company would be used free of cost by the future constructor.

The average unit prices adopted by the International Technical Committee for the work remaining to be done are as follows:

	Francs.
Section from Colon to Bohio, average price	3.20
Section from Bohio to Obispo, average price, applicable to work remaining to be done	4.00

Section from Obispo to Paraiso.—These are mainly the operations in the big central cut. The soil excavated by the old company is without analogy as to the difficulties it would occasion, in the remaining part; it was a surface clay that, in the climate of the Isthmus, constituted a more costly excavation than the hard soil remaining to be removed, which, as a future price, is estimated at, 5.50 francs per cubic meter. It is certainly quite conservative to discuss on that basis.

Section from Paraiso to end of canal.—The average price to be applied to the work remaining to be done is of 3.40 francs per cubic meter.

If now we apply these estimate basis prices to the amounts of excavation above stated for each section, we reach the following estimates which would represent the theoretical cost of their excavation if they were included simply as an additional bulk in the work remaining to be done, with all the facilities that now exist for this future work. By adding a general increase of 3.50 francs per cubic meter to the total thus obtained, we shall have an estimate that we deem may fairly be admitted for the value of that original work, including all the indirect expenses connected therewith, all the preliminary cost of organization and installations, all the used-up or still available values of machinery, of existing installations or working places, installations of workshops and laborers' quarters which will be used for future work, taking further into consideration the value of the labor unit at that time, the difficulties and risks of climate as they existed at the time of their execution:

	Francs.
Section from Colon to Bohio	54, 400, 000
Section from Bohio to Obispo	18, 800, 000
Section from Obispo to Paraiso	57, 750, 000
Section from Paraiso to end of canal	30, 600, 000
Grand total	161, 550, 000

As the general available amount is of 41,200,000 m. c., if we apply to it an increase of 3.50 francs per cubic meter we shall have a sum of 144,200,000 francs to be added to the preceding one, and giving the total of 306,000,000 francs (in round figures) to represent the cost that is to be named for the construction proper of the useful work of the old company; that is, the money usefully expended on the ground for that construction.

This total shows an average price of 7.40 francs per m. c. for the whole of the excavation done by the old company and available for the final construction of the canal. The amount actually removed by the old company was, as shown above, about 50,000,000 m. c. The expenses incurred on the Isthmus and paid by the company or the receiver for the execution of that work, including the preliminary organization expenses, the installations on the works, the expenses for construction, machinery, workshops, storehouses, and laborers' quarters, but not including the general administration expenses and the intercalary interest for capital account, amounted to 730,000,000 francs. (This amount does not include expenses concerning hospitals, buildings, and land constituting the company's private estate.)

The average cost per m. c. was therefore 14.60 francs, while the cost resulting from the above estimate of the value of useful work, forming a part of our grant, is but 7.40 francs. This comparison is an evidence of the conservative spirit we are showing when adding an increase of only 3.50 francs per cubic meter to the cost of original work, estimated as if it was to be done under the conditions of future work. To that must be added the general expenses of administration in Paris and on the Isthmus, the general office expenses, police, sanitary, department, etc.

As a rule, 8 per cent of the direct expenses incurred in the work are taken on that account for large undertakings, accomplished under normal conditions; it may be safe to adopt here a proportion of 12 per cent, which would give for the above total an increase on general expenses of 37,000,000 francs, and bring the total up to about 343,000,000.

This amount represents the funds that were to be raised and expended if for the method of conducting business which has been put in practice by the old company was to be substituted, by a hypothesis, another method, meeting all objections, as it is presumed will be applied in the future. But as such funds, as usually, would be raised by public subscriptions, there should be added to the above amount the expenses to be incurred for issuing the securities and for intercalary interests that would accrue on the capital during the period during which the works have been prosecuted. Estimating such interests at 5 per cent for an average period of four years for the whole of the capital, and adding 5 per cent in bulk for the expenses to be incurred for issuing securities, an increase is reached of 25 per cent, to be added to the above amount, and finally we get a total figure of 429,000,000 francs, representing the present value at which is to be estimated the portion of contribution resulting from the work done by the old company and available for final canal construction.

But, as previously stated, a portion of available excavations, executed on line of canal or on the diversions corresponding to the tide-level sections, has silted up, and it is necessary to remove that silt in order that the work of the old company may be restored. Therefore the expenses of this removal are to be deducted from the value of its contribution previously estimated. The amount of silt to be removed is of about 5,000,000 m. c., including the diversions on the Atlantic side and 2,000,000 m. c. on the Pacific side. The expenses of such work (the work being easy, as there is but silt and mud) may be estimated at 14,000,000 francs all included. The final value of the available contribution of the old company, determined at this date, or to take a formal date, on January 1, 1902, should be fixed at 415,000,000 francs.

To the work of the old company must be added the work done by the new company in order to determine the part of cooperation represented in the final canal construction by the whole of the work now done. To estimate the portion of grant to be credited on that account to the operations of the new company, it is sufficient to take the total figure of real expenses it will have incurred up to January 1, 1902, as no question could be raised as to the efficiency and economy of its expenses. These expenses, including general expenses, may be fixed at the round figure of 40,000,000 francs.

The last element remaining to be estimated in order to determine the total figure of what constitutes the second portion of our contribution is the element represented by the technical surveys, by data of all kinds collected on the Isthmus to be used as a basis for the investigations, and by the plans made on such investigations, explorations, and experimental work, etc. The said portion of expenses can not be directly estimated. But it may be fairly figured out by applying, as is usual in that case, a given percentage to the total amount of expenses that would represent the work of the canal proper supposed to be completed. It will be very conservative in this matter to adopt the coefficient percentage of 1.50 per cent, generally used for the surveys of large undertakings accomplished under normal conditions. The total amount of canal work, by adding to the expenses remaining to be incurred for the completion the expenses reasonably representing the work already done, may be estimated very approximately at 1,200,000,000 francs. The value to be credited to the surveys is therefore 18,000,000 francs.

Compensation for the Possible Profits as May Result from the Operation of Our Concession.

In the foregoing note we solely sought to determine what intrinsic value should be given to our actual contribution consisting in the work already done and other property we own on the isthmus.

The president of our board of directors, in his letter of May 15, 1901, to the president of the Isthmian Commission, suggested that it would be fair to account to the French company by prorating on the actual value of its contribution for the possible profits it would have derived from the concession if it retained the operation of it. The president of the Commission, while pointing out the difficulties, if not the impossibility, according to his opinion, of estimating such profits, intimated that in his judgment they might be accounted for in the selling price of the concession itself. We beg to state here how we think the question might be disposed of in the premises.

As previously shown, the French company's contribution consists in two portions, having each an essentially different character. The first is constituted by property having the character of private property. Whatever may be the figure it might be fixed at in negotiations to come, this will always be a property having its own value, independent from the chances of canal operation, and which must in every case form the object of a simple payment, either through immediate capital or by installments representing the equivalent of the capital that would have been paid immediately. The rate of interest on which to base the calculation of said installments would be the rate of interest that the company could safely get by the investment of the capital if it were paid in immediately.

The second portion of our contribution, the value of which we have analyzed up to January 1, 1902, in the elements of useful expenses that help constituting it, and which, in the proposed negotiations, will finally be estimated at a figure that we suppose represented by A, is formed by property and accomplished work that have no marketable value in themselves, but derive their value from their usefulness for the work of completing the canal. It may safely be called a commercial value, the income of which, if things were to follow their natural and normal course, would be variable and dependent on the net earnings to be derived from the operation of the canal itself. It would seem quite reasonable and fair that in consideration of this portion of our contribution, we should be allowed not a given capital equal to A or fixed installments equivalent of such capital, but an annual income from such capital that would be variable, according to the earnings derived from the operation of the canal supposed to be conducted on a profit-making basis. Thus would be realized the idea to include incidentally in the selling price of our concession, and of what we have done to accomplish the object thereof, the chances of possible profits we are to derive from it. There is no intention on our part to endeavor to estimate what said profits might prove in the consecutive years of the concession term; that would be a very unsafe operation without any practical value, because we would first have to imagine in an absolutely hypothetical manner the traffic the canal would furnish in the series of years succeeding its opening to navigation. It would be reasonable, on the contrary, to work in the same train of thought for a solution of this question by taking as an object of the study no longer the expected average income for the term of the concession or the expected annual income in the consecutive years, but only the earnings corresponding to annual amounts of tonnage that might be expected to turn out consecutively at undetermined times, and leaving the attribution of installments to be derived therefrom dependent on the actual realization of tonnage that had been used as a basis for their determination.

After determination of the quota of annual income that would accrue to the capital invested in canal construction, according to such or other circumstances of traffic in an industrial operating system reasonably conducted, there should be deducted from such a quota the normal interest incidentally involved in the installments allowed to the capital A, representing the interested contribution of the French company, and there should be allowed to it as a compensation for possible profits the additional normal interest in connection with the variable quota corresponding to the consecutively noted traffic. In such direction does it seem to us must be sought the compensation that it will be fair to allow to the company for the possible profits that it would have derived from its concession.

The investigation we have made into that subject, the developments of which are too long to be given here, has led us to the following results:

Supposing the fixed installments that would be allowed to the company as an equivalent of the sum A, at which figure the actual value of its contribution was to be fixed, provide in their calculation for an interest of 4 per cent, for instance, the additional income to be credited to it in consideration of possible profits of its concession would, according to actual conditions of canal traffic, be determined as shown in the following table:

Annual tonnages.	Additional income in consideration of possible profits.
	Francs per ton.
7,000,000	0.50
8,000,000	1.00
From 8,000,000 to 11,000,000	1.50
From 11,000,000 to 16,000,000	2.00
From 16,000,000 to 19,000,000	2.50
20,000,000 and more	3.00

DEPARTMENT OF STATE, ISTHMIAN CANAL COMMISSION,
Washington, D. C., October 18, 1901.

MAURICE HUTIN, Esq.,
President New Panama Canal Company, Washington, D. C.

DEAR SIR: Your letter, dated Paris, October 4, 1901, with the accompanying paper relative to the value of the concessions, property, and unfinished work of the Panama Canal Company, has been received and carefully considered.

I had hoped that upon your return from Paris you would be prepared to give a definite answer to the third question which was submitted to you in my letter of April 10, 1900, to wit, "For what sum of money, in cash, will the company transfer to the United States all of the rights, privileges, franchises, property, etc., of every description which it owns or controls in connection with the construction of a canal across the Isthmus of Panama?"

No direct answer had been made to this inquiry prior to November 30, 1900, when the Commission submitted its preliminary report to the President of the United States, and it was understood in our informal conferences that this question had not been answered because your company felt embarrassed by its relations with the Republic of Colombia, for the reason that the concession under which it is authorized to construct the canal did not then permit you to enter into negotiations for a sale of its property to a foreign government.

At a later date information reached me that the Colombian Government had relieved you of this embarrassment, and that you were at liberty to take up the subject with the Commission, and our conferences and correspondence were renewed.

On the 8th of May last I addressed a letter to you, calling your attention to the inquiries contained in my letter of April 10, 1900, and asking specifically for a reply to the first and third questions contained therein.

On the 10th of May you acknowledged the receipt of my letter and promised an early reply. The answer was afterwards received, dated May 15, 1901, expressing, in reply to the first question, a willingness to sell and transfer to the United States the canal property and concessions, if authorized by the Colombian Government, but there was still no direct response to the question as to price.

You stated that the value of the property would be fixed so far as possible by amicable valuation and agreement, with recourse to arbitration if an important difference of opinion should arise. At our subsequent conferences, and in my answer of May 16 to this letter, without replying to the suggestion as to the manner in which you would fix the value of the property, and without inquiry as to the basis and conditions of the arbitration suggested by you, I again called attention to my letter of April 10, 1900, and stated that there should be a specified reply to this third question as a basis for future negotiations; but your answer was deferred until your return to Paris, so that you might there consult with the directors of your company and have free access to their books and accounts.

The paper you now submit does not yet give a definite answer to the question, but it contains the elements from which a final sum can be ascertained. In the conferences which Mr. Pasco and myself have had with you during the past two days we have informally discussed the views presented in this paper, and have directed your attention to such items as seem objectionable, so that you might consider the causes of objection in preparing the final and definite offer to be submitted by the Commission to the President of the United States in its report. It is, perhaps, well to state the most important of these objections briefly in this formal reply to your letter.

1. The value of the shares of the Panama Railroad Company is estimated by you at about $3,500,000 higher than the estimate of this Commission in its preliminary report, and we are of the opinion that this property should not be estimated at so high a value.

2. The price for the canal concession and the interest charged upon a part of the money paid for the original contract with Colombia, was objected to as excessive because this concession will not serve the purpose of the United States, if it undertakes the completion of the canal. In that event a new contract must be arranged with the Government of Colombia by treaty, displacing that which now exists between the Republic and the Panama Canal Company.

3. The amount fixed for the work already done upon the canal project is also regarded as excessive, and is far beyond the value of the work as estimated by the Commission. Some of the reasons for this excess are that the company's estimate includes a valuation of the large amount of plant, machinery, locomotives, dredges, etc., now stored upon the isthmus in sheds and warehouses, which will not, in the opinion of the Commission, be of value to the United States, should it undertake the completion of the canal.

After stating the value of the work done by the old company, at a price considerably greater than estimated by this Commission, it is increased in your estimate by an additional charge of 3.50 francs per cubic meter, and to the increased price is added 12 per cent of the whole amount for "the general expenses of administration in Paris and on the isthmus, the general office expenses, police, sanitary, department, etc." To this sum is added 25 per cent for expenses "incurred for issuing the securities and intercalary interest that would accrue on the capital during the period during which the works have been prosecuted."

We have carefully considered the reasons stated for these additions, but are not convinced that they should be made.

4. The last part of the paper presents a claim for a share in the possible profits of the canal when completed. The law under which the Commission is acting contemplates the construction of a canal to be under the "control, management, and ownership of the United States." A proposition to share in the profits, upon any basis, is not likely to meet with the favorable consideration of Congress.

The price ultimately fixed by the company should be for an absolute sale of the Panama canal project, without any reservation whatever. If the United States purchases the property of the Panama Canal Company and incurs all the risk of a canal enterprise we do not accept your view that the company will have any basis for a claim in the profits which may accrue from its successful operation and management.

We will gladly confer with you further as to the items contained in your paper and aid you as far as we properly can in presenting any proposition you may desire to make with reference to the sale of the rights and property of your company to the United States Government.

When you have fully determined upon your proposition, or agreement, with reference to a sale, whether it be a definite offer of a fixed sum or of a sum to be fixed "by amicable valuation and agreement," recourse to be had to arbitration "if an important difference of opinion should arise," we will submit it in our report to the President; but we still believe that the direct offer of a fixed sum is much to be preferred.

In our recent conferences you have proposed that there should be an agreement between ourselves as to the value of the rights and property of the Panama Canal Company and an arbitration to conclude the matter in case of a disagreement; but the law under which the Commission is acting confers no power on it to enter into any agreement that would bind the United States Government, and an effort to do so would be futile. From the beginning of our correspondence and conferences upon this subject we have kept you advised that the Commission was authorized to obtain information for the President, and was not empowered to bind the United States Government by any agreement. My letter of April 10, 1900, contains this statement: "You understand, of course, that the Commission is not authorized to accept or reject any offer which it may receive, but is collecting information to be submitted to the President."

We can not, therefore, consider any proposition looking to an agreement, whether reached by conference or by arbitration, but as I have already said, we are willing to continue our informal discussions if you think we can be of assistance to you in preparing your final proposition.

In closing your letter you ask that if the canal should be completed and operated by the United States, "French merchant ships may be treated on a footing of absolute equality with the merchant ships of the United States." This subject has not been included in the duties assigned to this Commission, and therefore can not be considered by it, but is a proper matter for diplomatic action.

I have tried to make my statements clear, desiring to be frank with you, that there may be no room for misunderstanding, and hope that we shall soon be able to bring this matter, which I know has at times been full of difficulty and perplexity to you, to a satisfactory conclusion.

Believe me, my dear Mr. Hutin, with great respect,

Very sincerely, yours,

J. G. WALKER,
President of Commission.

DEPARTMENT OF STATE, ISTHMIAN CANAL COMMISSION,
Washington, D. C., October 22, 1901.

MAURICE HUTIN, Esq.,
President New Panama Canal Company, Washington, D. C.

DEAR SIR: I have to acknowledge the receipt of your message, through Mr. Boyard, stating that after the receipt of my letter of the 19th instant you had cabled to Paris, asking for further instructions; that when an answer was received you would notify me, and that you would not be ready to discuss further the question of a sale of the property of your company until a response was received from your board of directors.

I much regret the delay and feel compelled to call your attention to the fact that Congress will convene on the 2d day of December; that the report of this Commission should be in the hands of the President a considerable time prior to that date; that understanding that you wished to make a proposal for a sale of the Panama Canal Company's property, and desiring to give you every opportunity for doing so, the report has been held open for that purpose.

In this situation you must see the necessity for early and decisive action, and for fixing a date for closing the report of the Commission. This matter was first called to your attention at the sessions of the Commission held with you in Paris on the 7th and 8th of September, 1899. Since that time it has been the subject of frequent conferences and of a correspondence of some length, to which your attention is called, and particularly to my letter of April 10, 1900, in which the powers of the Commission were frankly stated and three definite questions asked; the substance of these questions being the willingness of the company to sell, its ability to do so, and the money, in cash, for which it would dispose of its property. These questions have been repeated at intervals since that date, and the third still remains unanswered.

When you left Washington in May last, the consent of the Colombian Government to a sale having been obtained, it was understood between us that upon your return to Paris you would consult your board of directors, and a definite answer would be made at an early date.

More than two years have passed since the subject was first presented to you, more than eighteen months since the specific questions were asked in my letter of April 10, 1900, and five months since your departure for Paris, with the understanding above referred to. Our correspondence since that time shows frequent postponements, and no result has yet been reached. Under these circumstances I feel that it is not unreasonable to suggest that the time has come when some definite and final action should be taken.

I therefore think it proper to say to you that any proposal that you wish to make will be received until the 5th of November next, at which date the Commission will be compelled to consider this question closed, so that its report may be completed.

This of course is not intended to prevent such conferences as you may desire in the meantime, and it is hoped that you may be able to present your final conclusions before the date mentioned.

Believe me, my dear Mr. Hutin, with great respect,

Very sincerely, yours,

J. G. WALKER,
President of Commission.

WASHINGTON, D. C., *November 2, 1901.*

Admiral JOHN G. WALKER,
President Isthmian Canal Commission, Washington, D. C.

MR. PRESIDENT: I have the honor to acknowledge receipt of your letters dated October 18 and 22 last. They contain a certain number of remarks, and even of criticisms, upon which I will dwell, if necessary, in due time. To-day, however, having only in mind the purpose of demonstrating the correctness of the propositions and conclusions of the present letter, I beg to recall to your attention but a few facts.

In your letter of October 22 you alluded to our conferences held in Paris on September 7 and 8, 1899. At those meetings you did, in fact, ask me for the first time under what conditions of price and by what means the Government of the United States could purchase the canal of Panama. In my reply I called your attention to the fact that the law of the Congress of the Republic of Colombia, under which we hold our concession, formally prohibits its sale to a foreign government, but that if we were relieved of that clause we would be willing to transfer our enterprise to the Government of the United States upon fair and equitable conditions.

Later on you renewed your questions, stating them more definitely in a letter dated April 10, 1900, and moreover you suggested to discuss them, admitting that the consent of the Government of Colombia had been obtained for the purpose of selling the concession to the United States.

In the interviews held prior to said letter, as well as in all those we had together in Washington until the end of the month of November, 1900, I was obliged to state to you that our company, for paramount reasons, could not accept such a ground of discussion. I told you repeatedly that our company could not afford to commit itself to any conditional agreement, even as the one proposed by you, because the company considered it indispensable to first obtain the previous authorization of the Colombian Government for the sale of the Panama Canal to the Government of the United States. It is, therefore (and this is the only critical remark I will venture to make in this letter), that I experienced some surprise in reading certain utterances relating to this matter and contained in the preliminary report of November 30, 1900.

During the month of February, 1901, an authorized representative of the Colombian Government, Mr. Martinez Silva, arrived in Washington. He was aware of the proposition of the United States eventually to purchase our concession. I requested him to state to me in which manner his Government would interpret and apply the clauses of our law of concession.

Mr. Martinez Silva replied, the 28th of March, 1901, that the Colombian Government would authorize the canal company to transfer its concession to the Government of the United States upon certain conditions which he had submitted to the latter Government.

On April 29 following he asked me what would be the basis upon which the company would be willing to make such transfer, supposing the previous authorization to do so had been obtained from the Government of Colombia. I stated them to Mr. Martinez Silva, with my reasons, in a letter I sent to him on May 1.

On the 8th of May following, you kindly informed me that Mr. Martinez Silva had forwarded to you a copy of my above-mentioned letter of May 1, and you again asked me to reply to the questions put in your letter of April 10, 1900, to which I have already referred.

Consequently, I answered you on May 15: "I am indebted to you, Mr. President, for having kindly admitted, in your above-mentioned letter of May 8, that our company has not, until the present, been in a position to reply to some of the questions which had been submitted to it by the Commission over which you preside.

"Under the new conditions now existing, it will be sufficient for me, in order to reply as you desire me to do, to the first and third questions of your letter of April 10, 1900, to confirm what I had the honor to write to Mr. Martinez Silva the 1st of the month."

I then repeated and confirmed the terms of my letter of May 1, 1901, to Mr. Martinez Silva, concerning the transfer of our concession, stating clearly and precisely to you, in that manner, that our company was thus actually answering the questions of your letter of April 10, 1900, by showing upon what basis and under what conditions it was willing to have the value of its concession and properties established.

You acknowledged receipt the following day, May 16, reproducing nearly word for word my letter of the day before and without entering any direct or fundamental objections to my propositions. My colleagues of the board of directors and myself have interpreted your answer—and I must add that we still do so—as creating an understanding between the Commission and our company, for the purpose of ascertaining together, by a practical method, the exact value of our concession and properties, so as to reach in this manner a fair and equitable basis to be used eventually in any negotiations before the Congress of the United States.

Consequently we proceeded to make out our estimates. They were calculated with the utmost care, and after most detailed and complete studies they were summed up in a memorandum, approved by our board of directors, which was handed to you with a letter dated Paris, October 4, last, and in which, once more, I expressed our sincere desire for conciliation and agreement.

I therefore could not help but experience a great surprise when I realized, during the conferences which took place after handing you said letter of October 4, that there existed now between us with regard to the method of discussion I had proposed to you on May 15, a disagreement which, heretofore, you had not made known to me, either verbally or in writing. In your letter of October 18, 1901, you confirmed this disagreement. You call my attention to the fact that when you wrote me on May 16 you did not reply to my suggestions concerning the manner in which was to be established the value of our properties—as if such silence on your part could constitutes a rejection of my suggestions—and you add that you did not inquire of me which would be the basis and conditions of arbitration when I had already suggested to you that such arbitration was to be made in the usual form.

The only point in your letter of October 18, 1901, upon which I wish to dwell at present, is the fact that you discuss therein for the first time the propositions of my letter of May 15 last. It is my duty to reply to your objections, which are summed up in the two following paragraphs of your letter of October 18: "In our recent conferences you have proposed that there should be an agreement between ourselves as to the value of the rights and property of the Panama Canal Company, and an arbitration to conclude the manner in case of disagreement; but the law under which the Commission is acting confers no power on it to enter into any agreement that would bind the United States Government, and an effort to do so would be futile.

From the beginning of our correspondence and conferences upon this subject we have kept you advised that the Commission was authorized to obtain information for he President, and was not empowered to bind the United States Government by any agreement. My letter of April 10, 1900, contains this statement: 'You understand, of course, that the Commission is not authorized to accept or reject any offer which it may receive, but is collecting information to be submitted to the President.' We can not, therefore, consider any proposition looking to an agreement, whether reached by conference or by arbitration, but as I have already said, we are willing to continue our informal discussions if you think we can be of assistance to you in preparing your final proposition."

Allow me to say to you, Mr. President, that never did we, either by word or in writing, make propositions carrying with them such scope and consequences as you suppose in your letter of October 18. I think that the text of my letters of May 15 and October 18, 1901, as well as the verbal explanations given to you, contradict such an interpretation of our intentions.

You will surely understand, Mr. President, that our board of directors can not and should not accept the estimates of the value of our concession and property, as given in the Preliminary Report of the Isthmian Canal Commission. These estimates are the result of the measurement of certain amount of work done and of the calculation of certain prices to be applied. We simply ask that, in any discussion with the Commission, as to work done and prices applied, both sides should be heard, in order mutually to agree upon them as far as possible. In case of disagreement of opinion we could, in certain instances, by mutual concessions, have reached an amicable understanding; but if our estimates had remained too far apart, we would have had recourse to technical arbitrators who would definitely have concluded the matter.

Under the present circumstances, and on account of your present declarations, I do not feel warranted to judge whether or not the Commission, whose duty consists in gathering information for the President of the United States, possesses the power to follow the method suggested by me. However, it is my duty to state that such a method would, in no way whatever, have committed the Government or the Congress of the United States in their decisions. This method would only have led to the establishment, for the real value of the concession and property of the New Panama Canal Company, of a price which would have bound the company alone.

Therefore, under the present circumstances, it is not sufficient for me to assert that the board of directors of the company has taken into account, as it should do, its duties and responsibilities. I believe, moreover, to have the right to say that the company's conduct is in accord with reason and equity. The board could not do otherwise but propose a price for the sale, which has been established according to calculations and estimates and which it considers exact and justified until the contrary is proven. The board deeply regrets that the Commission has not the power to discuss them after both sides had been heard.

This being the situation, I have the honor to confirm my above-mentioned letter of October 4, as well as the "memorandum" accompanying the same, except as regards the last part thereof, and upon which I will dwell later.

Referring again to your letter of October 18, in which, in general terms, you criticise our estimates, I desire to repeat that, with the same spirit of conciliation we have heretofore shown and in order to arrive at a reasonable understanding, we will always remain ready to discuss, when we will have before us one or several persons clothed with official authority and qualified to establish, with us, the basis of an agreement which will determine the price of the sale of our concession and properties.

A last question still remains to be examined. In your letter of October 18 you say, Mr. President, that you decline to adopt our view with regard to our request to share in the future benefits of the management of the canal. We could, I believe, continue to maintain that our claim is just and well founded; but, among other things, you have argued that such a combination would be prejudicial to the principle of absolute ownership of the canal by the United States. Under such conditions, and without intending to discuss that point of law, I herewith state that we are now ready prepared to relinquish totally our claim to a share in the eventual profits of the management of the canal, having in mind that this surrender constitutes on our part an act of conciliation which must be taken into account during the discussion of our other propositions.

Be pleased, Mr. President, to accept the assurance of my high consideration.

M. Hutin,
President and Director-General.

Department of State, Isthmian Canal Commission,
Washington, D. C., November 5, 1901.

Maurice Hutin, Esq.,
President and Director-General New Panama Canal Company,
Washington, D. C.

Mr. President: I have to acknowledge the receipt of your letter of the 2d instant and its English translation, which was received at this office after I had left last evening.

I understand from this letter that you withdraw your proposition with regard to sharing in the possible profits accruing from the canal after completion, and with that exception you confirm and stand upon the figures contained in your letter of October 4 and the accompanying memorandum, being:

"A study concerning the estimated value of the French company's contribution to the canal undertaking in case of a transfer of our concession to the United States Government."

These figures I understand to aggregate 565,500,000 francs, or $109,141,500.

Without replying to the criticisms contained in your letter of the 2d instant, I have to say that the Commission will take pleasure in presenting your figures and views to the President in its report, shortly to be completed.

Our conference with regard to the sale by the New Panama Canal Company of its property and concessions to the United States having now been concluded, I desire to thank you for the uniform courtesy which has attended our personal intercourse and correspondence; and, with expressions of high regard,

Believe me, my dear Mr. Hutin, very sincerely, yours,

J. G. Walker,
President of Commission.

Washington, D. C., *November 6, 1901.*

Admiral J. G. Walker,
President Isthmian Canal Commission, Washington, D. C.

Mr. President: I have duly received your letter of yesterday, the 5th of November, and, as was subsequently verbally agreed, I have the honor to answer it in order to make a few concluding observations and explanations.

First, it should be well understood that the English translation of my letter of the 2d of November which, in compliance with your wishes, I sent you on Monday evening, has value merely as a document drawn up for your accommodation, the French text alone being effective.

Secondly, I notice that you have added, according to the paper inclosed with our letter of the 4th of October last—which letter itself contains no figures—the different amounts which, according to us, represent the value of each of the holdings or pieces of property, their total constituting the value of the property owned by our company. The total, in francs, is correct, and I presume also the rate of exchange you have adopted. But whether each of these amounts is singly considered or their total it is essential to preserve their true character.

They represent, as has already been explained on different occasions, verbally and in writing, valuations that the company believes just, because it has established them with the greatest care and regard for material exactness. But the company admits that they may be criticised and that it would make reasonable concessions, if they were justifiable. You have told me that the Commission has not the power even to enter upon a discussion of this nature and I regret it very much. I therefore rely upon the promise you were kind enough to make me to submit our figures and our views to the President of the United States in your final report. I would be grateful to you, Mr. President, if you would be kind enough to confirm your own communication by that of all the documents, letters, and papers which, I believe, permit of our intentions and our aim being accurately appreciated.

I desire also, Mr. President, to confirm the fact that our company has the power, in fact as in right, to transfer to the Government of the United States its concession and its holdings by a legal and positive title, "free of all difficulties and contentions, of whatever nature, or from any person whatsoever, and particularly from the stockholders or creditors of the old canal company."

In conclusion, I consider it an agreeable duty, Mr. President, to express to you in turn my thanks for the constant courtesy that has presided over our personal relations.

Have the kindness to accept, Mr. President, the assurance of my high esteem and my devoted sentiments.

M. Hutin,
President and Director-General.

CHAPTER IX.

INDUSTRIAL AND COMMERCIAL VALUE OF CANAL.

An investigation of the Isthmian Canal from the standpoint of its use, aside from military considerations, has two phases—one industrial and the other commercial. A study of the resources and industries of the United States and the countries of the Pacific preceded and was made the basis of the investigation of traffic and tolls, because a knowledge of industrial conditions is essential to an understanding of the effects which the canal will have, and to an analysis of statistical data concerning commerce.

Industrial and commercial value of the canal.

From the nature of the subject investigated, some of the conclusions regarding the industrial effects of the canal must be based on premises concerning which differences of opinion may exist. Moreover, the presentation of the industrial data and a discussion of them can not be made as brief and concise as a mathematical demonstration. These limitations apply in less degree to the statistical material used in measuring the volume of traffic available for the use of the canal. The methods employed in the investigation, the data used, and the deductions made are presented in detail in Appendix NN. The general conclusions to which this inquiry has led are here given without claiming that they are absolutely correct in every particular, but they are close approximations to the truth attained by careful research, and furnish information necessary to a decision as to whether or not the canal should be constructed by the United States.

The canal and American industries.

The canal will assist a wide range of industries, agricultural, mineral, lumbering, and manufacturing, and will promote the progress of all sections of the country. The expenses and delays at present incurred in the commercial intercourse of the Central, Southern, and Eastern States with the Pacific markets of our own and foreign countries, and in the trade of our Pacific States with Europe, impose a serious limitation upon the progress of American industries. Cheaper and more expeditious access to Pacific markets will benefit not only the Northeastern States by giving them cheaper raw materials and larger markets for their varied manufactures, and the Southern States by increasing their exports of cotton, cotton goods, forest products, iron and steel manufactures, and fertilizers, but also the Central West.

The Central States are now manufacturing extensively for the foreign and domestic trade; the isthmian waterway will give them a larger business with the Pacific coast and enhance their ability to meet European competition in western South America, Australasia, and the Orient.

The canal and the trade of the Pacific Coast States.

The natural resources of the Pacific Coast States are such that their industries require an extensive commerce. Manufacturing activity is confined to a relatively narrow range, and large quantities of manufactured articles must be secured from the eastern part of the United States and from foreign countries. The major share of the exports, which consist mainly of food stuffs of various classes and of forest products, is now sent to Europe, the annual cargo tonnage of the maritime commerce with that continent amounting under the present unfavorable conditions of shipment to about a million and a half tons. The domestic and foreign trade of the Pacific Coast States is burdened with especially heavy transportation costs, whether the shipments be made by water or by rail. The cost of rail transportation is such that the tonnage of bulky commodities moved across the country for sale in American and European countries is now and must remain comparatively small. Cheaper transportation by an all-water route for the North Atlantic trade of the Pacific Coast States will be of great assistance to the development of that section.

The coal trade.

The canal will have an especially direct and important effect upon the market for American coal. Vessels engaged in our own or European commerce through the canal will find it to their advantage to purchase American fuel on our Atlantic or Gulf seaboards, or in West Indian and Central American stations. The larger commerce which the canal will cause to move across the North Pacific may increase the demand for the product of the Puget Sound mines. The low cost at which coal can be placed at tide water on the Gulf and Atlantic seaboards, and the fact that there will be a considerable movement of vessels in ballast or with part cargoes westward through the canal, makes it probable that the coal required for industrial purposes on the west coast of South and Central America, and for commercial uses in those regions, and to some extent in the coaling stations of the Pacific, will be supplied from the mines in the southern and eastern sections of the United States. The demands at home for the coal of all the mining centers of the United States will be enlarged by the canal in proportion to its effect upon the development of American industries.

Effect of the canal upon railway traffic.

The effect of the canal upon the railroads in the eastern and southern sections of the United States will be favorable. The lines in the central West will feel the competition in rates somewhat more than will the Eastern and Southern roads, but the only business that can be diverted from them is the low-class transcontinental traffic, and this will be fully compensated for by the larger traffic due to the canal's effect upon the development and diversification of the manufacturing and other industries of the section they serve. The railways connecting the Mississippi Valley with the Pacific ports are the roads with which the canal's competition will be strongest, and the rates on a large share of their through business will be regulated by the water route. The through or trans-Cordilleran business originating or terminating at Pacific ports and subject to diversion to the canal is not a heavy tonnage. It constitutes only a small part of their total traffic, and during recent years has contributed less than the growth of their local business to the increase in their total tonnage.

The use of the canal by sailing vessels.

Although over half the American tonnage now engaged in coastwise and foreign commerce consists of sailing vessels, steamers are taking their place so rapidly that probably only a small portion of the tonnage under the flag of the United States will consist of sailing vessels at the time of the completion of the isthmian waterway. Moreover, the canal will enlarge the demand for steamers, and hasten their substitution for sailing vessels. The Nicaragua route could be taken by the latter more advantageously than could one across Panama, but it is doubtful whether either route could be profitably used by sailing vessels in competition with steamers in any regular line of trade. There will always be a demand for sailing vessels for a part of our coastwise traffic, and for opening up foreign commerce with regions whose initial trade is small or of irregular volume. The canal will not eliminate them from ocean commerce, but will restrict the field of their employment.

The canal and the industries and trade of Pacific countries.

The canal will effect large results in developing the industries and commerce of Pacific countries and increasing their trade. Those countries possess abundant natural resources, produce large quantities of food products and raw materials indispensable to the people of the United States and Europe, and export many manufactured articles not obtainable elsewhere. Although the people of most Pacific nations other than Australia and New Zealand have small purchasing power per capita, their numbers are so great that their total imports can reach a large sum. The commerce of the Pacific at the present time is of great importance to the United States and Europe and is rapidly increasing. Our commerce with Pacific countries is growing at a larger rate per cent per annum than is our trade with Europe, and the isthmian canal will enable the United States to control a greater share of the Pacific trade than could otherwise be obtained. The canal will be especially beneficial to the trade of the United States with western South America, where Europe now controls most of the foreign commerce. The new route will give a decided advantage as regards distance over Europe in the commerce of that section.

Our ability to manufacture for the markets of the trans-Pacific countries is evidenced by our steadily increasing sales to them in spite of the present high cost of transportation. The canal will place Europe and the United States on a basis of equality in distance for the trade of the Orient and Australasia. At the present time the advantages are greatly with Europe.

Tonnage of available canal traffic, 1899.

A detailed study of the foreign commerce of the United States for the year ending June 30, 1899, and of the commerce of Europe with the western part of the American continents during the calendar year 1899, has been made to ascertain the tons of cargo or freight and the net-register tonnage of the vessels that might have passed through an isthmian canal had one been in existence. The cargo tonnage was found to amount to 6,702,541. This total does not include the comparatively small amount of freight that passed by water between our two seaboards, the statistics of which are not obtainable. It comprises 277,640 tons for the commerce between the Eastern seaboard of the United States and western South and Central America, Hawaii, and British Columbia; 1,528,860 tons for the commerce of our Eastern seaboard with Australasia, Oceania, Japan, China, and Siberia; 1,629,387 tons for the trade between the West coast of the United States and Europe, and 3,266,654 tons for the commerce between Europe and western South and Central America, western Mexico, Hawaii, and British Columbia. It does not include any of Europe's trade with other parts of the Pacific.

The tonnage of the vessels that might have used an isthmian canal in 1899 was ascertained by an examination of the statistics of entrances and clearances kept by the United States and European countries. The entrances and clearances for the commerce of the Eastern seaboard of the United States with Pacific America and with Australia, Oceania, the Philippines, Japan, China, and Siberia, and the vessel movements between the western coasts of the American continents and the North Atlantic American and European ports, were found to amount to 4,074,852 vessel-tons net register, including 336,998 tons for the commerce now crossing the Isthmus of Panama.

This total was compared with the results of a traffic investigation made by the New Panama Canal Company. The records of vessel movements kept by that company show a traffic for the calendar year 1899 of 3,848,577 tons net register for the commerce between Europe and the western coast of the American continent, between the Atlantic seaboard of America and trans-Pacific countries, and between the two American seaboards. The total obtained from the records kept by the

Panama Company does not include any vessel tonnage for the commerce now crossing the Isthmus. The addition of that tonnage, 336,998 tons, raises the total to 4,185,575.

In addition to this tonnage, which comprises only traffic originating or terminating in America, there should be included most of the commerce of northwestern Europe with New Zealand and the other islands of the Pacific east of Australia. New Zealand will be 1,503 miles nearer Liverpool by the isthmian canal than via the Suez route, and 2,405 miles nearer than by way of the Cape of Good Hope. The distances to Liverpool from the important groups of South Pacific islands north of New Zealand will be from 500 to 5,500 miles less via the isthmian canal than by way of Suez. The entrances and clearances of New Zealand's trade with northwestern Europe amounted to 481,178 tons net register in 1899, and the European commerce of the other islands east of Australia to 181,743 tons. Of this total traffic of 662,921 tons, 500,000 might have advantageously used an isthmian canal, and this amount should be added to the canal tonnage originating or terminating in America. This makes the total obtained by the Commission's investigation of the tonnage that might have used an isthmian canal in 1899, 4,574,852 tons net register; and the total obtained by adopting the New Panama Canal Company's figures for the traffic originating or terminating in America, 4,685,575 tons.

Growth of traffic. Probable tonnage, 1914.

Tables prepared by the New Panama Canal Company show that the vessel tonnage of the commerce between Europe and Pacific America and between the Atlantic seaboard of America and the eastern and western sides of the Pacific increased 25.1 per cent during the decade 1888–1898, and this rate has been adopted in estimating the traffic that will be available for the isthmian canal in 1914, by which year it is assumed that the waterway will have been completed and put in operation. This rate of increase would raise the available traffic of 1899, obtained by adding to the New Panama Canal Company's figures for tonnage originating or terminating in America the present traffic across the Isthmus of Panama and 500,000 tons of the commerce of New Zealand and other South Pacific islands with Europe—4,685,575 tons—to 5,861,654 tons in 1909 and to 6,556,260 tons in 1914. A growth of 25.1 per cent per decade would increase the total of 4,574,852 tons for 1899, obtained by the Commission's investigation of the statistics of entrances and clearances, to 5,723,140 tons in 1909 and 6,401,332 tons in 1914—the tonnage being net register in each case.

In all probability the future increase in that part of the world's commerce that would use an isthmian canal will be more rapid than the past growth has been, because in the Pacific countries of America, in Australasia, and in the Orient the industrial progress of the next two decades promises to be much greater than that of the past twenty years has been. The rate of increase, 25.1 per cent per decade, prior to the opening of the canal probably undervalues what will occur. It is certainly a conservative estimate.

Estimated traffic, 1924.

While it is not to be expected that the traffic of the isthmian waterway during the early years of its operation will increase as rapidly as did the tonnage passing the Suez Canal, the growth in the commerce using the Suez route constitutes the best basis for estimates regarding the rate of increase in the tonnage of the commerce that will use the American canal. This growth is shown by the following table in which the total tonnage for each five-year period is given:

Number of vessels and tonnage of the Suez Canal by quinquennial periods.

Years.	Number of vessels.	Net tonnage, Danube measurement.	Per cent increase.	Percentage which tonnage of each 5-year period is of tonnage. 1875–1879.
1870–1874	4,770	5,358,237		
1875–1879	7,684	10,995,214	105	
1880–1884	14,542	23,916,373	117	217
1885–1889	16,726	31,430,454	31	286
1890–1894	17,848	39,899,143	27	363
1895–1899	16,939	44,042,274	10	401

The tonnage of the second five-year period was 205 per cent that of the first, and the total for the third period 217 per cent that of the second. The traffic in 1880 was 3,057,422 tons, that of 1890, 6,890,094, an increase of 125 per cent. That of 1900 was 9,738,152 tons, a growth of 2,848,058 tons, or 41 per cent during the past decade. The initial tonnage of the Suez Canal being small, the rate of increase during the first decade was large. Should 1914 be the first year of the operation of the American canal, and the rate of increase in the traffic during the first ten years be 62½ per cent—half that of the Suez waterway during the second decade of its use—the estimated tonnage of the year 1914, in round numbers 6,500,000 tons net register, would be raised to approximately 10,500,000 tons in 1924.

The above totals for the tonnage that might have used an isthmian canal in 1899 do not include any of Europe's trade with Australia and Japan, a part of which would probably use an isthmian waterway. The distances from Great Britain to Sydney and Yokohama by the Suez and isthmian canal routes are approximately equal, and vessels going by America in either direction en route between Europe and Japan or Australia will pass regions from which there is a heavy export tonnage. If it be assumed that 10 per cent of the vessel tonnage of the Australian trade with the ports of northwestern Europe and 5 per cent of the tonnage of the Japanese commerce with those ports would have taken an American canal route, the totals for 1899 should be increased 316,223 tons, and be raised from 4,574,852 to 4,891,075 tons, and from 4,685,575 to 5,001,798 tons, or to approximately 5,000,000 tons. An increase of 25.1 per cent per decade would raise a traffic of 5,000,000 in 1899 to 6,996,217, or, in round numbers, 7,000,000 tons in 1914, and a growth of 62½ per cent during the succeeding ten years would make the tonnage of 1924 11,375,000.

Tolls and traffic.

The extent to which the isthmian canal is used will depend in part upon the tolls charged. The commerce of western South America with Europe will continue to pass the Straits of Magellan or to round Cape Horn, the trade of the American Atlantic seaboard with Australia will keep to the Good Hope route, and the traffic between our eastern seaboard and the Philippines and southern China will remain tributary to the Suez route, if the charges for passing the American canal are made greater than the saving to be effected by using that waterway. A toll of about $1 per ton net register could profitably be paid by the commerce between Europe and western South America, and by that of our eastern seaboard with Australia; a much higher charge would probably cause a large share of the business to continue to be done by the routes now used. For the commerce of our eastern ports with the Philippines and the mainland of Asia between Singapore and Shanghai the distances by way of the Suez and isthmian canals will be so nearly equal that the route chosen will depend largely upon tolls. Light charges at the American canal will give that waterway a large share of the tonnage; high tolls will cause the Suez route to be used.

The Suez tolls at the present time are 9 francs per ton net register, "Danube" measurement, and this charge amounts to somewhat more than $2 per ton net register, British or American measurement. The Suez tolls are levied by a corporation whose object is to secure the maximum revenue obtainable. With the exception of the trade between Europe and Australia, the commerce served by the Suez Canal can be charged a high toll without much restricting the tonnage using the waterway; consequently a large reduction in charges would not be compensated for by an increase in traffic, and the revenue would be less. It is not probable that the Suez Canal Company would find it profitable to reduce its tolls largely for the purpose of competing with the American waterway.

In fixing the charges for the use of an isthmian canal owned and operated by the United States Government, the principle of maximum revenue could not wisely be followed. The revenue-producing function of the canal will be a minor one as compared with its services in promoting the industrial and commercial progress and general welfare of the United States. The exaction of tolls that would much restrict the benefits derivable from the canal would not be to the advantage of the American people.

An annual traffic of 7,000,000 tons, at $1 per ton, will produce a revenue of $7,000,000. The expenses of operating and maintaining the Panama Canal are estimated at about $2,000,000 per annum, and those of the Nicaragua Canal at about $3,300,000. Upon this basis the net revenue by either route would not be sufficient, at the opening of the canal, to pay a rate of interest upon the capital invested, which would compensate a corporation for the risks involved. A large increase of traffic in the future is probable, and the revenue-producing value of the canal would be proportionately greater. It is the opinion of the Commission, however, that there are considerations more important than revenue. It may even be expedient for the United States to reduce the tolls to an amount which will barely cover the expenses of operation and maintenance.

The relative commercial advantages of the Nicaragua and Panama routes.

With the exception of the trade between western South America and our eastern seaboard, for which the Panama Canal would afford the shorter route, the distances for American commerce, both foreign and domestic, would be less by way of Greytown and Brito than by way of Colon and Panama. Including in each instance the length of the canal expressed in nautical miles, the distance between New York and San Francisco by way of Nicaragua would be 378 nautical miles less than via Panama. For New Orleans and San Francisco the difference is 580 miles, and, in general, the distances between our Atlantic and Pacific ports and between our eastern seaboard and trans-Pacific countries are shorter by the Nicaragua route. The distances from Europe to western South America would be less by way of Panama. From Europe to the North Pacific the Nicaragua route would be shorter.

Exclusive of the length of the canals, the sea distance between New York and San Francisco is 498 nautical miles less via Nicaragua than by way of Panama, and for New Orleans and San Francisco the difference is 700 miles. A part of the saving in distance at sea effected by using a Nicaragua canal instead of one at Panama would be offset by the longer time of transit at Nicaragua. An average steamer would require twelve hours to make the passage through the Panama Canal, and thirty-three hours through one across Nicaragua. For a 10-knot steamer this difference of twenty-one hours would be equivalent to 210 knots difference in distance at sea, and for a 15-knot steamer the difference in time of transit would be equivalent to 315 knots.

The Nicaragua route would be the more favorable one for sailing vessels, but this advantage is not important, because sailing vessels would probably be unable to compete with steamers to any considerable extent by either canal. They would certainly not be able to compete with steamers, both using the Panama Canal.

Benefits to Europe and United States compared.

As compared with Europe, the United States will derive from the canal greater benefits, both commercially and industrially. The commerce of Europe with the Pacific coast of North, Central, and South America, under existing conditions, is about as large as the total volume of the present traffic of the United States that may be considered tributary to the canal; but this fact does not indicate the relative advantages which the canal will possess for the trade of Europe and that of the United States. As soon as it has been opened, our trade with the west coast of South America will increase more rapidly, as will also the volume of our trade with the Orient. An Isthmian canal will strengthen the unity of the national and political interests of the United States, develop its Pacific territory, and promote the commerce and industries of the entire country. The benefits which Europe will derive from the canal will be commercial. In addition to this, ours will be political and industrial.

Chapter X.

MILITARY VALUE.

Military value in time of peace.

In time of peace an isthmian canal would afford a short passage for our cruisers from one ocean to the other, and would enable the necessary patrol duty of the Navy to be more efficiently performed, or performed by a smaller number of vessels. It would also have the same kind of value to the military arm of the Government that it has to the general commercial interests of the country, in facilitating the transportation of heavy ordnance and military stores, as well as troops and supplies.

In time of war.

In time of war a canal would offer a shortened line of communication, and might be of immense advantage to the power controlling it. When war is threatening, or in its earlier stages, the scattered ships could more readily and easily be collected; and subsequently, a fleet in the Pacific could be much more quickly reenforced from the Atlantic and vice versa. The canal, however, is but one link in a chain of communications, of which adjacent links are the Caribbean Sea on the east and the waters of the Pacific, near the canal entrance, on the west. Unless the integrity of all the links can be maintained, the chain will be broken. The power holding any one of the links can prevent the enemy from using the communication, but can itself use it only when it holds them all.

Canal one link in a chain of communications.

Canal operated by American citizens not available for the enemy.

The canal itself would be available to the United States, but not to its enemies, so long as its citizens remain in charge of it, filling the positions of pilots, lock keepers, and others upon whom the safety of a ship in transit depends. No commander would rely upon his enemies to the extent of trusting his vessel in such a position. The responsible authorities might do everything in their power to give safe passage to an enemy's vessel, as would be their duty if their Government had promised it; but among several hundred employees of every grade of character the chances are that there would be some one with the power and the will to so disable the canal that communication would be as effectually closed to the enemy as if it had never been opened.

The ability of the United States to hold the Caribbean Sea and the western approaches to the canal against all comers depends upon the future development of its naval resources, and is for the present at least questionable. There are several powers in the world any one of which might dispute the command of the approaches, and combinations of two or more powers might effect the same object. If successful, they would render the canal useless to the United States.

Canal useless to the United States unless it controls the sea.

It would be useless also to them unless they could occupy it and replace American citizens with citizens of their own or some friendly country. Assuming for the moment that the canal is subject to the operations of war, and that the enemy is free to attempt its occupation, it must be defended by the United States.

Useless also to the enemy unless he occupy it.

Fortification is of the nature of insurance. In its practice, then, are several maxims which may here be noted. One is that the greater the value of the prize, the greater the temptation to the enterprise of the enemy and the greater the amount of effort to be applied to the defenses. Another is that the farther the place to be defended is from supplies and reenforcements, the stronger must be the fortifications. Still another is that the less the natural features of the ground are favorable to defense, the more must strength be supplied by works of construction. From all three of these points of view the canal would require the maximum amount of fortification. It would be a prize of extraordinary value; it would be beyond the reach of reenforcements if the enemy control the sea; and the low, flat shore on the Atlantic side, as well as the great length of the canal, are unfavorable to defense. To defend it by fortifications on land would be a costly, difficult, and uncertain undertaking, and by absorbing resources which could better be employed elsewhere would be a source of weakness.

Defense by fortification.

If defended at all, the canal should be defended at sea by the Navy. But that again would be a source of weakness, because it would hamper the movements of the Navy, which is essentially the arm of attack. If a large force of the Navy is to be employed in guarding the canal, its power for offensive action, which is its normal employment, is diminished. If from force of circumstances the Navy be compelled to abandon the offensive, its services will be more valuable upon our coasts than in the Caribbean Sea.

Defense by Navy.

A much more certain and easy method of securing the use of the canal to ourselves, while closing it to our enemies, is to remove it from the operations of war by making it neutral.

Defense by neutrality.

Vulnerability of canal.

It is always to be borne in mind that during the excitements of war the canal will not be a safe place for the men-of-war of any nation, no matter who is nominally in control. A small party of resolute men, armed with a few sticks of dynamite, could temporarily disable it without very great difficulty.

Canal managed by foreigners.

What has been said of the use by her enemies of a canal operated by citizens of the United States would be equally applicable to the use by the United States of a canal operated by citizens of a country with which we were at war. The Panama Canal, for example, if operated by citizens of France, would not be available for the United States in a war with France, while it would be available for French vessels.

Canal free to enemy's vessels.

While there seems no doubt that the presence of American citizens in charge of the canal would be an adequate defense, it is proper to inquire what part it would play in war if the opposite theory were adopted, and the enemy's vessels were able to pass as freely as our own. This would be possible if the canal were under the control of foreigners, as well as in the supposition that all the persons engaged in operating a canal belonging to the United States were actuated by perfect self-restraint. In this case, as before, if the United States controls the sea, the shortened communication is to her advantage, but the advantage is with the enemy if he controls. A highway to our Pacific States and Territories is opened for the fleets of Europe, which does not now exist. It is not probable that they would often wish to use it, because only one or two of them have coaling stations so situated as to make that possible, and they would have richer game elsewhere. Under these circumstances the canal would to some extent weaken the defense of the United States.

Canal managed by American citizens a source of strength if neutral; a source of weakness if not neutral.

It is the opinion of the Commission that a neutral canal, operated and controlled by American citizens, would materially add to the military strength of the United States; that a canal, whether neutral or not, controlled by foreigners would be a source of weakness to the United States rather than of strength; and that a canal not neutral, to be defended by the United States, whether by fortifications on land or by the Navy at sea, would be a source of weakness.

Chapter XI.

COST OF MAINTENANCE AND OPERATION.

Data.

In order to form an estimate of the cost of maintaining and operating the Isthmian Canal, the Commission obtained data bearing on this point from the Suez, Manchester, Kiel, and St. Marys Falls canals.

Cost of maintenance and operation at Suez Canal.

There are no locks on the Suez Canal, but the channel is through drifting sand for a great part of its length. The entrance to the harbor of Port Said on the Mediterranean intercepts the drift of sand discharged from the Nile and carried along the coast by the easterly current. The maintenance of the Suez Canal therefore requires a large amount of dredging and consists mainly of this class of work. The operating expenses are also large, the great traffic involving heavy costs for pilotage. The general expenses for administration have necessarily been greater for the Suez Canal than for the Kiel or Manchester canals, on account of the distance of the work from the point of central control, a disadvantage which would also attend the operation of the Isthmian Canal. The annual cost of maintenance and operation of the Suez Canal is about $1,300,000, or about $13,000 per mile.

Cost of maintenance and operation of Kiel and Manchester canals.

The annual cost of maintenance and operation of the Kiel Canal is $8,600 per mile. The cost of maintenance only of the Manchester Canal is $9,500 per mile. These canals have locks and other mechanical structures, and therefore might be expected to have a higher cost of maintenance than the Suez Canal, which has none, but this appears to be more than offset by reduced cost of maintaining the prism and more economical central control. The traffic being light on these canals, the cost of pilotage and port service is small. The mechanical structures are now nearly new, and will soon require larger annual outlays for maintenance, while, with the increase of traffic, operating expenses will become larger.

Cost of maintenance and operation of the St. Marys Falls Canal.

The St. Marys Falls Canal, when compared with those just mentioned, is remarkable by reason of its short length, large proportion of mechanical structures, and immense traffic. Its length is about 1½ miles. Its annual traffic, limited by the severity of the winter to a period of about eight months, is nearly three times that of the Suez Canal, eight times that of the Kiel Canal, and ten times that of the Manchester Canal. Both maintenance and operating expenses are therefore very large, amounting to from $70,000 to $90,000 per year, or $46,000 to $60,000 per mile.

A more detailed examination would show still more clearly why the cost of maintenance and operation varies so widely in the several canals. The differences in the waterways and in the climatic and other conditions render it extremely difficult to derive from them an estimate applicable to the Isthmian Canal. This method, however, has been followed by the Commission d'Etudes, appointed by the liquidator of the old Panama Canal Company, the study being based on the corresponding costs at the Suez Canal and consideration being given to the radical differences in the waterways and the climates.

Basis of estimate of cost of maintenance and operation for Isthmian Canal.

This Commission has approached the problem in a somewhat different way. A project has been developed for an organization of the force and plant required for maintaining the prism and harbors, operating the canal, and providing for sanitary and police control. This has been worked out in much detail, and is intended to cover all expenses except the maintenance of masonry and metal structures, which are provided for by percentages on their cost. The damp climate of the isthmus, with its mild temperature, is very favorable for masonry structures, but unfavorable for those of iron and steel. The allowances for the maintenance of these structures are ½ per cent on the first cost for masonry and 7½ per cent for metal structures, including machinery.

It is obvious that the cost of maintenance and operation for the Nicaragua Canal would be much greater than for the Panama Canal. The former has four times the total length of the latter, or, excluding the deep-water portions of both routes, three and one-fourth times the length of excavated channel. It has also more locks, weirs, and other structures. In Grey Town harbor it has the most difficult harbor to maintain, and it is in the region of greatest rainfall. On the other hand, its magnitude can not be measured by length only. The total cost of construction gives a better idea of relative magnitudes. Moreover, the study given to the project of organization shows that the central control and general supervision, which form a large part of the total cost of maintenance and operation, differ but little in the two cases.

Estimates of cost of maintenance and operation.

The resulting estimates of the annual cost of maintenance and operation are as follows:

For the Nicaragua Canal	$3,300,000
For the Panama Canal	2,000,000

The Commission d'Etudes, using a different method, estimated the cost for the Panama Canal at 10,000,000 francs, ($1,940,000). The agreement is as close as could be expected in estimates of this kind.

CHAPTER XII.

CONCLUSIONS.

The investigations of this Commission have shown that the selection of "the most feasible and practicable route" for an isthmian canal must be made between the Nicaragua and Panama locations. Furthermore, the complete problem involves both the sea-level plan of canal and that with locks. The Panama route alone is feasible for a sea-level canal, although both are entirely practicable and feasible for a canal with locks. The time required to complete a sea-level canal on the Panama route, probably more than twice that needed to build a canal with locks, excludes it from favorable consideration aside from other serious features of its construction. It is the conclusion of this Commission, therefore, that a plan of canal with locks should be adopted.

A comparison of the principal physical features, both natural and artificial, of the two routes, reveals some points of similarity. Both routes cross the continental divide less than ten miles from the Pacific Ocean, the Panama summit being about double the height of that in Nicaragua. For more than half its length the location of each route on the Atlantic side is governed by the course of a river, the flow from whose drainage basin is the only source of water supply for the proposed canal; and the summit levels, differing but about 20 feet in elevation, Panama being the lower, are formed by lakes, natural in the one case and artificial in the other, requiring costly dams and wasteways for their regulation and for the impounding of surplus waters to reduce the effect of floods and to meet operating demands during low-water seasons.

The investigations made in connection with the regulation of Lake Nicaragua have demonstrated that that lake affords an inexhaustible water supply for the canal by that route. The initial proposition, on the other hand, for the Panama route is to form lake Bohio so as to yield a water supply for a traffic of 10,000,000 tons, which can be supplemented when needed by an amount sufficient for more than four times that traffic, by means of the Alhajuela reservoir. For all practical purposes this may be considered an unlimited supply for the Panama route. So far as the practical operation of a ship canal is concerned, therefore, the water-supply features on both lines are satisfactory.

The difficulties disclosed and likely to be encountered in the construction of the dams are less at Conchuda on the Nicaragua line than at Bohio on the Panama route. Both dams, however, are practicable, but the cost of that at Bohio is one-half more than that at Conchuda. A less expensive dam at Bohio has been proposed, but through a portion of its length it would be underlaid by a deposit of sand and gravel pervious to water. The seepage might not prove dangerous, but the security of the canal is directly dependent upon this dam, and the policy of the Commission has been to select the more perfect structure, even at a s mewhat greater cost. The wasteways at both locations present no serious difficulties. The advantages in the design and construction of the dams are in favor of the Nicaragua route.

The system of regulation at Lake Bohio consists only of the discharge of water over the crest of a weir, as the lake level rises under the influence of floods in the Chagres River. The plan of regulating the level of Lake Nicaragua is less simple, though perfectly practicable. It involves the operation of movable gates at such times and to such extent as the rainfall on the lake basin may require. The experience and judgment of the operator are essential elements in the effective regulation of this lake. The regulation of Lake Bohio is automatic.

The only means of transportation now found on the Nicaragua route are the narrow-gauge Silico Lake Railroad, about 6 miles in length, and the limited navigation of the San Juan River and the lake, but the Nicaraguan Government is now building a railroad along the beach from Greytown to Monkey Point, about 45 miles to the northward, where it proposes to establish a commercial port. By means of a pier, in the area protected by the point, goods and material for canal purposes can readily be landed and transported by rail to Greytown. Such piers are in constant use on our Pacific coast. This railroad and port would be of great value during the period of preparation and harbor construction, and should materially shorten that period. A well-equipped railroad is in operation along the entire length of the Panama route, and existing conditions there afford immediate accommodation for a large force of laborers.

The Nicaragua route has no natural harbor at either end. At both the Atlantic and Pacific termini, however, satisfactory harbors may be created by the removal of material at low unit prices, and by the construction of protective works of well-established design. An excellent roadstead, protected by islands, already exists at Panama, and no work need be done there for either harbor construction or maintenance. At Colon, the Atlantic terminus of the Panama route, a serviceable harbor already exists. It has afforded harbor accommodations for many years, but it is open to northers, which a few times in each year are liable to damage ships or force them to put to sea. Considerable work must be done there to create a suitable harbor at the entrance of the canal, which can be easily entered, and will give complete protection to shipping lying within it. The completion of the harbors as planned for both routes would yield but little advantage to either, but the balance of advantages, including those of maintenance and operation, is probably in favor of the Panama route.

The existence of a harbor at each terminus of the Panama route, and a line of railroad across the isthmus, will make it practicable to commence work there, after the concessions are acquired, as soon as the necessary plant can be collected and put in place, and the working force organized. This period of preparation is estimated at one year. In Nicaragua this period is estimated at two years, so as to include also the construction of working harbors and terminal and railroad facilities.

The work of excavation on the Nicaragua route is distributed; it is heaviest near Conchuda, at Tamborcito, and in the divide west of the lake. On the Panama route it is largely concentrated in the Culebra and Emperador cuts, which are practically one. As a rule distributed work affords a greater number of available points of attack, contributing to a quicker completion; but in either of these cases such difficulties as may exist can be successfully met with suitable organization and efficient appliances.

The time required for constructing the Nicaragua Canal will depend largely on the promptness with which the requisite force of laborers can be brought to Nicaragua, housed and organized at the locations of heaviest work along the route. The cut through the divide west of the lake probably will require the longest time of any single feature of construction. It contains about 18,000,000 cubic yards of earth and rock excavation, or a little less than 10 per cent of the total material of all classes to be removed. With adequate force and plant this Commission estimates that it can be completed in four years. This indicates, under reasonable allowance for ordinary delays, that if force and plant enough were available to secure a practically concurrent execution of all portions of work on the route, the completion of the entire work might be expected within six years after its beginning, exclusive of the two years estimated for the period of preparation.

The securing and organizing of the great force of laborers needed, largely foreigners, so as to adjust the execution of the various portions of the work to such a definite programme of close-fitting parts in a practically unpopulated tropical country, involves unusual difficulties and would prolong the time required for completion.

The greatest single feature of work on the Panama route is the excavation in the Culebra section, amounting to about 43,000,000 cubic yards of hard clay, much of which is classed as soft rock, or nearly 45 per cent of all classes of material to be removed. It is estimated that this cut can be completed in eight years, with allowance for ordinary delays, but exclusive of a two-year period for preparation and for unforeseen delays, and that the remainder of the work can be finished within the same period. The great concentration of work on this route and its less amount will not require so great a force of laborers as on the Nicaragua route; hence the difficulties and delays involved in securing them will be correspondingly diminished.

The total length of the Nicaragua route from sea to sea is 183.66 miles, while the total length of the Panama route is 49.09 miles. The length in standard canal section and in harbors and entrances is 73.78 miles for the Nicaragua route and 36.41 miles for the Panama route. The length of sailing line in Lake Nicaragua is 70.51 miles, while that in Lake Bohio is 12.68 miles. That portion of the Nicaragua route in the canalized San Juan is 39.37 miles.

The preceding physical features of the two lines measure the magnitude of the work to be done in the construction of waterways along the two routes. The estimated cost of constructing the canal on the Nicaragua route is $45,630,704 more than that of completing the Panama Canal, omitting the cost of acquiring the latter property. This sum measures the difference in the magnitude of the obstacles to be overcome in the actual construction of the two canals and covers all physical considerations, such as the greater or less height of dams, the greater or less depth of cuts, the presence or absence of natural harbors, the presence or absence of a railroad, and the amount of work remaining to be done.

The estimated annual cost of maintaining and operating the Nicaragua Canal is $1,300,000 greater than the corresponding charges for the Panama Canal.

The Panama route would be 134.57 miles shorter from sea to sea than the Nicaragua route. It would have less summit elevation, fewer locks, 1,568 degrees and 26.44 miles less curvature. The estimated time for a deep-draft vessel to pass through is about twelve hours for Panama and thirty-three hours for Nicaragua. These periods are practically the measure of the relative advantages of the two canals as waterways connecting the two oceans, but not entirely, because the risks to vessels and the dangers of delay are greater in a canal than in the open sea.

Except for the items of risks and delays, the time required to pass through the canals need be taken into account only as an element in the time required by vessels to make their voyages between terminal ports. Compared on this basis, the Nicaragua route is the more advantageous for all transisthmian commerce except that originating or ending on the west coast of South America. For the commerce in which the United States is most interested, that between our Pacific ports and Atlantic ports, European and American, the Nicaragua route is shorter by about one day. The same advantage exists between our Atlantic ports and the Orient. For our Gulf ports the advantage of the Nicaragua route is nearly two days. For commerce between North Atlantic ports and the west coast of South America the Panama route is shorter by about two days. Between Gulf ports and the west coast of South America the saving is about one day.

The Nicaragua route would be the more favorable one for sailing vessels because of the uncertain winds in the Bay of Panama. This is not, however, a material matter, as sailing ships are being rapidly displaced by steamships.

A canal by the Panama route will be simply a means of communication between the two oceans. That route has been a highway of commerce for more than three hundred years, and a railroad has been in operation there for nearly fifty years, but this has effected industrial changes of but little consequence, and the natural features of the country through which the route passes are such that no considerable development is likely to occur as a result of the construction and operation of a canal.

In addition to its use as a means of communication between the two oceans, a canal by the Nicaragua route would bring Nicaragua and a large portion of Costa Rica and other Central American States into close and easy communication with the United States and with Europe. The intimate business relations that would be established with the people of the United States during the period of construction by the expenditure of vast sums of money in these States and the use of American products and manufactures would be likely to continue after the completion of the work, to the benefit of our manufacturing, agricultural, and other interests.

The Nicaragua route lies in a region of sparse population and not in a pathway of much trade or movement of people; conditions productive of much sickness do not exist. On the other hand, a considerable population has long existed on the Panama route and it lies on a pathway of comparatively large trade along which currents of moving people from infected places sometimes converge, thus creating conditions favorable to epidemics. Existing conditions indicate hygienic advantages for the Nicaragua route, although it is probable that no less effective sanitary measures must be taken during construction in the one case than in the other.

The cost of constructing a canal by the Nicaragua route and of completing the Panama Canal, without including the cost of acquiring the concessions from the different Governments, is estimated as follows:

Nicaragua	$189,864,062
Panama	144,233,358

For a proper comparison there must be added to the latter the cost of acquiring the rights and property of the new Panama Canal Company. This Commission has estimated the value of these in the project recommended by it at $40,000,000.

In order to exercise the rights necessary for the construction of the canal and for its management after completion, the United States should acquire control of a strip of territory from sea to sea sufficient in area for the convenient and efficient accomplishment of those purposes. Measures must also be taken to protect the line from unlawful acts of all kinds, to insure sanitary control, and to render police jurisdiction effective. The strip should be not less than 5 miles wide on each side of the center line of the canal or 10 miles in total width.

No treaties now exist with any of the states within whose territory the two routes lie authorizing the United States to occupy its territory for the construction and operation of a canal. When it has been determined to undertake the work and the route has been selected, the consent of Colombia, or of Nicaragua and Costa Rica, for such occupation must be obtained before the inauguration of the enterprise, and one or more conventions must be entered into by the United States to secure the necessary privileges and authority.

The Republics of Nicaragua and Costa Rica are untrammeled by any existing concessions or treaty obligations and are free to grant to the United States the rights necessary for the attainment of these ends; and in December, 1900, demonstrated their willingness to have their territory so occupied by the United States by executing protocols by which it was agreed that they would enter into negotiations to settle in detail the plan and agreements necessary to accomplish the construction and provide for the ownership of the proposed canal whenever the President of the United States is authorized by law to acquire the necessary control and authority.

The Government of Colombia, on the contrary, in whose territory the Panama route lies, has granted concessions which belong to or are controlled by the New Panama Canal Company and have many years to run. These concessions, limited in time and defective in other ways, would not be adequate authority for the purposes of the United States, but while they exist Colombia is not free to treat with this Government. If the Panama route is selected these concessions must be removed in order that the two Republics may enter into a treaty to enable the United States to acquire the control upon the isthmus that will be necessary and to fix the consideration.

An agreement with the Panama Canal Company to surrender or transfer its concessions must include a sale of its canal property and unfinished work, and the Commission undertook, soon after its organization, to ascertain upon what terms this could be accomplished. Much correspondence and many conferences followed, but no proposition naming a price was presented until the middle of October, 1901, and after prolonged discussion it was submitted to the Commission in a modified form, on the 4th of November, to be included in its report to the President. The itemized statement appears in an earlier chapter of the report. The total amount for which the company offers to sell and transfer its canal property to the United States is $109,141,500. This, added to the cost of completing the work, makes the whole cost of a canal by the Panama route $253,374,858, while the cost by the Nicaragua route is $189,864,062, a difference of $63,510,796 in favor of the Nicaragua route. In each case there must be added the cost of obtaining the use of the territory to be occupied and such other privileges as may be necessary for the construction and operation of the canal in perpetuity. The compensation that the different States will ask for granting these privileges is now unknown.

There are certain physical advantages, such as a shorter canal line, a more complete knowledge of the country through which it passes, and lower cost of maintenance and operation in favor of the Panama route, but the price fixed by the Panama Canal Company for a sale of its property and franchises is so unreasonable that its acceptance can not be recommended by this Commission.

After considering all the facts developed by the investigations made by the Commission and the actual situation as it now stands, and having in view the terms offered by the new Panama Canal Company, this Commission is of the opinion that "the most practicable and feasible route" for an isthmian canal, to be "under the control, management, and ownership of the United States," is that known as the Nicaragua route.

We have the honor to be, sir, with great respect, your obedient servants,

J. G. Walker,
Rear-Admiral, United States Navy,
President of Commission.
Samuel Pasco.
Alfred Noble.
Geo. S. Morison.
Peter C. Hains,
Colonel, United States Corps of Engineers.
Wm. H. Burr.
O. H. Ernst,
Lieutenant-Colonel, United States Corps of Engineers.
Lewis M. Haupt.
Emory R. Johnson.

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57TH CONGRESS, 1st Session. | SENATE. | Doc. No. 54, Part 2.

REPORT

OF THE

ISTHMIAN CANAL COMMISSION,

1899-1901.

REAR-ADMIRAL JOHN G. WALKER,
UNITED STATES NAVY,
President.

HON. SAMUEL PASCO.
MR. GEORGE S. MORISON.
LIEUT. COL. OSWALD H. ERNST,
Corps of Engineers, U. S. Army.
LEWIS M. HAUPT, C. E.
ALFRED NOBLE, C. E.
COL. PETER C. HAINS,
Corps of Engineers, U. S. Army.
WILLIAM H. BURR, C. E.
PROF. EMORY R. JOHNSON.

LIEUT. COMMANDER SIDNEY A. STAUNTON,
UNITED STATES NAVY,
Secretary.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1902.

In the Senate of the United States,
February 18, 1902.

Ordered, That the following appendixes attached to the report of the Interoceanic Canal Commission be printed:

B. Historical notes relative to the Universal Interoceanic Canal Company, 1880–1894, prior to the organization of the new company.

C. List of documents furnished to the Commission by the New Panama Canal Company.

D. Report of the hydrography of the Panama Canal route, by Mr. A. P. Davis, chief hydrographer.

E. Waste weir dimensions and discharges of Lake Bohio.

F. Description of alternate location for canal between Gatun and Bohio.

G. Discussion of the time required for transit through an isthmian canal by the two routes.

H. Discharge of the canalized San Juan River.

I. Report of hydrographic investigations in Nicaragua, by Mr. A. P. Davis, chief hydrographer.

J. Survey from the upper San Juan to the Indio River, by Mr. A. B. Nichols, division engineer.

U. Contract between Nicaragua and the Atlas Steamship Company.

CC. Treaties between France and New Granada, 1856, and France and Colombia, 1892.

DD. Treaty between Spain and Colombia, 1831.

FF. Amended contract between Colombia and the Panama Railroad Company.

GG. Contract between Colombia and Interoceanic Canal Association, March 20, 1878. (Wyse concession.)

HH. Additional contract modifying that of May 20, 1878, December 10, 1890.

II. Contract granting extension to the Panama Canal Company in liquidation, April 4, 1893.

JJ. Contract granting further extension of time to the New Panama Canal Company, April 25, 1900.

KK. Memorandum showing legal status of the New Panama Canal Company, with laws, decrees of court, and charter.

MM. Contract between Nicaragua and the American Atlantic and Pacific Ship Canal Company, August 27, 1849.

NN. Report on industrial and commercial value of canal, by Prof. Emory R. Johnson.

Attest:

Charles G. Bennett, *Secretary.*

ISTHMIAN CANAL.

APPENDIX B.

HISTORICAL NOTES RELATIVE TO THE UNIVERSAL INTEROCEANIC CANAL COMPANY (1880–1894) UNTIL THE ORGANIZATION OF THE NEW COMPANY.

PRELIMINARY REMARKS.

The great excitement which followed the downfall of the old Panama Canal Company can be explained only by the universal character of the enterprise, the distinction of the man who directed it, and the importance of the interests involved.

That downfall, however, was so unfortunate as to be subservient to political passion. Hence, the attention of the public was turned aside from the work itself. Exaggeration, ignorance, and also bad faith finally destroyed confidence in the future of an enterprise which the excessive optimism and, we must add, the errors of Mr. de Lesseps had seriously jeopardized.

A little reflection and dispassionate reasoning will convince anyone that the construction of an interoceanic canal is, all proportions being observed, an industrial affair like any other. In order to be properly planned and regularly carried out, it had to be previously studied with care in all its details.

The solution to be adopted should not have been based upon preconceived ideas, however flattering they appeared, but upon serious and practical observation of the facts. Such a method was especially necessary for a work of such magnitude, difficulty, and perplexity.

Now, the real cause of the downfall of the old Panama Company was the lack of the serious studies which should have preceded its organization. In view of the results that would have been secured by such studies, in view of the enormous amount of work to be performed and the proportionate expense to be incurred, we may believe that the enterprise would have been, from the outset, based upon a plan and directed according to a programme different from those which were adopted by Mr. de Lesseps. It was only under the pressure of circumstances that Mr. de Lesseps decided to modify his original plan. It was, however, too late and success had become, for him, impossible.

In order to give a correct idea of the events which succeeded each other, it is necessary briefly to review the history of the old company. It will be seen that the original errors were followed by a succession of mistakes, the inevitable consequence of which was the final disaster.

Chapter I.

THE UNIVERSAL INTEROCEANIC CANAL COMPANY.

(1880–1889.)

I.—BRIEF SKETCH OF THE DISCOVERIES, EXPLORATIONS, AND PLANS FOR MARITIME CANALS ON THE AMERICAN ISTHMUS UNTIL 1879.

When Vasco Nuñez de Balboa, in 1513, had seen the Pacific Ocean, he ardently sought for a natural passage between the two oceans. At the very outset his idea was to utilize the course of the wide rivers of the Isthmus of Darien.

After his death, in 1520, Don Angel Saavedra, interpreting his views, proposed to Charles V to construct a canal through that isthmus.

A few years later, Hernan Cortéz, then master of Mexico, desired to dig a maritime canal through the Isthmus of Tehauntepec, and in his letters to Charles V he laid great stress upon the necessity of accomplishing that project.

Finally, in 1550, the Portuguese navigator Antonio Galvão published a book designed to show that it was possible to construct a ship canal through the isthmuses of Mexico, Nicaragua, Panama, and southern Darien.

Thus, at the close of the sixteenth century the four principal routes for an interoceanic canal were known.

Many explorations succeeded each other; but no serious effort was made, and none could be made, in a practical manner, at that time.

The interoceanic canal question was neglected and almost forgotten during the entire seventeenth century, and the greater part of the eighteenth.

It was England that, toward the close of the eighteenth century, attached to this question its full political and commercial importance. The British Government, with characteristic foresight, thought that the national interest rendered it imperative for it to secure possession of that part of the American isthmus which then seemed to offer the best route for the establishment of communication between the Atlantic and Pacific oceans. This was the cause of Nelson's unfortunate expedition against Nicaragua in 1778.

After that time, except during the Revolution and the first years of the Empire, explorations were multiplied. That of 1780 deserves special mention. It was organized by order of Charles III, King of Spain, and its object was the construction of a canal through the Isthmus of Panama. Humboldt, who visited the American isthmus in 1804, declared his preference for a route via the Isthmus of Darien. From 1814 to 1842 numerous surveys were made on the Isthmus of Tehauntepec.

Finally, in 1844, a Frenchman, Napoleon Garella by name, engineer in chief of mines, first made an accurate report concerning the Isthmus of Panama, which he had surveyed both with a view to the construction of a canal and of a railway. He had been sent by a French company which had received a concession for these two routes, and which, in pursuance of his report, decided in favor of the construction of a railway. But the events of 1848 came. The concession of the French company lapsed, and the railway was built, from 1850 to 1855, by an American company, which is still operating it.

At this same time the grave diplomatic incidents occurred between England and the United States which had reference to the control and the neutrality of the future interoceanic route, and which were terminated in 1848 by the Clayton-Bulwer treaty.

From 1850 to 1870 new explorers, most of whom were Americans, made new surveys in various parts of the Isthmus. Public opinion in the United States was passionately in favor of some of these routes; then the American Government resolved (1870) to cause the Isthmus to be surveyed, at its own expense, from Tehauntepec to Darien. The explorations lasted three years, and were still incomplete.

The Congress of Geographical Science, which met at Antwerp in 1871 and at Paris in 1875, gave its attention to the subject of an interoceanic canal. At this latter meeting *Mr. de Lesseps declared that, in his opinion, the authors of all the plans entertained up to that time had committed a serious error by examining only routes for canals with locks. He declared that an interoceanic canal, in order to meet all the requirements of commercial navigation, must be constructed on a level, as the Suez Canal had been.*

This formal and absolute opinion of Mr. Ferdinand de Lesseps was destined to prevail, four years afterwards, before the International Congress of Surveys. It was not fully adopted, however, by the congress of 1875, which confined itself to expressing the following wish:

> The congress expresses the wish that the governments interested in the construction of an interoceanic canal will have the surveys for such a canal made with as much activity as possible, and that they will adhere to the routes which offer to navigation the greatest facilities for access and traffic.

But, pending the intervention of the Powers, which might have caused a very long delay, the Society of Commercial Geography at Paris saw fit actively to pursue the solution of the problem. It had ascertained, from the debates of the recent congress, that the world was not in possession of full topographical information concerning the American isthmus. It was convinced, moreover, that it was impossible, without supplementary surveys, to make, intelligently, a choice of a route that should be based upon proofs and reasons. Only, the society had neither the resources nor the credit necessary to enable it to undertake the costly explorations which had to be made. It thought proper to place its work in more powerful hands, and to that end it organized, March 24, 1876, *a French committee to examine the subject of the construction of an interoceanic canal.* Mr. de Lesseps was chosen president of the committee; Admiral de la Roncière le Noury and Admiral Meurand were chosen vice-presidents; Messrs. Daubrée, Levasseur, and Delesse (of the institute), Count Foucher de Careil, and Messrs. Malte-Brun, Cotard, Maunoir, Hertz (Charles) were members; Mr. Bionne was secretary.

At the same time, General Turr and Lucien Napoleon Bonaparte-Wyse organized a civil association, which undertook to defray the expense of the explorations, and before the close of the year 1876 an international expedition, under the direction of Mr. L. N. B. Wyse, was operating on the ground. It finished its surveys in 1878. In the month of May, 1878, Mr. L. N. B. Wyse, in the name of the Civil Association, secured from the Government of Colombia the concession of the ship canal to be constructed through the territory of that country.

The French committee was then able to convoke a special congress, to which it submitted all the data which it had collected. We will briefly review the work of that congress, which adopted the name of "The International Congress of Surveys for an Interoceanic Canal."

II.—THE INTERNATIONAL CONGRESS OF SURVEYS FOR AN INTEROCEANIC CANAL.

(May 15–29, 1879.)

The International Congress of Surveys for an Interoceanic Canal held its sessions at Paris from the 15th to the 29th of May, 1879.

The 135 members who composed it were divided up into five large commissions, whose titles were the following: (1) Statistics; (2) Economical and commercial questions; (3) Navigation; (4) Technical questions; (5) Ways and means.

We will not discuss here anything but the conclusions which were formulated by the first and fourth commissions.

M. Levesseur, member of the institute, was, at the same time, president and reporter of the commission of statistics, which made the following predictions concerning the traffic of the canal:

> In ten years (in 1889), before which time the canal will, in all probability, not be opened to traffic, 5,250,000 tons at least will probably represent the commercial movement of the two oceans, and about 2,000,000 tons will represent that fraction of the commercial movement between the East and Europe which, as it seems, may be diverted from the route now followed, in order to take that of the American Isthmus; 7,250,000 tons in the aggregate.

M. Levasseur took care to forestall any voluntarily optimistic or erroneous interpretation of his conclusions. He called attention to the fact that they did not mean that 7,250,000 tons would necessarily take the route of the canal within a year from its opening, or even in the years following. What he desired to ascertain and establish was the capacity of the double reservoir by which the canal was to be supplied, offering to navigation incontestable advantages over the rival routes through the continent or to the south of the American continent.

M. de Lesseps was, afterwards, much more positive. He did not hesitate to consider the estimates made by M. Levasseur as representing the certain traffic of the canal as soon as it should be put into operation.

The fourth commission, which was specially charged with the technical examination of the various routes, had M. Daubrée, member of the institute, for its president, and Voisin Bey, formerly director-general of the work on the Suez Canal, for its reporter. It carefully examined all the plans that were submitted to it. Unfortunately, those plans were based upon incomplete data. For none of them could the amount of work to be done be accurately determined. As to prices and terms of construction, no standard of comparison and no precedent were available in order to fix them.

When one reads the reports of the sessions of that commission, one constantly recognizes the inspiration of M. de Lesseps, one perceives the action of his will, so persistent in forming a general opinion in favor of a plan for a canal on a level. The discussions of the commission were long, and sometimes very heated. It clearly appears, however, that opposition to the views of M. de Lesseps was manifested mainly by abstaining from voting. Thus, at the time of formulating their opinion concerning the conclusions reached in the report of Voisin Bey, 40 members absented themselves, 10 abstained from voting, and only 19 voted, 16 of whom voted in the affirmative. And still, those conclusions were not yet wholly absolute. They were as follows:

The Technical Commission is of opinion that the route of the interoceanic canal should be from the Gulf of Limon to the Bay of Panama; and it particularly recommends the construction of a ship canal on a level in that direction.

The prediction was made that the time necessary for the construction of the canal would be twelve years, and that the cost of the work would be 1 milliard (billion) and 70 millions. Supposing that the interest payable in the meantime would amount to 130,000,000, the total expenditure was to be 1,200,000,000.

The conclusions adopted by the congress in full session secured the complete triumph of M. de Lesseps. They were as follows:

The congress thinks that the construction of an interoceanic canal on a constant level, which is so desirable in the interest of commerce and navigation, is possible, and that such ship canal, in order to meet the indispensable facilities of access and utilization which should be offered, especially, by a communication of this kind, should be directed from the Gulf of Limon to the Bay of Panama.

However, in order to appreciate the bearing of these conclusions, the manner in which the votes were divided must be examined.

Of the 135 members who composed the congress, 37 were absent at the time when the vote was taken and only 98 voted. The votes, for almost all of which reasons were given, were as follows: Not voting, 12; noes, 8; ayes, 78.

By considering the names of those who abstained from voting, of those who were absent, and of those who voted no, it is seen that M. de Lesseps had against him a majority of the engineers and of the contractors who were members of the congress. One of them, Mr. Kleitz, inspector-general of bridges and roads, presented in support of his negative vote the following remarkable observations:

I do not adhere to the conclusions submitted to the vote of the congress, because they seem to me to be too positive and too absolute.

The only conclusions which thus far seem to me to be justified by the discussion of the various plans are the following:

1. The interoceanic canal should extend from the Gulf of Limon to the bay of Panama.
2. The surveys submitted to the congress are not sufficiently thorough to render it possible, without fuller information, to declare the possibility of the construction and operation of a canal on a level, and to make a choice, based upon reasons and proofs, between that system and that of a canal with locks.
3. The solution which should, if possible, be accomplished, is that of a canal on a level, because such a solution is better adapted to a large increase of traffic, and to securing the safety and rapidity of the passage.
4. In case the construction of a canal on a level should give rise to uncertainty to too serious difficulties or to excessive expense, a canal with locks would probably meet the requirements of maritime navigation.

These sensible observations of Mr. Kleitz were, unfortunately, not listened to. The International Congress of Surveys for an Interoceanic Canal closed its sessions May 29, 1879. M. de Lesseps announced that he would agree to place himself at the head of the new enterprise, and, confiding in his lucky star, he uttered these words:

If a general who has won his first battle is asked whether he desires to win another, he can not refuse.

It is interesting to remember, after what has just been quoted of the observations of Mr. Kleitz, and especially in view of the present plans, that the idea of a canal through the Isthmus of Panama, comprising an inner lake formed by a dam across the Chagres Valley, had already been mentioned and submitted for discussion to the Congress of 1879.

On the Panama line the route leaves the Chagres Valley at Matachin; the height of the water course is 14.60 meters at that point; taking about that level for the bottom of the basin, we may fix the water plane at level 24; that is to say, a little below the height of the highest waters, and we get rid of the Chagres, whose presence near the trenches constitutes an increase of expense and a considerable augmentation of the time required for the work.

It is useless to raise the summit level any higher; it is doubtful whether that represents any saving, owing to the cost of the feeders, which will always be very far from securing the full flow of the river for the requirements of navigation, as is done by the arrangement aforesaid.

This point being established, we might doubtless take the ordinary canal system and go down the valley, cutting its spurs.

Here, however, the abundance of water offers resources that are unknown in the temperate zones. It is, furthermore, very dangerous to the health of the men employed in the works to dig up the earth; this is certainly the greatest difficulty presented by this work.

The establishment of an artificial lake at the height of the summit level does away with all these inconveniences, while it replaces, for a great length, a canal with a narrow waterway by a route of more than 1,000 meters of minimum width, in which vessels may sail at any rate of speed desired, and may pass each other without the turning out places.

We should thus, at this low altitude, have a real Bosphorus (Bosporus), extending from one ocean to the other, which would be approached through short stretches of water and flights of locks that could be easily and rapidly passed.

This system of retention of water was proposed at La Tuyra by Mr. Celler, engineer in chief of bridges and roads; it has been proposed by M. Blanchet, in Nicaragua, and by others, since 1860, for the passages of Tehuantepec and Darien; but it is here much better indicated by the nature of the locality and the facilities offered by the Chagres Valley and River.

It is, we repeat, the natural method, because it does away with labor and with the unhealthiness of the soil, and because it is most advantageous to navigation.

Taking the plan of Messrs. Wyse and Reclus for greater practicability, we reach the conclusion, according to the above data, that the time required for passage through such a canal would be twelve hours, while in a canal with a narrow waterway and on a level it would be ten hours and a half—that is to say, vessels would lose an hour and a half in the passage, with much less chance of suffering damage. Following up this calculation, the conclusion is reached that the loss of time represents, for the navigation of the globe, a capital of 1,500,000 francs, and as regards the cost of construction a saving of money of nearly 600,000,000 francs, together with a saving of six years, at least, in the construction.

It is evident that the dams in the valley raising the water plane to level 24 should be as near as possible to the two oceans; the desirable points are the mouth of the Gatun River, kilometer 8 and kilometer 64, where they seem possible. In all cases, kilometers 22 and 62, which are the termini of the first and sixth sections of the plan, are perfectly practicable.

The maximum depth of the trench would be 72 meters, that is, 12 meters more than the drain of the City of Mexico, which is placed in volcanic tufa the nature of which is by no means good; its average depth is 39.50 meters; here, on the contrary, the hardness of the rocks furnishes complete security. Its cube is 8,553,000 meters, about 253,000 meters being of surface earth.

The dams fixed at level 26 have their foundations on a level with the oceans and 1.50 meters below the bed of the river. They have a height of retention of 22.50 meters, which is much less than that of the dams of the Sig and of the Habra in Algeria. Several valley dams in France, and particularly in Spain, are much higher, especially those of Saint-Etienne and Madrid.

At this height it is possible to construct with earth, which work is both economical and durable. The Tlélat dam, in Algeria, is of the same height, but it is well to make provision for concrete dams, mainly for the avoidance of unhealthiness of construction.

The Chagres drains 20 meters in five months. Its deflection for the purpose of allowing dredging and the establishment of foundations in its bed presents no difficulties.

A series of five locks would be attached to the dam. By this means the maneuvering would be very rapid. A set of machines would be established there, and it is probable that, with the aid of a reduction of the number of gates, the passage would be made in an hour and a quarter. If this were so, less trouble and loss of time would be met with than with a canal on a level and with a narrow waterway.

The ebb locks would form the six locks of the series, which would reduce the time lost in the canal and the amount of the work on the short lengths with a narrow waterway.

Two weirs of the total length of 800 meters would be established near the dams, probably by means of small trenches in the neighboring valleys; their absolute security can always be guaranteed by the riprap and piles at their foot.

In extraordinary freshets, giving 1,300 meters per second, the layer of outflowing water would be less than 1 meter thick; the current in the trench would be regulated by the length of the dam toward the Pacific.

If things are established in this manner the water plane is kept at its maximum, its variations being prevented. This is obeying natural laws while profiting by them and regulating them.

III.—THE FIRST ISSUE.

In order to construct a canal on a level through the Isthmus of Panama, the route for which had been fixed upon in a general way by the International Congress of Surveys, an association was immediately organized under the name of "The Universal Interoceanic Canal Company;" its capital was to be 400,000,000 francs, represented by 800,000 shares of 500 francs each.

The public subscription was opened in Europe and America on the 6th and 7th of August, 1879. It was not a success. Only 30,000,000 were subscribed for.

Bitter attacks had been made upon the enterprise. The amount of cost estimated was criticised as being too small, and the amount of the receipts estimated was criticised on the ground that it was too large. From a political point of view it was sought to arouse fears of hostility on the part of the United States of America.

While under prosecution Mr. Charles de Lesseps explained the causes of this violent opposition, and showed how his father had succeeded in putting a stop to it. He was obliged to consent to put the financial management of the enterprise in the hands of a group of persons connected with journalism and finance, who undertook to render public opinion favorable to the enterprise. It is not for us to dwell upon this point.

On the other hand, however, in order to meet the repeated criticisms of the insufficiency and inaccuracy of the first estimates, Mr. de Lesseps decided that new surveys should be made. In a letter bearing date of August 14, 1879, in which he admitted that the issue of the 6th and 7th of that month had not been successful, he announced that those supplementary surveys would be made with the approval of Mr. Couvreux and his associates, and that it would not be until his return from the isthmus that he would definitely organize the Interoceanic Canal Company.

IV.—THE INTERNATIONAL SURVEY COMMISSION.

M. de Lesseps embarked December 8, 1879, at St. Nazaire for Colon, where he landed on the 30th of that month.

An international technical commission accompanied him. The organization of this commission had been provided for and the work to be done by it had been defined by the concession law. According to article 1, section 3, of that law, it was to make the final surveys on the ground, and to fix upon the route of the line of the canal. It was, moreover, charged with replying, by the results of its surveys, to the criticisms of the opponents of the new enterprise, or simply to the observations of those who did not look without fear into a dark future.

On the 14th of February, 1880, the International Survey Commission decided upon the conclusions of its report determining the final conclusions concerning the construction of the Panama Canal.

Notwithstanding our desire to state nothing but facts, we can not help here referring to the haste with which the supplemental surveys of the colossal work that was about to be undertaken were made.

The estimates for the work proper, prepared by the international commission, amounted to 843,000,000 francs. The commission at the same time expressed the opinion that with a good and judicious organization the work could be finished in *eight years*. It was, as compared with the conclusions of the congress, a reduction of 200,000,000 francs in the total cost and a saving of four years in the time to be employed in the construction.

M. Ferdinand de Lesseps, however, thought that he could still further reduce the estimates of the international commission, although they were already notably lower than those of the technical commission of the congress of 1879. He stated the reasons of the reductions made by him, in a note written on the 22d of February, 1880, on the steamer which took him from Colon to New York. It was necessary, according to him, to provide for an expenditure of only 658,000,000 francs; and, in his opinion, the amount that would be saved in the excavation "would fully offset the interest payable to the shareholders on the capital expended during the construction."

Now, if we refer to the conclusions reached by the congress, we find that the estimates furnished by them, viz, 1,200,000,000 francs and twelve years, appeared insufficient to many of its members, who were experienced engineers and contractors, for the construction of a canal on a level. Nevertheless, Mr. Ferdinand de Lesseps thought that he could reduce them nearly 50 per cent.

If we further observe, as we shall hereafter show, that the amount of work to be done had been inaccurately estimated, the events about to follow, together with all their consequences, can easily be forseen.

V.—THE COUVREUX AND HERSENT CONTRACT—SUCCESS OF THE SECOND ISSUE OF SHARES.

Let us now briefly refer to the journeys made by Mr. de Lesseps, on his return from the isthmus with a view to promoting the enterprise, to the United States, England, Belgium, Holland, and in France.

The speeches delivered in these different countries clearly show the views, or, more accurately, the state of mind of Mr. de Lesseps and his partisans whom he had caused to share his faith, his enthusiasm, and his temerity. As we wish to forget and conceal nothing, we must point out, at the same time, in these public demonstrations, the part taken by self-esteem and by interests superexcited by such an enterprise.

The previous successes of Mr. de Lesseps, and his personal prestige, seemed to justify his optimism and boldness.

We must cite, as an instance, a speech delivered at Brussels, May 6, 1880, in which Mr. A Couvreux, jr. stated that his firm would undertake the construction of the Panama Canal, the cost of which it estimated at only *512,000,000 francs.*

This new reduction of the estimates of the international commission was the result of an estimate made upon the following basis: It had been supposed that the new surveys made, and even the results of the first preparatory work, would confirm the amount of work as estimated by the international commission.

Messrs. Couvreux & Hersent likewise thought that the application of the improvements recently made in machinery for boring and digging would render it possible to reduce the unit prices fixed by the congress of Paris and accepted by the international commission.

The total of 512,000,000 francs represented the cost of extraction and of the partial employment in the construction of dams, of the 75,000,000 cubic meters, which expense was estimated at 466,098,000 francs, increased by 45,902,000 francs for contingent work and accessories not specified.

At the time to which we are now referring, viz, in 1880, no one can be accused of bad faith. It is, moreover, with a real feeling of sadness that we now read the following passage of the speech which we are considering:

> It is certain that these prices are still in excess of the truth, and if the future shows that the estimates now adopted have not been reached, the wisdom of those who have prepared them must not be impugned, but their wise foresight must be recognized in the performance of so gigantic a task, which is to be accomplished in such new and almost unknown regions.

M. Ferdinand de Lesseps was, in fact, in full accord with Messrs. Couvreux & Hersent. These gentlemen had expressed to him their readiness to organize the enterprise and to do the work for the account of the company until the ship canal should be entirely completed.

The performance of the work was divided into two parts:

1. The period of organization, which was to last about two years, and during which the greater part of the material was to be prepared, as was the greater part of the installations; the work, moreover, was to be commenced at several points, so that an exact estimate of the cost would render it possible to fix the unit prices.

2. The period of enterprise proper, which was to last six years, and was to be regulated by a special agreement based upon the unit prices resulting from the work already done, and to be definitely decided upon by the company and Messrs. Couvreux & Hersent.

Consequently, Messrs. Couvreux & Hersent, acting with the regular powers of the company, were to form, both at Paris and Panama, an organization for the direction of surveys, and afterwards for the direction of work. After having made the surveys and caused to be constructed the plant, prepared the work yards, etc., they were to decide the technical or other questions connected with the execution of the works themselves.

Before the expiration of the two years fixed upon as the period of organization, installation, construction of plant and useful tests, Messrs. Couvreux & Hersent were to submit to the company the unit prices that were to serve as a basis for the organization of a joint-stock enterprise.

The unit prices being fixed by common consent, the work was to be done by Messrs. Couvreux & Hersent for the account of the company, and when the work should be finished the following settlement was to be made: A total and exact addition was to be made, but without interest, of all sums expended, with the exception of the expenses of the superior management of the company and those of the service of inspection. Furthermore, the general amount of all the work done was to be computed, and the unit prices fixed upon were to be applied to the quantities ascertained. The difference between the two results was to be the profit realized by the joint-stock enterprise, and that profit was to be wholly divided, according to a special agreement to be made for that purpose by the company and the contractors. In the meantime, and for the first period only, the contractors were to receive a bounty of 6 per cent on the total amount of the expenditures.

In this situation the issue of the 7th, 8th, and 9th of December, 1880, took place; it was for 300,000,000 francs, represented by 600,000 shares at 500 francs each.

The issue was subscribed for twice.

In order to attain this end what declarations and assertions had been made to the public?

It had been told that—

An international technical commission having met on the spot (at Panama), had declared that a ship canal was practicable.

The contractors, Messrs. Couvreux & Hersent, had presented their estimates and declared that the construction of the canal would not cost 500,000,000 francs, and would last eight years.

The estimate of an annual traffic assuring a revenue of 90,000,000 francs on 6,000,000 tons was to be considered as below the reality, and the revenue would be larger than had been supposed.

The Americans had recognized that the work of piercing the Isthmus of Panama would be an essentially international work, done for the benefit of all, and that its neutrality would be guaranteed by the concession itself, and would be absolute, which would secure the unrestricted cooperation of the wealthy and powerful American banks.

Until the close of the year 1882, Messrs. Couvreux & Hersent prosecuted the surveys and the preliminary work of the canal. On the 31st of December, 1882, they wrote to Mr. Ferdinand de Lesseps, proposing to him the annulment of their contract, declaring, however, that they were prepared to inaugurate the second period, the period of construction proper, on the terms provided in the contract; that is to say, on the basis of the unit prices resulting from the work which had already been done. They added, however, that it was their duty to call attention to the fact that such an agreement would be onerous to the company. It had happened, as ought to have been foreseen, that during the period of preliminary organization and installation the cost price of the work performed, burdened with a large amount of general and divers expenditures, increased by groping in the dark and by special inexperience with regard to the conditions prevailing on the isthmus, was found to be very high.

Messrs. Couvreux & Hersent observed, moreover, that they had found that the system of the division of contracts would meet, better than any other, the actual requirements of the situation, in that it would permit, first, a test of the different methods, and consequently a more speedy performance of the work. It was this system of small contracts that was adopted on the terms which we will mention hereafter, from 1883 up to the close of 1885.

VI.—THE SUPERIOR ADVISORY COMMISSION FOR THE WORK.

Early in the year 1881, Mr. de Lesseps, thinking that the new and detailed surveys which had been going on since the organization of the company were sufficiently far advanced to render it possible to decide upon definite plans for certain sections of the canal, created a superior advisory commission for the work, which was to act as a technical board, and to give its opinion with regard to all plans. This commission was composed of:

Mr. Lefébure de Fourcy, inspector-general of bridges and roads, president.

Mr. Daubrée, inspector-general of mines, director of the school of mines, member of the institute, vice-president.

Mr. Dirks, engineer in chief of the Waterstaat in Holland, vice-president.

Mr. Boutan, engineer of the corps of mines.

Commander Gioia, an Italian engineer.

Mr. de la Gournerie, inspector-general of bridges and roads, member of the institute.

Admiral Jurien de la Gravière, member of the institute.

Mr. Lalanne, inspector-general of bridges and roads, member of the institute.

Mr. Laroche, engineer in chief of bridges and roads, formerly engineer of the Suez Canal.

Mr. Larousse, hydrographic engineer, formerly engineer of the Suez Canal.

Mr. Oppermann, engineer in the corps of mines.

Mr. Pascal, inspector-general of bridges and roads, engineer in chief of the port of Marseilles.

Mr. Ruelle, engineer in chief of bridges and roads, director of construction of the railroads of P. L. M.

Voisin Bey, inspector-general of bridges and roads, formerly director-general of work on the Suez Canal.

Mr. Dauzats, consulting engineer of the company, secretary.

Subsequently, several new members were designated, and in particular Mr. Jacquet, inspector-general of bridges and roads, who made, on his return from the isthmus, whither he went in 1886, contemporaneously with Mr. A. Roussau, an important report.

We desire to call to mind that the functions of the commission were of a purely advisory character. The engineers who composed it took no part whatever in the construction, that is to say, in the preparation and control of the contracts and of the works.

We have thought proper to give their names and to point out the importance of their positions and functions, in order to have an opportunity to show once more that Mr. de Lesseps was able to cause eminent engineers to share his views regarding the practicability of the construction of a canal on a level. His personal influence was so great that none of these men, and none among them could be suspected, was willing or bold enough, perhaps, to concern himself about the financial consequences of the work.

VII.—PURCHASE OF THE SHARES OF THE PANAMA RAILROAD COMPANY.

We must call attention to an important act of the company which took place at this time. It was the purchase of almost all the shares of the American company owning the railroad from Colon to Panama. On this subject a few retrospective explanations are necessary.

An American company, organized in New York in April, 1849, secured from the Government of the United States of Colombia, April 15, 1850, a concession for a railroad between Colon and Panama. That first concessson was modified in 1867 so as to guarantee to the American company, with certain reservations, the exclusive monopoly of any means of communication (canals, roads, etc.) crossing the Isthmus of Panama from one ocean to the other as far as the limits of a certain determinate zone.

The ship canal which was to connect the two oceans passed into the zone reserved for the railroad company; but among the reservations made by the Government of Colombia was the right to grant a concession for piercing a ship canal, the terms being specified on which that right should be exercised.

In short, the railroad company could not oppose the opening of the canal, but it had a right to demand from the owners of that competing thoroughfare an indemnity which it was obliged to share with the Colombian Government. Mr. de Lesseps thought that the procedure provided for by the law governing the concession, with a view to enabling the two companies to reach an arrangement, would cause the loss of a great deal of time. Now, it was indispensable that such an arrangement should be made, for not only was the practical use of the railroad, which follows the line of the canal almost exactly, necessary to the progress of the work, but also the land, the wharves, and quays belonging to the railroad had to be utilized on the best terms by the canal company.

Mr. F. de Lesseps preferred to negotiate the purchase, pure and simple, of the majority of the shares of the railroad company, as the American law gave the most ample powers to the owner of the majority of the shares of the company. He thought that he found, in this manner of proceeding, two important advantages: In the first place, no modification was made in the American constitution of the Panama Railroad Company, and in the second place, the canal company secured, in the most simple and speedy manner, the necessary influence over the railroad company.

VIII.—THE SMALL CONTRACTS.

(1883–1885.)

We have seen how the contract of Messrs. Couvreux & Hersent came to an end. The company was obliged, in consequence, to secure some one to take charge of the direction of the work. It assigned this task to Mr. Dingler, engineer in chief of bridges and roads, who went to Panama in the month of February, 1883.

This was, in reality, the second period provided for from the outset, the period of construction, properly so called, of the canal which was then beginning to be built. Numerous work yards were opened or prepared all along the line of the canal. The highest peaks that the canal met with were attacked. Thus was to be obtained, following the route, a succession of platforms, more or less extensive, and of various heights. Thus was prepared the installation of large work yards best suited to permitting the most active and regular operation possible.

While he was organizing the work yards, Mr. Dingler examined the entire plan for a sea-level canal. His report is the only full statement of the question that has been made. It is a voluminous document, and can not be readily analyzed. It received the approval of the superior advisory commission.

The general provisions of the plan were the following: The canal, which had its origin in Limon Bay, at Colon, on the Atlantic, was established as far as Obispo, for about 45 kilometers, at the very bottom of the Chagres Valley; it then crossed the chain of the Cordilleras, which separates the Atlantic from the Pacific Ocean, between kilometers 45 and 56, and finally, beyond, developed itself in the valley of the Rio Grande as far as deep water in the Pacific, near the island of Naos, in the Bay of Panama.

The length of the line was 74 kilometers. The width of the canal at bottom was to be 22 meters, and it was to be 9 meters deep.

In order to moderate and regulate the floods in the Chagres, the flow of which may rise from 20 cubic meters at low water to 2,000 cubic meters when there is a high flood, a large dam had been projected at Gamboa across the valley of the Chagres, creating a reservoir capable of storing a part of the water of the floods. Their flow being thus reduced, the water of the Chagres and its affluents were to be borne to the sea by deflections opened on each side of the canal.

The cube of the excavations to be made was, at least, 120,000,000 meters, or 45,000,000 meters more than had been estimated by the international commission, and 75,000,000 more than the congress had indicated. Notwithstanding this enormous increase in the amount of work, M. de Lesseps adhered, in 1883 and 1884, to his assertion that the canal would be finished in 1888.

It was not until the meeting of the shareholders took place, July 29, 1885, that M. de Lesseps began to modify his preceding declarations. The date of the completion of the canal was deferred until the month of July, 1889, and the estimate of the congress of 1879 was again adopted for fixing the total expense at about $1,200,000,000.

Still, notwithstanding the reiterated assertions and assurances, it became evident that the organization and progress of the work would not permit the programme which had been established on the preceding basis to be carried out. While it was declared that the yield of the work yards was increasing progressively, it began to be realized that, notwithstanding the greatest efforts, it would be impossible to finish the work within the time and with the capital reckoned upon. In the month of July, 1885, hardly one-tenth of the total cubic amount of earth had been excavated; that is to say, of 120,000,000 cubic meters, but 12,000,000 cubic meters had been excavated.

We have now come to a time when the enterprise was severely criticised and and passionately discussed. The credit of the company began to be shaken. M. de Lesseps now thought necessary to appeal to the Government, which he did in a letter bearing date of May 27, 1885, whereby he asked for authority to issue lottery bonds. This first request (which had no result, as will be seen hereafter) was the beginning of an evolution in the programme for the construction of a canal on the level.

IX.—THE LARGE CONTRACTS (ENTERPRISES).

(1885–1887–1889.)

We have hitherto seen set on foot, under the direction of Mr. Dingler, a numerous series of contracts of varying importance, but none of which was charged, within its limits, with the complete construction of a canal on a level. We have likewise said that the amount yielded by the work yards of these different enterprises was too small, notwithstanding their progressive increase, to render it possible to foresee or hope for the completion of the canal at the time fixed.

The company realized that it must make a great effort in order to retain the confidence of the public. On the one hand, it sought to support its assertions relative to the performance of the work by engagements entered into by contractors. It endeavored, on the other hand, to strengthen its credit by Governmental intervention, which was manifested by the grant of a special favor which had already been extended to the Suez Canal Company.

Let us examine in the first place the organization adopted by the company in order to secure, as it thought, the completion of a canal on a level before the close of the year 1889.

The canal was divided into five large sections, each of which was intrusted to a general enterprise, except on the first 25 kilometers on the Atlantic side, where two enterprises were working side by side. These were the American Contracting and Dredging Company and the Jacob enterprise.

Messrs. Vignaud, Barbaud, Blanleuil & Co. were to do the work between kilometer 26 and kilometer 44.

The Public Works and Construction Company had charge of that part of the large trench comprised between kilometer 44 and kilometer 53.60, as well as of the Chagres dam.

The deepest trench, that of the Culebra (from kilometer 53.60 to kilometer 56), was conceded to an Anglo-Dutch enterprise, whose contract was assumed in the course of the year 1886 by the firm of Artigue, Sonderegger & Co.

Finally, Messrs. Baratoux, Letellier & Co. were to dig the canal from kilometer 55.456 to its extremity in the Pacific Ocean.

All these contractors had engaged to complete the work intrusted to them before the close of the year 1889.

Mr. Dingler was succeeded, as director of the work, by Mr. Leon Boyer. A mission to the isthmus was, furthermore, confided by the management of the company to one of the members of the superior advisory commission, viz, Mr. Jacquet, inspector-general of bridges and roads.

Finally, early in the year 1886, M. Ferdinand de Lesseps himself went to Panama, accompanied by M. Charles de Lesseps, by some of the high officers of the company, by delegates of the chambers of commerce of Marseilles, Rouen, Bordeaux, and St. Nazaire, and by various prominent Englishmen and Americans. We will also mention Mr. Pescheck, an engineer attached to the embassy of Germany at Paris, who afterwards became a member of the superior advisory commission for the work.

M. Ferdinand de Lesseps returned to France at the close of the month of March, 1886, with his travelling companions. He immediately announced that he felt the utmost confidence in the speedy completion of the canal.

At this very time two statements were made in favor of the declarations made and the hopes entertained by M. F. de Lesseps. The first was a report of the commission on petitions of the Chamber of Deputies. A large number of stockholders and bondholders of the Panama Canal Company had petitioned that that company should be authorized, as the Suez Canal Company had been, to issue lottery bonds. The commission was unanimously of opinion that the authority asked for should be quickly granted to M. de Lesseps, and referred the matter to the competent ministers.

The second is found among the very favorable reports of the representatives of the chambers of commerce who had accompanied M. F. de Lesseps to the isthmus. To these were joined indorsements of those same chambers of commerce and of various general boards.

During this time the great enterprises recently constituted were organized and set on foot on the isthmus. It was, *a priori*, certain, and it was soon but too evident that they would be powerless to meet their engagements. Three experienced engineers charged, under different titles, with a distinct mission of examination and inspection, were then on the isthmus. Not one of them hesitated to declare that the hopes entertained by M. F. de Lesseps were without foundation.

The first was Mr. Armand Rousseau, then engineer in chief of bridges and roads, ex-deputy, ex-assistant secretary of state at the ministry of public works, whom the Governmont, before formally complying with the request of M. de Lesseps, had delegated on the Isthmus to make a report to it on the situation of the case.

Mr. Rousseau did not conceal the fact, in the whole course of his report, that the completion of the canal with the resources estimated and within the time announced, seemed to him to be more than problematical, unless the company should decide to make important reductions and simplifications in its plans, that is unless it should build the canal with locks. Although Mr. Rousseau did not formally give this advice, it was doubtless because he thought that the official character of his mission did not permit him to do so.

The second, Mr. Jacquet, inspector-general of bridges and roads, came to the Isthmus, having been sent by the company itself. The conclusions reached by him in his report are very clearly stated, and, it must be admitted, are very courageous if his position is considered as a representative of the company and if the state of mind is known which still prevailed at that time among the backers and friends of M. de Lesseps.

Mr. Jacquet declared that, after having visited the work yards and having realized the difficulties of the enterprise, he had reached the conviction that it was necessary to renounce the completion of the canal on a level, and to adopt the plan of a canal with locks on the very line of the canal in course of construction.

The third engineer whose opinion we must mention was Mr. Léon Boyer, director of works on the canal, who died a few months after his arrival in Panama. He likewise declared that the construction of a canal on a level was impossible within the time and at the cost estimated. He laid special stress upon the delay that would certainly result from the excavation of the great trench. Desiring, doubtless, not to oppose too directly the very positive views expressed by M.

F. de Lesseps, he recommended a method which he declared to be provisional, and which consisted in crossing the central mass after it had been sufficiently lowered, by the aid of hydraulic elevators. The deepening of the great trench was to be continued after the canal was in operation.

But M. F. de Lesseps would not hear a word. He continued, on the contrary, earnestly to declare his intention to pursue the construction of a canal on a level.

The Government was disposed, at that time, to grant him its aid. On the 17th of July, 1886, the minister of public works laid before the chamber a bill to authorize the issue of lottery bonds by the Panama Company.

The commission charged with the examination of the bill of the Government declined, early in the month of July, to appoint a reporter before the recess of the legislative bodies.

This was postponing the vote for several months, and M. de Lesseps did not think proper to agree to this postponement. He withdrew the request which he had made to the Government, and obtained from the meeting of the stockholders permission to issue a new series of bonds, which succeeded like the others.

Notwithstanding the efforts made, the true state of the case began to appear in all its gravity. In spite of the attempts made during the year 1886, it became impossible not to recognize the correctness of the estimates made by the engineers of the company themselves, which were at variance with the engagements made by the contractors.

X.—THE TEMPORARY CANAL WITH LOCKS.

(1887–1888.)

A new evolution was preparing. While, in principle, the superiority of a canal on a level over any other remained uncontested and incontestable, the financial situation of the company forced it to seek for a more speedy and less costly solution. Could a dreadful crisis be thus avoided? It was hoped so, but events showed that such a crisis was inevitable.

The manifest desire of the company to seek its salvation in a new way was shown very early in 1887. It is proper to mention here a meeting of the superior advisory commission for the work, which was held in the month of January, 1887, and at which the question of a canal with locks was clearly presented.

At the same time a new delegation, under the direction of M. Charles de Lesseps, was sent to the Isthmus. It recognized once more the impossibility of completing the excavation of the central mass within the short time that had been announced.

Unfortunately, this opinion, although it was not new, was not immediately announced by the management of the company with proper clearness and with all the necessary frankness. Once more were the difficulties and dangers experienced which result from declarations which have become sincere too late, for the public was accustomed to believe assertions of a different character. Too energetic protests had been made against the opinions of the engineers, who, in 1885 and 1886, had pointed out the perils of the situation, and proposed solutions that could be accomplished more speedily, and, what was more important, at less expense. It was, consequently, necessary to prepare a movement of public opinion, such as was required by the situation.

In his report to the meeting of the stockholders, which was held in July, 1887, M. F. de Lesseps gave it to be understood that the company was seeking for new solutions, speedy, and such as would render it possible, without abandoning the plan of a canal on a level, to open a temporary canal for operation at the time appointed.

Time was passing, but the decisive action which the situation called for was not taken. Furthermore, considerable expense was being incurred for work of which a part would be useless.

The superior advisory commission which met in the month of January, 1887, had charged a subcommission to examine the various plans of construction or of temporary operation of the canal which were laid before it by the company. This subcommission met only in the month of September, 1887. The superior commission, at its full meeting in the month of October following, deliberated concerning the conclusions of its subcommission and replied in the affirmative, unanimously, to the following two questions of principle which were propounded to it by the management of the company:

> Is it possible to establish in the central mass an upper level which would permit the work of a canal at the sea level to be finished by applying the method of dredging to the excavation of this portion?
>
> Will it be possible, as soon as these arrangements shall have been completed and without interrupting the work of deepening, to begin the operation of a ship canal between the two oceans?

In accordance with these conclusions, and with new engagements entered into at the same time by the various contractors, the engineers of the company were charged with preparing a plan whose cost, increased by the charges for interest and management during the periods accepted by the contractors, and at the rates of the various contracts concluded, was not to exceed 600,000,000 francs. The date for the completion of the work had been set for the close of the year 1891. It is impossible to avoid being struck with the haste and rapidity with which this new plan was prepared.

The expenditures entailed by the plan to be adopted had to be low enough to leave ground for the hope that the public would lend its assistance to the last. It was necessary at the same time to reduce, as far as possible, the time for the completion of the work, so as to remain within the limit of the period allowed by the law granting the concession.

The line of the new route of the canal, which was called a temporary canal with locks, did not differ from the line adopted for the canal on a level.

The canal had a single track and the surface of its summit level was 49 meters above the level of the oceans. The effort had been made to reduce the depth of the trench as far as possible, for the double purpose of gaining time and reducing expenses. It had thus become necessary to admit that the summit level would have to be fed by elevating machinery. For the sake of economy also, provision had been made for locks with a single chamber. The construction of these locks was intrusted to Mr. Eiffel, a new contractor.

But it was necessary, furthermore, to create the necessary financial resources. The situation was even worse than it had been in 1885. In order to restore the damaged credit of the company recourse was had to the same means as at that time, which means were identical with those which at a critical period had rendered the completion of the Suez Canal possible.

On the 15th of November, 1887, M. de Lesseps again requested the Government to authorize him to issue lottery bonds. At the same time petitions signed by the bondholders of the company were sent from all parts of France to the members of the Senate and Chamber of Deputies soliciting the same favor.

On the 1st of March, 1888, M. F. de Lesseps called an extra general meeting of the stockholders and made known to them in detail the new programme for the completion of the canal. On the same day a bill due to parliamentary initiative provided that the Panama company should be authorized to issue lottery bonds. This bill was taken into consideration March 26, 1888, and on the next day a special commission of 11 members was appointed to examine it.

The report of this commission was laid before the Chamber in its session of April 23, 1888. The debates lasted three days and ended on the 28th of April by the passage of the bill by a majority of 156 votes (284 ayes and 128 noes). The bill was transmitted to the Senate on the 30th of April.

The committees of the Senate appointed, on the 17th of May, the members of the commission charged with the examination of the bill passed by the Chamber. It was discussed in the sessions of June 4 and 5, and was likewise passed by the Senate.

It now only remained to utilize this law. On the 9th of June M. F. de Lesseps made known the terms of the lottery bond loan, which bonds were publicly issued on the 26th of June following.

Two million lottery bonds were issued, the price of each being 360 francs, bearing interest at the rate of 4 per cent per annum, all of them being payable at 400 francs each by a civil amortization association and sharing in semimonthly drawings. But only 800,000 bonds were subscribed for.

This was undeniable proof of the diminution of the credit of the company and of the influence of M. de Lesseps.

This partial failure rendered a new issue necessary. In order to make preparations therefor Messrs. Ferdinand and Charles de Lesseps, in the months of October and November, 1898, made visits and held conferences in different parts of France.

The new issue took place on the 29th of November. It was conditional. The balance of the bonds, or about 1,200,000 bonds, were offered to the public, but the subscription was not to become irrevocable until 400,000 of the bonds should have been placed.

Now, less than 200,000 bonds were subscribed for.

This was, for the company then existing, a demonstration of its inability, from a financial point of view, to continue the enterprise which it had begun. Consequently, M. de Lesseps and his coworkers resolved to withdraw, and to yield the direction of the affair to others.

They stated the true situation to the Government, which, with the laudable intention of promoting the continuation of the work and of preventing the definitive downfall of the company, laid before the committee of the Chamber December 14, 1888, a bill authorizing the postponement for three months of the payment of the amounts which the company owed, including the coupons of the shares and bonds. It was hoped that it would be possible during that time to find some combinations to set the enterprise on its feet again. But the very next day, December 15, the Chamber refused to take up the discussion of the Government's bill.

M. F. de Lesseps himself caused the adoption of another measure which the situation of the case rendered necessary.

As the Panama Company was considered as a civil association, he petitioned, on the 14th of December, the presiding judge of the civil court of the Seine to appoint temporary managers.

By an order issued December 15 the civil court of the Seine appointed Messrs. Denormandie, Baudelot, and Hue as temporary managers, with the most ample powers, to manage and administer temporarily the interests of the company, and especially to secure the continuation of the work, and to take, to that effect, all necessary measures which the situation and the interests of the creditors called for.

The temporary managers endeavored, but without success, to reorganize the enterprise with the assistance of the governor of the *Crédit Foncier*, but their effort was unsuccessful. They then decided to call a general meeting of the shareholders on the 26th of January, 1889.

They considered that the appointment of a judicial receiver of the company was necessary. They proposed to the meeting, for the discharge of these duties, Mr. Joseph Brunet, who had formerly been a magistrate, a senator, and a minister.

On the 4th of February, 1889, the civil court of the Seine, in accordance with the desire expressed by the shareholders, appointed Mr. Joseph Brunet judicial receiver of the Universal Interoceanic Canal Company.

Here ends the first part of the historical sketch of the creation of the Panama Canal.

Chapter II.

RECEIPTS AND EXPENDITURES OF THE UNIVERSAL INTEROCEANIC CANAL COMPANY.

THE WORK DONE.

We think proper to give here a table of the receipts and expenditures at the beginning of the year 1890, that is to say, after the private cancellations and the settlement of the account of the various enterprises.

RECEIPTS.

The receipts of the Panama Company from the day of its organization until the 8th of March, 1890, consisted of the following elements:

1. Capital of the company and loans.

	Francs.
600,000 shares of 500 francs each, having produced	297, 705, 125. 00
250,000 obligations of 500 francs, 5 per cent, having produced	109, 263, 197. 50
600,000 obligations of 500 francs, 3 per cent, having produced	168, 251, 865. 00
495,762 obligations of 500 francs, 4 per cent, having produced	144, 331, 713. 80
458,802 new obligations, first series, 1,000 francs each, having produced	205, 972, 430. 00

	Francs.
258,887 new obligations, second series, 1,000 francs each, having produced	112,874,830.00
89,802 new obligations, third series, 1,000 francs each, having produced	34,869,115.20
849,249 new obligations, lottery, having produced	185,871,173.78
357,699 lottery bonds (lottery obligations issued by the receiver), having produced	12,543,184.29
Proceeds of the company's capital and of the loans	1,271,682,637.57
Various receipts and yields	39,666,589.24
Expenses not yet paid	18,343,851.93
Total amount of the sums collected or remaining due by the company	1,329,693,078.74

EXPENDITURES.

2. *Expenditures on the Isthmus.*

	Francs.
Expenditures for management and salaries on the Isthmus	82,704,415.065
Rents, expenditures for keeping in order, etc	16,505,352.72
Purchase of articles and material for consumption	29,239,602.22
Purchase and transportation of heavy material	119,374,679.14
Surveys and preparatory work	1,354,733.78
Central workshops and management	29,947,885.18
Various constructions, buildings, and general installations	47,038,528.74
Work of excavation and works of construction	443,171,124.34
Domain: Purchase of lands	4,753,275.27
Sanitary and religious service	9,183,841.77
Total amount of expenditures on the Isthmus	783,273,438.225

b. *Expenditures at Paris.*

	Francs.
Price of the concession paid to the International Civil Association	10,000,000.00
Security paid to the Colombian Government	750,000.00
Expenses incurred before the formation of the company	23,061,221.35
American committee	12,000,000.00

Amounts payable by the company—Interest paid.

	Francs.
On shares	67,347,494.18
On 5 per cent obligations (bonds)	37,264,049.866
On 3 per cent obligations	40,623,743.841
On 4 per cent obligations	32,761,083.596
On new obligations, first series	27,052,483.832
On new obligations, second series	6,517,882.158
On new obligations, third series	1,753,413.367
On lottery obligations	2,301,210.04
	215,621,361.18

Amortizations.

	Francs.
Payment of 5 per cent obligations	965,571.25
Payment of 3 per cent obligations	4,215,931.15
Payment of 4 per cent obligations	1,582,078.35
Payment of new obligations, first series	12,460,167.85
Payment of new obligations, second series	3,304,337.11
	22,528,085.71
Taxes on bonds payable by the company	3,207,721.022
Sundry expenditures for the bond service	1,904,951.713

Cost of issue.

[Francs.]

Designation of the loans.	Costs of syndicate.	Cost of advertising, etc.	Commission for placing.	Signatures, bonds, supplementary work, printing, and sundry outlays.	Total.
5 per cent bonds	5,000,000.00	1,365,847.04	1,148,575.13	315,232.98	7,829,655.15
3 per cent bonds	5,950,000.00	2,249,994.75	2,005,230.60	502,848.24	10,708,073.59
4 per cent bonds	4,735,200.47	1,688,520.85	1,926,552.18	562,181.56	8,912,455.06
New bonds	5,336,412.50	2,992,616.40	2,750,188.23	684,915.35	11,764,132.48
New bonds, second series	3,250,354.54	2,359,806.31	1,527,946.90	487,286.98	7,625,394.75
New bonds, third series	1,175,166.45	2,474,637.25	639,374.46	704,533.35	4,993,711.51
Lottery bonds	11,000,000.00	7,301,131.55	10,900,832.84	2,048,816.16	31,250,780.55
Total francs	36,447,133.96	20,432,554.15	20,898,700.34	5,305,814.62	83,084,203.07

	Francs.
Agents of the Colombian Government	213,800.00
Cost of management in France:	
Boards of management and direction	6,212,291.97
Salaries of employees in all branches of the service	5,117,221.51
Sundries	3,713,393.81
Building of the company and furniture	2,087,397.58
Compensation paid to Messrs. Couvreux & Hersent on the cancellation of their contract	1,200,000.00
Total	18,544,104.87
Total amount of expenditures at Paris	390,701,648.925

The general expenditures may be summed up as follows:

	Francs.
Total amount of expenditures at Panama	783,273,438.225
Total amount of expenditures at Paris	390,701,648.925
Purchase of the shares of the Panama Railroad	93,268,186.73
Payment for the formation of the civil associations of lottery obligations	32,264,680.71
Advance to the Colombian Government	2,455,075.00
Amount of the sums paid, but in litigation or advanced and left for the account of sundry debtors	11,455,801.59

Assets of the company March 8, 1890, consisting of:

	Francs.	
Cash in safe at Panama	2,200,941.21	
Cash in safe at Paris	3,823,266.03	
Notes and acceptances at Paris	10,250,031.33	
		16,274,238.57
Total equal to the receipts		1,329,693,078.75

The amount of work done is furnished by the tables showing the situation of the various enterprises.

The cube of the excavations is as follows:

	Cubic meters.
By the small enterprises, during the period from 1883 to 1885 throughout the whole extent of the canal	11,729,787.013
By the small enterprises which existed until 1888	1,893,576.968
By the large enterprises:	
From Colon 0 to kilometer 25—	
Enterprise American Contracting and Dredging Company	16,991,797.158
The Jacob Enterprise	2,324,095.402
From kilometer 25 to kilometer 44—	
Enterprise Vignaud, Barbaud, Blanleuil & Co	3,642,986.660
From kilometer 44 to kilometer 53.60—	
Enterprise of the Public Works and Construction Company	3,421,870.590

By the large enterprises—Continued.	
From kilometer 53.60 to kilometer 55.486—	Cubic meters.
Anglo-Dutch Enterprise	846, 824. 810
Enterprise Artigue, Sonderegger & Co	2, 255, 401. 650
From kilometer 55.486 to the extremity of the canal in the bay of Panama—	
Enterprise Baratoux, Letellier & Co	6, 691, 724. 870
Excavations for the Eiffel Enterprise locks	843, 004. 740
Total	50, 641, 079. 861

It would be proper to add to this total cube the excavations made by hired labor either in the canal or at its approaches for the installations, and whose cube amounts to about 5,000,000 meters.

The metallic parts of the locks which were supplied by the Eiffel Enterprise at the time when the work was suspended, comprised, on the spot, at the Isthmus, 4,710 tons of iron and 11,430 tons of cast iron, and in France, stored at various factories, 5,755 tons of cast iron, manufactured or unmanufactured.

The delegation of the survey commission created by the receiver, which went to the Isthmus in 1890, declared that the amount of work done was very considerable. It recognized that the plant provided by the old company, whose purchase, transportation, and putting into place had cost 150,000,000, was in a good state of preservation, and that, with the exception of some special machinery, it seemed likely to be sufficient, in great part, for the completion of the work. This machinery has been kept in good condition, having been affected only by normal wear and tear and deterioration. Its preservation has been comparatively easy, for everything, that could be, was housed or sheltered, that is to say, machines used in dry excavation and tools used in the shops. The floating plant, however, has suffered more, especially that which, being made fast in the channels at the two extremities of the canal, has been exposed to the action of the salt water. The commission declared, furthermore, that the outfit of the shops was more than sufficient for the repairs of the plant, and that the number of dwelling houses for the employees and the workmen was enormous, and even seemed excessive, since there were accommodations for from 26,000 to 27,000 workmen.

Finally, the commission thought that leaving out of consideration the work and the installations which had been rendered useless by the abandonment of the project of a canal on a level, the value of the useful work done and of the machinery on the Isthmus was to be estimated at 450,000,000 francs.

Chapter III.

THE LIQUIDATION.

(1889-1894.)

We have already said that, by an order of the civil court of the Seine, bearing date of February 4, 1889, Mr. Joseph Brunet was appointed receiver of the Universal Interoceanic Canal Company, with the most ample powers, "especially to cede or transfer to any new company the whole or a part of the assets of the company, in order to conclude or ratify with the contractors of the Panama Canal any agreements having for their object the securing of the continuation of the work, and to conclude, for this purpose, all loans and to furnish all security."

The condition of the enterprise was then highly critical on the Isthmus. It was impossible to stop work immediately in the work yards, where several thousand men were employed, without danger of giving rise to serious disturbances. The contractors were likewise obliged to discharge their employees, to turn their machinery over to the company, and to settle their accounts with it.

Notwithstanding the dangers and difficulties then existing, Mr. Brunet thought that a new company might be organized for the completion of the canal.

The course which he proposed to pursue was outlined at once. With a view to preventing any sudden interruption of the work, he ratified an agreement which had been concluded between the temporary managers and the contractors, whereby the latter engaged to continue the work, although reducing its amount as far as possible. In consequence of these agreements the work was continued on the Isthmus up to various dates, running from March 15 to May 15, 1889.

Mr. Brunet likewise thought that it was very highly important, whether he could resume the work directly or could succeed in organizing a company to complete the canal, to release the liquidation from the onerous contracts made by the old company. The cancellation of these various contracts took place in the course of the year 1889.

In order to procure the necessary capital to preserve the work done, to keep the plant in proper condition, and to provide for the expenses of a survey commission which he proposed to organize in order to examine the condition of the canal as regarded its completion, the receiver secured from the Chambers the passage of the law of *July 15, 1889*, which authorized him to negotiate, *without restriction as to price and without interest*, the lottery obligations not placed in the issue of 1889. These new bonds were termed lottery bonds. The law declared at the same time that sums accruing from the sale of these bonds were undistrainable to the amount of 34,000,000.

During the same period final judgments had recognized the *civil* character of the old company and consolidated the powers of the receiver. They had, moreover, recognized that the holders of encumbered lottery bonds had a right to stop payments due to the old company, which would have been a serious matter for the liquidation and would have deprived it of all its resources, if it had not secured from the legislative branch of the Government the passage of the law of July 15, 1889.

Mr. Brunet organized without delay, under the presidency of Mr. Guillemain, inspector-general, director of the National School of Bridges and Roads, the survey commission, composed of French and foreign engineers, whose duty it was to proceed to a careful examination of the exact condition of the work. To this end a delegation of five members, presided over by Mr. Germain, hydrographic engineer of the navy, sailed for the Isthmus December 10, 1889.

A few days afterwards Mr. Brunet contracted the germs of the disease which was soon to carry him off.

On the 13th day of February, 1890, he secured the appointment of Mr. Achille Monchicourt by the civil court as coreceiver. As he constantly grew worse, Mr. Brunet was obliged to hand in his resignation, and on the 8th of March, 1890, Mr. Monchicourt was appointed sole receiver, with the powers previously conferred upon Mr. Brunet.

Mr. Monchicourt received on the 5th of May, 1890, *the full report of the survey commission*, completed by seven appendices,

That report declared, with the necessary reservations, that in the opinion of the commission—

1. It was possible to complete the canal in eight years, with a system of locks having a lift of from 8 to 11 meters united in groups on each slope.
2. That the plant on the Isthmus was in a satisfactory condition, and might suffice for the completion of the canal.
3. That, as the work to be done might be estimated at 580,000,000 francs, the amount to be asked of the public was to be placed at 900,000,000. The cost of the work already done and the value of the plant on the Isthmus were estimated by the commission at 450,000,000 francs.

Struck by this report, and resting upon its conclusions, the receiver designated, without delay, *Mr. Lucien Napoleon Bonaparte Wyse* to go to Bogotá and negotiate with the Colombian Government an extension of the time granted for the completion of the maritime canal by the law governing its concession.

After conferences which lasted from July 25 to December 10, 1890, Mr. L. N. B. Wyse signed a treaty providing for *an extension of ten years.*

Thus reassured on the essential point, viz, the extension of the time necessary for the resumption and completion of the interrupted work, the receiver devoted himself to *the organization of a new company.* He had, in fact, realized, like Mr. Brunet, the disastrous character of an actual liquidation, the difficulty and the dangers of realizing the assets, the difficulty and even the impossibility of distributing them when realized, the legal formalities being duly observed. He had understood that all the interests involved, both material and moral, called for a reorganization of the enterprise.

The Colombian Government, by a *contract signed April 14, 1893*, granted a new extension until October 31, 1894, to organize a new company which should have, from the date of its organization, ten years in which to complete the ship canal.

During these years, viz, 1891, 1892, and early in 1893, the receiver had, by a series of compromises confirmed by the civil court, settled most of the lawsuits then existing with the *enterprises of the old company.* He had resisted, *amid the most serious legal difficulties, the attempts of some creditors and some bondholders*, who did not hesitate, for badly understood individual interests, to disturb a work that was carried on in the general interest. He had, moreover, to struggle during the same period for the reorganization of the work against grave judicial events that were determined or complicated by press polemics and parliamentary discussions on which we do not consider it necessary to dwell here.

The receiver, after these judicial debates, instituted the *civil proceedings* which were called for by the facts revealed by the two examinations. He had, in the couse of the same year, 1893, settled by compromises the greater part of the suits in which the liquidation was interested. He found himself early in that year (January 26, 1893) in presence of a series of judgments pronounced by the civil court of the Seine, complying with the *individual petitions of bondholders* for the payment of the sums paid in by them, for that of all damages, of unpaid coupons, of legal interest, and, after these judgments, pronounced notwithstanding appeal, the interested parties had made a series of seizures bearing upon the lottery bonds that had not been placed and upon other property belonging to the liquidation.

Early in 1892 Mr. Monchicourt had foreseen these difficulties which, in the name of private interests, seemed likely to baffle all his efforts and to imperil forever the reorganization of the work by rendering its vast assets and resources unavailable.

He had called the attention of the governmental authorities to the peril of the legal situation as regarded such suits, and had proposed, with a view to the transfer of the assets to a company organized for the completion of the canal, or at least with a view to an equitable division among all the bondholders, a special legislative modification of the case of the interoceanic canal.

He actively resumed his efforts after the judgment of January 26, 1893, and soon won his case.

The very important law of July 1, 1893 (article 2), provided that "actions of any kind which the bondholders of the Universal Interoceanic Canal Company had, whether against the legally appointed receiver or against the managers as being responsible, or for restitution for any other cause, should be brought by an attorney appointed at the request of the procurator of the Republic practicing before the civil court of the Seine by a judgment rendered in the council chamber."

The court of the Seine thus appointed, July 4, 1893, Mr. Lemarquis attorney for the Panama bondholders.

According to this law (article 1) all similar proceedings then before the courts were suspended.

By securing, April 4, 1893, at Bogota *the contract authorizing a second extension*, and, July 1, 1893, by the agreement of the governmental authorities in France, *the special law for the liquidation of the Interoceanic Canal Company*, Mr. Monchicourt had, notwithstanding the extreme difficulties of that time, prepared the way for the reorganization of the work. Illness did not long permit him to enjoy the success of his efforts.

On the 21st of July, 1893, the state of his health compelled him to secure from the court of the Seine the appointment of Mr. Gautron as coreceiver. Messrs. Monchicourt and Gautron worked together until March 14, 1894, on which day Mr. Monchicourt died.

There remained but a short time to effect, before October 31, 1894, the actual reorganization of the enterprise.

To this end, Mr. Gautron, the receiver, and Mr. Lemarquis, the attorney for the bondholders, secured, by a *series of compromises*, from the managers of the old company, from the credit companies, from the contractors, and from a certain number of persons to whom various securities had been assigned, their *cooperation in the new work*, in the form of a *subscription to shares of the company for the completion of the canal;* the amount necessary to complete the full sum was to be asked of the bondholders and shareholders of the old company.

The by-laws of the New Panama Canal Company were regularly filed on the 26th of June, 1894.

The capital of the company was divided into 650,000 shares of 100 francs each, 600,000 of which were to be subscribed for; 50,000, wholly unincumbered, were to be sent to the Colombian Government in pursuance of the laws and contracts authorizing the extensions.

The assets of the old company were transferred by the receiver to the new company, with precise enumerations and on terms which were clearly defined by the by-laws. These arrangements relative to the transfer of the assets were confirmed by the civil court. The court set aside objections of third parties which had been presented either with a view to protecting the general interest, by Mr. Lemarquis, or in behalf of private interests.

The new company was thus definitely established.

Appendix C.

LIST OF DOCUMENTS RECEIVED BY THE ISTHMIAN CANAL COMMISSION FROM THE NEW PANAMA CANAL COMPANY.

Fifteen copies Dossier C, containing 27 subdossiers, in 8 volumes; total number of maps and documents in one dossier, 157. (Lithographed.)

Fifteen copies Dossier D, containing 16 subdossiers, in 6 volumes; total number of maps and documents in one dossier, 65. (Lithographed.)

Ten files, each containing 4 lithographed documents treating of the method to be followed in making excavation at Culebra.

Fifteen copies "Notes techniques." (Printed.)

Fifteen copies atlas to accompany foregoing, each containing 17 lithographed plates.

Ten copies note by General Abbot on the Régime of the Chagres. (Lithographed.)

Ten copies note by General Abbot on the Feeding of the Canal. (Lithographed.)

Ten copies note by General Abbot on the Ratios of the Discharges of the Chagres at Gamboa and Bohio, and the Ratio of these Discharges to the Rainfall in the Drainage Areas above these points. (Lithographed.)

Ten copies pamphlet containing: I. "Geological investigation on the Isthmus," by Marcel Bertrand and Philippe Zurcher. II. "Volcanic phenomena and earthquakes of Central America," by Marcel Bertrand. (Printed.)

Eleven copies report of 1898 of the "Comite technique," in French. (Printed.)

Eleven copies English translation of the report of 1898 of the "Comite technique." (Printed.)

Fourteen copies of the charter of the New Panama Canal Company, in French. (Printed.)

Ten copies English translation of the charter of the New Panama Canal Company. (Printed.)

Fourteen copies treaty of 1846 between the United States and the Republic of Colombia. (Printed.)

Eleven copies "Actes de concession." (Printed.)

Twelve copies English translation of the concessions granted to the canal company. (Printed.)

Fourteen copies Political Relations of the United States and the Republic of Colombia to the Panama Canal. (Printed.)

Fourteen copies International Convention for Securing the Free Navigation of the Suez Canal. (Printed.)

Ten copies of the forty-ninth annual report of the board of directors of the Panama Railroad Company. (Printed.)

Thirteen copies general map of the Isthmus of Panama, scale 1:96000, by Colonel Totten. (Lithographed.)

Three copies of the harbor of La Boca, scale 1:5000. (Lithographed.)

Twelve copies, on parchment paper, of the general topographic map, scale 1:5000. (Lithographed.)

Ten copies of the above map, on linen, in detached sheets. (Lithographed.)

Ten files, each containing the following documents relative to the constitution of the New Panama Canal Company: Reports of the board of directors and of the commissioners, and balance sheets for the years 1894, 1895, 1896, 1897, 1898, and 1899 (printed); charter (printed); judgment of the civil court of the Seine, rendered February 4, 1889 (manuscript); law of the 1st of July, 1893 (printed); judgment of the civil court of the Seine, of the 29th of June, 1894, confirming the charter of the company (manuscript).

Six manuscript copies, in French, of the proces-verbal of the meetings of the commission at Paris.

1 copy hydrographic map of Colon Harbor, scale 1:5000, made by the old company in 1883. (Tracing.)

1 copy hydrographic map of Colon Harbor, scale 1:5000, made by the new company in 1895. (Tracing.)

1 copy geological profile of the Panama Canal, made by the old company. Scales: Horizontal, 1:5000; vertical, 1:500. (Lithographed.)

1 copy plan showing the location of the test pits sunk at Culebra. Scale 1:2000. (Tracing.)

1 copy drawing showing the geological sections of the test pits sunk at Culebra. Scales: Vertical, 0.005 to 1 meter; horizontal, 0.04 to 1 meter. (Tracing.)

One copy plan showing the location of the test pits at Emperador. Scale 1:5000. (Tracing.)

One copy drawing showing the geological sections of the test pits sunk at Emperador. Scales: Vertical, 0.005 to 1 meter; horizontal, 0.04 to 1 meter. (Tracing.)

One copy drawing showing the profile of the preparatory cunette at the Emperador. Culebra cut on 1st of July, 1899. Scales: Vertical, 1:500; horizontal, 1:5000. (Black print.)

One copy drawing showing the cross sections of the preparatory cunette at the Emperador. Culebra cut on the 1st of July, 1899. Scales: Vertical, 1:500; horizontal, 1:5000. (Black print.)

One copy profile on the center line of the canal, La Boca section, showing the various surveys made since the suspension of work by the old company (1889), 1895, 1897, and 1898. Scales: Horizontal, 1:5000; vertical, 1:1000. (Tracing.)

One copy plan of the harbor of La Boca, scale 1:1000, showing the soundings made by the new company in conjunction with the Panama Railroad Company. (Tracing.)

One copy drawing showing the locks at Bohio; general plan and geological profile, showing borings. Scales: Vertical, 1:500; horizontal, 1:1000. (Tracing.)

One copy plan of the borings at Bohio, scale 1:1000, made on the sites of the dam across the valley of the Chagres, of the spillway, and of the discharge channel leading from the spillway. (Tracing.)

One copy drawing showing the geological section across the valley of the Chagres, following the center line of a dam at Bohio. Scales: Horizontal, 1:1000; vertical, 1:500. (Tracing.)

One copy plan showing the location of the borings at Obispo, and geological profiles of the dams. Scales: Plan, 1:5000; profiles, horizontal 1:2000, vertical 1:500. (Tracing.)

One copy plan and geological sections showing the borings for the locks at Paraiso, Pedro-Miguel, and Miraflores. Scales: Plan, 1:5000; general profile, horizontal 1:5000, vertical 1:500. (Tracing.)

One copy plan and geological sections from the borings at Gamboa, made by the old company and by the new company in 1896. Scales: Plan, 1:2000; geological sections, 1:500 and 1:200. (Tracing.)

One manuscript copy of the curve, showing the discharge of the Chagres.

One manuscript copy of the inventory of the new Panama Canal Company's property on the Isthmus.

Two manuscript copies of the June report of the engineer in charge at Culebra.

One copy tabular statement of expenses at Emperador section, from July 1, 1897, to June 30, 1898. (Manuscript.)

One copy tabular statement of the expenses at Culebra section, from July 1, 1897, to June 30, 1898. (Manuscript.)

One copy tabular statement of expenses at Emperador section, from July 1, 1898, to June 30, 1899. (Manuscript.)

One copy tabular statement of expenses at Culebra section, from July 1, 1898, to June 30, 1899. (Manuscript.)

One manuscript copy of Mr. Choron's analysis of the cost per cubic meter of concrete.

One manuscript copy note giving the areas of Lake Bohio at elevations 17 and 20.

One manuscript copy note giving the areas of Lake Alhajuela at elevations 55, 61, and 68.

One file containing the following documents relative to the study of the probable traffic of an interoceanic canal: (1) Note on the above study with nine appendices (manuscripts); (2) dictionary of the ports of the Pacific (manuscript); (3) results of the years 1888, 1895, 1896, 1897, and 1898 (manuscript); (4) résumé of the report of Mr. Michel, Chevalier—1844 (manuscript); (5) résumé of the report of Mr. Napoleon Garella—1845 (manuscript); (6) résumé of the report of Prince Napoleon—1846 (manuscript); (7) résumé of the report of Mr. F. Belly—1858 (manuscript); (8) résumé of the report of Mr. Kelly and of Admiral Davis—1876 (manuscript); (9) résumé of the report of Mr. Joseph Nimmo—1880 (manuscript); (10) text and résumé of the report of Mr. Levasseur—Congress of 1879 (text in print, résumé in manuscript); (11) résumé of the report of the second and third commissions of the international congress (manuscript); (12) résumé of the report of the "Commission d'Etudes"—Mr. Daymard, 1890 (manuscript); (13) résumé of the report of Mr. P. Bunau-Varilla—1892 (manuscript); (14) résumé of the report of Mr. Keasby (manuscript); (15) Note on the tonnage of ships (manuscript); (16) two numbers of the Shipping and Mercantile Gazette (specimens) (printed); (17) one number Lloyd's Weekly Shipping Index (specimen) (printed).

One copy Instructions and Regulations Relating to the Measurement of Ships and Tonnage under the Merchant Shipping Act, 1894. (In print.)

One copy manuscript note (attached to the above) giving references to be consulted for the method of obtaining American tonnage.

One copy index map showing the canal company's original arrangement of sheets for the large topographic map, scale 1:5000. (Lithographed and mounted on linen.)

File containing manuscript copies of the following communications addressed by the representatives of the New Panama Canal Company to the representatives of the United States Government: The company to President McKinley, November 18, 1898; Mr. Cromwell to Secretary Hay, December 2, 1898; Mr. Cromwell to Secretary Hay, December 3, 1898; Mr. Cromwell to Secretary Hay, December 21, 1898; the company, by Director-General Hutin and General Counsel Cromwell, to the President, February 28, 1899; the company, by the same, to Chairman Burton, of the Rivers and Harbors Committee, February 27, 1899; the company, by the same, to the President, March 11, 1899.

Records of tide observations at Colon.

Records of tide observations at Panama.

Tabular statement of freight rates, prepared by Mr. Maurel in his investigations of savings to shippers.

General statement by Mr. Hutin, giving past history of canal, a statement of the amounts of money raised and expended, and the results accomplished by both the old and the new companies.

Plan of borings at site of diversion, Upper Gigante. (Tracing.)

Longitudinal section of same. (Tracing.)

Port de la Boca, soundings, September, 1899, and February, 1900. (Tracing.)

Port de la Boca, port and maritime channel, scale 1:2000. (Tracing.)

Port de la Boca, longitudinal profile. (Tracing.)

Sketch and description of the Transporteurs de Deblais a lame d'acier, inspected by the Commission near Tavernilla. (Manuscript.)

Proceedings and report of the International Consultative Commission upon the Suez Canal, 1884, 1885, in French. (Printed.) (Returned by request): Extracts from the report of the Commission d'Etudes, giving estimates of cost of maintenance of Panama Canal; cost of maintenance of the Manchester Ship Canal, 1895–1899; regulations for the navigation of the Suez Canal.

Longitudinal profile, Atlantic maritime section, showing rock.

Cross sections, Atlantic maritime section, showing rock.

Recapitulation of quantities of rock to be excavated in Atlantic maritime section.

Tabular statement showing operating expenses of the Kiel Canal for the years 1897, 1898, 1899.

FIG. 1.—SCENE ON THE UPPER CHAGRES RIVER.

APPENDIX D.

REPORT ON HYDROGRAPHY OF PANAMA CANAL ROUTE, MADE FOR THE ISTHMIAN CANAL COMMISSION BY ARTHUR P. DAVIS, CHIEF HYDROGRAPHER.

CONTENTS.

LIST OF ILLUSTRATIONS.

WASHINGTON, D. C. *March 15, 1901.*

Rear-Admiral J. G. WALKER,
President Isthmian Canal Commission.

SIR: I have the honor to transmit herewith a report on the hydrography of the Panama Canal route. It includes a full account of the work prosecuted by me under your authority, and also the most important portions of the results obtained by the Panama Canal Company, together with a discussion of the same and the conclusions derivable from all the information at hand.

Yours, with respect,

ARTHUR P. DAVIS,
Chief Hydrographer.

THE HYDROGRAPHY OF PANAMA.

The hydrographic problem of the Panama Canal project requires a knowledge of the magnitude and habit of the flood discharge of the Chagres River and also in a minor degree of the tributaries of the Chagres and of the Rio Grande on the southern end of the line. It also requires a knowledge of the minimum flow of the Chagres River considered as a feeder to the summit level and the locks of the canal. Incidental to these matters the determination of rainfall is important, considered both as a source of water supply and as a hindrance to construction.

Some observations upon these points were taken by the old Panama Canal Company, and since the organization of the new company the records have been much more thorough and complete of the discharge of the Chagres at Gamboa and Bohio. Since April, 1899, measurements have also been made at Alhajuela, where it is proposed by the canal company to construct a reservoir to serve as a regulator of the floods of the river and to store water for the use of the canal. The measurements of rainfall taken by the company were made at points where stream measurements were being made, and at La Boca, the southern end of the canal line, this record, however, being very short. These data are supplemented by rainfall records kept at Colon by the Panama Railway Company. This is the oldest record of rainfall in the vicinity of the Panama Canal, and is of great value in the study of hydrographic problems connected therewith.

The work undertaken by this Commission consists mainly in an examination of the observations and results already obtained by the company, of a verification of their methods by actual field observations, and of an extension of the rainfall information, as far as possible, over the basin of the Chagres River.

These operations were undertaken in November, 1899, and placed in charge of Mr. W. W. Schlecht, whose description of methods is appended to this report. In July and August, 1900, the writer made a personal inspection of the records of the old and new companies at the office of the Panama Canal Company in Paris, obtaining many details of value regarding the methods and data employed in arriving at the conclusions published by the company. It was found that the data obtained by the old company prior to the organization of the new was very fragmentary and incomplete, considerable periods being entirely skipped. The most serious lack of information was with respect to the magnitude of the great floods that have been observed upon the Isthmus, especially the maximum flood of 1879. The observations taken by the new company are far more complete and satisfactory, but, unfortunately, they do not include any flood discharge as great as those that occurred under the régime of the old company.

Every facility for the investigation of these records was extended by the Panama Company, and every possible assistance in the investigation was courteously rendered by Gen. Henry L. Abbot, of the comité technique.

THE CHAGRES RIVER.

The main trunk of the Chagres is formed by two principal branches. The Pequeni rises near the Caribbean coast, flows nearly south until it meets the Chagres proper a short distance above Alhajuela. The general course of the Upper Chagres from its source is southwest, and it continues in the same general direction after receiving the waters of

FIG 2.—FLUVIOGRAPH AT BOHIO.

FIG. 3.—OVERHANGING LEDGE ON UPPER CHAGRES RIVER.

the Pequeni to the mouth of the Obispo, where the proposed canal line leaves its valley. Its course is then westward to Tavernilla and from that point to its mouth its course is nearly northwesterly. Its total length is over 120 miles without including minor bends, although the width of the Isthmus at its mouth is less than 50 miles. The various drainage areas are about as follows:

	Sq. miles.
Total area of Chagres drainage basin	1,400
Upper Chagres (above Pequeni)	300
Rio Pequeni	175
Above Alhajuela	505
Between Alhajuela and Gamboa	130
Above Gamboa	635
Rio Obispo	38
Between Gamboa and Bohio	245
Above Bohio	880
Between Alhajuela and Bohio	375
Below Bohio	520
Lower Gatun	145

The district below Bohio, drained by the Chagres and its tributaries, consists mainly of low hills and swamps. The river is sluggish, the effect of the tide being plainly perceptible at Bohio at low water, although the tidal fluctuations of the Caribbean are very slight. Above this point there are some modifications, the declivity being greater and the country higher and less swampy. Several rapids occur in this portion of the river, and above Obispo rapids are frequent and the river swift. The Upper Chagres is flanked by steep, rocky hills clothed with luxuriant vegetation, rapids are frequent, the water is everywhere swift and is very clear except in times of freshet. The stream is sinuous in many parts and bordered frequently by rock cliffs, lending variety to the scene, which is everywhere one of surpassing beauty. In some cases the convex curve of the stream with its swift current has undermined the limestone cliffs, leaving overhanging ledges and producing caverns of considerable extent. A photograph of one of these is shown in fig. 3.

Measurements of discharge of the Chagres were made during 1900 at all three of the stations maintained by the company, namely, Alhajuela, Gamboa, and Bohio, to check the methods and results for the information of the Isthmian Canal Commission. A comparison of these results with those submitted by the company may be made from the following tables. It will be seen that the company's results are much the smaller. This is partly accounted for by the disagreement in gauging results, as obtained by current meters, and by taking 80 per cent of the velocity of surface floats; but this explanation does not apply to Bohio, where the gauging results are practically in agreement. The principal reason may be formed by an examination of the rating curves as plotted in fig. 6.

It will be seen that the "general" curve, which is the one used for most of the computations made by the company, gives much lower values for all gauge heights than indicated by the measurements of discharge, and, in addition to this, the measurements themselves are too small, at least for Alhajuela and Gamboa. The fact that the results obtained by the float method were too small was pointed out by General Abbot in his note "Sur le régime du Chagres," page 6, where he remarked that—

In these calculations the velocities measured are to be multiplied by 0.8. This is too great a reduction if we take account of the fact that the floats are to be liberated on all the river, and not limited to the center. According to my opinion, a coefficient of 0.9 would be sufficient.

If the factor 0.9 were used in reducing the float measurements, as suggested by General Abbot, they would very nearly agree at Alhajuela and Gamboa with the current meter measurements, but at Bohio the agreement would not be so close.

It is important to note, however, that the results obtained and put forth by the company are very conservative, the error being on the side of safety when considering the low water flow, and as a different formula, called the "special" formula, is used for floods at Gamboa and Bohio, this error does not enter into them, and, as will be seen by the diagram, the special formulæ agree closely with the observations.

Detailed descriptions of the stations and a discussion of methods will be found in Mr. Schlecht's report, appended hereto, page 52.

ALHAJUELA STATION ON CHAGRES RIVER.

This is the point on the Chagres, about 11 miles above Gamboa, where the Panama Canal Company proposes to build a high masonry dam to impound water for the use of the canal and to assist in the storage of floods. The dam site is about 7 miles, by the course of the river, below "Dos Bocas," the junction of the two main branches of the Chagres; the gauging station being about half a mile below the dam site.

The company established the station on the 15th day of April, 1899, and still maintains it. The results given by the company are summarized as follows:

Estimated monthly discharge of Chagres River at Alhajuela.

[Drainage area, 505 square miles.]

OBSERVATIONS OF THE PANAMA CANAL COMPANY.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.		Rainfall in basin.
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.	
1899.							*Inches.*
April 15-30	1,024	600	706	22,400	....	....	....
May	28,420	494	1,590	97,760	3.15	3.63	....
June	4,200	1,165	2,150	127,930	4.26	4.75	....
July	15,640	1,235	2,220	136,500	4.40	5.07	....
August	27,430	1,660	3,280	201,680	6.50	7.49	....
September	11,160	1,450	2,400	142,800	4.75	5.30	....
October	9,990	1,590	2,650	162,940	5.25	6.05	....
November	28,660	1,520	2,930	174,350	5.80	6.47	....
December	11,160	1,580	2,260	138,960	4.17	5.15	....
The year	28,660	....	2,430	1,205,320	....	43.91	....
OBSERVATIONS OF THE NEW PANAMA CANAL COMPANY.							
1900.							*Inches.*
January	11,150	1,020	1,590	97,760	3.15	3.63	2.27
February	1,130	565	812	45,100	1.60	1.67	.38
March	777	425	530	32,590	1.05	1.21	.32
April	2,050	318	565	33,620	1.12	1.25	4.06
May	13,770	388	1,340	82,400	2.65	3.06	11.88
June	7,730	880	1,550	92,230	3.07	3.42	16.57
July	18,180	1,230	2,190	134,660	4.33	4.99	14.61
August	20,400	1,520	2,820	173,400	5.58	6.43	13.01
September	11,650	1,270	2,150	127,930	4.26	4.75	15.60
October	24,780	1,730	3,210	197,380	6.36	7.33	16.39
November	11,680	1,620	2,965	176,430	5.87	6.55	14.92
December	20,540	1,130	2,290	140,800	4.53	5.22	3.76
The year	24,780	318	1,840	1,334,300	3.64	49.51	113.80

FIG. 4.—CRISTOBAL COLON.

FIG. 5.—ALHAJUELA.

Estimated monthly discharge of Chagres River at Alhajuela—Continued.

FROM OBSERVATIONS OF THE ISTHMIAN CANAL COMMISSION.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.		Rainfall in basin.
	Maximum.	Minimum.	Mean.		Second feet per square mile.	Depth in inches.	
1900.							*Inches.*
January	14,535	1,230	1,941	119,350	3.84	4.43	2.27
February	1,365	652	916	50,870	1.81	1.88	.38
March	849	497	608	37,380	1.20	1.38	.32
April	2,032	395	631	37,550	1.25	1.39	4.06
May	17,460	476	1,588	97,640	3.14	3.62	11.88
June	10,395	1,025	1,934	115,080	3.83	4.27	16.57
July	21,950	1,814	3,148	193,560	6.23	7.18	14.64
August	27,400	2,157	4,094	251,730	8.11	9.35	13.01
September	17,065	1,720	3,101	184,520	6.14	6.85	15.60
October	31,740	2,710	4,889	300,610	9.68	11.16	16.39
November	20,670	2,223	4,504	268,010	8.92	9.95	14.92
December	28,020	1,396	3,286	202,050	6.50	7.49	3.76
The year	31,740	395	2,567	1,858,350	....	63.95	113.80

Ratio of run-off to rainfall = 60 per cent.

COMPUTED FROM RATING TABLE OF ISTHMIAN CANAL COMMISSION, USING THE GAUGE HEIGHTS OF THE PANAMA CANAL COMPANY AS THE ARGUMENT.

Month.	Maximum.	Minimum.	Mean.	Total in acre-feet.	Second feet per square mile.	Depth in inches.	Rainfall in basin.
1901.							
January	5,070	850	1,165	71,630	2.31	2.66	....
February	3,530	560	766	42,540	1.52	1.58	....
March	2,290	415	541	33,260	1.07	1.23	....
April	3,040	265	509	30,290	1.01	1.13	....
May	35,460	815	2,050	126,050	4.06	4.68	....
June	21,280	990	2,360	140,430	4.67	5.21	....

GAMBOA STATION ON CHAGRES RIVER.

This is the station of longest record of any on the isthmus. It is near the point where the canal line leaves the valley of the Chagres; the river valley ascending from this point to the northeast, while the canal line proceeds to the southeast to cut through the continental divide to the Pacific. It was at one time proposed to construct a dam at this point, and the canal company began observations here, but a careful examination of the records in Paris failed to bring to light any continuous record of river stages prior to 1892, but a number of discharge measurements for 1889–1891 were obtained, and are given herewith. A graphic exhibit of the flow from 1893 to 1898 is shown in figure 7, and a comparison with Alhajuela and Bohio for 1899 and 1900 is shown in figure 8.

Annual summary of discharge measurements made by the Panama Canal Company at Gamboa.

Year.	Discharge in second-feet.			Total in acre-feet.	Run-off.		Rainfall at Colon.
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.	
1892	42,000	....	....	....	....	....	....
1893	51,100	759	3,610	2,612,607	5.69	77.14	131.89
1894	26,190	530	3,770	2,732,284	5.94	80.68	153.69
1895	27,990	565	2,880	2,083,740	4.53	61.55	151.54
1896	....	....	2,880	2,093,910	4.53	61.83	131.51
1897	42,190	....	3,880	2,806,070	6.11	82.84	138.03
1898	28,770	777	3,000	2,169,630	4.72	64.05	115.55
1899	26,190	706	2,580	1,870,500	4.06	55.25	133.02
1900	23,720	388	2,360	1,705,100	3.72	50.35	[a]108.01

[a] Mean rainfall on basin.

Estimated monthly discharge of Chagres River at Gamboa.

[Drainage area, 635 square miles.]

OBSERVATIONS OF THE NEW PANAMA CANAL COMPANY.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.		Colon rainfall (inches).
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.	
1892.							
May	28,770	2,345	5,311	326,561	8.36	9.64	18.03
June	17,930	2,260	3,590	213,620	5.65	6.30	16.97
July	27,320	2,232	7,114	437,423	11.20	12.91	21.77
August	25,910	3,531	5,950	363,084	9.37	10.80	15.98
September	7,275	3,178	4,476	266,341	7.05	7.87	16.26
October	19,840	3,284	5,848	359,580	9.21	10.62	6.69
November	42,000	3,990	6,715	399,570	10.57	11.80	26.30
December	25,200	2,860	5,968	366,958	9.40	10.84	11.30
The year	42,000			2,733,137			
1893.							
January	2,892	1,865	2,293	140,991	3.61	4.16	1.73
February	3,563	1,423	1,993	110,686	3.13	3.26	3.82
March	6,512	759	1,134	69,727	1.79	2.06	1.81
April	23,102	1,201	3,190	189,818	5.02	5.60	8.07
May	26,620	1,497	3,045	187,229	4.80	5.53	6.56
June	6,039	2,147	3,200	190,410	5.04	5.62	12.32
July	17,300	2,034	3,472	213,484	5.47	6.31	11.50
August	21,140	3,146	4,538	279,031	7.15	8.24	15.12
September	10,389	2,430	3,813	226,890	6.00	6.69	9.92
October	9,535	2,260	3,733	229,533	5.88	6.78	12.28
November	19,840	3,249	4,494	267,412	7.08	7.90	17.80
December	51,100	3,178	8,252	507,396	13.00	14.99	30.94
The year	51,100	759	3,610	2,612,607	5.69	77.14	131.89
1894.							
January	26,189	2,175	3,858	237,219	6.08	7.01	5.35
February	2,260	1,201	1,633	90,692	2.57	2.68	1.65
March	1,225	742	948	58,290	1.50	1.73	.35
April	2,317	572	760	45,223	1.20	1.34	2.16
May	13,278	530	1,358	83,500	2.14	2.47	9.85
June	7,190	798	2,180	129,719	3.43	3.82	12.24
July	18,222	1,349	4,199	258,186	6.61	7.62	19.10
August	14,804	2,670	3,864	237,588	6.09	7.02	23.03
September	18,462	2,486	4,402	261,937	6.93	7.73	18.78
October	6,039	2,860	[a] 4,690	288,370	7.38	8.51	12.40
November	21,780		[a] 6,530	388,560	10.28	11.47	23.66
December	32,510		[a] 10,620	653,000	16.72	19.28	25.12
The year	32,510	530	3,770	2,732,284	5.94	80.68	153.69
1895.							
January	14,610	1,910	3,530	217,050	5.56	6.41	3.86
February	3,350	1,160	1,480	82,200	2.33	2.43	1.89
March	3,210	850	1,200	73,790	1.89	2.18	2.09
April	14,120	565	1,130	67,240	1.78	1.99	21.73
May	12,430	1,760	3,210	197,380	5.06	5.83	16.77
June	25,560	1,690	2,930	174,350	4.61	5.14	9.25
July	21,000	1,410	2,860	175,850	4.50	5.19	17.09
August	19,340	2,050	3,740	229,960	5.89	6.79	14.13
September	12,140	600	3,140	186,840	4.95	5.52	12.09
October	27,990	1,690	4,590	282,230	7.23	8.34	16.46
November			3,280	195,170	5.17	5.77	20.47
December			3,280	201,680	5.17	5.96	15.71
The year	27,990	565	2,880	2,083,740	4.53	61.55	151.54
1896.							
January			2,220	136,500	3.50	4.04	4.02
February			1,130	65,000	1.78	1.92	1.30
March			[a] 630	38,740	.99	1.14	2.01
April			3,070	182,680	4.84	5.40	9.02
May			3,280	201,680	5.17	5.96	16.46
June			3,810	226,710	6	6.69	8.50
July			2,720	167,250	4.28	4.94	13.58
August			2,580	158,640	4.06	4.6[illegible]	15.51
September			3,420	203,500	5.39	6.01	12.84
October			3,180	195,530	5	5.76	13.98
November			4,980	296,330	7.84	8.75	15.63
December			3,600	221,350	5.67	6.54	18.66
The year			2,880	2,093,910	4.53	61.83	131.51

[a] These means are obtained by averaging the discharge measurements.

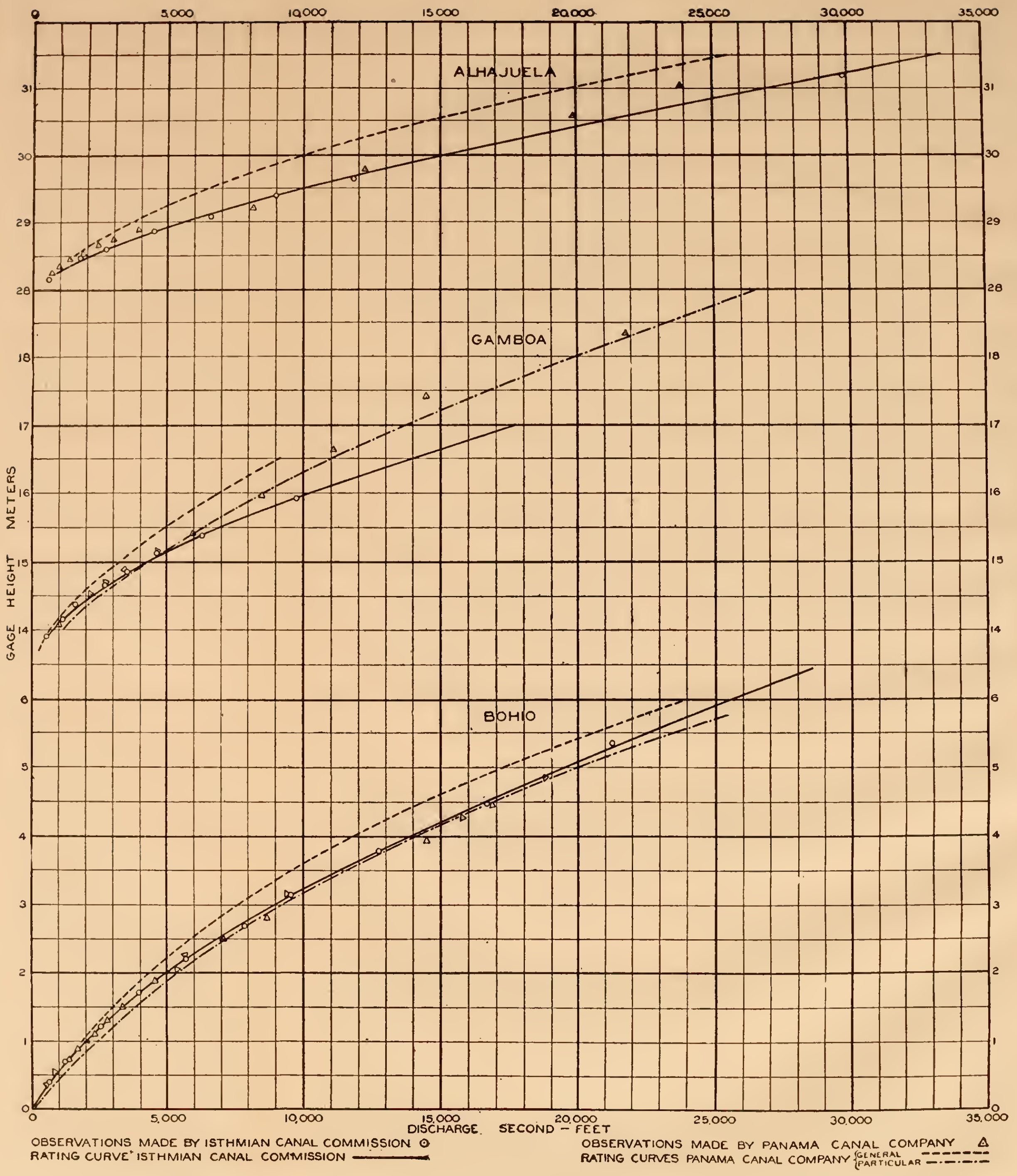


FIG. 6.—COMPARISON OF GAGING CURVES, SHOWING THE REASON FOR THE DISCREPANCY IN THE RESULTS OBTAINED BY THE PANAMA CANAL COMPANY AND THE ISTHMIAN CANAL COMMISSION.

Estimated monthly discharge of Chagres River at Gamboa—Continued.

OBSERVATIONS OF THE NEW PANAMA CANAL COMPANY—Continued.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.		Colon rainfall (inches).
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.	
1897.							
January	....	....	5,120	314,800	8.06	9.29	3.42
February	....	....	1,130	62,760	1.78	1.85	.04
March	....	....	777	47,780	1.22	1.41	.28
April	....	....	670	39,870	1.06	1.18	3.74
May	42,190	2,050	6,710	412,580	10.57	12.19	16.34
June	12,110	3,920	6,570	390,910	10.35	11.55	18.82
July	13,480	4,270	5,360	329,570	8.44	9.73	14.06
August	....	....	[a]4,090	251,480	6.44	7.42	17.24
September	....	....	[a]3,850	229,090	6.06	6.76	17.20
October	13,870	2,050	3,560	218,900	5.60	6.46	5.83
November	18,250	3,070	4,130	245,750	6.50	7.25	22.16
December	20,020	1,450	4,270	262,550	6.72	7.75	18.90
The year	42,190	....	3,880	2,806,070	6.11	82.84	138.03
1898.							
January	27,710	2,010	4,310	265,010	6.80	7.84	5.04
February	2,930	1,130	1,480	82,200	2.33	2.43	.35
March	2,540	777	1,020	62,720	1.60	1.84	1.58
April	28,770	777	1,840	109,490	2.90	3.24	4.72
May	9,920	1,340	2,470	151,870	3.89	4.48	12.83
June	11,650	1,380	2,860	170,180	4.50	5.02	16.38
July	18,960	2,330	4,240	260,700	6.68	7.70	21.89
August	14,510	2,470	4,130	253,940	6.50	7.49	10.91
September	7,270	1,660	2,540	151,140	4	4.46	10.24
October	20,470	1,340	3,460	212,750	5.45	6.28	11.38
November	27,600	1,020	5,190	308,830	8.17	9.12	12.28
December	5,790	1,690	2,290	140,800	3.60	4.15	7.95
The year	28,770	777	3,000	2,169,630	4.72	64.05	115.55
1899.							
January	22,060	1,730	3,490	214,600	5.50	6.34	6.93
February	....	....	950	52,760	1.50	1.56	6.49
March	....	....	950	58,410	1.50	1.73	1.26
April	6,740	706	1,060	63,070	1.67	1.86	.43
May	20,470	706	1,910	117,440	3	3.46	13.90
June	14,120	1,310	2,470	146,970	3.89	4.34	6.41
July	14,120	1,340	2,820	173,400	4.44	5.12	27.68
August	26,190	1,870	4,240	260,700	6.68	7.70	14.80
September	11,750	1,660	3,180	189,220	5	5.58	16.55
October	13,730	1,840	3,390	208,440	5.34	6.16	15.04
November	23,890	1,870	3,740	222,550	5.89	6.57	14.49
December	13,200	1,620	2,650	162,940	4.17	4.81	9.04
The year	26,190	706	2,580	1,870,500	4.06	55.23	133.02

OBSERVATIONS OF THE NEW PANAMA CANAL COMPANY.

1900.							
January	12,920	1,060	1,690	103,910	2.66	3.07	2.09
February	1,165	600	810	44,980	1.28	1.33	.35
March	670	424	530	32,590	.83	.96	.29
April	1,870	388	565	33,620	.89	.99	3.94
May	12,320	424	1,340	82,400	2.11	2.43	11.15
June	10,020	918	1,940	115,440	3.06	3.41	15.94
July	16,910	1,480	3,350	205,980	5.27	6.08	14.47
August	20,620	1,620	3,565	219,200	5.61	6.47	12.43
September	16,060	1,450	3,070	182,680	4.83	5.39	14.69
October	23,720	2,050	4,520	277,920	7.12	8.21	15.78
November	17,540	1,910	4,060	241,590	6.40	7.14	13.86
December	21,920	1,160	2,680	164,790	4.22	4.87	3.02
The year	23.720	388	2,360	1,705,100	3.72	50.35	108.01

[a] These means are obtained by averaging the discharge measurements.

Estimated monthly discharge of Chagres River at Gamboa—Continued.

FROM OBSERVATIONS OF THE ISTHMIAN CANAL COMMISSION.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.		Rainfall at Colon.
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.	
1900.							*Inches.*
January	14,030	889	2,026	124,570	3.19	3.66	2.09
February	1,420	726	970	53,870	1.53	1.59	.35
March	805	509	641	39,410	1.01	1.16	.29
April	1,745	443	637	37,900	1	1.11	3.94
May	15,900	492	1,615	99,300	2.54	2.91	11.15
June	12,550	1,205	2,426	144,360	3.82	4.25	15.94
July	21,980	2,058	4,104	252,350	6.62	7.62	14.47
August	26,300	2,222	4,692	288,500	7.39	8.51	12.43
September	20,060	1,899	3,750	223,140	5.91	6.59	14.69
October	29,900	2,795	5,846	359,460	9.21	10.61	15.78
November	22,760	2,461	5,415	322,220	8.53	9.52	13.86
December	27,900	1,509	3,380	207,830	5.32	6.13	3.02
The year	29,900	443	2,974	2,152,910	....	63.66	108.01

Ratio of run off to rainfall = 59 per cent.

COMPUTED FROM RATING TABLE OF ISTHMIAN CANAL COMMISSION, USING THE GAUGE HEIGHTS OF THE PANAMA CANAL COMPANY AS THE ARGUMENT.

1901.							
January	4,020	911	1,236	76,000	1.94	2.24	....
February	2,960	560	817	45,370	1.27	1.32	....
March	1,480	395	544	33,450	.86	.99	....
April	2,760	278	498	29,630	.78	.87	....
May	26,300	955	2,190	134,660	3.45	3.98	....
June	18,310	1,205	2,500	148,760	3.94	4.40	....

BOHIO STATION, ON CHAGRES RIVER.

The present plans of both the Isthmian Canal Commission and the Panama Canal Company provide for a dam at Bohio. The company established a fluviograph here in 1895, and a record of discharge has been kept ever since.

Annual summary of discharge measurements made by the Panama Canal Company at Bohio.

Year.	Discharge in second-feet.			Total in acre-feet.	Run-off.		Rainfall at Colon (inches).
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.	
1895	27,750	710	4,510	3,263,810	5.12	69.52	151.54
1896	28,950	600	4,220	3,062,960	4.80	65.28	131.51
1897	38,790	495	4,850	3,514,390	5.51	74.88	138.03
1898	27,890	780	3,960	2,865,730	4.50	61.07	115.55
1899	25,870	600	3,400	2,458,420	3.86	52.40	133.02
1900	23,860	490	3,520	2,551,810	4	54.38	[a] 108.67

[a] Mean rainfall on basin.

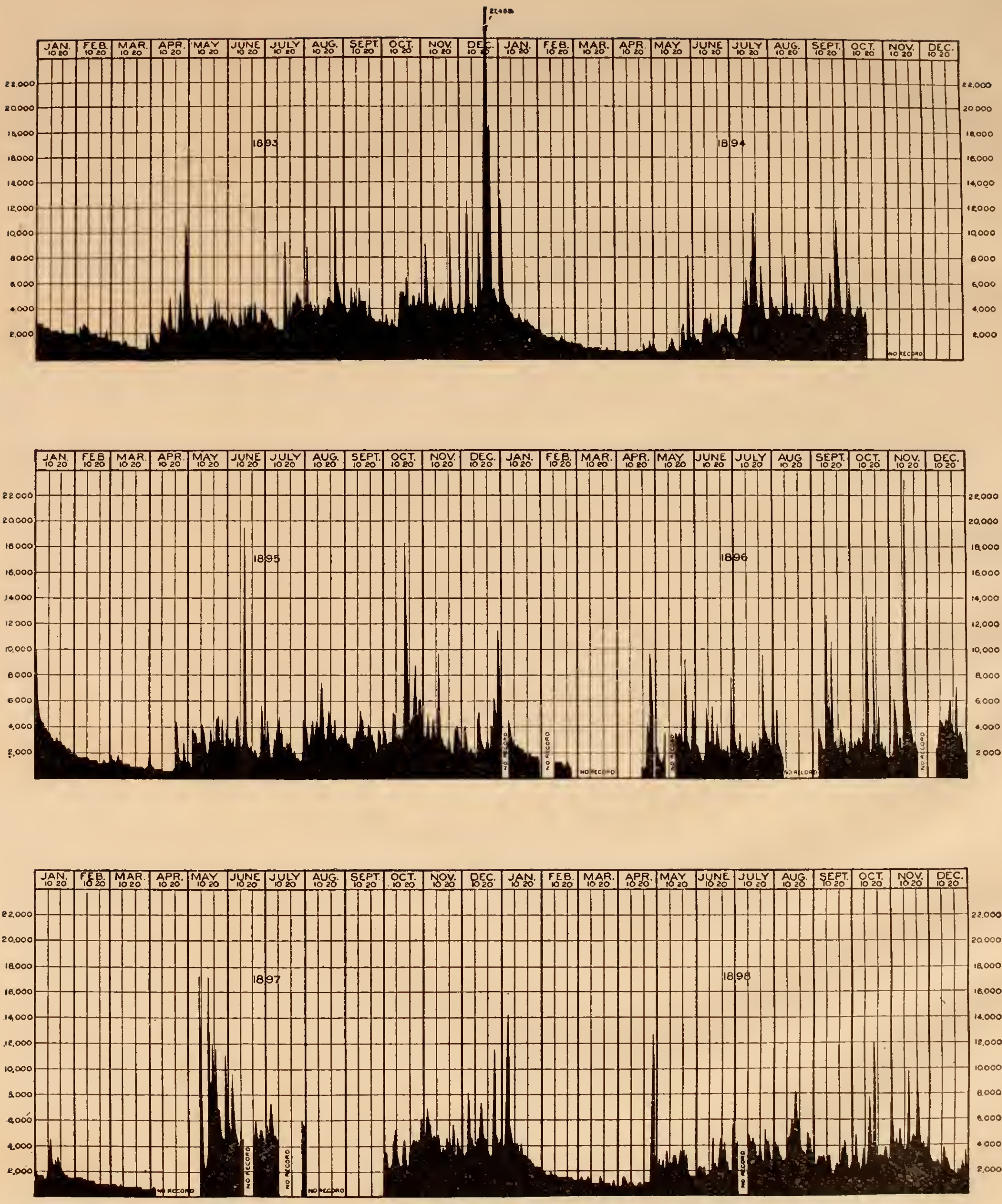


FIG. 7.—HYDROGRAPHS OF THE CHAGRES RIVER AT GAMBOA, PLOTTED FROM OBSERVATIONS OF THE PANAMA CANAL COMPANY.

Estimated monthly discharge of Chagres River at Bohio.

OBSERVATIONS OF THE PANAMA CANAL COMPANY.

[Drainage area, 880 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.		Rainfall at Colon.
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.	
1895.							*Inches.*
January	20,721	2,290	[a]4,550	279,770	5.17	5.96	....
February	2,930	1,900	[a]1,380	76,640	1.57	1.63	....
March	....	....	[a]1,060	65,180	1.20	1.38	....
April	11,540	710	[a]1,060	63,070	1.20	1.34	....
May	13,830	1,380	[a]4,170	256,400	4.74	5.46	....
June	10,770	2,290	[a]4,310	256,460	4.89	5.46	....
July	19,980	1,910	[a]4,590	282,230	5.22	6.02	....
August	15,500	1,940	[a]6,920	425,500	7.86	9.06	....
September	21,320	2,540	[a]5,790	344,530	6.58	7.34	....
October	27,750	2,610	[a]6,920	425,500	7.86	9.06	....
November	18,640	4,020	[a]6,070	361,190	6.90	7.70	....
December	27,180	2,610	[a]6,950	427,340	7.90	9.11	....
The year	27,750	710	4,510	3,263,810	5.12	69.52	....
1896.							
January	10,450	1,910	[a]4,730	290,840	5.38	6.20	....
February	2,470	1,020	[a]1,550	89,160	1.76	1.90	....
March	1,940	740	[a]880	54,110	1	1.15	....
April	25,030	600	[a]1,690	100,570	1.92	2.14	....
May	16,270	1,730	[a]4,940	303,750	5.61	6.47	....
June	13,240	2,080	[a]4,200	249,920	4.77	5.32	....
July	22,950	2,430	[a]3,140	193,070	3.57	4.12	....
August	11,930	2,650	[a]3,500	215,200	4	4.61	....
September	....	....	[a]5,930	352,860	6.74	7.52	....
October	....	....	[a]6,350	390,450	7.22	8.32	....
November	19,100	....	[a]7,590	451,640	8.62	9.62	....
December	28,950	3,880	[a]6,040	371,390	6.86	7.91	....
The year	28,950	600	4,220	3,062,960	4.80	65.28	....
1897.							
January	5,370	3,390	[a]2,050	126,050	2.33	2.69	....
February	....	....	[a]1,590	88,300	1.81	1.88	....
March	1,380	600	[a]710	43,660	.81	.93	....
April	14,160	495	[a]880	52,360	1	1.12	....
May	38,790	850	[a]7,980	490,670	9.07	10.46	....
June	12,910	3,460	[a]4,200	249,920	4.77	5.32	....
July	17,400	2,860	[a]5,120	314,820	5.82	6.71	....
August	18,460	2,820	[a]7,270	447,010	8.26	9.52	....
September	21,110	4,130	[a]6,880	409,390	7.82	8.72	....
October	17,540	3,390	[a]7,480	459,930	8.50	9.80	....
November	22,100	3,810	[a]6,950	413,550	7.90	8.81	....
December	22,100	3,670	[a]6,810	418,730	7.74	8.92	....
The year	38,790	495	4,850	3,514,390	5.51	74.88	....
1898.							
January	27,250	2,260	5,650	347,400	6.42	7.40	....
February	3,320	1,230	1,690	93,860	1.92	2	....
March	2,400	810	1,090	67,020	1.24	1.43	....
April	24,000	780	2,010	119,600	2.28	2.54	....
May	8,510	1,450	2,680	164,790	3.05	3.52	....
June	15,140	1,760	3,350	199,340	3.81	4.25	....
July	23,860	2,890	6,570	403,970	7.47	8.61	....
August	15,500	3,000	5,300	325,880	6.02	6.94	....
September	8,540	2,150	3,210	191,000	3.65	4.07	....
October	23,370	2,080	5,050	310,510	5.74	6.62	....
November	27,890	3,810	7,840	466,510	8.91	9.94	....
December	6,670	1,980	2,860	175,850	3.25	3.75	....
The year	27,890	780	3,960	2,865,730	4.50	61.07	....

[a]These means are obtained by averaging the discharge measurements.

Estimated monthly discharge of Chagres River at Bohio—Continued.

OBSERVATIONS OF THE NEW PANAMA CANAL COMPANY.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.		Rainfall at Colon.
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.	
1899.							*Inches.*
January	22,240	1,800	3,848	236.600	4.37	5.04	....
February	2,540	1,340	1,730	[illegible]	1.98	2.06	....
March	1,410	740	988	60,750	1.12	1.29	....
April	3,280	635	1,090	64,860	1.24	1.38	....
May	17,540	600	2,050	126,050	2.33	2.69	....
June	5,470	1,910	3,140	186,840	3.57	3.98	....
July	17,750	1,660	3,950	242,880	4.49	5.18	....
August	25,870	3,040	5,720	351,700	6.50	7.49	....
September	9,531	2,440	4,240	252,300	4.82	5.38	....
October	16,130	2,720	4,940	303,750	5.61	6.47	....
November	24,250	2,790	5,300	315,370	6.02	6.72	....
December	15,280	940	3,600	221,360	4.09	4.72	....
The year	25,870	600	3,400	2,458,420	3.86	52.40	....

BASED ON DISCHARGE MEASUREMENTS MADE BY THE ISTHMIAN CANAL COMMISSION.

Month.	Maximum.	Minimum.	Mean.	Total in acre-feet.	Second-feet per square mile.	Depth in inches.	Rainfall at Colon.
1899.							
January	21,830	1,900	4,150	255,170	4.72	5.44	6.93
February	2,810	1,300	1,795	99,690	2.04	2.12	6.49
March	1,420	665	943	57,980	1.07	1.23	1.26
April	3,670	570	1,057	62,900	1.20	1.34	.43
May	17,440	540	1,900	116,830	2.16	2.49	13.90
June	6,440	2,030	3,500	208,260	3.98	4.44	6.41
July	17,730	1,710	4,372	268,820	4.97	5.73	27.68
August	24,520	3,370	6,425	395,060	7.30	8.42	14.80
September	10,225	2,680	4,858	289,070	5.52	6.16	16.55
October	16,285	2,990	5,511	338,860	6.26	7.22	15.04
November	23,320	3,080	5,732	341,080	6.51	7.26	14.49
December	15,430	2,210	3,950	242,880	4.49	5.18	9.04
The year	24,520	540	3,697	2,676,600	4.18	57.03	133.02

OBSERVATIONS OF THE NEW PANAMA CANAL COMPANY.

Month.	Maximum.	Minimum.	Mean.	Total in acre-feet.	Second-feet per square mile.	Depth in inches.	Rainfall at Colon.
1900.							
January	10,410	1,480	2,120	130,350	2.41	2.78	2.44
February	1,380	810	1,060	58,870	1.20	1.25	.33
March	920	600	740	45,500	.84	.97	.32
April	1,765	490	706	42,010	.80	.89	3.78
May	9,672	490	1,620	99,610	1.84	2.12	10.45
June	10,840	1,340	2,860	170,180	3.25	3.63	15.67
July	21,180	2,010	5,610	344,940	6.38	7.36	15.28
August	19,240	2,440	5,260	323,420	5.98	6.89	12.36
September	18,070	2,260	4,770	283,830	5.42	6.05	14.33
October	23,860	3,180	7,000	430,410	7.95	9.17	15.48
November	20,300	3,740	6,600	392,730	7.50	8.37	15.10
December	22,870	1,800	3,740	229,960	4.25	4.90	3.13
The year	23,860	490	3,520	2,551,810	4	54.38	108.67

FROM OBSERVATIONS OF THE ISTHMIAN CANAL COMMISSION.

Month.	Maximum.	Minimum.	Mean.	Total in acre-feet.	Second-feet per square mile.	Depth in inches.	Rainfall at Colon.
1900.							
January	10,155	1,441	2,203	135,460	2.50	2.87	2.44
February	1,640	802	1,052	58,420	1.20	1.24	.33
March	877	570	681	41,870	.77	.88	.32
April	1,845	442	652	38,800	.74	.82	3.78
May	9,500	506	1,670	102,680	1.92	3.20	10.45
June	12,700	1,640	3,185	189,520	3.62	4.04	15.67
July	20,650	2,521	5,960	366,470	6.77	7.80	15.28
August	18,900	2,859	5,880	361,550	6.68	7.70	12.36
September	17,800	2,651	5,190	308,830	5.90	6.58	14.33
October	23,000	3,802	8,220	505,430	9.34	10.77	15.48
November	19,800	4,464	7,540	448,660	8.57	9.56	15.10
December	22,100	1,949	4,100	252,100	4.66	5.37	3.13
The year	23,000	442	3,880	2,809,790	....	60.83	108.67

Ratio of run-off to rainfall = 55 per cent.

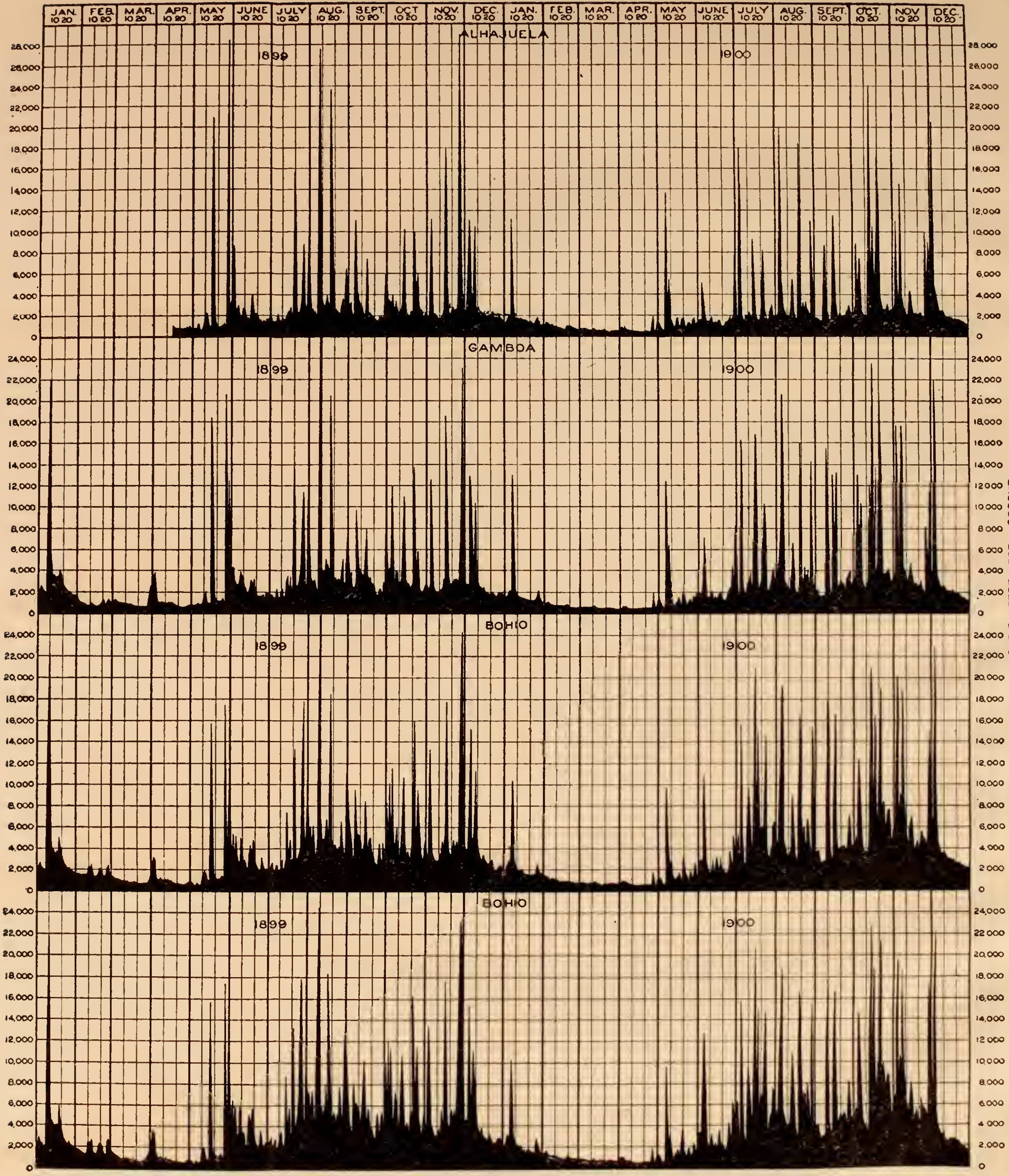


FIG. 8.—COMPARATIVE HYDROGRAPHS OF CHAGRES RIVER.

Alhajuela, Gamboa, and the upper Bohio diagram are drawn from observations of the Panama Canal Company; the lower diagram from observations of the Isthmian Canal Commission.

Estimated monthly discharge of Chagres River at Bohio—Continued.

COMPUTED FROM RATING TABLE OF ISTHMIAN CANAL COMMISSION, USING THE GAUGE HEIGHTS OF THE PANAMA CANAL COMPANY AS THE ARGUMENT.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.		Rainfall at Colon.
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.	
1901.							*Inches.*
January	3,400	975	1,508	92,720	1.71	1.91	....
February	2,680	618	937	52,040	1.06	1.10	....
March	1,975	400	654	40,210	.74	.85	....
April	2,443	255	521	31,000	.59	.65	....
May	19,180	860	2,400	147,570	2.73	3.15	....
June	13,010	1,390	2,890	171,970	3.28	3.66	....

MINOR STREAMS ON THE ISTHMUS OF PANAMA.

In a minor degree it is required to know something of the volume and regimen of the Grande River, which is followed by the canal line from Paraiso to the Pacific. Also of the tributaries of the Chagres, which are to be conducted to the sea independent of the canal.

Observations on all of these were made in 1900 sufficient to show that no difficult problems are involved in their control. A detailed description of work and results on these streams will be found in Mr. Schlecht's report, page 52.

THE FLOODS OF THE CHAGRES RIVER.

The projected canal from Colon to Panama is 49 miles in length, and for more than half this distance it follows the valley of the Chagres. The magnitude of a flood discharge is, therefore, important in its relation to the works necessary for controlling and discharging the surplus waters without injury to the works or obstruction to navigation.

Although nearly the entire country is clothed with vegetation, much of which is very dense, the slopes are so precipitous and rock is so near the surface that the heavy tropical rainfall often produces sudden freshets in the river. A violent rainfall of a few hours converts the banks of the Chagres in the vicinity of Alhajuela and above into a series of small torrents and cascades, causing the river to rise very suddenly and flow with great velocity. It is this feature that lends such importance to the study of the floods of the Chagres in their relation to the proposed canal.

It is stated by the officers of the Panama Railway Company that previous to 1879 no freshet had occurred in the Chagres of magnitude sufficient to cause serious damage to the property of the railway company or to delay its operations. The flood of 1879 caused great damage to the railway and obstructed traffic for a considerable period, and the conclusion follows that it is far greater than any flood that had occurred since the construction of the railway was begun. This conclusion is verified by the testimony of the oldest inhabitant of the vicinity. Since 1879 sufficient attention has been paid by canal officials to render it certain that no flood equal in magnitude to that of 1879 has since occurred. The flood occurred in November, but we do not know how long it lasted, except that a violent storm raged for six days throughout the Isthmus, the precipitation amounting to 320 millimeters at Panama.

The only actual information existing other than that of a general character from the officials of the Panama Railway above referred to is the testimony of Mr. Sosa, a young Colombian engineer, who, by inquiry from the inhabitants or otherwise, decided upon certain points as high water of this flood in the neighborhood of Bohio. Mr. Sosa was unfortunately drowned in the sinking of *La Burgoyne*, and it is not known how accurate his information was, excepting that he expressed his entire reliance upon it. By his testimony the river reached an elevation of 12 meters above sea level at Bohio at its maximum stage. From the measurements made of the floods of less magnitude and from the large number of measurements of the river at its lower stage a curve has been plotted expressing the relation of discharge and gauge height at Bohio. The existing observations are in satisfactory accordance, and by extrapolating this curve upward to include the flood of 1879 we obtain a discharge for the river at Bohio for gauge height 12 meters of 3,860 cubic meters, or about 136,000 cubic feet per second. The curve and the data upon which it is based are shown in figure 9, page 45, and is submitted as being the best conclusion permitted. The plotted observations are those given by General Abbot in his note "Sur le régime du Chagres," pages 24 to 27. The results obtained by the company at Bohio being in practical accordance with those observed by this Commission, are accepted without change.

In this connection three points should be remembered—first, the discharge for "cote" 12 may be greater than here indicated; second, the flood of 1879 may have reached a higher elevation than "cote" 12; third, it is possible that a larger flood than that of 1879 may occur in the future.

Under these circumstances it seems unsafe to consider the maximum flood wave to be expected on the Chagres at less than 140,000 cubic feet per second.

Four great floods occurred since 1879, of which the discharge at Gamboa has been measured or estimated by the Panama Canal Company as follows:

Date.	Gauge height.	Discharge maximum.	Mean for forty-eight hours.	Percentage.
	Meters.	*Cub. meters.*	*Cub. meters.*	
November 25, 1885	23.60	1,638	1,077	66
December 12, 1888	23.56	1,628	1,270	78
December 1, 1890	23.70	1,663	833	50
December 17, 1893	21.72	1,207	759	63

The flood of 1879 seems to have been longer sustained than any of the others, and it seems likely that the ratio of the mean discharge to the maximum should be somewhat greater than the others. General Abbot has assumed the mean discharge for forty-eight hours for this flood at 80 per cent of the maximum, and this appears to be approximately correct. Eighty per cent of 140,000 cubic feet per second is 112,000 cubic feet per second.

The area of Lake Bohio according to the plans adopted by this Commission are as follows:

Elevation.	Acres.	Square miles.
20 meters 65.6 feet	14,771	23.08
25 meters 82 feet	23,542	36.78
26 meters 85.3 feet	24,627	38.48

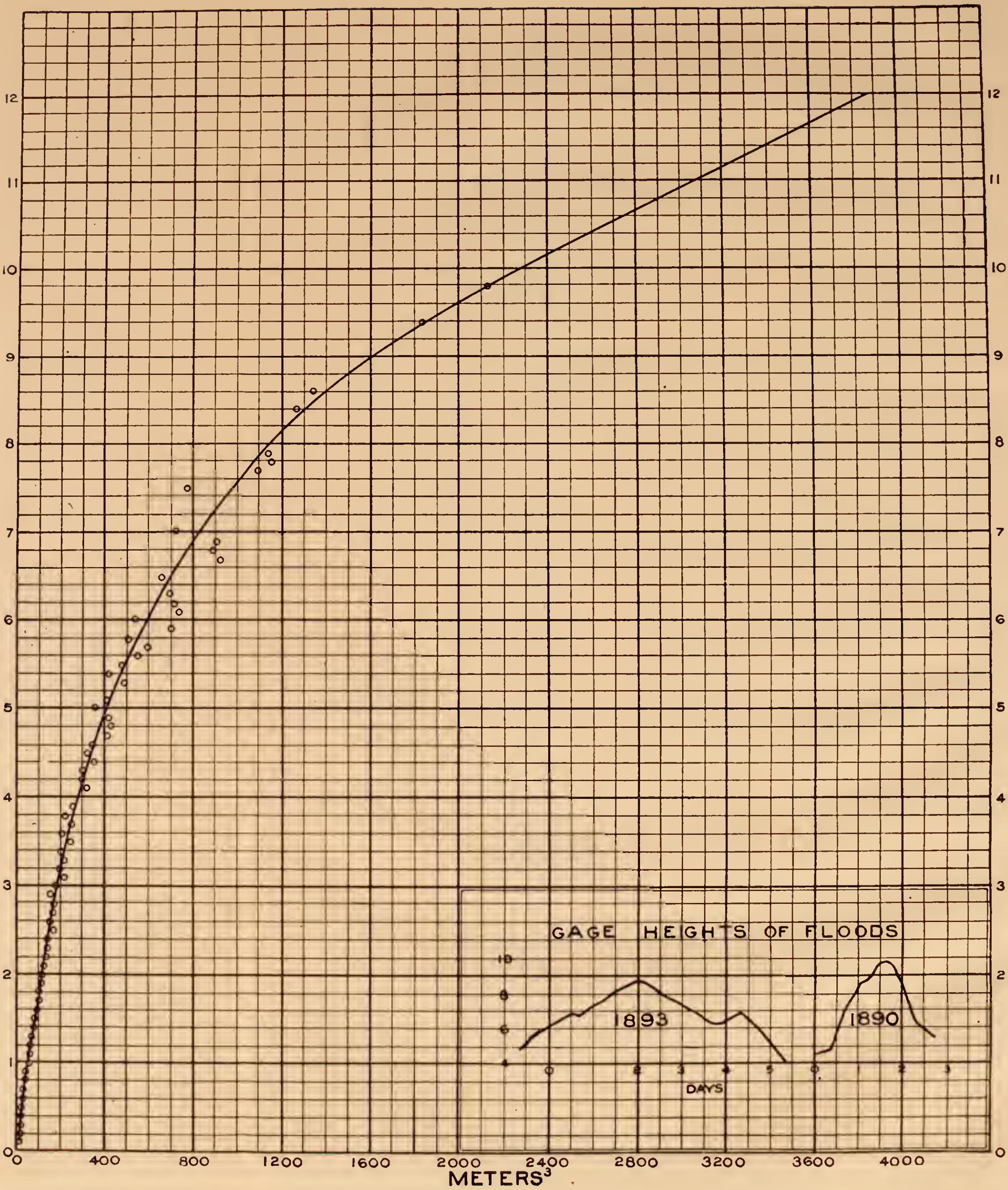


FIG. 9.—RATING CURVE FOR FLOODS OF THE CHAGRES RIVER AT BOHIO.

Constructed by the Isthmian Canal Commission from observations of the Panama Canal Company, 1890–1899

The waste weir provided is to be at elevation 85 feet above sea level or slightly less than 26 meters, and is to have a length of 2,000 feet. This flow continued for forty-eight hours would result in a total discharge of 444,300 acre-feet, or about 9,300 acre-feet per hour. A sustained discharge of this amount would raise the lake to a head of about 6.6 feet over sill of the weir. This, however, may be taken as the extreme condition, which will never be exceeded.

LOW WATER OF THE CHAGRES RIVER.

The Chagres River being the one feeder to the summit level of the proposed canal, its mean and minimum flow is very important as indicating the amount of storage that must be provided for the operation of the canal during the dry season. The mean flow for the various months of the year as determined by averaging all the monthly records at Gamboa in our possession since 1892, are as follows:

	Cubic feet per second.		Cubic feet per second.
January	3,310	July	4,010
February	1,330	August	4,080
March	900	September	3,540
April	1,530	October	4,110
May	3,180	November	4,790
June	3,280	December	4,850

Averaging these quantities, we find the mean annual discharge is about 3,200 cubic feet per second. As the maximum consumption and loss by leakage and evaporation is but little over 1,000 cubic feet per second, we find that the month of March is the only month having a shortage in average years, and as this is the record for Gamboa, and the discharge at Bohio, where the dam is to be constructed, is somewhat greater, we may say that the requirements of the canal are less than the average discharge for any month in the year, and if one-third of the mean annual flow can be saved, there will be ample for canal purposes.

But some years furnish less water than others, and to correctly solve the problem of the water supply for the canal we must consider the yield in the minimum year.

In all the observations at Bohio the lowest monthly means are for the months of March and April, 1891, as shown by the mean of eight measurements made in each of those months. More records, however, are at hand for Gamboa than for Bohio, and the lowest reading at the Gamboa fluviograph occurred in the spring of 1901, when for a period of about two and one-half months the fluviograph at Gamboa indicated a stage of less than 14 meters almost continuously, the lowest point reached being 13.72. This corresponds to a discharge of from 7 to 8 cubic meters per second.

In the examination of the records in Paris an elevation at Gamboa was found for the last three days of March, 1896, giving the stage as 13.1 meters. The rest of the month of March and the first half of April are entirely blank, no record having been kept. It is impossible that this could have been a fluviograph record, since the river would be dry before reaching so low an elevation at the location of the fluviograph, and the only plausible explanation is that given by the officers of the company that this record was on a rod a considerable distance below the fluviograph, and this statement is confirmed by the reports of discharge on these dates, which are 16.8, 16.8, and 16.9 cubic meters, respectively, leaving no doubt that at this time the river was above the stage reached in 1900. No other record gives a stage of river as low as that reached in 1900.

The year 1891, however, seems to have had a still lower dry-season flow. No fluviograph records were obtainable, except such as were given with the measurements of discharge, and these do not show any stage as low as that of 1900, but in so long a time the bed of the river would be likely to change, and the measurements show that it has done so. Of actual gaugings we have (p. 48) 8 for February, 8 for March, and 8 for April. The measurement on the 1st of May shows low water, while that of May 4 exhibits a freshet.

The indications of the gaugings are that up to February 14 the discharge of the river was above the requirements of the canal, while from February 15 to May 3 they were below. This is the same period for which 8 measurements per month were made at Bohio. The means are 39 cubic meters per second for February, 17 for March, and 17 for April. This is the lowest discharge at Bohio of which we have record. It is, of course, not certain that a drier year has not occurred or will not occur, and in making the estimates it will be assumed that the mean of 17 cubic meters or 600 cubic feet per second is continuous for ninety days, from February 1 to May 1.

The requirements and losses of the canal in operation, as estimated by this Commission, are as follows:

	Cubic feet per second.
Lockage	406
Power	200
Leakage	257
Evaporation	207
Total	1,070

Applying this quantity, we have for the ninety days, from February 1 to May 1:

	Acre-feet.
Total leakage, lockage, and evaporation, 1,070 cubic feet per second	191,000
Less inflow	107,000
Deficit	84,000

Taking 24,000 acres as the area of the lake, this will lower the lake about 3.5 feet. An allowance of this amount is therefore ample for the most extreme case.

This brings the elevation of the lake to 81.5 feet, which may be regarded as the elevation reached in the minimum year of a long series, and would occur perhaps only once in a generation. If the consumption and loss should be less than 1,070 cubic feet per second the deficit would, of course, be diminished.

The dry season of 1900 would have brought the lake level to an elevation of about 82.5.

The possibility always remains of constructing a large reservoir at Alhajuela, which will not only guard against all possibility of annoying currents in Lake Bohio, but will store sufficient water for use in the dry season so that the lake need never decline below the sill of the waste weir.

It is indeed true, as stated by General Abbot, that the Chagres is a river well adapted to the service of the proposed Panama Canal.

Discharge measurements made on Chagres River at Gamboa.

[Made by Panama Canal Company.]

Date.	Height.	Discharge.
1889.		
September 27	15.4	4,448
September 30	15.4	4,977
October 2	15.7	5,154
October 5	15.8	5,613
October 9	15.1	3,951
October 12	15.4	5,330
October 15	15.0	3,459
October 19	15.9	6,107
October 23	15.4	4,977
October 26	15.1	3,600
October 30	15.2	4,165
Mean	....	4,707
November 2	15.4	5,366
November 6	15.2	4,236
November 9	15.4	4,942
November 14	15.0	3,812
November 16	15.4	4,765
November 20	15.2	4,660
November 22	17.1	11,614
November 30	15.1	3,600
Mean	....	5,374
1890.		
January 13	16.8	9,531
Mean	....	9,531
February 14	14.5	1,412
February 21	14.4	1,412
February 27	14.3	1,236
Mean	....	1,353
March 1	14.3	1,270
March 6	14.2	1,094
March 11	14.2	882
March 19	14.2	882
March 27	14.4	1,341
Mean	....	1,094
April 8	14.2	812
April 10	14.1	600
April 14	14.1	600
April 17	14.1	565
April 19	14.1	600
April 22	14.1	586
April 25	14.1	777
April 29	14.4	1,306
Mean	....	731
May 3	17.6	14,470
May 6	14.8	3,530
May 9	14.4	1,165
May 12	15.8	6,707
May 16	16.1	8,013
May 20	15.2	3,990
May 23	14.8	2,824
May 27	15.2	3,990
May 30	14.8	2,753
Mean	....	5,271
June 3	15.4	4,483
June 6	15.6	4,518
June 7	16.8	10,307
June 10	16.4	8,472
June 13	14.8	2,471
June 17	16.8	11,120
June 20	15.5	4,730
June 24	15.1	3,636
June 27	15.2	3,777
Mean	....	5,946

Date.	Height.	Discharge.
1890.		
July 1	15.4	4,483
July 7	15.2	3,954
July 8	15.2	3,636
July 8	17.2	11,331
July 16	15.6	5,013
July 18	15.4	4,518
July 22	15.2	3,777
July 25	16.6	8,930
July 29	15.0	3,000
Mean	....	5,404
August 1	14.8	2,400
August 5	15.4	4,624
August 8	15.3	4,377
August 12	15.8	5,720
August 14	16.2	7,554
August 19	15.3	4,306
August 22	15.2	4,060
August 26	15.9	6,954
August 29	15.3	4,448
August 31	17.1	12,320
Mean	....	5,676
September 5	15.4	4,977
September 9	15.2	4,130
September 12	15.6	5,330
September 13	17.7	15,890
September 16	16.0	6,920
September 19	15.5	5,083
September 21	16.3	8,225
September 26	15.4	4,342
September 30	15.9	6,460
Mean	....	6,817
October 3	15.4	4,518
October 7	15.4	4,660
October 10	15.9	5,825
October 14	15.3	3,742
October 17	15.2	4,024
October 21	15.1	3,600
October 24	17.1	10,307
October 25	18.4	17,900
October 31	15.3	3,777
Mean	....	6,483
November 4	15.2	3,777
November 7	15.1	3,565
November 11	15.4	4,412
November 14	15.2	3,990
November 18	15.0	3,018
November 22	15.6	5,048
November 25	15.4	4,589
November 29	15.1	3,248
Mean	....	3,956
December 2	18.0	14,296
December 5	15.6	5,471
December 9	15.6	6,178
December 12	15.2	3,600
December 16	15.4	4,554
December 19	15.5	5,295
December 23	15.4	4,836
December 26	15.4	5,013
December 30	15.2	3,990
Mean	....	5,915
1891.		
January 2	15.1	3,353
January 6	14.9	2,612
January 9	15.1	3,177
January 13	14.7	1,836
January 16	14.7	1,765
January 20	14.6	1,482

Discharge measurements made on Chagres River at Gamboa—Continued.

Day.	Height.	Discharge.
1891.		
January 23	14.6	1,553
January 27	14.6	1,341
January 30	14.5	1,341
Mean		2,051
February 3	14.5	1,236
February 6	14.5	988
February 10	14.4	1,130
February 13	14.5	1,024
February 17	14.4	847
February 20	14.4	928
February 24	14.3	709
February 27	14.3	709
Mean		946
March 3	14.3	720
March 6	14.3	681
March 10	14.3	745
March 13	14.3	582
March 17	14.2	540
March 20	14.2	551
March 24	14.2	600
March 27	14.2	434
March 31	14.2	515
Mean		596
April 3	14.2	572
April 7	14.1	568
April 10	14.1	547
April 14	14.1	441
April 17	14.1	614
April 21	14.2	522
April 24	14.1	544
April 28	14.1	473
Mean		535
May 1	14.2	512
May 4	18.2	18,285
May 8	14.5	1,701
May 12	14.1	618
May 15	14.1	512
May 19	15.0	3,036
May 22	14.4	1,423
May 26	14.7	2,404
May 29	14.8	2,580
Mean		4,524
June 2	14.7	2,051
June 5	14.7	2,365
June 9	14.7	2,230
June 12	14.3	1,097
June 16	14.5	1,750
June 19	15.8	6,080
June 23	14.7	1,860
June 26	14.4	1,377
June 30	14.8	2,602
Mean		2,379
July 3	14.5	1,518
July 7	14.6	1,871
July 8	17.5	11,967

Date.	Height.	Discharge.
1891.		
July 13	16.0	5,825
July 17	14.7	1,977
July 21	15.0	3,000
July 24	14.7	1,588
July 28	15.5	4,483
July 31	14.7	1,906
Mean		3,793
August 4	14.9	2,683
August 7	15.2	3,777
August 11	14.9	2,577
August 14	14.7	2,259
August 18	15.0	3,142
August 21	14.8	2,330
August 25	15.0	3,354
August 28	14.7	2,120
Mean		2,780
September 1	15.4	4,130
September 4	15.1	3,000
September 8	15.3	4,312
September 11	14.8	2,259
September 15	14.7	2,083
September 18	14.7	1,518
September 21	15.7	4,590
September 29	14.8	2,330
Mean		3,032
October 2	14.9	2,316
October 6	14.7	2,120
October 9	14.6	1,870
October 13	15.1	3,390
October 16	16.4	6,848
October 20	15.4	4,095
October 23	15.6	4,836
October 27	15.5	4,695
October 30	15.4	3,954
October 31	17.0	10,555
Mean		4,468
November 3	15.1	3,142
November 6	15.5	4,377
November 10	15.4	3,636
November 13	15.2	3,565
November 17	14.9	2,294
November 19	19.2	26,475
November 24	15.3	3,848
November 27	17.5	12,637
Mean		7,497
December 1	16.9	9,955
December 4	15.6	4,907
December 8	17.5	12,885
December 11	15.1	2,930
December 15	15.0	2,790
December 18	14.8	2,153
December 22	14.8	3,083
December 27	14.7	1,730
December 29	14.6	1,590
Mean		4,670

RAINFALL.

Notwithstanding the fact that the isthmus is narrow and the cordillera low in the vicinity of Panama, there is a striking difference of rainfall between the Caribbean or northern and the Pacific or southern coast of the isthmus in this region. The contrast is similar, though not so striking as that between the east and west coasts of Nicaragua. The mean rainfall at Colon as shown by a record of nearly thirty years is 130 inches, while that at Panama, though not so well determined, is only 66.8. The precipitation at Panama and vicinity is confined almost entirely to the months from May to November, inclusive, the rest of the year being the dry season. At Colon, though the rainfall is less during the dry season, there is still quite a precipitation, the mean for April being 4.54 and for January 3.73, while these two months are dry on the Panama side. February and March are less likely to yield any considerable precipitation, but no month is exempt from rainfall on the coast of the Caribbean. The upper portion of the Chagres drainage basin represents the mean between these extremes. (See map.)

The longest record of rainfall in the vicinity is that of Colon, which continues from March, 1881, to date, with the exception of a period of twenty-one months in 1888-89. This station, however, is not on the Chagres drainage, and the records which are in that basin are not so long. They are mainly at Gamboa and Obispo, with very short records at Bohio, Gorgona, and Alhajuela. Short records also exist at Panama, at La Boca, the south end of the canal, and at Naos, an island in the Bay of Panama.

The long records of stream flow at Gamboa and Bohio, together with an approximate knowledge of the area of the drainage basin, and the observations of rainfall, constitute a valuable contribution to the knowledge of the ratio of rainfall to run off in the Tropics, the weakest point being the information on rainfall, the only records in the basin being confined to the lower valley, and being, moreover, very short. If a definite relation could be established between the long Colon record and the mean of the Chagres basin, it would increase the value of these data to an important extent. For this purpose, five stations above Alhajuela were established in 1899, two at different points on Rio Pequeni at Salamanca and Las Minas, one on the Upper Chagres at Santa Barbara, and two at high elevations above the river valley. Of the latter, one is on a hill between the Chagres and Pequeni, 700 feet above the nearest point of the Chagres, and the other is between the Chagres and Puente, about 500 feet above the river. Salamanca and Las Minas were discontinued at the end of 1900. The others were discontinued October 30, 1900. Their relative location is shown on the map. These stations, considered with those lower in the basin, are taken as the mean for the basin, and compared with observations at Colon as follows:

Rainfall at Colon compared with the mean rainfall in the basin of the Chagres River.

Month.	Colon.				Basin.
	1872 (maximum).	1884 (minimum).	1900.	Mean for 30 years.	1900.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	3.57	3.39	6.06	3.56	2.44
February	.75	.39	.33	1.52	.33
March	.83	.39	1.06	1.55	.32
April	1.30	4.33	.75	4.42	3.78
May	21.43	10.16	12.25	12.27	10.45
June	22	10.32	11.65	13.46	15.67
July	19.90	15.59	16.81	16.92	15.28
August	19.97	13.27	17.04	15.53	12.36
September	16.20	9.37	9.37	12.77	14.33
October	30.32	8.66	16.33	14.20	15.48
November	19.11	7.05	20.28	20.56	15.10
December	13.12	3.62	[a]9.04	12.49	[a]3.59
Total	168.50	86.54	120.97	129.25	109.13

Mean rainfall on basin: 129.25, 109.13, 120.97, or 116.60 inches.

[a] To obtain a comparison for a complete year, the rainfall for December, 1899, is included, because during December, 1900, many stations in the basin were discontinued.

Monthly rainfalls.

[1862–1874, by Drs. White and Kluge, surgeons Panama Railroad Company; 1881–1898, by Panama Canal Company; 1898–1900, by Panama Railroad Company.]

COLON.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1862	......	......	......	......	......	......	......	......	......	13.10	43.01	16.83	......
1863	1.75	2.94	.85	4.70	13.09	15.32	25.76	10.34	15.54	11.22	17.59	15.21	134.31
1864	1.90	.77	.78	.44	15.87	8.78	16.54	13.37	17.85	12.83	17.90	16.40	123.43
1865	1.10	1.08	.02	3.89	9.22	16.85	9.61	18.39	8.55	9.69	22.16	5.58	106.14
1866	3.99	1.07	.21	4.07	14.76	12.17	16.72	12.72	18.82	15.04	21.72	8.42	129.71
1867	1.56	.80	.48	1.20	11.88	8.85	16.03	19.82	5.35	20.50	......	......	......
1868	1.17	2.77	2.18	.87	7.24	18.11	20.60	12.50	16.16	13.13	21.58	3.72	120.03
1869	.83	.77	.49	5.04	6.72	10.66	18.22	14.02	8.98	14.82	24.13	10.10	114.78
1870	4.30	3.33	4.95	6.46	20.95	12.48	15.60	16.35	6.74	11.21	32.42	14.85	149.64
1871	15.42	.53	.05	1.52	1.63	7.70	23.27	11.56	8	12.58	12.38	4.94	99.58
1872	3.57	.75	.83	1.30	21.43	22	19.90	19.97	16.20	30.32	19.11	13.12	168.50
1873	6.33	.25	.13	2.18	3.92	13.20	12.50	10.69	10.91	14.30	11.77	.94	87.12
1874	5.33	1.34	3.94	18.02	8.92	15.87	13.62	17.28	8.22	16.65	20.62	7.89	137.70
1881	......	......	1.08	2.52	10.04	15.28	12.24	6.46	6.30	12.91	22.13	10.35	......
1882	1.65	1.10	1.69	1.73	13.23	18.90	19.10	13.94	10.63	14.96	22.09	5.08	124.10
1883	1.85	.47	.55	1.77	11.85	10.08	13.39	25.43	11.14	16.77	11.10	10.94	115.34
1884	3.39	.39	.39	4.33	10.16	10.32	15.59	13.27	9.37	8.66	7.05	3.62	86.54
1885	.87	.59	.55	1.34	7.91	16.61	22.99	20.32	17.44	7.99	24.17	25.51	146.29
1886	2.13	5	9.17	1.58	13.15	16.38	11.10	12.20	7.52	14.33	21.89	22.72	137.17
1887	2.01	.67	.47	10.63	10.28	16.50	17.05	16.89	15.63	19.61	31.81	13.33	154.88
1888	.63	1.58	1.26	......	......	......	......	......	......	......	......	......	......
1889	......	......	......	......	......	......	......	......	......	......	......	......	......
1890	7.24	1.02	2.01	2.99	9.76	17.24	10.24	20.51	22.99	21.77	19.49	19.06	154.32
1891	2.52	.51	1.50	.51	23	7.99	14.02	15.98	17.48	17.48	19.49	4.25	124.73
1892	.98	2.01	3.98	5	18.03	16.97	21.77	15.98	16.26	6.69	26.30	11.30	145.27
1893	1.73	3.82	1.81	8.07	6.58	12.32	11.50	15.12	9.92	12.28	17.80	30.94	131.89
1894	5.35	1.65	.35	2.16	9.85	12.24	19.10	23.03	18.78	12.40	23.66	25.12	153.69
1895	3.86	1.89	2.09	21.73	16.77	9.25	17.09	14.13	12.09	16.46	20.47	15.71	151.54
1896	4.02	1.30	2.01	9.02	16.46	8.50	13.58	15.51	12.84	13.98	15.63	18.66	131.51
1897	3.42	.04	.28	3.74	16.34	18.82	14.06	17.24	17.20	5.83	22.16	18.90	138.03
1898	5.04	.35	1.58	4.72	12.83	16.38	21.89	10.91	10.24	11.38	12.28	7.95	115.55
1899	6.93	6.49	1.26	.43	13.90	6.41	27.68	14.80	16.55	15.04	14.49	9.04	133.02
1900	6.06	.33	1.06	.75	12.25	11.65	16.81	17.04	9.37	16.33	20.28	4.13	116.06
Mean.	3.56	1.52	1.55	4.42	12.27	13.46	16.92	15.53	12.77	14.20	20.56	12.49	129.25

BOHIO.

1896	......	......	......	......	15.63	8.54	5.55	......	25.51	13.35	17.05	......	......
1897	......	......	3.07	8.11	18.54	14.10	15.83	25.20	17.48	26.02	19.57	22.05	......
1898	12.36	1.26	3.03	10.59	11.61	19.76	34.96	38.31	13.31	28.23	21.81	6.38	204.61
1899	9.37	4.49	3.28	1.10	10.35	14.80	17.76	12.99	8.90	19.33	10.43	6.18	118.98
1900	7.06	.48	1.04	2.89	7.42	18.40	17.79	14.02	15.40	18.43	24.98	4.02	131.93
Mean.	9.60	2.08	2.60	5.67	13.31	15.12	18.38	22.63	16.12	21.07	18.77	9.66	155.01

GORGONA.

1896	......	......	......	......	9.02	6.81	5.16	8.98	13.35	10.94	14.37	......	......
1897	......	.08	......	2.60	25.12	13.54	9.65	16.93	15.98	14.41	7.16	7.91	......
1898	3.42	.20	.00	1.38	5.04	4.37	18.50	19.88	......	7.72	9.61	3.94	......
1899	3.78	2.01	3.31	......	......	......	......	......	......	......	......	4.58	......
1900	2.63	.13	.20	3.15	7.07	12.48	19.72	11.04	11.25	11.93	......	......	......
Mean.	3.28	.60	1.17	2.38	11.56	9.30	13.26	14.21	13.53	11.25	10.38	5.48	96.40

GAMBOA.

1881	......	......	......	......	......	10.63	12.40	9.17	10.39	11.06	12.95	4.76	......
1882	......	......	.51	1.50	15.47	6.26	10.12	9.88	11.81	8.15	11.81	1.38	......
1883	......	......	......	2.60	9.68	11.02	6.54	15.94	4.13	10.04	7.01	6.30	......
1884	......	.71	.28	6.46	6.18	13.35	9.62	16.50	10.55	22.36	6.18	2.20	......
1885	.20	.20	.00	1.38	11.06	10.35	9.06	15.51	16.10	9.33	13.23	11.06	97.48
1886	.55	1.06	.71	2.76	15.71	10.55	11.69	16.38	9.13	13.62	16.10	4.61	102.87
1887	2.20	.08	.28	6.85	11.02	19.45	14.02	19.17	11.50	14.88	21.06	16.28	136.19
1888	.12	.63	.35	1.26	20.47	11.93	3.27	10.24	12.28	9.57	16.18	16.34	102.64
1889	1.97	4.53	1.42	.00	4.37	9.10	7.28	10.51	11.42	13.07	8.70	3.35	75.72
1890	4.06	.35	2.36	3.03	13.27	11.65	10.43	15.35	8.90	21.41	9.92	4.29	105.03
1891	.63	.00	.35	2.13	7.48	9.29	6.06	8.50	10.47	15.71	10.67	6.38	77.67
1892	1.10	.67	2.56	4.72	16.81	8.54	13.98	14.33	13.74	11.10	10.24	6.58	104.37
1893	.67	1.06	.71	7.41	11.89	10.71	15.87	7.95	10.24	16.50	13.90	20.87	117.81

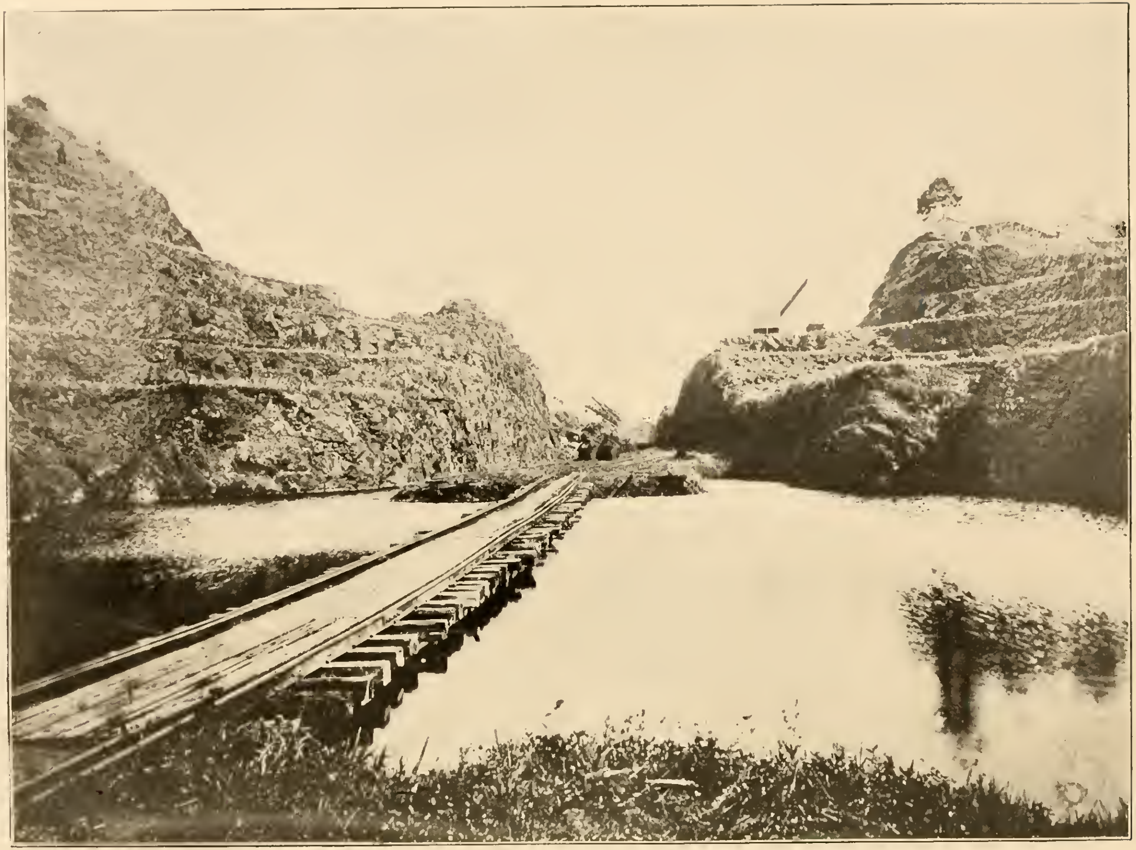


FIG. 10.—OBISPO LOCK SITE, USED AS A METER-RATING STATION BY THE ISTHMIAN CANAL COMMISSION.

Monthly rainfalls—Continued.

GAMBOA—Continued.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1894	1.46	.16	.04	1.34	10.94	8.78	10.08	8.42	15.16	15.28	10.67	8.27	90.60
1895	......	......	......	......	......	......	......	......	......	......	......	......	......
1896	......	......	......	......	3.35	3.31	5.79	......	......	......	......	......	......
1897	......	.20	.28	3.23	17.44	12.64	9.10	17.20	18.82	12.80	5.91	8.62	......
1898	2.76	.12	.00	1.42	5.32	4.65	18.43	20.16	4.10	8.70	14.57	2.40	82.60
1899	5	1.73	1.34	1.42	8.54	8.78	9.45	10.95	13.46	7.95	8.70	2.68	80.00
1900	1.01	.16	.13	3.21	6.76	12.15	13.45	8.92	9.24	12.11	10.67	.79	78.60
Mean.	1.67	.78	.71	2.99	10.88	10.17	10.35	13.06	11.19	12.98	11.74	7.06	93.58

BAS OBISPO.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1884	1.10	.35	.35	2.16	3.86	11.97	8.46	10.51	13.98	12.40	6.93	2.64	74.71
1885	.24	.12	.00	1.14	7.36	8.74	6.34	12.84	12.87	8.94	11.10	11.50	81.23
1886	.83	.87	.87	1.69	17.44	12.91	9.02	8.27	10.20	9.37	15.63	3.90	91.00
1887	2.28	.00	.12	3.19	10.16	15.43	10.87	8.03	10.98	7.36	14.06	15.79	98.27
1888	.16	.51	.32	.91	11.58	11.93	1.93	7.76	7.13	3.82	10.59	10.08	66.72
1889	.79	.32	1.10	6.50	4.57	9.84	6.42	8.98	13.46	13.23	8.54	3.78	77.53
1890	4.53	.12	2.56	2.56	13.07	14.96	9.88	12.16	13.03	4.80	6.54	7.95	92.16
1891	6.10	.00	.35	2.16	5.83	11.54	6.10	7.76	12.32	14.49	8.35	8.72	83.82
1892	.79	.63	2.56	4.76	15.16	10.51	13.10	11.93	17.36	10.28	11.02	6.97	105.07
1893	.55	1.34	.71	3.19	19.57	10.75	14.37	9.57	10.63	19.84	13.35	19.13	123
1894	1.97	.32	.20	1.38	11.89	10	10.59	......	......	......	......	......	......
Mean.	1.76	.42	.83	2.69	10.95	11.69	8.83	9.78	12.20	10.45	10.61	9.05	89.26

CULEBRA.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1883[a]	......	......	......	1.26	11.50	10.32	......	10.71	5.47	......	......	5.04	......
1884	.20	.04	.67	3.78	......	......	10.24	13.62	8.70	10.12	11.18	1.46	......
1885	.28	.00	.00	1.61	15.39	......	4.29	5.35	11.38	10.63	7.20	......	......
1886	.43	.55	.16	1.18	13.78	12.64	14.33	8.19	7.36	20.63	14.29	5.43	98.97
1887	3.15	.00	.04	3.50	7.91	9.96	6.10	8.74	7.64	9.65	12.13	7.95	76.77
1888	.24	.04	.51	.35	11.42	7.99	2.91	6.54	11.26	5.75	9.53	7.72	64.25
1894	......	......	......	......	......	......	......	......	12.13	13.50	13.23	......	......
1895	......	.75	......	......	......	......	......	......	......	......	......	......	......
Mean.	.86	.23	.28	1.95	12	10.23	7.57	8.86	9.13	11.71	11.26	5.52	79.60

[a] Observations at Emperador.

PANAMA.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1879	.04	2.52	5.71	5.55	10.28	6.46	7.91	7.24	9.02	9.80	19.21	.98	84.73
1880	1.89	.12	.16	1.61	4.45	5	9.88	11.46	7.91	11.81	6.46	5.51	66.26
1881	.16	.16	.35	3.23	10.35	13.78	7.20	4.49	8.94	9.68	9.72	2.48	70.55
1882	.00	.12	.00	.98	5.24	6.18	5.35	4.05	4.05	6.69	10.91	2.01	45.60
1894[a]	......	......	......	......	......	7.48	12.72	6.42	7.32	10.51	6.73	8.27	......
1895[a]	1.38	.08	......	......	......	......	......	......	......	......	......	......	......
1899[a]	......	......	......	......	......	......	......	......	6.14	11.98	8.92	4.35	......
1900[a]	.76	.00	.00	2.24	11.21	8.91	15.81	5.99	......	......	......	......	......
Mean.	.70	.60	1.24	2.72	8.31	7.97	9.81	6.61	7.23	10.08	10.32	3.93	69.52

[a] Observations at La Boca.

NAOS.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1881	......	......	......	......	......	......	......	......	......	......	7.48	2.87	......
1882	.00	.04	.04	.94	4.53	5.08	1.61	1.14	1.14	2.72	5.04	2.84	25.12
1883	.59	.00	.00	1.93	4.45	2.56	5.47	5.51	4.64	4.25	7.24	3.11	39.76
1884	2.01	.04	.00	.94	4.84	4.17	4.65	2.99	5.71	8.31	8.62	1.34	43.62
1885	.55	.20	.00	.91	2.56	5.63	2.64	5.51	4.17	9.96	4.37	4.92	41.42
1886	.00	.28	1.81	1.92	5.20	6.26	9.61	5.91	20.75	6.10	4.49	3.74	66.06
1887	.79	.04	.04	2.36	5.24	9.88	4.06	6.69	6.97	7.05	8.82	5.59	57.52
1888	.08	.00	.04	.28	5.55	4.88	2.01	5.71	8.58	8.11	4.02	1.30	40.55
1889	.00	.00	.91	4.41	5.79	5.43	......	......	......	......	......	......	......
Mean.	.50	.08	.35	1.71	4.77	5.49	4.29	4.78	7.42	6.64	6.26	3.21	45.50

TEMPERATURE.

Monthly temperature observed by the Panama Canal Company in degrees Fahrenheit.

Month.	La Boca.			Alhajuela.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
1899.						
July	91	70	78.8	88	72	79.7
August	88	68	75	94	71	80
September	91	69	77	97	72	80.6
October	86	70	76.4	94	71	78.8
November	88	69	76.8	91	72	79.5
December	89	68	77.9	91	66	78.9
1900.						
January	88	68	77.7	90	66	76.8
February	89	70	77.5	92	66	79.5
March	90	68	79.7	93	64	79.7
April	90	68	80	94	64	80.9
May	90	73	80.9	94	68	78
June	89	74	80.4	94	70	78.9
July	88	73	79.3	90	70	77.3
August	91	72	80.3	90	70	78.4
September	91	72	80.6	92	70	76.4
October	....	....	79.4	89	69	77.7
November	88	72	78.8	89	69	77.3
December	89	73	80.2	90	68	78.1
The year	91	68	79.6	94	64	78.3

REPORT OF W. W. SCHLECHT, HYDROGRAPHER FOR PANAMA.

WASHINGTON, D. C., *February 27, 1901.*

SIR: I have the honor to submit the following report of my work on the Isthmus of Panama, performed under your direction:

Although during former years hydrographic records were collected by the Panama Canal Company on several streams, at present all investigations are confined to the Chagres River, which really presents the only important hydrographic problems relative to an interoceanic canal across the Isthmus of Panama, and as Alhajuela, Gamboa, and Bohio have at different times been considered as probable dam sites, these places have been selected as hydrographic stations. In order to obtain the daily mean gauge height and a record of the rapid fluctuations of the river, the canal company has installed continuous self-registering river gauges, or "fluviographs" at these points with an observer at each. The scale of the fluviograph record is 1 millimeter (vertical) = 2 centimeters of rise; and 5 millimeters (horizontal) = 1 hour, so that each centimeter of rise and each ten minutes of time may be easily read. It was at once apparent that no improvement on this means of obtaining the desired information could be introduced so the records were simply checked each day at 6 a. m. and 6 p. m., and with very few exceptions no material error was ever found.

The measurements for the discharge are made by means of floats of 1 to 3 feet immersion, and 2 to 3 inches diameter, the latter size being used only at times of flood, so all may be considered as surface floats, and a length of course of 60 meters at Alhajuela, and Gamboa, and 80 meters at Bohio. Cross-sections of the courses are taken 10 meters apart; and from these a table of mean sectional areas for different stage of the river is computed for each station. Following are the

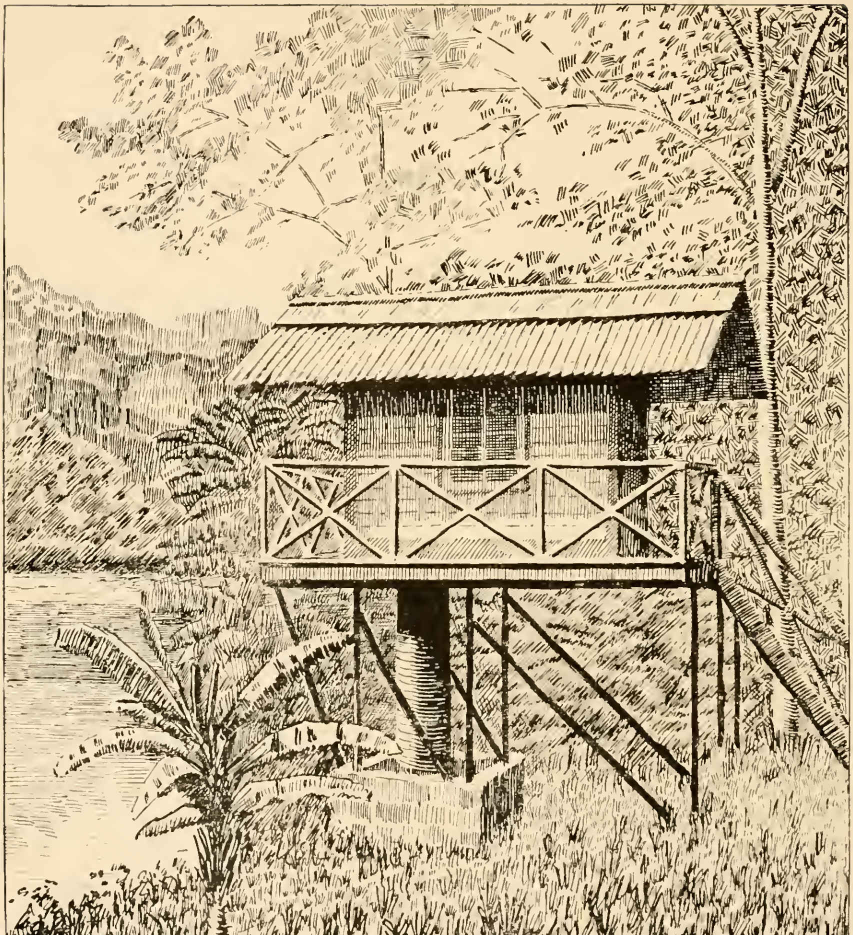


FIG. 11.—FLUVIOGRAPH AT ALHAJUELA.

instructions to the observers, concerning the method of obtaining the discharge which are carefully followed:

The observations should be made in calm weather. The floats should have but a small portion exposed above the surface of the water. The float should be liberated a short distance above the first profile, so that at the moment it crosses that section, it will have attained the velocity of the water; the observer will note the moment of passage at the first section, and then go to the lower section and note its passage at that section.

The discharge is then obtained by means of the formula D = 0.80 A V; D = discharge; A = mean sectional area; V = the velocity as obtained by the observations on the floats.

It is possible to materially improve on this means of obtaining the discharge, especially as the coefficient 0.80 is arbitrary. Accordingly, permanent hydrographic stations were established at Alhajuela, Gamboa, and Bohio, with an observer and current meter equipment at each.

ALHAJUELA.

The canal company's gauging station at Alhajuela is but a short distance below the proposed dam site. It has high, steep banks to each side and a width of about 250 feet, and at normal stage a mean depth of 4 or 5 feet. But it is on a slight bend, and the cross sections along the course differ considerably in area and conformation. Thus, at gauge height, 29 meters, we have 145, 135, and 133 square meters as the area at the upper end, middle, and lower end of the course. About 60 feet above the upper range a three-fourths inch cable is stretched across the river, with marks giving at normal stage the one-fourth, one-half, and three-fourths points of the width of the river. These marks are used to show the points at which to release the floats. The fluviograph is 200 yards below, and a secondary rod divided into centimeters is firmly set in the bank at the gauging station. The reading of this rod is used as the argument in the table giving the mean area.

On October 31, 1899, a No. 8 telegraph wire was stretched across the river about 60 feet above the canal company's cable. This was divided into 10-foot lengths, and was used to hold a boat in a fixed position while the velocity was being measured. This wire could be readily raised or lowered. While in use it was lowered so that a man in the bow could seize it and hold the boat in the desired position. While not in use it was raised 20 or 25 feet above the surface of the river—that is, beyond the reach of floods. A crutch, with a pulley, was fastened to the bow of the boat, over which the current meter was lowered. The crutch was fastened so that the pulley was at least 3 feet in front and 1 foot to one side of the cutwater. Thus the displacement of the boat could not affect the measured velocity.

The first current meter measurement was made on October 31, 1899, with new small Price electric meter No. 35, which had been rated at Chevey Chase in July. Two simultaneous determinations of the discharge were made, the first by measuring the velocity at 0.6 depth below the surface at each station, and the second by measuring the velocity at each 1 foot of depth at the same stations and then taking the mean as the mean velocity at that station. The river was divided into twelve sections, varying from 10 feet wide near the banks where the velocity across the stream changes rapidly, to 30 feet near the center where it is more uniform.

Following are the results:

Fluviograph=28.565 meters.

First method.—Mean velocity=1.92 feet per second; discharge= 2.280 second-feet.

Second method.—Mean velocity=1.90 feet per second; discharge= 2,257 second feet.

From the above we see that at Alhajuela the velocity at 0.6 depth below the surface gives practically the mean velocity in a section.

Following are specimen computations for discharge to show in detail the method used by the hydrographic office, Isthmian Canal Commission, and by the Compagnie Nouvelle du Canal de Panama:

Gauging made August 18, 1900, on Chagres River, at Alhajuela, by the Isthmian Canal Commission.

[Time, 8.40 to 9.30 a. m. Current meter=large Price electric No. 94. Fluviograph, 28.51 meters.]

Distance from initial point.	Depth.	Depth of observations.	Time seconds.	Revolutions.	Revolutions per second.	Velocity.	Section width.	Mean depth.	Area.	Discharge.
	Feet.						*Feet.*	*Feet.*	*Sq. feet.*	*Sec. feet.*
68 feet	R. B.									
71 feet	2					[a].35	6	2	12	4
80 feet	4.1	2.5	100	23	.23	.80	11	4.1	45	36
90 feet	3.7	2.2	100	25	.25	.86	10	3.7	37	32
100 feet	4.7	2.8	100	32	.32	1.08	15	4.7	70	75
120 feet	4.2	2.5	100	28	.28	.96	20	4.2	84	81
140 feet	4.4	2.6	100	35	.35	1.18	20	4.4	88	104
160 feet	4.7	2.8	100	40	.40	1.35	20	4.7	94	127
180 feet	5	3	100	58	.58	1.97	20	5	100	197
200 feet	5.4	3.2	100	71	.71	2.38	20	5.4	108	257
220 feet	5.7	3.4	100	77	.77	2.56	20	5.7	114	292
240 feet	5.8	3.5	100	76	.76	2.53	20	5.8	116	293
260 feet	5.2	3.1	100	74	.74	2.47	20	5.2	104	257
280 feet	4.2	2.5	100	67	.67	2.26	15	4.2	63	142
290 feet	3.8	2.3	100	59	.59	2.00	10	3.8	38	76
300 feet	3.3	2	100	49	.49	1.66	10	3.3	33	55
310 feet	3	1.8	100	19	.19	.67	10	3	30	20
318 feet	2					[a].30	5	2	10	3
320 feet	L. B.									
Total							252		1,146	2,051

2051÷1146=1.79 feet per second=mean velocity.

[a] Estimated.

Gauging made August 18, 1900, on Chagres River, at Alhajuela, by canal company, by means of floats.

[Floats were 2 feet sticks, 1¼ inches in diameter, weighted at one end so as to float vertically. Time, 8 a. m. Fluviograph, 28.50 meters. Length of course=60 meters.]

No. of float.	Distance from right bank.	Time.			Computations.
		Upper range.	Lower range.	Elapsed.	
		h. m. s.	*h. m. s.*	*Seconds.*	
1	One-fourth width of river	7 55 6	7 57 15	129	
2	do	7 55 14	7 57 26	132	
3	One-half width of river	8 4 4	8 5 23	79	Area=101.45 m^2.
4	do	8 4 11	8 5 32	81	$\frac{60}{102.2}$=.472=velocity.
5	Three-fourths width of river	8 11 17	8 12 56	99	
6	do	8 11 25	8 12 58	93	

$\frac{613}{6}$=102.2=mean time,

then 101.45 × .472 × 0.80=47.884 m^3 per second, or 1,690 second-feet.

The company's result was 1,690 cubic feet per second, being only 82 per cent that of this Commission, which was 2,051. Since the gaugings were made at almost the same time and gauge height, the above discrepancies are greater than they should be. The ratio was almost constant in all the simultaneous observations at Alhajuela, and is explainable as follows: The coefficient of 0.80 is too small, considering that floats are released at three sections. Owing to the curvature of the channel, the currents are not parallel to the bank and floats Nos. 1 and 2 always approach the right bank and at times cross the lower range within 10 feet of the bank. The second float at times passes the first float, although liberated about ten seconds later. Generally a distance between ranges of 60 meters is too long, as the error introduced by the more erratic drift of the float is not balanced by the greater accuracy in the time, unless the channel is straight and the cross section exceptionally uniform.

Although it is useless to introduce any degree of refinement in the computation of float measurements unless the course is exceptionally good, still the above method of obtaining the mean velocity is erroneous, as it is obtained by dividing the length of the course by the mean time. The true mean velocity is the mean of the velocities of the filaments which constitute the stream. It may be mathematically shown that unless the observed time of all the floats is the same the result obtained by the above method is always too small and that the error increases as the differences in the observed times increase. The method as employed introduces an error varying from 3 to 5 per cent. The balance of the discrepancy is mainly accounted for by the coefficient 0.80 being too small.

On December 26 Mr. R. G. DuBoulay was put in charge of all the hydrographic observations at Alhajuela, which included measuring the Chagres at Alhajuela and at Santa Barbara, the Gatuncillo, and the Chilibre rivers.

In all 74 measurements of the Chagres River at Alhajuela were made, varying in gauge height from 28.12 meters to 31.39 meters. The first high flood of the year, that of July 3 and 4, cut into the crest of the rapids just below the fluviograph, thus changing the relation between gauge height and the discharge, so that two rating tables are necessary.

RATING TABLE FOR STATION ON CHAGRES RIVER AT ALHAJUELA.

This table is applicable only from October 1, 1899, to July 3, 1900:

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Meters.	*Sec.feet.*	*Meters.*	*Sec.feet.*	*Meters.*	*Sec.feet.*	*Meters.*	*Sec.feet.*
28	....	28.75	3,440	29.50	9,105	30.25	15,985
28.05	355	28.80	3,775	29.55	9,530	30.30	16,475
28.10	455	28.85	4,120	29.60	9,960	30.35	16,965
28.15	560	28.90	4,470	29.65	10,395	30.40	17,460
28.20	675	28.95	4,825	29.70	10,835	30.45	17,955
28.25	815	29	5,185	29.75	11,280	30.50	18,455
28.30	985	29.05	5,550	29.80	11,730	30.55	18,950
28.35	1,185	29.10	5,920	29.85	12,185	30.60	19,450
28.40	1,410	29.15	6,300	29.90	12,645	30.65	19,950
28.45	1,655	29.20	6,685	29.95	13,110	30.70	20,450
28.50	1,920	29.25	7,075	30	13,580	30.75	20,950
28.55	2,200	29.30	7,470	30.05	14,055	30.80	21,450
28.60	2,495	29.35	7,870	30.10	14,535	30.85	21,950
28.65	2,800	29.40	8,275	30.15	15,015		
28.70	3,115	29.45	8,685	30.20	15,500		

This table is applicable only from July 4, 1900, to date:

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Meters.	*Sec. feet.*	*Meters.*	*Sec. feet.*	*Meters.*	*Sec. feet.*	*Meters.*	*Sec. feet.*
28	....	28.90	4,990	29.80	13,090	30.70	23,710
28.05	355	28.95	5,380	29.85	13,630	30.75	24,320
28.10	455	29	5,775	29.90	14,180	30.80	24,935
28.15	560	29.05	6,175	29.95	14,740	30.85	25,550
28.20	675	29.10	6,575	30	15,310	30.90	26,165
28.25	815	29.15	6,980	30.05	15,890	30.95	26,780
28.30	990	29.20	7,390	30.10	16,475	31	27,400
28.35	1,200	29.25	7,810	30.15	17,065	31.05	28,020
28.40	1,445	29.30	8,240	30.20	17,660	31.10	28,640
28.45	1,720	29.35	8,680	30.25	18,260	31.15	29,260
28.50	2,025	29.40	9,130	30.30	18,860	31.20	29,880
28.55	2,355	29.45	9,590	30.35	19,460	31.25	30,500
28.60	2,710	29.50	10,060	30.40	20,065	31.30	31,120
28.65	3,080	29.55	10,540	30.45	20,670	31.35	31,740
28.70	3,455	29.60	11,030	30.50	21,275	31.40	32,360
28.75	3,835	29.65	11,530	30.55	21,880	31.45	32,980
28.80	4,215	29.70	12,040	30.60	22,490	31.50	33,600
28.85	4,600	29.75	12,560	30.65	23,100		

The table of "Monthly discharge" was then computed, using these rating tables with the daily mean gauge height, as given by the fluviograph, as the argument; but on days of flood—that is, days in which the river rises over gauge height, 29—the daily mean discharge is obtained by taking the mean of the discharge corresponding to the bihourly height. This is necessary, as the increment increases rapidly with equal increases of gauge height. This table will be found on page 55.

TRIBUTARIES BETWEEN ALHAJUELA AND GAMBOA.

The mean monthly discharge of all the tributaries between Alhajuela and Gamboa was obtained by subtracting the discharge at the former station from the discharge at the latter, month by month.

Estimated monthly discharge of tributaries to the Chagres River between Alhajuela and Gamboa.

[Drainage area, 130 square miles.]

Month.	Mean discharge.	Total.	Run-off.		Rainfall.[a]
			Per square mile.	Depth.	
1900.	*Sec. feet.*	*Acre-feet.*	*Sec. feet.*	*Inches.*	*Inches.*
January	85	5,226	.65	.75	1.41
February	54	2,999	.42	.44	.10
March	33	2,029	.25	.29	.08
April	6	357	.05	.06	3.66
May	27	1,660	.21	.24	8.46
June	492	29,276	3.78	4.20	14.97
July	956	58,782	7.35	8.46	16.58
August	598	36,769	4.60	5.30	9.74
September	649	38,620	4.99	5.74	13.22
October	957	58,840	7.36	8.47	12.68
November	911	54,210	7.01	7.82	12.01
December	94	5,780	.72	.83	.97
The year	407	294,518	....	42.60	93.88

[a] Mean of observations at Alhajuela and Gamboa.

Ratio of run-off to rainfall = 45 per cent.

The chief tributaries between Alhajuela and Gamboa are the Chilibre and the Gatuncillo. Weekly gaugings of these were made, and their gauge height was read three times per week. These observations in a general way furnished the relation of the discharge of each one to the total increase of discharge between the stations, which is as follows:

	Per cent.
Chilibre	36
Gatuncillo	26
Other sources	38
Total	100

The highest observed gauge height on the Chilibre was 22 feet, giving a computed discharge of 3,700 second-feet. On the Gatuncillo the highest observed gauge height was 16 feet, giving a computed discharge of 2,500 second-feet.

The following experiments with rod floats were made at Alhajuela to find the relation between the surface velocities and the mean velocity in a vertical section:

Float experiments made August 22, 1900 (fluviograph = 28.81).

I. FULL-DEPTH ROD FLOATS OF 2 TO 3 INCHES UNIFORM DIAMETER.

Distance from right bank . feet..	20	40	60	80	100	120	140	160	180	200	220
Length of floats..............do...	7.5	5	5	5	3.5	3.5	3.5	3.5	3.5	3.5	2
Elapsed time..........seconds..	87	78	78	77	75	57	55	55	59	64	93
Velocity...... feet per second..	2.27	2.53	2.53	2.56	2.63	3.46	3.58	3.58	3.34	3.08	2.12

Mean = 2.88 feet per second.

II. FLOATS OF 1½ FEET LENGTH, 2 INCHES UNIFORM DIAMETER.

Distance from right bank . feet..	20	40	60	80	100	120	140	160	180	200	220
Elapsed time..........seconds..	72	75	70	68	63	53	50	45	51	58	71
Velocity.......feet per second..	2.74	2.63	2.81	2.90	3.13	3.72	3.94	4.38	3.86	3.40	2.77

Mean = 3.30 feet per second.

Ratio = 2.88 ÷ 3.30 = 0.87.

The discharge obtained by using 2.88 as the mean velocity is 4,040 second-feet, which compares favorably with discharges obtained by means of current meters.

CHAGRES RIVER AT SANTA BARBARA.

The gauge height of the Chagres River at Santa Barbara was read by C. Clauzel at 6 a. m. and 6 p. m. and at times of important fluctuations. The discharge measurements were made with current meters and surface floats. After comparing several float measurements with simultaneous current-meter measurements a coefficient of 0.85 was adopted to reduce the observed velocity of the floats to the mean velocity of the cross section. Thirty-five current-meter and 110 float measurements were made, from which the following rating table was computed:

Rating table, Chagres River, at Santa Barbara.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	*Sec.ft.*	*Feet.*	*Sec.ft.*	*Feet.*	*Sec.ft.*	*Feet.*	*Sec.ft.*
1.0	....	3.4	1,790	5.8	5,520	8.2	10,500
1.1	....	3.5	1,915	5.9	5,715	8.3	10,720
1.2	....	3.6	2,040	6.0	5,910	8.4	10,945
1.3	....	3.7	2,170	6.1	6,110	8.5	11,170
1.4	....	3.8	2,300	6.2	6,310	8.6	11,400
1.5	....	3.9	2,430	6.3	6,510	8.7	11,640
1.6	....	4.0	2,565	6.4	6,710	8.8	11,890
1.7	300	4.1	2,700	6.5	6,915	8.9	12,155
1.8	320	4.2	2,840	6.6	7,120	9.0	12,445
1.9	350	4.3	2,980	6.7	7,325	9.1	12,745
2.0	390	4.4	3,125	6.8	7,530	9.2	13,055
2.1	440	4.5	3,270	6.9	7,735	9.3	13,375
2.2	500	4.6	3,420	7.0	7,940	9.4	13,700
2.3	570	4.7	3,575	7.1	8,150	9.5	14,025
2.4	650	4.8	3,730	7.2	8,360	9.6	14,350
2.5	750	4.9	3,890	7.3	8,570	9.7	14,675
2.6	855	5.0	4,055	7.4	8,780	9.8	15,000
2.7	965	5.1	4,225	7.5	8,990	9.9	15,325
2.8	1,075	5.2	4,400	7.6	9,200	10.0	15,650
2.9	1,190	5.3	4,580	7.7	9,415	11.0	18,900
3.0	1,305	5.4	4,765	7.8	9,630	12.0	22,150
3.1	1,425	5.5	4,950	7.9	9,845	13.0	25,400
3.2	1,545	5.6	5,140	8.0	10,060		
3.3	1,665	5.7	5,330	8.1	10,280		

REMARKS.—The zero of the gauge rod is at elevation 170.8 feet.

Estimated monthly discharge of Chagres River at Santa Barbara.

[Drainage area, 300 square miles.]

Month.	Discharge.			Total.	Run-off.		Rainfall in basin.
	Maximum.	Minimum.	Mean.		Square mile.	Depth.	
1900.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*	*Sec. feet.*	*Inches.*	*Inches.*
January	8,360	700	1,205	74,090	4.02	4.63	1.34
February	1,020	390	542	30,100	1.81	1.88	.21
March	415	320	369	22,690	1.23	1.41	.10
April	8,570	300	430	25,590	1.43	1.60	5.52
May	16,625	310	1,003	61,670	3.34	3.88	13.15
June	6,510	610	1,338	79,620	4.46	4.98	21.51
July	19,875	802	1,900	116,830	6.33	7.31	13.53
August	18,250	1,020	2,348	144,370	7.83	9.02	11.22
September	13,055	965	1,717	102,170	5.72	6.38	16.08
October	33,600	1,365	3,601	221,420	12.00	13.84	17.00

GAMBOA.

The canal company's gauging station at Gamboa is about 100 yards above the mouth of the Obispo River, or about 300 yards below the proposed dam site. Although by no means an ideal station, on account of the tributary just below it, which may at times produce backwater, and also on account of the broken water produced by a whirlpool above it, still it is the best section within several miles to each side of it. The banks are fairly high, and the course straight. Floods rising over gauge height, 18 meters, will cover the left bank, and some water will flow through the digging for the canal, and thus will not be included in the discharge measured at the gauging station. It then becomes necessary to make the measurement at Gorgona, where, although the

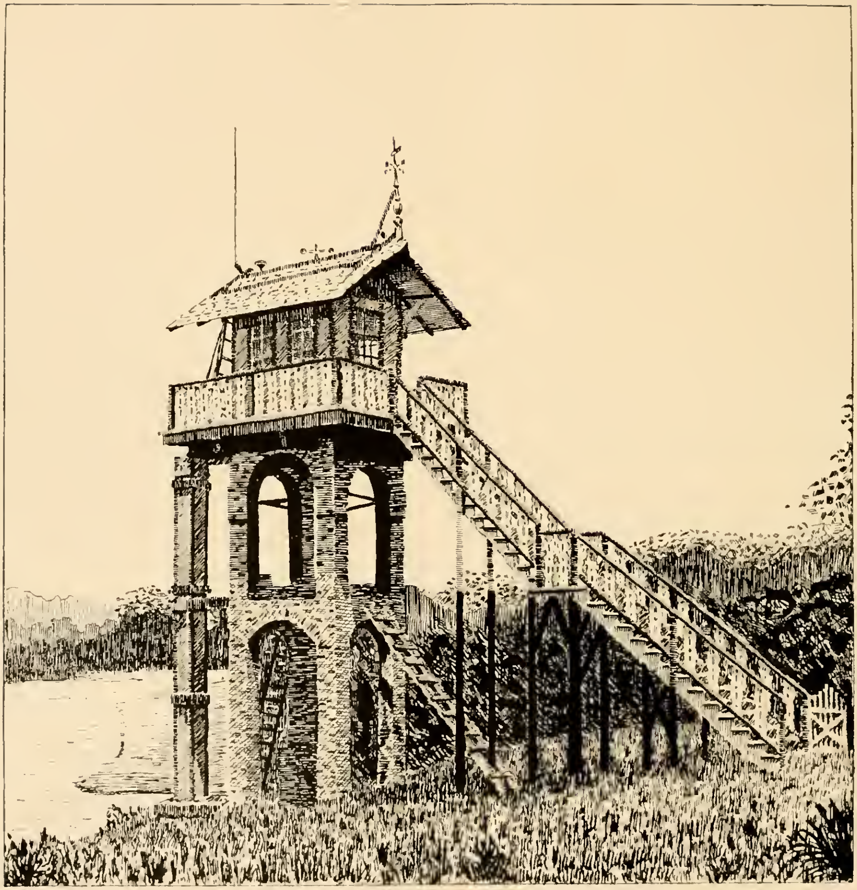


FIG. 12.—FLUVIOGRAPH AT GAMBOA.

discharge of the Obispo is added, better results are obtained. The fluviograph, which is similar to the one at Alhajuela, is one-half mile above the gauging station. Discharge measurements are made with floats in the same way as at Alhajuela.

As the chief object of the work was to check the observations of the canal company, it was necessary to locate the station near theirs, although for current meter measurements this location is poor. Near the left bank the river is swift and shallow, and toward the right it is sluggish and deep, thus a large per cent of the discharge has a low velocity, which during low stages falls below 0.30 feet per second, and it is in these low velocities that the current meter works at the greatest disadvantage. The unnatural condition of the river is due to the spoil composed of large pieces of rock, which were deposited along the left bank during construction times.

On this account this station did not receive the same attention as Alhajuela and Bohio, and no permanent observer was stationed here, but the writer, with the assistance of R. McD. Geraty, made discharge measurements whenever time permitted. Thirty-three measurements were made in the same general way as at Alhajuela, ranging in gauge height from 13.85 to 16 meters, from which the rating table and estimated monthly discharge table were computed. (Table of estimated monthly discharge. See page 58.)

Rating table for Chagres River at Gamboa.

This table is applicable from October 1, 1899, to date.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Meters.	*Sec. feet.*	*Meters.*	*Sec. feet.*	*Meters.*	*Sec. feet.*	*Meters.*	*Sec. feet.*
13.5	....	14.9	3,650	16.3	12,550	17.7	23,150
13.6	....	15.0	4,115	16.4	13,290	17.8	23,930
13.7	250	15.1	4,605	16.5	14,030	17.9	24,710
13.8	395	15.2	5,135	16.6	14,775	18.0	25,500
13.9	560	15.3	5,690	16.7	15,525	18.1	26,300
14.0	745	15.4	6,280	16.8	16,275	18.2	27,100
14.1	955	15.5	6,905	16.9	17,025	18.3	27,900
14.2	1,205	15.6	7,550	17.0	17,780	18.4	28,700
14.3	1,480	15.7	8,215	17.1	18,540	18.5	29,500
14.4	1,775	15.8	8,900	17.2	19,300	18.6	30,300
14.5	2,090	15.9	9,605	17.3	20,060	18.7	31,100
14.6	2,425	16.0	10,330	17.4	20,820	18.8	31,900
14.7	2,795	16.1	11,070	17.5	21,590	18.9	32,700
14.8	3,205	16.2	11,810	17.6	22,370	19.0	33,500

BUENA VISTA AND BOHIO.

The canal company's gauging station is at Buena Vista, or about one-half mile above the proposed dam site. It is on a long, straight stretch of the river, of 220 feet width, with high, steep banks. The cross sections are very similar, and the velocities across the stream are very uniform. It is almost an ideal station for discharge measurements, its sole defect being that at times of extreme low water the tides of the Atlantic may slightly affect the velocity.

The fluviograph is at Bohio and is the counterpart of the one at Alhajuela, but the tides are noticeable whenever the height of the river is less than 0.5 meter, so that below this stage a rating table may give slightly erroneous results, as the same gauge height at different times may not correspond to the same discharge. A gauge rod divided into centimeters is firmly set in the bank at the gauging station. The reading of this is used in obtaining the mean area of cross section.

In making discharge measurements the canal company has no means whatever to show the points at which to release the floats, this matter being left to the judgment of the boatmen who release the floats at points which they estimate as the one-quarter, one-half, and three-quarters of the width; still, as previously stated, the velocities across the streams vary slightly, so that the results are but slightly affected by any errors of judgment of the boatmen.

On December 27, 1899, Mr. Inocencio Galindo, jr., was put in charge of the hydrographic work at Bohio, which included weekly measurements of the chief tributaries between Gamboa and Bohio, such as the Caño Quebrada, Gigante, Frijolitos, Frijoles, and the Agua Salud. Occasional trips were also made to the Trinidad and Gatun rivers, at which times measurements were made.

Mr. R. McD. Geraty made frequent trips to this station to assist in and to check the work.

Eighty-six measurements for discharge were made, ranging in gauge height from 0.28 to 5.43 meters.

The summary of discharge will be found on page 40.

Rating table for Chagres River at Bohio.

This table is applicable only from December, 1899, to date.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Meters.	*Sec.feet.*	*Meters.*	*Sec.feet.*	*Meters.*	*Sec.feet.*	*Meters.*	*Sec.feet.*
0.1	....	1.6	3,610	3.1	9,305	4.6	17,150
.2	330	1.7	3,930	3.2	9,760	4.7	17,730
.3	490	1.8	4,260	3.3	10,225	4.8	18,310
.4	650	1.9	4,600	3.4	10,700	4.9	18,890
.5	820	2.0	4,950	3.5	11,185	5.0	19,470
.6	1,015	2.1	5,310	3.6	11,680	5.1	20,060
.7	1,230	2.2	5,680	3.7	12,185	5.2	20,650
.8	1,465	2.3	6,060	3.8	12,700	5.3	21,240
.9	1,715	2.4	6,440	3.9	13,225	5.4	21,830
1.0	1,975	2.5	6,830	4.0	13,765	5.5	22,420
1.1	2,235	2.6	7,220	4.1	14,315	5.6	23,020
1.2	2,495	2.7	7,620	4.2	14,870	5.7	23,620
1.3	2,755	2.8	8,025	4.3	15,430	5.8	24,220
1.4	3,020	2.9	8,440	4.4	16,000	5.9	24,820
1.5	3,305	3.0	8,865	4.5	16,570	6.0	25,420

The following current meter observations were made on July 31 at Buena Vista to test the assumption that the velocity at 0.6 depth below the surface is the mean of the velocities in a vertical section:

Distance from right bank.					
50 feet.		110 feet.		160 feet.	
Depth of observation.	Velocity.	Depth of observation.	Velocity.	Depth of observation.	Velocity.
Feet.	*Ft. per sec.*	*Feet.*	*Ft. per sec.*	*Feet.*	*Ft. per sec.*
1.0	3.75	1.0	3.85	0.5	3.69
2.0	3.75	2.0	3.72	1.5	3.63
3.0	3.72	3.0	3.66	2.5	3.63
4.0	3.63	4.0	3.59	3.5	3.53
5.0	3.56	5.0	3.53	4.5	3.50
6.0	3.52	6.0	3.43	5.5	3.43
7.0	3.43	7.0	3.40	6.5	3.24
8.0	3.21	8.0	3.24	7.5	3.08
9.0	2.91	9.0	3.05	8.5	2.61
9.7	2.35	9.5	2.31	....	....
Mean	3.44	....	3.44	....	3.37
0.6 depth	3.52	....	3.43	....	3.45

The width of the river at the time of the observations was 214 feet, the gauge height 2.26 meters, and the total depth at the stations in order from the right bank was 9.9, 9.9, and 9.1 feet As there is less than one-half foot below the last measurement, one-half weight is given to these in obtaining the mean, except in the last case, where there is also but one-half foot above the first measurement. These observations were made from a boat. The meter was lowered to the specified depth, and the revolutions for two consecutive fifty seconds were noted; if these did not agree, the revolutions for fifty additional seconds were noted, and the mean of these was then used as an argument in the rating table to obtain the velocity.

TRIBUTARIES BETWEEN BOHIO AND GAMBOA.

The largest tributary between Bohio and Gamboa is the Caña Quebrada; minor tributaries in order of their size are the Obispo, Gigante, Frijoles and Frijolitos, and Agua Salud. By subtracting the mean monthly discharge of the Chagres at Gamboa from the discharge at Bohio the discharge of all the tributaries was obtained.

Estimated monthly discharge of tributaries to the Chagres River between Gamboa and Bohio.

[Drainage area, 245 square miles.]

Months.	Mean discharge	Total.	Run-off. Per square mile.	Run-off. Depth.	Rainfall.[a]
1900.	*Sec. feet.*	*Acre-feet.*	*Sec. feet.*	*Inches.*	*Inches.*
January	177	10,890	0.72	0.83	3.57
February	82	4,550	.33	.34	.26
March	40	2,460	.17	.20	.46
April	15	900	.06	.07	3.08
May	55	3,380	.22	.25	7.08
June	759	45,160	3.10	3.46	11.01
July	1,856	114,120	7.57	8.73	16.99
August	1,188	73,050	4.85	5.59	11.33
September	1,440	85,690	5.88	6.56	11.96
October	2,374	145,970	9.69	11.17	15.27
November	2,125	126,440	8.68	9.68	17.82
December	720	44,270	2.94	3.39	2.40
The year	908	656,880	....	50.27	101.23

[a] Mean of observations at Bohio, Gorgona, and Gamboa.

Ratio of run-off to rainfall = 50 per cent.

The tributaries named were gauged on an average of once per week, and the following table depends upon these data:

Rivers.	Maximum measured discharge.	Minimum measured discharge.	Mean.	Per cent of total discharge.[a]
	Sec. feet.	*Sec. feet.*	*Sec. feet.*	
Caño Quebrada	1,640	17	335	37
Obispo	1,177	1	90	10
Gigante	281	0	65	7
Frijoles and Frijolitos	219	5	55	6
Agua Salud	90	3	33	4
Other sources	....	....	330	36
Total	....	....	908	100

[a] Per cent of the total inflow between Gamboa and Bohio contributed by each stream.

DRAINAGE AREA OF THE CHAGRES RIVER.

The drainage area of the Chagres River above Bohio is only approximately known and depends upon the following data:

Totten's Map of the Isthmus of Panama gives that portion of the divide lying between latitude 9° 0′ and 9° 20′ N., longitude 80° 30′ and 80° 50′ W. It also gives the divide of the Rio Boqueron, i. e., the northwestern extremity of the drainage area. The survey of the Mandinga River by this Commission gives the eastern divide at longitude 79° 15′ W.

The survey of the Chagres River above Santa Barbara gives the northeastern extremity of the drainage basin at latitude 9° 25′ N., longitude 79° 15′ W. It also gives an idea of the size and general direction of the tributaries.

The northern and southern portions of the divide, not included in Totten's map, have been approximately determined from the Atlantic and Pacific oceans, and in these parts the greatest probable error exists.

SEDIMENT OBSERVATIONS.

Observations to determine the amount of sediment carried by the Chagres River were made at Alhajuela and Bohio, by means of water samples representing the mean condition of the river.

Months.	Alhejuela.		Bohio.	
	Mud.	Solid matter.	Mud.	Solid matter.
1900.	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*
June	75,900	15,180	152,720	30,540
July	....	....	763,800	152,760
August	406,100	81,230	580,000	116,000
September	208,300	41,660	396,800	79,360
October	485,040	97,000	....	....

Five cubic yards of mud are assumed to equal 1 cubic yard of solid matter.

TRINIDAD AND GATUN RIVERS.

Below Bohio the major part of the Chagres flows through the almost completed cut for the canal, its old channel being in many places choked by vegetation. In this stretch it receives the waters of two large tributaries, the Trinidad and the Gatun. Frequent trips to these were made and current meter measurements were made each time. No gauge rods were set on these streams, because if they were set less than 10 miles up, the fluctuations of the Chagres would materially influence the rod reading, the slope of the rivers being very slight, and the time taken in these trips would be longer than the time taken in making a gauging. The inflow between the mouth and station would also be omitted.

Discharge of the Gatun and Trinidad rivers.

GATUN.

Date.	Discharge.	Date.	Discharge.	Date.	Discharge.	Date.	Discharge.
1899.		1900.		1900.		1900.	
Nov. 17	1,213	Feb. 22	160	Apr. 23	117	July 5	945
Dec. 9	688	26	186	26	237	9	1,559
29	442	Mar. 1	109	May 3	71	12	916
		6	197	14	65	16	962
1900.		12	142	18	225	19	729
Jan. 11	359	15	111	21	240	25	923
19	218	19	164	30	217	Aug. 2	922
25	259	23	133	June 7	315	24	1,021
Feb. 1	209	26	178	11	348	Sept. 5	420
6	216	Apr. 5	130	14	285	11	1,111
8	198	12	88	18	214	18	888
12	160	17	133	21	225		
15	151	20	98	28	616		

	Second-feet.
Maximum	1,569
Minimum	65
Mean	528

TRINIDAD.

Date.	Discharge.	Date.	Discharge.	Date.	Discharge.	Date.	Discharge.
1899		1900.		1900.		1900.	
Nov. 17	1,687	Feb. 15	291	May 10	463	July 16	1,594
Dec. 9	2,371	19	299	14	244	19	2,255
29	896	22	264	18	610	25	2,295
		26	358	21	620	Aug. 2	2,144
1900.		Mar. 1	365	24	533	7	1,375
Jan. 8	1,210	6	368	30	1,094	24	1,464
11	744	15	143	June 7	2,373	30	2,521
15	705	19	242	11	1,379	Sept. 5	1,403
19	574	23	221	14	993	8	1,283
22	599	26	304	18	931	11	2,120
25	569	Apr. 12	204	21	1,358	18	2,607
29	555	17	226	28	1,537	21	1,474
Feb. 1	631	20	220	July 2	1,337	27	2,256
6	439	23	225	5	1,577		
8	492	May 1	261	9	1,574		
12	450	3	286	12	1,868		

	Second-feet.
Maximum	2,607
Minimum	143
Mean	1,110

The "mean" is the mean of the monthly means.

HYDRAULICS OF THE CHAGRES RIVER AT ALHAJUELA AND BOHIO.

At Alhajuela and Bohio the fluviograph rods and gauge rods were read each time a gauging was made; the difference in these simultaneous readings in connection with the distance between the rods, the measured discharge, and several cross sections of the river furnished the slope, the mean hydraulic radius, and the mean velocity. From these data the value of the coefficient for roughness "N" in "Kutter's formula" was computed.

At Alhajuela the distance between the rods is 200 meters; the bed of the river is small gravel and the banks are steep and free from weeds and bushes. At Bohio the distance between the rods is 1,335 meters; the bed is clay, with small gravel and free from detritus; the banks are high but are covered with weeds and bushes.

ALHAJUELA.

Gauge height.	Mean area.	Mean discharge.	Mean velocity.	Hydraulic radius.	Slope.	"N."
28.15	815	580	0.71	3.84	0.000025	0.027
28.28	910	953	1.05	4.16	.000050	.026
28.51	1,075	1,928	1.80	4.74	.000095	.023
28.68	1,200	2,926	2.44	5.17	.000144	.022
28.84	1,320	4,040	3.01	5.58	.000211	.023
29.46	1,785	9,361	5.20	7.23	.000350	.020
31.01	3,000	25,872	8.62	11.50	.000892	.026

BOHIO.

1.59	1,340	2,560	1.91	5.90	0.000097	0.025
2.50	2,000	6,100	3.05	8.58	.000142	.024
3.19	2,500	8,930	3.58	10.42	.000165	.026
4.42	3,400	14,600	4.29	13.10	.000210	.029
5.50	4,040	21,020	5.20	14.70	.000277	.029

RIO GRANDE.

From Culebra to the Pacific Ocean the line of the canal follows the valley of the Rio Grande; therefore an idea of the floods and the general characteristics of this stream becomes valuable. Accordingly, on October 25, 1899, two gauge rods were set at Pedro Miguel, the first being 250 yards above and the second 30 yards below the mouth of the Pedro Miguel River. The lower rod could not be set farther downstream on account of the high tides of the Pacific Ocean, the tidal effect at Miraflores being at least 5 feet.

These rods were read at 6 a. m. and 6 p. m., and additional readings were taken during floods.

Estimated monthly discharge of Grande River at 250 yards above the mouth of the Pedro Miguel.

[Drainage area, 10 square miles.]

Month.	Discharge.			Total.	Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.	
1899.	*Sec. ft.*	*Sec. ft.*	*Sec. ft.*	*Acre-ft.*	*Sec. ft.*	*Inches.*	*Inches.*
November	410	10.0	35.0	2,082	3.50	3.90	8.67
December	65	3.0	13.0	800	1.30	1.50	2.34
1900.							
January	37	1.0	3.0	184	0.30	0.35	0.56
February	1	0.5	0.7	39	0.07	0.07	0.09
March	2	0.0	0.2	12	0.02	0.02	0.00
April	1	0.0	0.3	18	0.03	0.03	2.73
May	210	0.6	11.0	676	1.10	1.27	10.66
June	650	3.0	44.0	2,618	4.40	4.91	10.30
July	550	5.0	114.0	7,010	11.40	13.14	25.04
August	283	2.0	50.0	3,074	5.00	5.76	6.52
September	660	11.0	38.0	2,261	3.80	4.24	6.75
October	370	30.0	60.0	3,690	6.00	6.92	8.68
The year	660	0.0	31.0	22,464	....	42.11	82.34

Ratio of run-off to rainfall = 0.51 per cent.

Estimated monthly discharge of Grande River at 30 yards below the mouth of Pedro Miguel.

[Drainage area, 19 square miles.]

Month.	Discharge.			Total.	Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.	
	Sec. ft.	*Sec. ft.*	*Sec. ft.*	*Acre-ft.*	*Sec. ft.*	*Inches.*	*Inches.*
1899.							
November	790	27.0	81.0	4,820	4.26	4.75	8.67
December	100	12.0	26.0	1,600	1.37	1.58	2.34
1900.							
January	50	3.0	7.0	430	0.37	0.43	0.56
February	3	0.0	1.0	56	0.05	0.05	0.09
March	3	0.0	0.2	12	0.01	0.01	0.00
April	2	0.0	0.5	31	0.03	0.03	2.73
May	310	1.0	24.0	1,476	1.26	1.45	10.66
June	1,550	10.0	105.0	6,250	5.53	6.17	10.30
July	1,850	21.0	295.0	18,140	15.53	17.90	25.04
August	1,550	12.0	142.0	8,730	7.47	8.61	6.52
September	1,550	18.0	80.0	4,760	4.21	4.70	6.75
October	800	34.0	112.0	6,885	5.90	6.80	8.68
The year	1,550	0.0	74.0	53,190	....	52.48	82.34

Ratio of run-off to rainfall=0.637 per cent.

PRECAUTIONS FOR ACCURACY.

The following precautions were taken so that any constant errors in the results might be detected: The current meters were rerated. Simultaneous gaugings with two meters were frequently made, which would show whether rerating was necessary. The meter at one station was at times exchanged for the meter at another. The gauging section was occasionally moved several hundred yards up or down stream, thus any local conditions giving erroneous results, such as diagonal currents, etc., could be detected. To eliminate errors of personal equation the observers were changed.

Rating the meters.—At Obispo there is a pool formed in the excavation for the "Obispo lock." It is 130 feet long, 100 feet wide, and over 12 feet deep. It has no current except after a heavy rainfall. A railroad trestle spans it across its longest dimension, and, as a push car is readily obtainable, we have excellent conditions for rating meters.

An outrigger was fastened to the car, from which the meter was freely suspended so as to be at least 3 feet below the surface of the water. The car was then pushed at a uniform velocity over a measured course of 80 feet and the time and revolutions were noted. Thus the relation between the revolutions per second and velocity per second was obtained. Forty or fifty trips were made at velocities varying from 0.30 feet per second to 9 feet per second, each trip being at a uniform velocity; thus any change in the relation between the revolutions per second and the velocity per second was obtained.

The following table shows the care taken to reduce the error due to the rating table as far as practicable to a minimum; it also shows the effect of constant and ordinary use:

Summary of rating tables for current meters.

Meter No.	93.			94.		47.	
Date of rating.	Dec. 16, 1899.	Mar. 8, 1900.	July 7, 1900.	Mar. 20, 1900.	Oct. 11, 1900.	Dec. 16, 1899.	Sept. 6, 1900.
Revolutions per second.	Velocity (feet per second).						
0.50	1.72	1.72	1.66	1.69	1.71	1.25	1.21
1.00	3.42	3.36	3.37	3.25	3.35	2.38	2.40
1.50	5.02	4.94	4.88	4.75	4.90	3.53	3.60
2.00	6.62	6.52	6.33	6.25	6.45	4.68	4.80
2.50	8.22	8.12	7.78	7.77	8.00	5.83	6.02
3.00	9.82	9.72	9.23	9.32	9.55	6.98	7.32
3.50	11.42	11.32	10.68	10.87	11.10	8.13	8.62
4.00	13.02	12.92	12.13	12.42	12.65	9.28	9.92

Meters Nos. 93 and 94 are "large Price electric meters," and No. 47 is a "small Price electric meter."

RAINFALL.

Rainfall observations are made by the Panama Canal Company at Bohio, Gamboa, Alhajuela, and Panama, and the Panama Railroad Company keeps a record at Colon. These records give a good idea of the amount and distribution of the rainfall along the canal line, but it was also deemed desirable to obtain the mean rainfall on the basin of the Chagres River and its relation to one of the old records. With this object in view rain gauges were set in the Upper Chagres and Pequeni basins, so distributed with reference to altitude and distance up the river as to give practically the mean rainfall; but, owing to the numerous and almost impassable rapids on the upper Chagres, it was impracticable to set these very far up. Following is a description of the location of the rain gauges referred to Dos Bocas, which is the junction of the Chagres and Pequeni rivers.

SANTA BARBARA, RIO FEA, AND RIO PUENTE.

The observations at these stations were made by C. Clauzel. Santa Barbara is on the Chagres River, 3 miles ESE. of Dos Bocas, at an elevation of 225 feet above sea level. The observations were made at 6 a. m. and 6 p. m.

Rio Fea gauge is on a hill between the Chagres and the Rio Fea; it is 4.5 miles NE. of Dos Bocas, at an elevation of 850 feet. It was observed four times per week.

Rio Puente gauge is on a hill in the Puente River basin, 4 miles SE. of Dos Bocas, at an elevation of 610 feet. Observations were made each day at 10 a. m.

SALAMANCA AND LAS MINAS.

The rainfall at these stations was observed by Simon Bolivar. Salamanca is on the Pequeni 5.5 miles N. of Dos Bocas at an elevation of about 200 feet. Observations were made at 6 a. m. and 6 p. m.

Las Minas is 12 miles NNE. of Dos Bocas at an elevation of about 250 feet. Observations were made three times per week.

The results of these observations are appended herewith.

Very respectfully,
W. W. Schlecht,
Hydrographer.

Mr. A. P. Davis,
Hydrographer, Isthmian Canal Commission,
Washington, D. C.

Rainfall for 1899–1900.

GORGONA.

Day.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1....	0.00	0.00	0.00	0.00	0.00	0.25	0.56	0.80	0.00	0.05	1.15
2....	.00	.30	.00	.03	.00	.00	.18	.30	.10	.03	.12
3....	.29	.10	.00	.00	.00	.00	.00	.00	.61	.00	.46
4....	1.39	.00	.00	.00	.30	.00	.48	.35	.09	.00	.40
5....	....	.00	.00	.00	.45	.00	1.40	.00	.07	.00	.38
6....	.05	.10	.00	.00	.00	.06	1.70	.00	.00	.60	.50
7....	....	.00	.00	.00	.00	.15	.30	.15	.64	.56	.00
8....	.04	.00	.00	.00	.00	.10	.00	.10	.33	.00	.00
9....	.00	.00	.00	.00	.00	1.20	.00	.78	.26	.10	.00
10....	.00	.05	.00	.00	.00	.00	.46	.55	.00	2.78	.18
11....	1.58	.35	.00	.02	.00	.85	.00	.72	.80	.00	.00
12....	.35	.00	.05	.00	.00	.00	.30	2.40	.30	.00	1.36
13....	.00	.00	.00	.00	.00	.00	.20	.05	.88	.15	.05
14....	.10	.25	.00	.00	.00	.00	.00	.10	1.30	.30	1.40
15....	.00	.00	.00	.00	.00	.35	.90	3.45	.00	.70	.00
16....	.03	.00	.00	.00	1.00	.00	.22	.00	.25	2.45	.50
17....	.00	.05	.00	.10	.00	.00	.50	2.87	.00	.10	.10
18....	.00	.00	.03	.00	.00	.00	.55	.35	.00	.90	.00
19....	.00	.00	.00	.00	.00	.10	.00	.30	1.43	.18	.24
20....	.00	.00	.05	.00	.00	2.25	2.15	.64	.20	.00	.05
21....	.00	.00	.00	.00	.00	.00	.06	.12	.60	.00	.68
22....	.00	.00	.00	.00	.00	.00	.00	.30	.25	.70	.18
23....	.00	.00	.00	.00	.00	.00	.30	.60	.00	.17	.14
24....	.00	.00	.00	.00	.00	.02	.00	.20	.25	.05	.70
25....	.25	1.28	.00	.00	.00	.22	1.35	.00	.15	.00	.77
26....	.24	.00	.00	.00	1.10	.18	.00	.25	.00	.13	.32
27....	.00	.00	.00	.00	.00	.20	.35	.20	.23	.95	1.57
28....	.00	.10	.00	.00	.00	.00	.12	.00	2.10	.35	.28
29....	.26	.00	....	.00	.00	.74	.30	.74	.03	.00	.00
30....	.00	.05	....	.00	.30	.00	.10	1.70	.05	.00	.40
31....	.00	.00	....	.05	....	.40	....	2.90	.12	....	....
Total	4.58	2.63	.13	.20	3.15	7.07	12.48	19.72	11.04	11.25	11.93

SANTA BARBARA, ON CHAGRES RIVER.

Day.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1....	....	0.00	0.00	0.00	0.09	0.41	2.91	0.00	0.03	0.62	0.52
2....	....	.03	.02	.00	.00	1.19	.25	.00	.78	.00	.67
3....	....	.06	.00	.00	.22	.00	1.05	.91	.05	.00	.86
4....	....	.02	.00	.02	.00	.00	1.32	.16	.78	.00	.19
5....	....	.06	.00	.00	.01	.15	1.65	.00	.09	.00	.05
6....	1.50	.57	.01	.00	.00	.07	.72	.15	.08	.14	.00
7....	.45	.02	.03	.01	.00	.14	.06	.30	.12	.02	.06
8....	.20	.01	.00	.00	.00	.23	.04	.00	.04	1.59	.03
9....	....	.05	.00	.00	.00	2.36	.25	.66	.00	2.79	.04
10....	....	.01	.01	.04	.00	.15	.02	.08	.00	.02	.12
11....	....	.01	.00	.00	.00	1.00	.68	.60	1.21	.24	.15
12....	....	.01	.00	.00	.00	.03	.02	.04	1.75	.00	1.49
13....	.05	.00	.00	.00	.00	.04	.57	.00	.92	.72	1.82
14....	....	.01	.00	.00	.00	.65	.38	2.86	.02	.46	.30
15....	.04	.00	.00	.00	.00	.00	.10	.25	.00	.68	.05
16....	.00	.00	.00	.00	.00	.02	.65	.80	.00	.10	.17
17....	....	.00	.00	.02	.00	.00	.85	.60	.00	.06	.02
18....	....	.00	.01	.00	.00	.11	.10	.02	.00	.01	.76
19....	.02	.00	.06	.00	.00	.29	.39	.90	.06	.77	.20
20....	.00	.00	.02	.00	.00	.00	.37	.64	1.25	.24	2.07
21....	.04	.00	.00	.00	.00	.00	.00	.18	.06	2.33	.15
22....	.00	.03	.00	.00	.00	.38	.37	.78	.26	.41	.12
23....	.01	.01	.00	.00	.00	.65	.08	.19	.95	.48	.01
24....	.02	.11	.00	.00	.00	.93	2.10	.16	2.38	.03	.71
25....	.03	.22	.00	.00	.18	.27	2.32	.22	.22	.18	.31
26....	.16	.08	.00	.00	3.48	.00	.31	.58	.07	3.01	.18
27....	.06	.00	.00	.00	.01	.86	.63	.03	.00	.72	.75
28....	.02	.02	.00	.00	.00	.45	2.08	.85	.92	.02	.00
29....	.00	.00	....	.00	.33	.19	.10	.72	.57	.02	.00
30....	.01	.08	....	.00	1.11	1.03	2.17	.01	.02	.00	....
31....	.01	.00	....	.00	....	2.07	....	.96	.02	....	....
Total	2.62	1.41	.16	.09	5.43	13.67	22.54	13.65	12.65	15.66	11.80

Rainfall for 1899–1900—Continued.

RIO PUENTE.

Day.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1....	....	0.01	0.00	0.00	0.06	0.64	0.80	2.06	0.04	0.95	0.74
2....	....	.05	.02	.00	.00	.00	.08	.00	3.28	.10	.40
3....	....	.05	.00	.00	.09	.26	.24	.10	.70	.00	1.10
4....	....	.12	.00	.00	.00	.00	.86	.67	1.20	.00	1.00
5....	....	.00	.00	.02	.02	.00	1.72	.00	.30	.03	.37
6....	....	.03	.01	.00	.00	.02	3.82	.17	.14	.46	.05
7....	1.03	.30	.03	.00	.00	.02	.10	.33	.80	.05	.08
8....	....	.01	.00	.00	.00	.37	.04	.00	1.12	.10	.03
9....	....	.03	.00	.00	.00	.56	.02	.83	.02	1.41	.05
10....	....	.00	.01	.05	.00	1.74	.18	.05	.00	1.52	.14
11....	....	.02	.00	.00	.00	.91	.17	.63	.03	.02	.17
12....	....	.00	.00	.00	.00	.42	.27	.36	.90	.05	.05
13....	....	.00	.00	.00	.00	.04	.02	.00	3.21	.03	2.10
14....	.50	.00	.00	.00	.00	.13	1.13	.02	1.61	1.64	1.90
15....	....	.00	.00	.00	.00	.42	.03	3.20	.00	.60	.30
16....	.05	.00	.00	.00	.00	....	.07	.10	.00	.95	.25
17....	....	.00	.00	.01	.00	.02	.70	.94	.00	.60	.15
18....	....	.00	.00	.00	.00	.00	1.03	.99	.00	1.40	.05
19....	....	.00	.05	.00	.00	.20	.04	1.05	1.15	.90	.75
20....	.00	.00	.00	.00	.00	.90	.93	.43	.00	.22	.50
21....	.00	.00	.00	.00	.00	.00	.02	1.30	1.56	.25	2.05
22....	.00	.02	.00	.00	.00	.00	.18	.99	.06	1.42	.12
23....	.00	.02	.00	.00	.00	.00	.08	.60	.23	.38	.08
24....	.00	.00	.00	.00	.00	.65	.04	.10	.55	.52	.00
25....	.00	.13	.00	.00	.00	.10	3.16	.11	1.35	.04	.40
26....	.08	.15	.00	.00	1.05	.38	.46	.75	.10	.40	.60
27....	.10	.02	.00	.00	.00	.00	.70	.00	.15	1.32	.70
28....	.02	.00	.00	.00	.00	.03	.74	.05	.72	.11	1.02
29....	.03	.00	....	.00	.37	.60	.98	1.08	.03	.00	.00
30....	.00	.00	....	.00	.02	.87	.74	1.20	.76	.00	....
31....	.00	.06	....	.00	....	.83	....	.03	.08	....	....
Total	1.81	1.02	.12	.08	1.61	10.11	19.35	18.14	20.09	15.50	15.15

SALAMANCA, ON PEQUENI RIVER.

Day.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	0.00	0.10	0.00	0.02	0.14	0.35	0.96	1.80	0.00	0.55	0.34	1.10	0.15
2....	1.10	.10	.21	.01	.01	.04	.47	.00	.69	.00	1.50	1.31	1.18
3....	.00	.11	.01	.00	.26	.00	.06	.72	.50	1.35	.42	.04	.33
4....	1.50	.02	.00	.05	.02	.00	.42	.37	1.21	.00	.23	.47	.19
5....	.09	.30	.00	.00	.00	.97	1.43	.08	.06	.42	.00	.56	.00
6....	.02	1.09	.10	.03	.00	.22	.07	.39	.10	.51	1.01	2.09	.00
7....	.20	.04	.02	.02	.00	.09	.12	.10	.00	.00	.24	1.43	.00
8....	.01	.01	.00	.00	.00	.67	.00	.01	.00	1.85	.01	.08	.00
9....	.02	.05	.00	.05	.00	2.59	.45	1.27	.07	3.32	.15	.27	.00
10....	.00	.04	.00	.04	.00	.06	.67	.67	.10	.00	.03	.00	.00
11....	.08	.00	.00	.00	.00	.36	.00	.35	.00	1.22	.77	.02	.27
12....	.02	.00	.00	.01	.00	.37	.00	.01	.02	.00	.11	1.57	.00
13....	.00	.00	.00	.00	.00	.14	.20	.04	.43	.73	1.56	.43	.00
14....	.20	.00	.00	.00	.00	.06	.00	1.16	.01	1.84	.40	.00	.02
15....	.03	.07	.00	.00	.00	.04	.02	.17	.00	.86	.38	.00	.18
16....	.00	.01	.00	.00	.00	.00	.33	.00	.00	.40	.62	.03	.00
17....	.10	.02	.00	.04	.12	.00	.89	.00	.00	.00	.07	1.28	.22
18....	.02	.00	.00	.06	.00	.97	.00	.03	.00	.00	1.56	.00	.00
19....	.00	.00	.14	.05	.00	.60	.00	.21	.30	.73	1.19	.00	.00
20....	.05	.00	.02	.00	.00	.04	.00	1.14	1.85	.47	2.27	.00	.07
21....	.07	.05	.00	.00	.00	.00	.45	.27	.08	.35	.02	1.53	.27
22....	.00	.07	.00	.00	.00	.00	.06	.09	.19	.13	.30	.41	.00
23....	.00	.09	.00	.00	.00	.00	.00	.05	.14	.80	.00	.06	.00
24....	.02	.01	.00	.00	.00	.37	.00	.10	1.71	.31	.02	.00	.00
25....	.05	.60	.00	.00	.87	.38	.00	.01	1.01	1.84	1.00	.00	.00
26....	.23	.28	.00	.00	1.10	.00	.09	.18	.00	.13	.00	.20	.03
27....	.49	.03	.00	.00	.04	.06	.14	1.09	.00	.38	....	.10	.01
28....	.05	.03	.00	.00	.00	.70	.67	.07	1.24	.00	2.00	.88	.00
29....	.20	.00	......	.00	.27	.61	.87	.07	.20	.02	....	.77	.00
30....	.04	.08	......	.00	.39	.47	.00	.00	.06	.60	....	.14	.00
31....	.00	.00	......	.00	......	1.99	......	.01	.00	......	....	....	.00
Total.	4.59	3.20	.50	.38	3.22	12.15	8.37	10.46	9.97	18.81	16.20	14.77	2.92

Rainfall for 1899–1900—Continued.

PEDRO MIGUEL.

Day.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug.	Sept.	Oct.
1....	0.00	0.00	0.00	0.00	0.00	0.25	0.22	0.00	0.00	....	1.23
2....	.00	.15	.00	.00	.00	.00	.10	.00	.00	....	.45
3....	.17	.00	.00	.00	.00	.00	.17	.35	.43	0.79	.53
4....	.08	.00	.00	.00	.00	.00	.30	.60	.44	.00	.78
5....	.00	.00	.00	.00	.04	.00	1.21	.00	.10	.02	.45
6....	.55	.10	.00	.00	.00	.65	1.30	.05	.10	.51	.02
7....	.00	.00	.00	.00	.00	1.52	1.45	.03	.40	.02	.21
8....	.51	.00	.00	.00	.00	.49	.00	.20	.00	.00	.01
9....	.80	.00	.00	.00	.00	1.22	.00	.78	.00	1.12	.02
10....	.00	.00	.00	.00	.00	.45	.20	.61	.00	.01	.00
11....	.00	.00	.00	.00	.00	.00	.00	.62	.00	.00	.02
12....	.00	.00	.09	.00	.00	.00	.07	1.10	.20	.00	.45
13....	.12	.00	.00	.00	.00	.00	.00	.02	1.50	.05	.39
14....	.06	.00	.00	.00	.00	.00	.16	.00	.00	.02	.87
15....	.00	.00	.00	.00	.00	.73	.00	3.00	.15	.15	.27
16....	.05	.00	.00	.00	.12	.00	.00	.00	.00	.67	.78
17....	.00	.00	.00	.00	.00	.00	.04	1.31	.00	.19	.02
18....	.00	.00	.00	.00	.00	.22	1.57	1.10	.10	.09	.05
19....	.00	.00	.00	.00	.00	.25	.05	1.00	.45	.04	.03
20....	.00	.00	.00	.00	.00	.95	1.69	1.20	.00	.22	.03
21....	.00	.00	.00	.00	.89	.00	.15	1.35	.00	.80	.51
22....	.00	.00	.00	.00	.65	.06	.00	1.10	.00	.16	.01
23....	.00	.00	.00	.00	.00	.49	.14	2.50	.00	.08	.42
24....	.00	.00	.00	.00	.00	.00	.04	.25	.00	.71	.00
25....	.00	.10	.00	.00	.10	.27	.23	.57	.00	.08	.15
26....	.00	.12	.00	.00	.48	.28	.02	2.10	.50	.20	.09
27....	.00	.00	.00	.00	.00	.21	.82	.70	.50	.25	.35
28....	.00	.00	.00	.00	.20	.00	.00	.00	1.50	.25	.01
29....	.00	.00	....	.00	.00	.97	.26	1.40	.15	.30	.00
30....	.00	.09	....	.00	.25	.64	.11	2.00	.00	.02	.28
31....	.00	.00	....	.00	....	1.01	....	.10	.00	....	.25
Total	2.34	.56	.09	.00	2.73	10.66	10.30	25.04	6.52	6.75	8.68

Rainfall for 1900.

ISTHMUS OF PANAMA.

Stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Colon	6.06	0.33	1.06	0.75	12.25	11.65	16.81	17.04	9.37	16.33	20.28	4.13	116.06
Bohio	7.06	.48	1.04	2.89	7.42	18.40	17.79	14.02	15.40	18.43	24.98	4.02	131.93
Gorgona	2.63	.13	.20	3.15	7.07	12.48	19.72	11.04	11.25	11.93	....	....	....
Gamboa	1.01	.16	.13	3.21	6.76	12.15	13.45	8.92	9.24	12.11	10.67	.79	78.60
Pedro Miguel	.56	.09	.00	2.73	10.66	10.30	25.04	6.52	6.75	8.68	[a]8.67	[a]2.34	82.34
Alhajuela	1.82	.04	.03	4.10	10.16	17.79	19.73	10.56	17.20	13.26	13.36	1.14	109.19
Campañas	1.54	.05	.11	2.66	8.57	22.12	12.78	12.49	13.55	15.34	....	....	....
Santa Barbara	1.41	.16	.09	5.43	13.67	22.54	13.65	12.65	15.66	11.80	[b]13.50	[a]2.62	113.18
Rio Fea	1.26	.26	.11	5.60	12.64	20.48	13.41	9.79	16.51	21.98	....	[a]2.06	....
Rio Puente	1.02	.12	.08	1.61	10.11	19.35	18.14	20.09	15.50	15.15	....	[a]1.81	....
Salmanca	3.20	.50	.38	3.22	12.15	8.37	10.46	9.97	18.81	16.20	14.77	2.92	100.95
Las Minas	4.90	1.17	1.21	4.39	12.53	10.91	12.43	15.01	9.90	19.91	16.63	7.23	116.22

[a] For 1899. [b] Estimated.

APPENDIX E.

WASTE-WEIR DIMENSIONS AND DISCHARGE FOR LAKE BOHIO.

The determination of the dimensions of the waste weir for Lake Bohio involves the simultaneous discharge of the Chagres River into the lake and the outflow from the latter through the weir during floods. It becomes necessary, therefore, to establish formulæ, or curves, exhibiting certain results arising from the conditions which would attend the concurrent flood flow into and out of Lake Bohio. These formulæ, or curves, necessarily do not represent the actual conditions with mathematical exactness, but they approximate the natural conditions of the lake closely enough to determine with confidence the dimensions of the waste weir and the variation of the head of water on it during a given period of variation of flood in the Chagres River.

The discharge of the waste way will not be through a thin edge weir, but over a rounded masonry lip or crest, for which the coefficient is not precisely known. A careful consideration of the results of experiments with rounded crests, including those of Bazin, appears to indicate that the value of 3.5 for the weir coefficient is, on the whole, justifiable for the present case, and it will be used in the following investigations. It may be a little too large for small heads or a little too small for the greater heads used.

In deducing the following formulæ it will be assumed that during the period of flood considered the discharge of the river per unit of time (per second) increases at a uniform rate until the maximum stage is reached; then that it remains at that stage for a definite time, and subsequently decreases at a uniform rate generally not the same as the rate of rise. As a matter of fact, the uniform rate of increase is the only one of the two of practical importance in this investigation, and it is to be determined from data supplied by observation of actual floods.

Obviously, water may begin to flow over the crest of the waste way at any stage of the river at its point of entrance into the lake, depending on the proximity of prior floods and the draft recently made on the waters of the lake. The stage of the river, therefore, taken to coincide in time with the beginning of flow over the rounded crest of the waste weir, must be a matter of judgment in view of known data.

The notation to be used is the following:

t_1=time in seconds measured from beginning of flow over weir.
T_1=value of t_1 at instant the river reaches its greatest elevation.
v_1=discharge of the river in cubic feet per second at any time t_1.
V_1=discharge of the river in cubic feet per second at the time T_1.
r=rate (uniform) of variation of discharge of river per unit of time.
b=length of weir in feet.

h=head of water on weir in feet; and H=greatest value of h.
a=uniform rate of variation of h per unit of time, so that $h=at_1$ and $H=aT$; $T>T_1$.
V=greatest discharge over weir in cubic feet per second; V may or may not be equal to V_1.
e=discharge of river per unit (second) of time when lake is at elevation of crest of weir.
Q=general value of discharge over weir in cubic feet per second. V is the greatest value of Q.
c=weir coefficient, taken equal to 3.5.
D=total discharge of weir in cubic feet in time T (seconds).
A=area in square feet of surface of the lake.
L=total storage in cubic feet in reservoir or lake above the elevation of the crest when head on the weir is H feet.

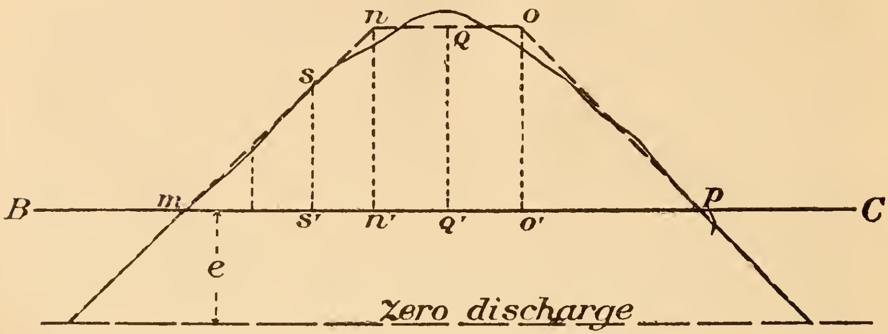


FIG. 1.

The full line of figure 1 represents the fluviograph record of the rise of the Chagres River during a flood at Bohio. Inasmuch as this discussion must cover all the water flowing into Lake Bohio, this fluviograph record will be treated in the application of the formulæ as if it belonged to the river at its point of entrance into the lake. The datum line BC indicates the stage of the river at the beginning of flow over the crest of the waste weir. Hence the point m is the zero or origin of the time t_1, which is measured horizontally along mp and toward the latter point. The ordinates above BC represent heights of rise above that datum at any time t_1 in seconds measured from m. The trapezoid $mnop$ is the equivalent of the actual record area above BC. The line qq' is midway between nn' and oo'. It is evident that the horizontal line no indicates the maximum stage of the river remaining constant during the period no.

The discharge of the river in cubic feet per second corresponding to any height of rise ss' is v_1, which becomes V_1 when the greatest rise nn' is reached. The time in seconds represented by ms' and corresponding to ss' is t_1. For the greatest rise nn', $t_1=T_1=mn'$. The distance e is the height of the datum BC above the base line of no discharge in the river; this distance is used to represent the unit discharge of the river when t_1 is zero.

By means of the notation taken there may be written:

$$v_1=e+rt_1 \text{ and } V_1=e+rT_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The mean discharge per unit of time is:

$$\frac{v_1+V_1}{2}=r\frac{t_1+T_1}{2}+e \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The discharge in cubic feet per second over the weir for any head h is given by the formula:

$$Q=3.5\, bh^{3/2} \qquad (3)$$

The rate of inflow into the reservoir per unit of time is given by equation (1).

In the time dt_1 the discharge of the river is $edt_1+dt_1\, dt_1$. During the same time the volume of water in the reservoir increases by the amount Adh and the discharge over the weir is $3.5\, bh^{3/2}\, dt_1$. The sum of the second and third of these quantities must be equal to the first. Consequently, the differential equation sought will be:

$$(e+rt_1)\, dt_1=A\,dh+3.5\, bh^{3/2}\, dt_1 \qquad (4)$$

Hence:

$$h=\frac{e}{A}\, t_1+\frac{r}{2A}\, t^{2}{}_{1}-\frac{3.5\, b}{A}\int_{0}^{t_1} h^{3/2}\, dt_1 \qquad (5)$$

If this equation were integrated, the desired relation between h and t_1 would at once be found, but the resulting equation would be too complicated to be easily worked in the final computations.

The main features of the curve expressing the relation between h and t_1 can be discovered by means of equation (2). That equation gives:

$$\frac{dh}{dt_1}=\frac{e+rt_1-3.5\, bh^{3/2}}{A} \qquad (6)$$

Therefore:

$$\frac{d\left(\dfrac{dh}{dt_1}\right)}{dt_1}=\frac{r+3.5\, b\,\dfrac{d\,(h^{3/2})}{dt_1}}{A} \qquad (7)$$

When h is small the second number of equation (5) is positive, and negative when h is large. This shows that the curve, of which h is the ordinate and t_1 the abscissa, is convex toward t_1 in the vicinity of 0 and concave in the upper part of the curve, as indicated in figure 2.

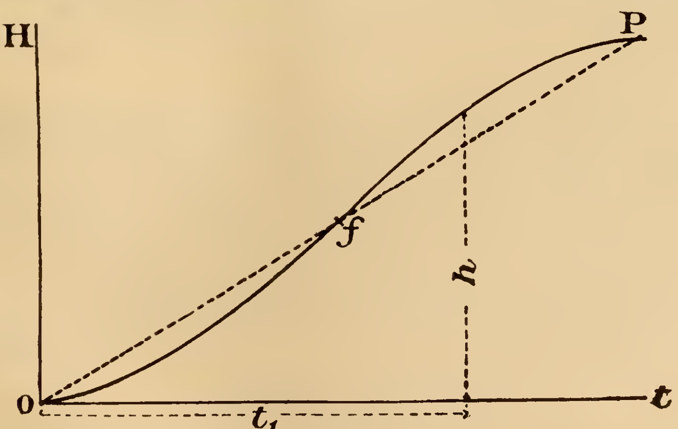


FIG. 2.

If the flood remains at its maximum stage a sufficient length of time the curve will become horizontal at same point P and remain so, or the curve may become horizontal after the maximum stage has passed, but in the latter case it will not remain horizontal.

After the flood reaches its maximum stage the unit discharge $V_1 = e + rT_1$ may remain constant for a definite length of time. In that case the rise of the lake surface, i. e., the increase of h, will follow a different law from that shown by equation (5). By writing V_1 for $(e + rt_1)$ in equation (4):

$$\frac{dh}{dt_1} = \frac{V_1 - 3.5\, bh^{3/2}}{A} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

or

$$dt_1 = A \frac{dh}{V - 3.5\, bh^{3/2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

This equation may readily be integrated.

If $k = \left(\frac{V_1}{-3.5\, b}\right)^{1/3}$ the integral will take the form:

$$\frac{t_1}{A} = -\frac{1}{3\,(3.5\, b)\, k} \log \frac{k^2\, kh^{1/2} + h}{(k + h^{1/2})2} - \frac{2}{\sqrt{3}\,(3.5\, b) k} \tan -1 \left(\frac{2h^{1/2} - k}{\sqrt{3} k}\right) \quad . \quad (10)$$

By giving known values to t_1 and h the value of the constant of integration, C, can be determined for any given case.

Equation (6) will enable that portion of the curved line to be constructed showing the relation between h and t_1 during the rising stage of the river, since $\frac{dh}{dt_1}$ is the tangent of the inclination of the curve to the coordinate t_1. Similarly, equation (8) by the same method of tangents will enable that portion of the curved line to be constructed belonging to the highest stage of the river where that stage holds constant for a suitable length of time.

These investigations are subject to one source of criticism when applied to so large a reservoir as Lake Bohio, because it is implicitly assumed that the surface of the lake remains horizontal at all times, whatever may be the rate of inflow or outflow. In this case the point of inflow may be fifteen or more miles from the discharging weir, giving a sensible slope to the lake surface and causing the head on the weir to increase for a considerable time after the river ceases to rise, or possibly after the river begins to fall.

In the application of the preceding analysis to the computations for the Bohio weir the curves OMKS and O′M′K′S′ in figure 3 have been constructed, OM and O′M′ belonging to the rising stage of the river, and MK and M′K′ to the constant maximum stage. S and S′ are the highest points of the curves and show the greatest heads on the weir. The rising curves KS and K′S′ show that the head on the weir may continue to increase for some time after the river begins to fall.

The complete consideration of the Lake Bohio problem requires the determination of the discharge over the weir during the entire time of the increase of head on the latter. This requires the integral

$$\int 3.5\, bh^{3/2} dt_1 = 3.5\, b \int h^{3/2} dt_1$$

to be made. The complicated forms of equations (5) and (10) show that that integral is practically unworkable.

By referring to figure 3 it will be observed that straight lines may be drawn from O to either K or S, or from O′ to either K′ or S′, which will have nearly equal portions of the true curves on either side of them, making it permissible to use these straight lines for a first approximation.

If, then, a be some suitable constant coefficient, under this approximate law there will result:

$$h = at_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

The same result can be shown by a purely analytic method to be a reasonable first approximation, and equation (11) will be used in the investigations which follow.

In consequence of the great length of the waste weir and the practical suppression of end contractions it must be assumed that there will be no end contraction. Hence the general expression of the weir discharge will be:

$$Q = cbh^{3/2} = ca^{3/2}\, bt_1^{3/2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

At the maximum height to which the water will rise on the weir:

$$Q = V = ca^{3/2}\, b\, T \therefore a = \left(\frac{V}{cb}\right)^{2/3} \frac{1}{T} \quad . \quad . \quad . \quad . \quad (13)$$

The total discharge over the weir, while the head increases uniformly from o to $H = a\,T$, is:

$$D = \int_o^T Q\, dt = ca^{2/3}\, b \int_o^T t^{3/2}\, dt = \frac{2}{5}\, ca^{3/2}\, b\, T^{5/2} \quad . \quad . \quad . \quad (14)$$

Since $H^{5/2} = a^{5/2}\, T^{5/2}$; $D = \frac{2c}{5a}\, b\, H^{5/2}$ . . . . (15)

Substituting a from equation (13) in equation (15):

$$D = \frac{2}{5} \frac{(cb)^{5/3}}{V^{2/3}}\, TH^{5/2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

The volume L impounded in the lake above the elevation of the crest of the weir added to the discharge over the weir during the time T is equal to the discharge of the river during the same time T. If T_1 represents the time during which the flood discharge of the river rises from v_1 to V_1, the following equation will hold true:

$$\frac{2}{5} \frac{(cb)^{5/3}}{V^{2/3}} TH^{5/2} + L = \left(\frac{v_1 + V_1}{2}\right) T_1 + (T - T_1)\, V_1 \quad . \quad . \quad . \quad (17)$$

Hence—

$$T = \frac{L + \left(\frac{V_1 - v_1}{2}\right) T_1}{V_1 - \frac{2}{5} \frac{(cb)^{5/3}}{V^{2/3}} H^{5/2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

If it is desired that the head on the weir shall not exceed H, then from equation (12) the length of the weir must be at least:

$$b=\frac{V}{cH^{3/2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

The most simple expression for the time T is given by equation (16):

$$T=\frac{5}{2}\frac{D}{H^{5/2}}\frac{V^{2/3}}{(cb)^{5/3}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

In equation (20), however, the discharge D is not generally known, and it will be necessary to use equation (18) in order to determine T.

In the following computations it will be assumed that the unit discharge v_1 of the river is 17,657 cubic feet (500 cubic meters) per second at the beginning of discharge over the weir, i. e., $v_1=e$.

In making the application of the preceding formulæ to the problem presented at Lake Bohio, it will be necessary to consider first a head of water of 5 feet on a waste weir 2,000 feet long, in connection with a flood discharge in the Chagres River increasing uniformly from 17,657 cubic feet (500 cubic meters) per second to 112,000 cubic feet (3,170 cubic meters) per second during a period of 26.43 hours, or 95,145 seconds, and remaining at that maximum stage for 14.25 hours, or 51,300 seconds, the sum of the two periods being 146,445 seconds. The rate of discharge after the maximum period has passed is not needed. The surface area of Lake Bohio at the elevation of the crest of the waste weir is about 38.5 square miles, or 1,073,318,400 square feet. At an elevation of 5 feet higher that surface area becomes about 43 square miles, or 1,198,771,200 square feet. The product of half the sum of these two areas by 5 gives the volume of water impounded in the lake with a 5-foot head on the weir as

$L=5,680,224,000$ cubic feet.

The other data required are:

$v_1=17,657$ cubic feet per second$=e$.

$V_1=112,000$ cubic feet per second.

$T_1=95,145$ seconds.

$c=3.5$ and $b=2,000$ feet.

Hence by equation (12):

$Q=V=3.5 \times 2,000 \times (5)^{3/2}=78,262$ cubic feet.

Introducing these various quantities in equation (18) there will result:

$T=126,009$ seconds.

$=35$ hours.

As this period is 5.68 hours less than 40.68 hours, the total time of rising and remaining at the maximum height, it is probable that under the conditions of the flood assumed, the head of water on the weir would rise a little above 5 feet, but a little only.

The total amount discharged over the weir while the head increases to 5 feet is by equation (16):

$D=3,944,711,745$ cubic feet.

If a flood discharge of 140,000 cubic feet be assumed in the river it is interesting to determine approximately how long it would have to continue in order to raise the head on the weir to 7 feet. By equation

(12) the discharge over the weir (2,000 feet long) with a head of 7 feet is:

$$Q = V = 129{,}642 \text{ cubic feet per second.}$$

As before, $v_1 = 17{,}657$ cubic feet per second.

Also, $V_1 = 140{,}000$ cubic feet per second.

Again, assume $T_1 = 95{,}145$ seconds.

At an elevation of 7 feet above the crest the area of the lake surface is 1,249,394,752 square feet, while at the elevation of the crest the area, as before, is 1,073,318,400 square feet. The half sum of these areas multiplied by 7 gives the volume stored in the lake above the crest as:

$$L = 8{,}129{,}496{,}032 \text{ cubic feet.}$$

These quantities inserted in equation (18) will give:

$$T = 158{,}307 \text{ seconds.}$$
$$= 43.98 \text{ hours.}$$

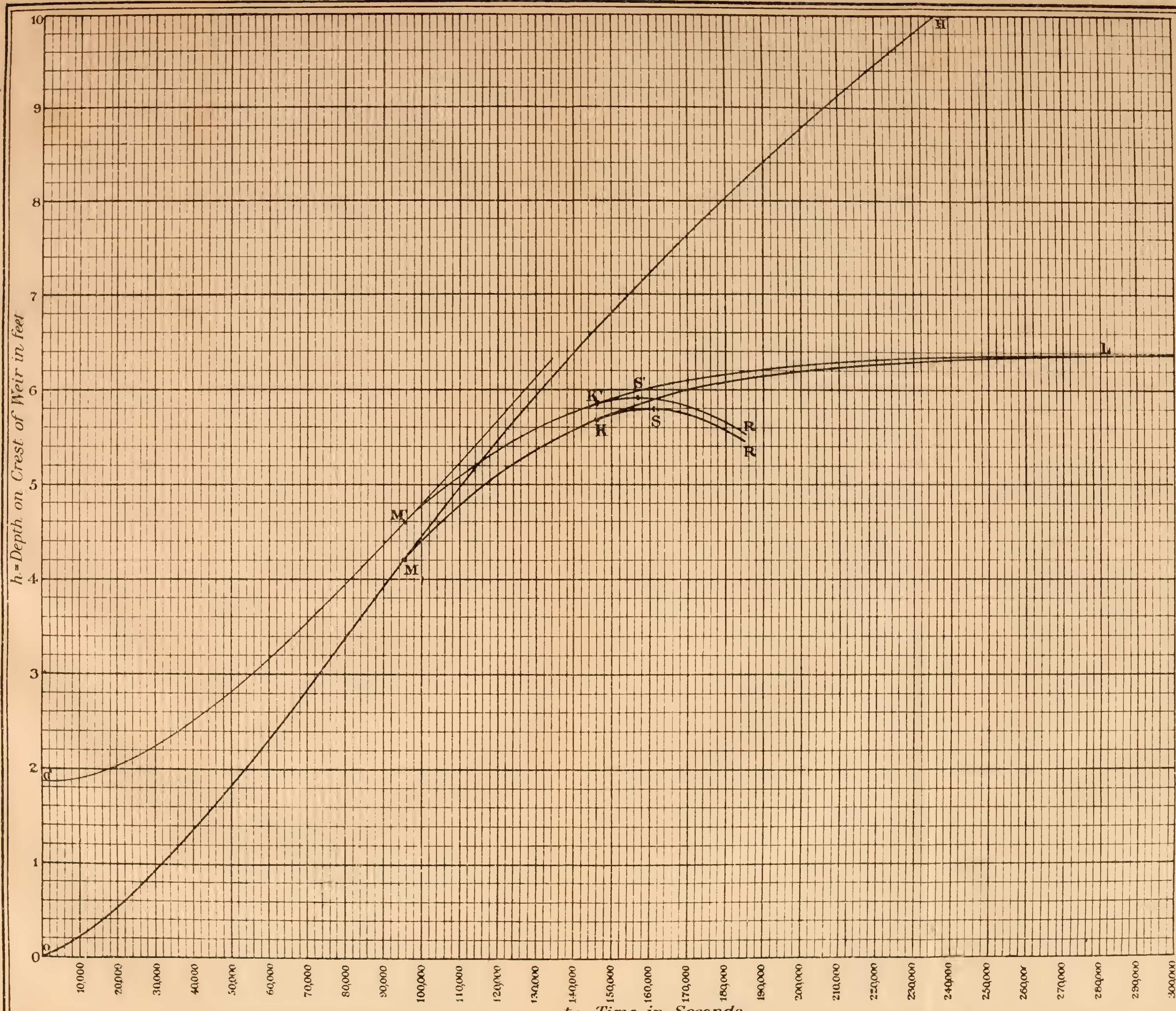
As the period of increasing discharge has been taken at 26.43 hours (95,145 seconds), it is thus seen that the maximum discharge of 140,000 cubic feet per second would have to be maintained for probably eighteen hours or more in order to produce the head of 7 feet on the weir crest. This is a contingency so excessively remote as to be practically impossible. The total discharge over the weir while the head rises from 0 to 7 feet is, by equation (16):

$$D = 8{,}007{,}498{,}655 \text{ cubic feet.}$$

The general conditions assumed in the preceding applications of the formulæ established are, in the main, essentially the same as those taken by M. Choron in his fifth hypothesis, on page 54 of his Notes Techniques.

The curve OMKS of figure 3 shows the relation between the head on the weir and the time from the beginning of flow over the weir for the first of the preceding set of computations. It indicates that the greatest head on the weir would be 5.8 feet. This is a little too high on account of the neglect of the actual slope of the surface of the lake, as has already been observed. The approximate computations show that the greatest head would be a little over 5 feet. It is probable that 5.5 feet is about right. The curve and computations practically confirm each other.

The O′M′K′S′ exhibits the relation between head on the weir and time, and the assumption that there is a discharge over the weir of 17,657 cubic feet per second, when there is an equal discharge of the river, followed by the same flood as before. The greatest head on the weir is but one-tenth of a foot greater than in the previous case, showing that the difference in assumptions has no material effect on the maximum head, either as to amount or time. The volume of water discharged during the period of increasing head would be materially greater in the latter case than in the former.


h = Depth on Crest of Weir in feet
t = Time in Seconds
0
1
2
3
4
5
6
7
8
9
10
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
110,000
120,000
130,000
140,000
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190,000
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210,000
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260,000
270,000
280,000
290,000
300,000
H
L
K'
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C

Appendix F.

DESCRIPTION OF ALTERNATIVE LOCATION FOR CANAL BETWEEN GATUN AND BOHIO.

Between Gatun and Bohio the French location of the canal follows the low part of the valley of the Chagres. The location of the Panama Railroad is more direct, but passes over a little higher ground. This portion of the canal crosses the old bed of the Chagres six times, and the Chagres has abandoned its old bed and now flows through the canal for a distance of 4 miles. The estimates of the Commission include a channel between the Peña Blanca and Agua Clara swamps and a levee which will keep the Chagres out of the canal through which it now flows. A study has been made of another location (practically that of the Lull survey of 1875), which, if adopted, would allow the river to flow in its present course, would make the channel between the two swamps unnecessary, and would shorten the canal. A survey was run on a direct line between Gatun and Bohio, a location made, and estimates prepared. This is shown on plate 21 by a broken line.

This cut-off line leaves the French location at mile 7.39, and connects with it at mile 16.81. It is 8.18 miles long or 1.25 miles shorter than the distance by the canal line between these two points. It is a single straight line 4.92 miles long, connected with the canal at the east end by a curve 1.105 miles long with a radius of 13,230 feet, and at the west end by a curve 2.16 miles long with a radius of 13,720 feet.

This line crosses the Panama Railroad twice, the location of which will have to be changed for about a mile. For the first 2.17 miles it lies in a low, flat country; it then strikes what is known as Tiger Hill, involving some heavy work for nearly a mile; it then again enters a low, swampy country, broken by occasional small, low hills, which continues the rest of the distance. All the hills consist largely of rock; between the hills the material is earth, the portion of which north of Tiger Hill would be excavated with dredges, and that south of Tiger Hill treated as dry-earth excavation. The hard material in the hills would be wasted on the west side of the canal so as to form a levee, back of which the earth would subsequently be placed, forming an embankment of indefinite width.

The estimated cost of 8.18 miles of the cut-off line (including $75,000 for change in Panama Railroad) is $9,938,601. The estimated cost of the corresponding portion of the canal on the old location is $8,093,414, to which must be added the channel between the two swamps, $2,448,076, making a total of $10,541,590, a difference of $602,989 in favor of the cut-off line, which in view of the less perfect knowledge of the ground is of no practical importance. The cut-off line represents a saving in distance of 1.25 miles, and eliminates three curves and 73 degrees of curvature, and is worthy of further study, but for purposes of estimate the old location is retained.

Appendix G.

TIME REQUIRED FOR TRANSIT THROUGH AN ISTHMIAN CANAL.

The time required for the passage of a ship through the proposed isthmian canal will depend upon the speed attainable and permissible in the various sections and the delays occasioned by lockages and by meeting other ships. Attainable speed here means the speed limited by the power of the ship. From this deductions are to be made in some cases to give the permissible speed. Attainable and permissible speed.

This discussion will embrace four type ships, as follows: Type ships.

	Length.	Beam.	Draft.	I. H. P.
	Feet.	*Feet.*	*Ft. in.*	
Type A	400	50	24 6	1,900
Type B	400	50	32 0	2,300
Type C	540	60	32 0	3,300
Type D	650	70	32 0	4,500

The draft given refers to fresh water. The power is sufficient to give the ship a speed of 12½ miles per hour in open sea. The miles referred to in this discussion are statute miles.

The area of the midship section of each ship is assumed to be 96 per cent of the inclosing rectangle. The block coefficient is taken as 0.8. This expresses the ratio of displacement to the product of length of keel, beam and draft. The mean cross section is therefore 0.8 × beam × draft. Coefficients.

No experiments on the comparative speeds attainable by large seagoing ships in open sea and in restricted waterways, carried on in a scientific and comprehensive manner, are known to have been made. The movement of small boats in small canals at low speeds has been the subject of extended experiment and careful study. The most notable of these have been made recently in France and Germany. They have been summarized and discussed by Mr. Elnathan Sweet in a paper accompanying the report of the engineer and surveyor of New York on the proposed barge canal from Lake Erie to the Hudson River. These experiments were carried out in great number and detail, but on boats of such different model, of so much smaller dimensions, and at such moderate speeds that they can not be applied directly to the problem of speeds of large seagoing ships through an isthmian canal. However, the analysis of the problem by Herr R. Haack, who conducted the experiments in Germany, is suggestive and useful in the present discussion. Available data. Experiments in France and Germany summarized by Mr. E. Sweet.

Back current.

While a ship moves forward its length in a canal, a volume of water equal to its displacement must move back past the ship.

Let A = wet cross section of canal, square feet.
a = mean cross section of ship, square feet.

$$r = \frac{A}{a}$$

V = speed of ship past a fixed land point, in miles per hour.
v = velocity of backward current past the moving ship in miles per hour; approximately it may be thus expressed:

Approximate formula for backward current.

$$v = \frac{a}{A - a} V = \frac{V}{r - 1}.$$

This is the expression ordinarily used. Herr Haack points out the important fact that it is not the correct measure of v. The passage of a boat through a canal is accompanied by a depression of the water surface which begins at or a little ahead of the bow and continues past the boat some distance astern. The water which moves past the boat while the latter passes a fixed point is not only the boat's displacement, but also the volume measured by this depression into the length of the boat and width of the canal. Taking this movement also into consideration, Haack proceeds to deduce an expression for the relation between V, v and the resistance of the boat.

Let $\triangle A$ = reduction of wet cross section of canal caused by sinking of water surface during passage of boat.
R = resistance of boat.
L = length of boat in feet.
w = weight of 1 cubic foot of water.
C = coefficient to be determined by experiment.

Then $A - \triangle A - a$ = area of cross section of water remaining between the boat and the bottom and sides of the canal.
$(\triangle A + a)\,V$ = volume of water displaced in a unit of time.
$(A - A - a)\,v$ = volume flowing in the section $A - \triangle A - a$ past a given point in a unit of time.

These volumes are identical, hence

$$(A - \triangle A - a)\,v = (\triangle A + a)\,V$$

and

Correct formula for backward current.

$$v = \frac{\triangle A + a}{A - \triangle A - a}\,V \quad . \quad . \quad (1)$$

Which is the correct value of v.

The weight of water kept in motion by the movement of the boat is

$$w\,(A - \triangle A - a)\,L$$

and Haack gives the following expression for the work required for moving it during a unit of time:

$$C\,w\,(A - \triangle A - a)\,L\,v \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and places this equal to the work of the resistance of the boat during a unit of time; that is,

$$R\,V = C\,w\,(A - \triangle A - a)\,L\,v \quad . \quad . \quad . \quad . \quad (3)$$

Tractive resistance.

The determination of the value of the coefficient requires the measurement of the sinking of the water surface and the retractive resistance R. Mr. Sweet does not give the value of C as determined by Haack, or state whether it is constant or variable except indirectly by showing the curves of resistance for the boats used in the experiments. For the reasons already given these curves are not applicable to the present case. There is needed a series of experiments with large ships in restricted waterways approximating closely the ships and channels of the future isthmian canal.

In the absence of such experiments the inquiry resolves itself first into the estimation of the speed attainable in a restricted channel by a ship whose speed in open sea is known. This requires a consideration of the various causes of retardation encountered by a ship when it passes from broad, deep water into such a channel.

Backward current past a ship in a canal.

When a ship moves upstream in a broad, deep river its speed through the water is essentially the same as in open sea. Its speed past a fixed point will be its open-sea speed less the velocity of the current. In this respect the backward current in a canal is analogous to the river current and is to be deducted from the open-sea speed of the ship.

The determination of the velocity of the backward current requires, as Haack points out, and as indicated in formula (1), that the depression of the water surface between the ship and the sides of the channel be known. Haack observed this carefully in his experiments, but no record has been found of such observations during the passage of a large ship through a ship canal. The writer therefore proceeded to make a limited series at the St. Clair Flats Canal. This series included 29 ships. One of these was rejected because its dimensions are not given in the Marine Register. Six were rejected because they were without cargoes, and the observations on them little pertinent. The observations consisted of: First, measurements at intervals of 5 seconds from a fixed horizontal plane, to the water surface before, during, and after the passage of a ship, covering the period when the surface of the water varied from the normal; second, a record of the time taken by the ship in passing; third, soundings across the canal opposite the observation point to determine its cross section; fourth, measurement by rod floats of the normal current in the canal.

Observations at St. Clair Flats Canal.

The St. Clair Flats Canal is a channel without locks, 296 feet wide and about 7,200 feet long. The sides are vertical with timber revetments. The depth, which was dredged to 16 feet for about 20 feet from the sides and to 20 or 21 feet in the remainder of the channel, has increased opposite the point of observation to 26 feet at the center. The point of observation was 2,280 feet from the upper end of the canal.

The observed time of passing, with the length of ship taken from the Marine Register, gave the speed of the ship, which was corrected for the normal current in the canal. For the calculation of the ratio r_1, which is the quotient resulting from dividing the area of the cross section of the canal by the midship section of the ship, the coefficient of the ship's midship cross section is assumed to be 0.96, the same as for the type ships. This is probably too large for the smaller ships, but substantially correct for the larger ones.

The measurements of the water surface were made about 1 foot out from the vertical side of the canal. They may not represent exactly the mean water surface between the ship and sides of the canal, but it is believed the difference is not great. While a ship was approaching, the water surface at the point of observation remained nearly or quite normal until the bow was within 25 to 100 feet of the cross section of the canal, passing through the observing station. The water then began to fall, attained its maximum depression a little aft the center of the ship, then began to rise and again attained the normal 50 or 100 feet behind the ship.

These distances varied with different ships and are to be taken only in a general way.

For the calculation of the average depression of water surface opposite the passing ship, the distances between observations were plotted as abscissas and the depression of the water surface as ordinates, the total distance plotted being the keel length of the ship. This gave a longitudinal section during the time of the ship's passing. The area of this section divided by the keel length gave the average depression.

The results of the observations are given in the following table:

TABLE I.—*Results of observations at St. Clair Flats Canal during passage of ships.*

Name of ship.	Keel.	Beam.	Draft.	r_1.	Depression of water surface. Maximum.	Depression of water surface. Mean.	V.	v.
	Feet.	*Feet.*	*Feet.*		*Foot.*	*Foot.*	*Miles.*	*Miles.*
Manistique	157	31	12.00	19.15	0.21	0.15	5.78	0.31
V. Swain	187	33	13.50	15.99	.25	.20	6.66	.43
Pueblo	225	36	16.50	11.99	.58	.50	8.24	.82
New York	268	36	16.50	11.99	.97	.80	10.07	1.17
W. H. Sawyer	201	37	13.50	14.26	.21	.17	6.71	.48
Choctaw	266	38	17.75	10.56	.67	.46	7.28	.79
Vega	301	38	18.00	10.40	.42	.31	7.20	.74
Spokane	311	38	17.50	10.71	.83	.58	8.66	1.00
Frontenac	270	40	18.00	9.89	.83	.66	7.42	.94
Philip Minch	275	40	17.50	10.17	.42	.30	6.81	.71
Seneca	290	40	16.00	11.13	.75	.57	8.41	.90
Masaba	292	40	17.50	10.17	1.00	.83	8.13	1.12
Roman	296	40	17.75	10.03	.75	.53	7.06	.84
Iroquois	242	41	17.00	10.22	.63	.44	7.95	.89
Livingstone	281	41	17.50	9.93	.92	.72	8.23	1.07
T. W. Palmer	281	41	19.00	9.14	.58	.44	7.77	.96
Hudson	288	41	15.50	11.21	.54	.39	8.62	.86
Niagara	266	42	17.00	9.98	.42	.31	7.40	.79
America	274	42	16.50	10.28	.42	.27	7.38	.75
Manola	282	42	18.50	9.17	.46	.32	6.34	.74
S. R. Kirby	294	42	18.00	9.42	.67	.60	6.35	.82
Presque Isle	406	50	19.00	7.50	.92	.68	7.04	1.15
Mean				11.06	.62	.46	7.52	

In observations on ships of such different types as those in the preceding list, moving at such different rates of speed, great apparent eccentricity in result should be expected. Much of this, however, will disappear if the ships are classified with respect to r_1 and averages taken as in the next table.

TABLE II.

Value of r_1.	Number of ships averaged.	Mean value of r_1.	Mean depression of water surface.	Mean speed of ship (V) per hour.
			Foot.	*Miles.*
7.5	1	7.5	0.68	7.04
9–10	6	9.59	.51	7.25
10–11	8	10.32	.46	7.56
11–12	4	11.58	.56	8.83
14–20	3	16.47	.17	6.72

These results are plotted in figure 1, attached hereto, with r_1 as abscissas and depressions (d) as ordinates. A line to represent the relations is shown, which passes reasonably near all the points. The point $r_1=11.58$, $d=0.56$, should lie considerably below the line, because it corresponds to the largest value of V; and the point $r_1=16.47$, $d=0.17$, should lie above the line, because it corresponds to the smallest value of r.

The same figure shows the depressions which have been used for this discussion for the isthmian canal. They exceed those given by the observations as far as the latter extend, and should do so, because the calculated speeds in the discussion for the large channels, where r_1 is large, exceed those observed in the St. Clair Flats Canal. For values of r_1 less than 7.50 the assumed depressions have for basis only the writer's judgment in interpreting the experiments. For $r_1=1$ it is obvious the depression would equal, theoretically, the normal depth of water in the canal. Between the point and the point corresponding to $r_1=7.50$ there may be material difference of opinion as to the location of the depression curve.

The backward current is only one of the new conditions set up when a ship passes from open sea into a restricted channel. The depression of the water surface must increase the head resistance to the ship's motion. In the observations at the St. Clair Flats Canal the measurements of depression were made, as before stated, at the side of the channel where the depression occurred in advance of the ship, which passed at a distance of 100 to 175 feet from the observing station. As far as could be judged by watching the movement of the ship, without actual measurement, this depression does not occur immediately in front of the ship. It appears probable that the excess in height of water against the bow over the height against the stern may be taken as safely equal to the mean depression of the water's surface, or d. The pressure and horse- Increased head resistance.

power required to overcome it may be calculated as follows:

Let h = excess of elevation of water against bow, compared with elevation at stern, in feet. This is taken equal to the mean depression d.

a_1 = midship section of ship in square feet.

w = weight of 1 cubic foot of water in pounds.

P = opposing pressure in pounds.

$V_1 = \frac{5280}{3600}$ V = speed of ship in feet per second.

H = horsepower of ship's engines.

H_1 = horsepower required to overcome end pressure.

Then

$$P = Chwa_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

in which C is a coefficient depending on the ship's model. It will be taken here as $\frac{1}{6}$

The horsepower required to overcome P when the ship moves at the rate V_1 is

$$H_1 = \frac{PV_1}{550} = \frac{Chwa_1}{550} V_1 = \frac{1}{6} \frac{hwa_1}{550} V_1 \quad . \quad . \quad . \quad (4)$$

and the power remaining to overcome the other resistances is $H - H_1$. The speed of the ship will therefore be reduced. For moderate speeds the horsepower required to move a ship varies approximately as the cube of the speed. If V_2 represents the speed in miles per hour which the ship would attain in the restricted channel if there were required no deduction for head resistance,

$$H : H - H :: V^{3/2} : V^3$$

$$V^3 = \frac{H - H_1}{H} V^{3/2} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

It might seem that the deductions for backward current and increased head resistance were all that are required to give the speed of a ship in a canal. No allowance, however, has yet been made for the changed conditions in the mass of water near the ship, such as eddies, which would not occur to the same extent in deep water, increased friction of the water on the channel bed, etc.; some of the conditions unknown or imperfectly understood, but consuming more or less of the power of the ship's engines. No deduction has yet been made which would be applied to a ship passing through shoal water of unlimited width, but it is well known that there is a material reduction of speed in wide, shoal water. The rate of this retardation doubtless increases with the speed of the ship. A few comparisons have been made of the speed of ships in the deep water of Lake Huron and the shoal water of Lake St. Clair, where the depth of water exceeds by 2 or 3 feet the usual draft of loaded ships. The loss of speed in the shoal water is about 15 per cent, while using the same steam as in deep water. There is probably in this

Shoal water deduction.

case no appreciable backward current; the water to fill the void behind the moving ship can reach it more quickly by a lateral movement from the unlimitedly wide water. The observed reduction of speed is probably caused almost wholly by the work done in forming eddies, overcoming friction between the water and the bed of the lake, etc., and should be taken into account in calculating the attainable speeds to be expected in a restricted channel. This should apply, however, only when the draft of the ship is within 2 or 3 feet of the depth of the channel. It should be reduced for type A, which will have 5.5 feet more clearance under the keel than the other types. It should also be reduced for all types in those channels where, on account of tides, as in Panama Bay, or on account of storage, as in the summit levels of both routes, the clearance usually exceeds 3 feet by a considerable amount; it is deemed best, however, not to attempt to draw narrow distinctions, but to apply the reduction of 15 per cent to ships of types B, C, and D in all channels of whatever depth. For type A a reduction of 10 per cent is applied for shoal-water effect. It should obviously be less than for the ships of deeper draft, but the difference of 5 per cent may be too great or too small. These percentages are applicable only when the open-sea speed of the ship is 10 to 13 miles per hour.

Calculation of attainable speeds.

These several reductions have been applied to the normal speed of each of the type ships in each of the different channels of both routes, with the results given in Table III. In order to show more clearly how the results are obtained the calculation will be given for a single case:

Channel—standard for firm earth.
Top width, 269 feet.
Side slopes at top, 1 on 1.
A = area of cross section = 7,189.5 square feet.
Ship, type B, H. P. = 2,300 = H.
a_1 = midship section = $50 \times 32 \times 0.96$ = 1,536 square feet.
a = mean section = $50 \times 32 \times 0.8$ = 1,280 square feet.
Depression of water surface assumed to be 1.2 feet.

$$\triangle A = (269 - 1.2)\ 1.2 = 321 \text{ square feet.}$$
$$\triangle A + a = 1,601 \text{ square feet.}$$
$$A - \triangle A - a = 5,588 \text{ square feet.}$$
$$v = \text{backward current} = \frac{1601}{5588} V = 0.287\ V.$$

Speed of ship in open water	12.5	miles per hour.
Deduction for shoal water 15 per cent	1.875	miles per hour.
Speed in wide shoal water	10.625	miles per hour.

Since the head resistance depends on the speed of the ship as finally deduced it is necessary to assume a value of V.

Assume V = 7.9 miles per hour.
= 11.59 feet per second.
V = 0.287 V = 2.267 miles per hour.

Deduct this from speed of ship in wide shoal water.

$10.625-2.267=8.358=$ speed of ship without deduction for increased head resistance $=V_2$.

For head resistance

$$P=\frac{1}{6}\times 1.2\times 62.5\times 1,536=19,200 \text{ pounds.}$$

Horsepower required to overcome it

$$=\frac{19200}{550}\times 11.59=405=H_1.$$

$$H-H_1=1895.$$

From equation (5).

$$V^3=\frac{1895}{2300}\times(8.358)^3=(7.84)^3.$$

$$V=7.84.$$

Since this does not agree with the assumed value of V, a new trial must be made. The correct value is 7.85.

In the calculations for the following table the depth of water in the channel in the summit level of the Panama Canal is taken as 38 feet; in the summit level of the Nicaragua Canal, 39 feet; in the Pacific section of the Panama Canal, 45 feet, and in all other excavated channels, 35 feet. Allowance has been made in the deepened San Juan for the river section outside of the deepened channel by assuming side slopes of 1 on 4. In the excavated channel in Lake Nicaragua the channel section is computed as having side slopes of 1 on 5.

TABLE III.—*Calculated speeds through isthmian canal channels by ships having sufficient power for a speed of 2.5 miles per hour in open sea.*

Section.	Area of wet section.	Type ship A.				Type ship B.			
		r_1.	Depression of water surface.	V.	v.	r_1.	Depression of water surface.	V.	v.
	Square feet.		*Feet.*	*Miles per hour.*	*Miles per hour.*		*Feet.*	*Miles per hour.*	*Miles per hour.*
Canal in rock, summit level excepted, Nicaragua	5,250	4.46	1.3	8.28	2.38	3.42	1.7	7.07	2.93
Canal in rock, west divide, Nicaragua	5,700	4.90	1.2	8.52	2.17	3.71	1.6	7.33	2.67
Canal in rock, Culebra cut, Panama	5,966	5.07	1.1	8.64	2.07	3.88	1.5	7.47	2.55
Canal in firm earth	7,189.5	6.11	.9	8.96	1.83	4.68	1.2	7.85	2.25
Canal in sand or silt	8,925	7.59	.8	9.28	1.53	5.81	1	8.13	1.84
Channel in Panama Bay	15,075	12.82	.6	9.97	.94	9.81	.7	9.14	1.08
Channel in San Juan River, deepened	15,834	13.47	.6	9.97	.94	10.31	.7	9.15	1.08
Channel in Lake Nicaragua, deepened	19,305	16.41	.5	10.18	.75	12.57	.6	9.37	.90
Harbors and entrances, 500 feet wide	21,175	18.02	.5	10.24	.69	13.79	.6	9.49	.83

TABLE III.—*Calculated speeds through isthmian canal channels by ships having sufficient power for a speed of 2.5 miles per hour in open sea.*—Continued.

Section.	Area of wet section.	Type ship C. r_1.	Type ship C. Depression of water surface.	Type ship C. V.	Type ship C. v.	Type ship D. r_1.	Type ship D. Depression of water surface.	Type ship D. V.	Type ship D. v.
	Square feet.		*Feet.*	*Miles per hour.*	*Miles per hour.*		*Feet.*	*Miles per hour.*	*Miles per hour.*
Canal in rock, summit level excepted, Nicaragua	5,250	2.85	2.1	6.53	3.55	2.44	2.4	6.01	4.18
Canal in rock, west divide, Nicaragua	5,700	3.09	1.9	6.87	3.22	2.65	2.2	6.39	3.79
Canal in rock, Culebra cut, Panama	5,966	3.24	1.8	7.02	3.07	2.77	2.1	6.55	3.62
Canal in firm earth	7,189.5	3.93	1.5	7.32	2.70	3.34	1.8	6.94	3.21
Canal in sand or silt	8,925	4.84	1.2	7.95	2.24	4.15	1.4	7.61	2.63
Channel in Panama Bay	15,075	8.18	.7	9.03	1.27	7.01	.8	8.85	1.49
Channel in San Juan River, deepened	15,834	8.59	.7	9.06	1.25	7.36	.8	8.85	1.48
Channel in Lake Nicaragua, deepened	19,305	10.47	.6	9.30	1.04	8.98	.7	9.13	1.21
Harbors and entrances, 500 feet wide	21,175	11.49	.6	9.44	.94	9.85	.7	9.27	1.12

The speeds in the foregoing table are plotted on figure 2 as ordinates with values of r_1 as abscissas. Two curves appear, one for type A, the other for types B, C, and D. The curve for type A is an asymptote to a horizontal through $V=11.25$. The curve for types B, C, and D is asymptote to a horizontal through $V=10.625$. For the larger channels neither of these curves can be much in error. At the other extremity both curves must pass through the point where $V=0$ and $r_1=1$. Tests are needed at intermediate points, and particularly where the value of r_1 corresponds with the standard sections in earth. *Speeds plotted and curve drawn.*

All steamships are run under check while passing through the St. Clair Flats Canal where, on account of the crowded navigation, more than one hundred vessels passing per day, involving frequent meetings of ships in the canal, speeds are limited by regulations to 8 miles per hour. The estimated traffic through the isthmian canal is about ten ships per day, and the meetings can be provided for more judiciously by reducing the speed of both ships at meeting points, and in the narrower channels by tying up one of them. *Speed through St. Clair Flats Canal limited by regulations.*

Information has been sought regarding the amount of checking, measured by the revolutions of the engines, ordinarily made by ships passing the St. Clair Flats Canal. In open water, at moderate speeds, the speed of a ship varies almost directly with the number of revolutions; in other words, with moderate speeds, the percentage of slip of the propelling wheels is nearly constant. As the speed is increased beyond that suitable for the model of the ship, the slip increases, and at high speeds the increase in speed would be much less than the increase in the number of *Reduction of speed in St. Clair Flats Canal.*

revolutions. In a canal increase of slip becomes appreciable at a lower speed than in open water. If the number of revolutions were increased greatly the increase of speed would be materially less, but if, on the other hand, the number of revolutions were increased a small amount the increase in speed would be in corresponding proportion. Inquiries of shipowners and navigators elicited the statement that on approaching the canal the revolutions were reduced 20 to 25 per cent. With no more reduction than this it might be concluded, without serious error, that with the ordinary power of the engines the speed through the canal would be increased in like proportion. If this rule be applied to the average results given in Table II, assuming the reduction in revolution before entering the canal to have been 20 per cent, the speeds of 7.04, 7.25, 7.56, 8.83, and 6.72 miles observed would become 8.80, 9.06, 9.30, 11.04, and 8.40 if the full power of the engines were used. These are plotted in figure 2, in the points G, H, I, K, and L. The very low value of the observed speed in the last case is due to the fact that two of the three ships entering into this average were towing other ships, one having three, the other two. If the open-sea speed of these ships is less than 12½ miles per hour, which is probable, as few lake freighters equal it, and if allowance were made for this the points G, H, etc., would plot a little higher.

Observations on Lake Huron and in St. Clair Flats Canal.

The following observations have been taken on four ships for the purposes of this study. They were of the largest class now navigating the lakes:

1. The time and number of revolutions across Lake Huron. The distance being known, the speed and number of revolutions per minute become known.

2. While in the open lake the steam was throttled to the same extent as during the passage through the St. Clair Flats Canal. The number of revolutions were taken each minute for five minutes. It is assumed that the speed was reduced in proportion to the number of revolutions.

3. The time passing through the St. Clair Flats Canal was noted. The length of the canal being known, the speed in miles per hour can be calculated. The comparison of the speed under check in Lake Huron with the speed through the canal with the same steam pressure and valve opening furnishes the percentage of loss due to the special resistance in the canal. If the increase of speed with the engines developing full power were in the same proportion in the canal as in open sea the speed to be expected in the canal could be easily determined. The process used here is as follows:

Ship No. 1.—When running at full speed the rate was 11.24 miles per hour; number of revolutions per minute, 74.42. When running under check, with same steam opening as when passing through the canal, the number of revolutions was 56 per minute, and the speed would be $\frac{56}{74.42} \times 11.24 = 8.46$ miles per hour. In the canal the speed was 6.01 miles per hour. The loss of speed due to canal resistance is then $\frac{8.46-6.01}{8.46}=0.29$, or 29 per cent.

If the full power of the engines had been used with the same proportionate loss of speed on account of canal resistance the speed in the canal would have been 11.42 $(1-0.29)=7.98$ miles per hour.

If the power of the ship had been sufficient to propel it 12.5 miles per hour instead of 11.24, the canal speed with full power of engines and the same assumptions as to increase of speed would have been $12.5\times(1.00-0.29)=$ 8.88 miles. For this ship $r_1=8.50$. The speed is plotted at M, Plate II.

Ship No. 2.—Full speed in open lake, 11.51 miles per hour. Revolutions per minute at full speed, 71.43. Revolutions per minute in open lake while under check, 43. Speed in canal with same steam, 4.88 miles per hour. Following the same method as before, the calculated speed with full power of engines capable of moving the ship 12½ miles per hour in open sea would be 8.81 miles per hour. In this case $r_1=7.79$. The point is plotted at N.

Ship No. 3.—Full speed in open lake, 10.61 miles per hour. Revolutions per minute in open lake at full speed, 78.35. Revolutions per minute in open lake while under check, 59. Speed in canal with same steam, 6.75 miles per hour. Calculated speed in canal with full power of engines capable of moving the ship 12½ miles per hour in open lake, 10.56 miles per hour. In this case $r_1=7.68$. The point is plotted at V.

Ship No. 4.—Full speed in open lake, 13.13 miles per hour. Revolutions per minute in open lake at full speed, 84.79. Revolutions per minute in open lake while under check, 63.2. Speed in canal with same steam, 7.92 miles per hour. Calculated speed in canal with full power of engines capable of moving the ship 12½ miles per hour in open lake, 10.12 miles per hour. In this case $r_1=8.14$. The point is plotted at W.

There is considerable discrepancy in these results, two of the points (M and N) falling near the curve of calculated speeds, but a little below it, the other two falling considerably above it. Considerable variation would be produced by difference in ship models. The variations may also be due to inaccuracies in observations, particularly in regard to the exact steam opening while the engines were under check. The assumption that increase in number of revolutions will give the same proportion of increase in speed in a canal as in open sea is not exactly true, although the error will not be great, with the channel, increase of revolutions, and speed taken here. If the channel were smaller the error would be greater. Another consideration to be taken into account is the fact that the ships passing the St. Clair Flats Canal have more water under the keel than assumed for types B, C, and D in the standard earth sections. For the summit-level sections, however, the clearance will be about the same as in the St. Clair Flats Canal.

Information was obtained from the manager of one of the steamship lines giving for two ships the number of revolutions of the engines in open lakes and in the canal. It may be assumed, without great error, in these cases that the efficiency of the engines in producing speed was reduced in inverse proportion. The data and calculations are as follows:

Ship No. 5.—Revolutions per mile in open lake, 404; in canal, 530. Loss in efficiency of engines for producing speed$=1-\frac{404}{530}=23.8$ per cent. Calculated speed in canal with engines capable of moving the ship $12\frac{1}{2}$ miles per hour in open lake$=12\frac{1}{2}$ x $(1-.238)=9.52$ miles per hour. In this case $r_1=7.61$. The point is plotted at X.

Ship No. 6.—Revolutions per mile in open lake, 346; in canal, 457. Loss in efficiency of engines for producing speed $=1-\frac{346}{457}=24.3$ per cent. Calculated speed in canal with engines capable of moving the ship $12\frac{1}{2}$ miles per hour in open lake $=12\frac{1}{2}\times(1-.243)=9.46$ miles per hour. In this case $r_1=9.42$. The point is plotted at Y.

These points fall near the curve for type A. These calculations are also based on the assumption that speed would vary directly as the number of revolutions, both in open lake and in the canal, which, as above stated, is somewhat in error.

Calculated speeds may be too high.

These data, taken collectively, appear to confirm the calculated speeds in the part of the curve near M and N; but the data being inexact and the basis of the calculations involving some error, it seems to be judicious to adopt for the present discussion a little lower speeds in the vicinity of these points. To the right of these points the possible error is less, the speeds being definitely known for wide shoal water. To the left of the given points the data are not so good and the possibility of material error is greater. The St. Clair Flats Canal is the only one in the United States traversed at speed by deep-draft ships, but the channel is so wide (296 feet) and the value of r_1 so great that the observations do not apply directly when r_1 is less than 7.5. In the canal sections of the isthmian waterway, the value of r_1 will vary for the type ships from 7.59 to 2.44. (See Table III.) Systematic observations on such channels with large ships are much needed.

Observations at Suez Canal.

The best opportunities for such observations would be afforded at the Suez Canal, for at this waterway are found a channel of moderate cross section and a heavy traffic with large ships. Only two observations made there are available. The first one is reported by Sir Charles Hartley (Minutes of Proceedings, Inst. C. E., vol. 141, p. 169), who cites the case of the steamship *Austral* on a passage made in 1885.

> On the straight reaches of the canal, between Lake Timsah and Suez, the ship only made 5 knots an hour with 43 revolutions of her screw. Whereas, in the open sea, with the same number of revolutions, she made 11 knots.

There was a tide of half a knot per hour in her favor in the canal. The speed of 11 knots per hour is almost identical with that assumed for the type ships. Deducting from the observed speed for the tidal current, the corrected speed in the canal would be 4.5 knots or 5.17 statute miles per hour. If this speed was observed between Lake Timsah and the Bitter Lakes, the value of r_1 would be 2.95. The point thus determined is platted at P in figure 2. If the speed was noted on the larger section between the Bitter Lakes and Suez, r_1 would be 3.25, and the point thus determined is platted at Q. The clearance under the keel of the *Austral* was less than assumed for the type ships in the isthmian canal. The reduction of speed was therefore somewhat greater than would be sustained by the latter. The second observation at Suez is reported by Mr. Lionel B. Wells (M. P. I. C. E., vol. 141, p. 208) as follows: In 1898 he had visited the Suez and traveled along the canal thence to Imailia. The passage occupied from 5.30 p. m. until 11.45 p. m., the average speed, irrespective of stoppages, being therefore more than 6 knots per hour. The steamship was 320 feet long, 39 feet wide, and drew about 21 feet, her gross tonnage being 2,260 tons; he was told that 11 knots was good speed at sea. In the canal 8 knots per hour were made at times, for the regulation as to maximum speed (5.33 knots per hour) was disregarded. The tide was against the ship, but the velocity of current is not stated. There is the same uncertainty here as in Hartley's observations as to the section of the canal where the speed of 8 knots was observed. The enlargement of the canal to the dimensions reported in 1899 is supposed to have been completed. The points for the two sections are platted at R and S in figure 2 without allowance for the opposing current. The ship had nearly the same clearance under the keel as type A will have in the isthmian canal. The observation is therefore applicable to that type, and the points are found to fall near its attainable speed curve.

Observations at Kiel Canal.

Referring to the Kaiser Wilhelm (Kiel) Canal, the chief constructing engineer, Mr. Fülscher, states (M. P. I. C. E., vol. 141, p. 207):

> Vessels capable of making 16 knots per hour in the open sea and having an immersed midship section of about 1,400 square feet only made between 5 and 6 knots per hour for the same expenditure of power when passing through that canal, which had a cross-sectional water area of 4,520 square feet. * * * Vessels having an immersed midship section of between 645 and 753 square feet, being about one-sixth of the cross-sectional water area, traversed the canal without undue expenditure of power and without causing objectionable waves at a speed of about 6½ knots per hour.

The speed for the ship of 1,400 square feet section is platted at T, and for the smaller ship last mentioned at U, fig. 2.

The foregoing data from the Suez and Kiel canals indicate that for values of r_1 considerably less than 7, the calculated speeds for types B, C, and D are too high. The material reduction of speed when the ship's keel is near the channel bed has been taken into account in the preceding pages. An analogous reduction of speed must be incurred when the ship's sides approach the sides of the channel, and this may not have been fully measured by the allowances made for backward current and depression of water surface. A new curve for these types is therefore drawn which, will coincide with the so-called "calculated attainable speed curve" in very wide shoal water, would pass a little below G, H, I, M, and N, where the calculated speeds are certainly not much in error, and thence to the left, where the data are less definite, deviates more widely, passing below T and a little above P and Q. It is deemed proper to give greater weight to G, N, and M than to U. The new curve is marked "Type ships B, C, and D. Final curve for attainable speeds."

The calculated curve for type A is well supported for values r_1 of 7 to 8 by Mr. Wells's observation in the Suez Canal. It is deemed judicious, however, to draw a new curve for this type also, with corresponding reduction of speed, because the data applicable are not quite so full.

The final curve for types B, C, and D may be further tested by the St. Clair observations. Referring to the group of four ships in Table II having r_1 between 11 and 12, the record shows that all of them had speeds of more than 8 miles per hour, the mean being 8.83. It may be accepted as certain that these ships ran under check and that their average sea speed is less than 12½ miles per hour. The observed speed in the canal is platted at O in figure 2 and falls but little below the final curve; that is to say, the speed by the curve was nearly equaled by ships of less average power than assumed running under check. The ships of this group are not remarkable in any way. They are medium-sized freight ships and it happened that they were checked less while passing the canal than the other groups.

Speed limit fixed by backward currents.

In the smaller channels, where formed in earth, the attainable speeds are not permissible because of the injurious results to the canal banks. This injury is caused mainly by wave wash, but to some extent by backward currents. While the waves produced by the passage of a ship are not directly proportional to the backward current, there seems to be no better way of fixing a speed limit than by reference to the current. In the Suez Canal speeds are permitted which produce backward currents exceeding 4 feet per second. In the Amsterdam Canal the largest ships are limited to speeds causing a backward current of about 2.3 feet per second. In both cases the banks are of sandy material, easily moved. In the Manchester Canal the largest ships are permitted a speed of 6 miles per hour, causing a backward current of 3.3 feet per second. These currents, it should be said, are calculated from the approximate formula $v = \frac{V}{r_1 - 1}$, in which

v is the velocity of back current, V the speed of the ship, and r_1 the quotient obtained by dividing the wet cross section of the canal by the ship's midship section. The actual velocities are a little greater, and in the Suez and Manchester canals they are further augmented by tidal currents. Tides and floods will cause currents in the Isthmian Canal, augmenting the calculated backward current, which, it is assumed for this discussion, should not exceed 3 feet per second, or 2.05 miles per hour. The resulting limiting speeds are shown in figure 2. It will be noted that this line replaces that part of the final speed curve concerning which any question could plausibly be raised.

Finally, speeds are to be read from the diagram, as follows:

Type.	Earth channels, from line—	Rock channels, from line—
Ship A	a d e	g d e
Ships B, C, D	a b c	f b c

Reduction of speed on curves.

If the width of the channel were not increased on curves and the speed of the ship were not reduced, the difficulty of steering and the risks to ships would be greater than on tangents. The projects for the isthmian canal provide for a widening on curves which varies inversely with the radius of curvature, and possibly this may fully compensate. It is believed, however, that a reduction of speed would be made on approaching any curve. If practicable so to make it, such a reduction might vary directly with the degree of curvature and inversely with the width, but a schedule thus made would be too complex for practical use. Since the curves on the Panama route are generally of larger radius than on the Nicaragua route, the reduction of speed need not be so great. A reduction of speed of 20 per cent in the narrow sections of the Nicaragua route, and of 15 per cent in the narrow sections of the Panama route would seem to be sufficient. In the San Juan River and the harbor entrances, where the width is greater but the curvature sharp, the reduction may be taken 15 per cent; in Lake Nicaragua and Panama Bay, where the curvature is slight, the reduction may be 10 per cent.

TABLE IV.—*Schedule of speeds proposed as a basis for calculating the time of transit through the Panama and Nicaragua canals.*

[Speeds in statute miles per hour.]

	Tangents or curves.	Type A.	Type B.	Type C.	Type D.
Rock cuts:					
East and west of summit level, Nicaragua	Tangents	7.5	6.0	5.0	4.5
	Curves	6.0	5.0	4.0	3.5
West divide, Nicaragua	Tangents	7.5	6.0	5.5	4.5
	Curves	6.0	5.0	5.0	4.0
Culebra cut, Panama	Tangents	8.0	6.5	5.5	5.0
	Curves	6.5	5.5	4.5	4.0
Canal section in firm earth	Tangents	8.0	7.0	6.0	4.5
	Curves [a]	7.0	6.0	5.0	4.0
	Curves [b]	6.5	5.5	4.5	3.5
Canal section in sand and silt	Tangents	8.5	7.5	7.0	6.0
	Curves [a]	7.0	6.5	6.0	5.0
	Curves [b]	6.5	6.0	5.5	5.0
Channel in Panama Bay	Tangents	9.5	8.5	8.5	8.0
	Curves	8.5	8.0	7.5	7.5
San Juan River, where deepened	Tangents	9.5	8.5	8.5	8.0
	Curves	8.0	7.5	7.0	7.0
Lake Nicaragua, where deepened	Tangents	10.0	9.0	8.5	8.5
	Curves	9.0	8.0	7.5	7.5
Lake Bohio	Tangents	10.0	10.0	10.0	9.5
	Curves	9.0	9.0	9.0	8.5
San Juan River, where not deepened	Tangents	10.0	9.5	9.0	9.0
	Curves	8.5	8.0	7.5	7.5
Lake Nicaragua, where not deepened.		12.5	12.5	12.5	12.5
Harbor and harbor entrances	Tangents	10.0	9.0	9.0	8.5
	Curves	8.5	7.5	7.5	7.0

[a] Panama. [b] Nicaragua.

The foregoing schedule applied to the two routes gives the times of transit across the Isthmus shown in Tables V and VI, but without allowance for delays at meeting points and at locks.

TABLE V.—*Time of transit through the Panama Canal without allowance for meetings or lockages.*

	Tangents or curves.	Distance.	Type A.	Type B.	Type C.	Type D.
		Stat. miles.	*Hours.*	*Hours.*	*Hours.*	*Hours.*
Canal section:						
Firm earth	Tangents	10.76	1.35	1.54	1.80	2.39
	Curves	6.85	.98	1.14	1.37	1.71
Sand and silt	Tangents	3.48	.41	.46	.50	.58
	Curves	2.50	.36	.38	.42	.50
Culebra cut	Tangents	3.00	.37	.46	.55	.60
	Curves	3.02	.46	.55	.67	.75
Channel in Panama Bay	Tangents	3.90	.41	.46	.46	.49
	Curves	.51	.06	.07	.07	.07
Colon Harbor and entrance	Tangents	.39	.04	.04	.04	.05
	Curves	2.00	.24	.27	.27	.29
Lake Bohio	Tangents	6.18	.62	.62	.62	.65
	Curves	6.50	.72	.72	.72	.76
Total		49.09	6.02	6.71	7.49	8.84

TABLE VI.—*Time of transit through the Nicaragua Canal without allowance for meetings or lockages.*

	Tangents or curves.	Distance.	Type A.	Type B.	Type C.	Type D.
		Stat. miles.	*Hours.*	*Hours.*	*Hours.*	*Hours.*
Canal section:						
Firm earth	Tangents	17.99	2.25	2.57	3.00	4.00
	Curves	10.45	1.61	1.90	2.32	2.99
Sand or silt	Tangents	19.93	2.34	2.66	2.85	3.32
	Curves	8.39	1.29	1.40	1.53	1.68
Rock, West divide	Tangents	4.79	.64	.80	.87	1.06
	Curves	3.89	.65	.78	.78	.97
Rock, exclusive of West divide	Tangents	2.94	.39	.49	.59	.65
	Curves	2.32	.39	.46	.58	.66
San Juan River:						
Where deepened	Tangents	12.58	1.32	1.48	1.48	1.57
	Curves	13.77	1.72	1.84	1.97	1.97
Not deepened	Tangents	5.15	.52	.54	.57	.57
	Curves	7.86	.92	.98	1.05	1.05
Lake Nicaragua:						
Where deepened	Tangents	26.69	2.67	2.97	3.14	3.14
	Curves	1.56	.17	.19	.21	.21
Not deepened		42.27	3.38	3.38	3.38	3.38
Harbors and entrances	Tangents	2.04	.20	.23	.23	.24
	Curves	1.04	.12	.14	.14	.15
Total		183.66	20.58	22.81	24.69	27.61

To obtain the full time of transit the time consumed by lockage and the delays at meeting points are to be added.

Time consumed by lockage.

The time required for lockage is here taken to be the delay caused by a lockage. It is the period beginning when the ship begins to slacken speed on approaching a lock and ending when it has acquired full speed after leaving it, less the time that is required to pass over the same distance at full canal speed. The delay while waiting for the locking of another ship will be considered further on.

The channel in the vicinity of the lock is taken to be of standard canal section in firm earth. While this is not true in every case, the resulting error is not material. The approaching ship must reduce speed and be under perfect control while yet at a considerable distance from the lock. Its movements while approaching, passing, and leaving the lock are supposed to be as follows:

1. The speed of the approaching ship is to be reduced to 1.7 miles per hour (150 feet per minute) at a point 700 feet distant from the lock-gate quoin. This reduction of speed is to be made at the rate of 1 mile per hour while moving 500 feet.

Observations on a large number of lake freight ships show that when the engines are stopped the speed is reduced at an average rate of 1 mile per hour while moving less than 400 feet. (See report U. S. Board of Engineers on Deep Waterways.) A like increase of speed occurs when the engines are again started.

2. The ship is to continue at the speed of 1.7 miles per hour until its stern is within 150 feet of the lock-gate quoin (200 feet, if moving down stream) and then is to come to a stop in the next 200 feet and during two and two-thirds minutes, backing the wheel if necessary.

Observations on 35 ships entering the lock of the St. Marys Falls Canal show that a stop from a speed of 125 feet per minute is made in 100 feet and in 1.4 minutes.

3. The time required to open or close a pair of lock gates is taken at two minutes.

At the Ymuiden lock, on the Amsterdam Canal, the observed time was one and one-third minutes.

4. The time required for filling and emptying the several locks is given in the following table, VII. (See Appendix A for details of calculation.)

TABLE VII.—*Time required for filling and emptying locks.*

	Filling.		Emptying.	
Panama route.	*Min.*	*Sec.*	*Min.*	*Sec.*
Lower lock at Bohio	13	7	16	19
Upper lock at Bohio	16	19	13	7
Upper lock at Pedro Miguel	13	14	10	39
Lower lock at Pedro Miguel	10	39	13	14
Miraflores lock	13	24	13	24
Nicaragua route.				
Lock No. 1	14	56	14	56
Lock No. 2	10	42	10	42
Lock No. 3	10	42	10	42
Lock No. 4	14	43	14	43
Lock No. 5	12	49	12	49
Lock No. 6	13	17	13	17
Lock No. 7	13	17	13	17
Lock No. 8	12	18	12	18

5. A ship leaving the lock is to acquire a speed of 1.7 miles per hour while moving 300 feet, requiring four minutes, and is then to gain speed at the rate of 1 mile per hour while moving 500 feet, until full canal speed is attained.

Observations of 30 ships leaving the lock of the St. Marys Falls Canal gave as mean results an acquired speed of 1.7 miles per hour while moving 200 feet in two and one-third minutes, and then an increase of speed of 1 mile per hour while moving 360 feet. The observations extended only until a speed of 3 miles per hour was attained.

These rules applied to the Bohio locks result in the time interval given in the next table:

TABLE VIII.—*Time required to pass Bohio locks.*

[In minutes.]

	Type A.	Type B.	Type C.	Type D.
Reducing speed to 1.7 miles per hour	8.8	8.0	7.2	5.5
Moving at 1.7 miles per hour until stern is 175 feet from lock-gate quoin	6.2	6.2	7.1	7.8
Coming to full stop in first lock	2.7	2.7	2.7	2.7
Closing lock gates	2.0	2.0	2.0	2.0
Filling (or emptying) first lock	13.1	13.1	13.1	13.1
Opening second gates	2.0	2.0	2.0	2.0
Moving into second lock:				
Attaining speed of 1.7 miles per hour	4.0	4.0	4.0	4.0
Proceeding at this speed 300 feet	2.0	2.0	2.0	2.0
Coming to full stop in second lock	2.7	2.7	2.7	2.7
Closing second gates	2.0	2.0	2.0	2.0
Filling (or emptying) second lock	16.3	16.3	16.3	16.3
Opening third gates	2.0	2.0	2.0	2.0
Moving out of lock and attaining full speed:				
Attaining speed of 1.7 miles per hour	4.0	4.0	4.0	4.0
Increasing to full canal speed	8.8	8.0	7.2	5.5
	76.6	75.0	74.3	71.6
Time required to traverse this distance at full canal speed ... minutes	12.6	12.8	13.0	13.6
Time lost at locks ... do	64.0	62.2	61.3	58.0
Distance traversed ... feet	8,886	7,886	6,886	5,386

These are the net delays if all movements are made without loss of time. In practice this would not be possible. In 1894 the lock at the St. Marys Falls Canal was worked nearly to its full capacity, and the tonnage through it was about 0.62 of the theoretical capacity of the lock. Probably ships were awaiting lockage 90 to 95 per cent of the time. If this is correct, about 50 per cent should be added to the calculated time of lockage to obtain the time used in actual work. This allowance is adopted for the present discussion. The resulting time lost by lockages is given for the two routes in Tables IX and X.

TABLE IX.—*Time lost by lockages on the Panama route.*

	Type A.	Type B.	Type C.	Type D.
Bohio locks ....minutes..	64.0	62.2	61.3	58.0
Pedro Miguel locks ....do....	58.5	56.7	55.8	52.5
Miraflores lock ....do....	36.4	34.8	34.1	31.3
Total ....minutes..	158.9	153.7	151.2	141.8
Total ....hours	2.65	2.56	2.52	2.36
Add 50 per cent for sundry delays	1.32	1.28	1.26	1.18
Total delays for lockages..........hours..	3.97	3.84	3.78	3.54

TABLE X.—*Time lost by lockages on the Nicaragua route.*

	Type A.	Type B.	Type C.	Type D.
Atlantic slope:				
Lock No. 1 ....minutes..	37.9	36.3	35.6	32.8
Lock No. 2 ....do....	33.7	32.1	31.4	28.6
Lock No. 3 ....do....	33.7	32.1	31.4	28.6
Lock No. 4 ....do....	37.7	36.1	35.4	32.6
Pacific slope:				
Lock No. 5 ....do....	35.8	34.2	33.5	30.7
Lock No. 6 ....do....	36.3	34.7	34.0	31.2
Lock No. 7 ....do....	36.3	34.7	34.0	31.2
Lock No. 8 ....do....	35.3	33.7	33.0	30.2
Total ....minutes..	286.7	273.9	268.3	245.9
Total ....hours	4.78	4.57	4.47	4.10
Add 50 per cent for sundry delays	2.39	2.28	2.23	2.05
Total delay for lockages..........hours..	7.17	6.85	6.70	6.15

Delays at meeting points.

Meetings occurring in the excavated channels will cause delay. No allowance need be made for meetings in deep water in Lake Nicaragua, Lake Bohio, or the San Juan River. Meetings may also occur at locks.

Meetings in channels.

It is obvious that if two ships of type D meet in the regular canal section one must tie up while the other passes at reduced speed. Ships of type A could meet anywhere, but one would probably tie up while the speed of the other would be reduced. In channels 200 to 300 feet wide it is not likely that either ship would tie up, but both would reduce speed.

Since a ship of any type may meet another of any type, a vast number of possible cases will arise. It is not practicable to investigate each on a different basis, and the same rules will be assumed to apply to all. These rules are as follows:

1. In the section of 150 feet bottom width, passing places are assumed to be 5 miles apart where all meetings must occur. One of the two ships about to meet will tie up at the passing place and await the other. As an average, the waiting ship will arrive at the passing place, while the other is $2\frac{1}{2}$ miles distant. It will be assumed that the moving ship passes the waiting ship at half speed, maintaining the minimum speed for an average distance of 2,000 feet. The rates of reduction and increase of speed are taken the same as for the calculations of delays at locks. The delay to each of the two ships is calculated and the mean taken. In order to simplify the calculations it is assumed that the approaching ships are moving before reducing speed at the rates scheduled in Table IV for canal section in firm earth on tangents.

2. In the channels 200 to 300 feet wide neither ship will stop, but both will reduce speed to 4 miles per hour, maintaining this rate for an average distance of 2,000 feet. In order to simplify the problem the reductions will be calculated from the speeds scheduled in Table IV for tangents in the San Juan River where deepened.

Meetings in narrow canal sections.

The delay caused by a meeting in the canal section is shøwn in Table XI.

TABLE XI.—*Delay at meeting points in canal section 150 feet wide at bottom.*

[In minutes.]

	Type A.	Type B.	Type C.	Type D.
Delay to waiting ship:				
Elapsed time while reducing speed to 1.7 miles per hour	8.8	8.0	7.2	5.5
Elapsed time from speed of 1.7 miles per hour to full stop	2.7	2.7	2.7	2.7
Elapsed time waiting for meeting ship to run $2\frac{1}{2}$ miles	21.2	23.4	26.3	36.2
Elapsed time to attain speed of 1.7 miles per hour	4.0	4.0	4.0	4.0
Elapsed time to attain full canal speed	8.8	8.0	7.2	5.5
Total elapsed time	45.5	46.1	47.4	53.9
Total distance traversed ... feet	6,800	5,800	4,800	3,300
Time required to move this distance at full canal speed	9.7	9.4	9.1	8.9
Delay to waiting ship	35.8	36.7	38.3	45.0
Delay to moving ship:				
Elapsed time while reducing speed to half speed	3.9	3.9	3.9	3.9
Elapsed time while running 2,000 feet at half speed	5.6	6.5	7.6	10.1
Elapsed time while regaining full canal speed	3.9	3.9	3.9	3.9
Total elapsed time	13.4	14.3	15.4	17.9
Total distance traversed at reduced speed ... feet	6,000	5,500	5,000	4,250
Time required to move this distance at full canal speed	8.5	8.9	9.4	10.7
Delay to moving ship	4.9	5.4	6.0	7.2
Total delay for both ships	40.7	42.1	44.3	52.2
Mean delay for both ships ... minutes	20.3	21.1	22.1	26.1
Mean delay for both ships ... hours	.34	.35	.37	.43

Assuming that a mean of five ships enter the canal each way per day, each ship will meet one going in the opposite direction every two and four-tenths hours as an average. The number of meetings in the canal sections will be the quotient arising from dividing the total number of hours required to traverse them by 2.4.

Let T = time required to traverse the canal sections of the route without meetings, in hours.
n = number of meetings.
t = time lost at each meeting, in hours.
Then $T+nt$ = total time in canal sections.

$$n=\frac{T+nt}{2.4}=\frac{T}{2.4-t} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

T is obtained in Tables V and VI; t from table XI. Applying the formula there results the number of meetings and the delays given in Tables XII and XIII.

TABLE XII.—*Number of meetings for each ship in the canal sections of the Panama route and delays therefrom.*

	Type A.	Type B.	Type C.	Type D.
Number of hours traversing sections of 150 feet, bottom width, excluding meetings	3.93	4.53	5.31	6.53
Average number of meetings	1.91	2.21	2.62	3.31
Delay in transit ..... hours	.65	.77	.97	1.42

TABLE XIII.—*Number of meetings for each ship in the canal sections of the Nicaragua route and delays therefrom.*

	Type A.	Type B.	Type C.	Type D.
Number of hours traversing sections of 150 feet, bottom width, excluding meetings	9.56	11.06	12.52	15.32
Average number of meetings	4.64	5.40	6.17	7.78
Delay in transit ..... hours	1.58	1.89	2.28	3.35

The delays to a ship in transit on account of meetings in the wide channels is calculated in the same manner as for the canal sections.

TABLE XIV.—*Delay at a meeting point in the channel in San Juan River, Lake Nicaragua, or Panama Bay.*

[In minutes.]

	Type A.	Type B.	Type C.	Type D.
Elapsed time while reducing speed to 4 miles per hour	3.9	3.2	2.3	0.7
Elapsed time while running 2,000 feet at 4 miles per hour	5.6	5.6	5.6	5.6
Elapsed time while regaining speed	3.9	3.2	2.3	.7
Total elapsed time ..... minutes	13.4	12.0	10.2	7.0
Total distance traversed ..... feet	6,000	5,000	4,000	2,500
Time required to traverse this distance at full allowed speed ..... minutes	8.5	8.1	7.6	6.4
Delay to ship ..... minutes	4.9	3.9	2.6	.6
Delay to ship ..... hours	.08	.07	.04	.01

TABLE XV.—*Number of meetings for each ship in the channel excavated in Panama Bay and delays therefrom.*

	Type A.	Type B.	Type C.	Type D.
Number of hours traversing channel	0.47	0.53	0.53	0.56
Average number of meetings	.20	.23	.23	.24
Delays in transit ... hours	.02	.02	.01	.00

TABLE XVI.—*Number of meetings for each ship in the channel excavated in the San Juan River and Lake Nicaragua.*

	Type A.	Type B.	Type C.	Type D.
Number of hours traversing channel	5.84	6.43	6.75	6.84
Average number of meetings	2.50	2.76	2.86	2.87
Delays in transit ... hours	.20	.19	.11	.03

Meetings at locks.

It is not likely that a full working force will be provided for both sets of locks, the duplicate locks being provided to enable repairs to be made to either separately without closing the canal to navigation and as insurance against delay to navigation in case of accident to either lock. It is assumed, however, that both sets will be in use, when in order. If a ship should arrive while another is being locked it will have to wait until the other is out of the way, or until some of the working force can be spared to attend to it. Except at the initial locks, ships following each other will be spaced by previous lockages, and so will delay each other but little. Meetings, however, are as likely to occur at locks as anywhere else in proportion to the time consumed there. If the second ship arriving were obliged to wait until the first one was entirely clear of the lock and approach, the average delay when one occurred would be one-half the time required for a lockage (not the time lost by lockage). Only one of two meeting ships would suffer this delay and the average loss of time to each ship would be one-fourth the time required for a lockage. In practice, however, the delay would probably be a little less because, after the first ship has been tied up in the lock, a part of the force could be spared to begin operating the duplicate lock. The time thus saved would provide for all delays to ships following each other. The full allowance will therefore be made here for meeting ships and none for following ships. The number of meetings is the total delay for lockages as obtained from Tables IX and X, by applying formula (7). The time required for passing the locks is the calculated time plus the allowance of 50 per cent for sundry delays. The time lost by a meeting at the Bohio locks is estimated as shown in Table XVII.

Average delay to each ship.

TABLE XVII.—*Delay caused by a meeting at Bohio locks.*

[Interval between arrival of ship at a point 700 feet from the lock-gate quoin and the point when in leaving the lock it has attained a speed of 1.7 miles per hour. This is taken to be the maximum delay which a second ship would meet. Data from Table VIII.]

[In minutes.]

	Type A.	Type B.	Type C.	Type D.
Moving at 1.7 miles per hour until stern is 175 feet from lock-gate quoin	6.2	6.2	7.1	7.8
Coming to full stop in lock	2.7	2.7	2.7	2.7
Closing lock gates	2.0	2.0	2.0	2.0
Filling (or emptying) first lock	13.1	13.1	13.1	13.1
Opening second gates	2.0	2.0	2.0	2.0
Moving into second lock	8.7	8.7	8.7	8.7
Closing second gates	2.0	2.0	2.0	2.0
Filling (or emptying) lock	16.3	16.3	16.3	16.3
Opening third gates	2.0	2.0	2.0	2.0
Attaining speed of 1.7 miles per hour	4.0	4.0	4.0	4.0
Maximum delay to waiting ships	59.0	59.0	59.9	60.6
Average delay to waiting ships	30.0	30.0	30.0	30.0
Average delay to both meeting ships	15.0	15.0	15.0	15.0
Average delay with 50 per cent added	22.0	22.0	23.0	23.0

From the foregoing table the average delay to all ships at the Bohio flight of two locks would be fifteen minutes. In a similar way the average delay at other locks is calculated, with the following results:

TABLE XVIII.—*Delays caused by meetings at each of the locks or flights of the Panama route.*

[In minutes.]

	Type A.	Type B.	Type C.	Type D.
At Bohio locks	15.0	15.0	15.0	15.0
At Pedro Miguel locks	13.0	13.0	14.0	14.0
At Miraflores lock	8.0	8.0	8.0	8.0
Total	36.0	36.0	37.0	37.0
Mean {minutes	12.0	12.0	12.0	12.0
Mean {hours	.2	.2	.2	.2
Mean, with 50 per cent added ... hours	.3	.3	.3	.3

TABLE XIX.—*Delays at meetings at each of the locks of the Nicaragua route.*

[In minutes.]

	Type A.	Type B.	Type C.	Type D.
At Lock No. 1	8.0	8.0	8.0	8.0
At Lock No. 2	7.0	7.0	7.0	7.0
At Lock No. 3	7.0	7.0	7.0	7.0
At Lock No. 4	8.0	8.0	8.0	8.0
At Lock No. 5	7.0	7.0	8.0	8.0
At Lock No. 6	8.0	8.0	8.0	8.0
At Lock No. 7	8.0	8.0	8.0	8.0
At Lock No. 8	7.0	7.0	8.0	8.0
Totals	60.0	60.0	62.0	62.0
Mean {minutes	7.5	7.5	7.8	7.8
Mean {hours	.12	.12	.13	.13
Mean with 50 per cent added ... hours	.18	.18	.19	.19

These delays for each meeting multiplied by the number of meetings give the following tables, XX and XXI:

TABLE XX.—*Number of delays while awaiting lockage on the Panama route and delays therefrom.*

	Type A.	Type B.	Type C.	Type D.
Number of delays per transit	1.89	1.83	1.80	1.69
Time of each delay ... hours	.30	.30	.30	.30
Total delay	.57	.55	.54	.51

TABLE XXI.—*Number of delays while awaiting lockage on the Nicaragua route, and delays therefrom.*

	Type A.	Type B.	Type C.	Type D.
Number of delays per transit	3.23	3.09	3.02	2.78
Time of each delay ... hours	.18	.18	.19	.19
Total delay	.58	.56	.57	.53

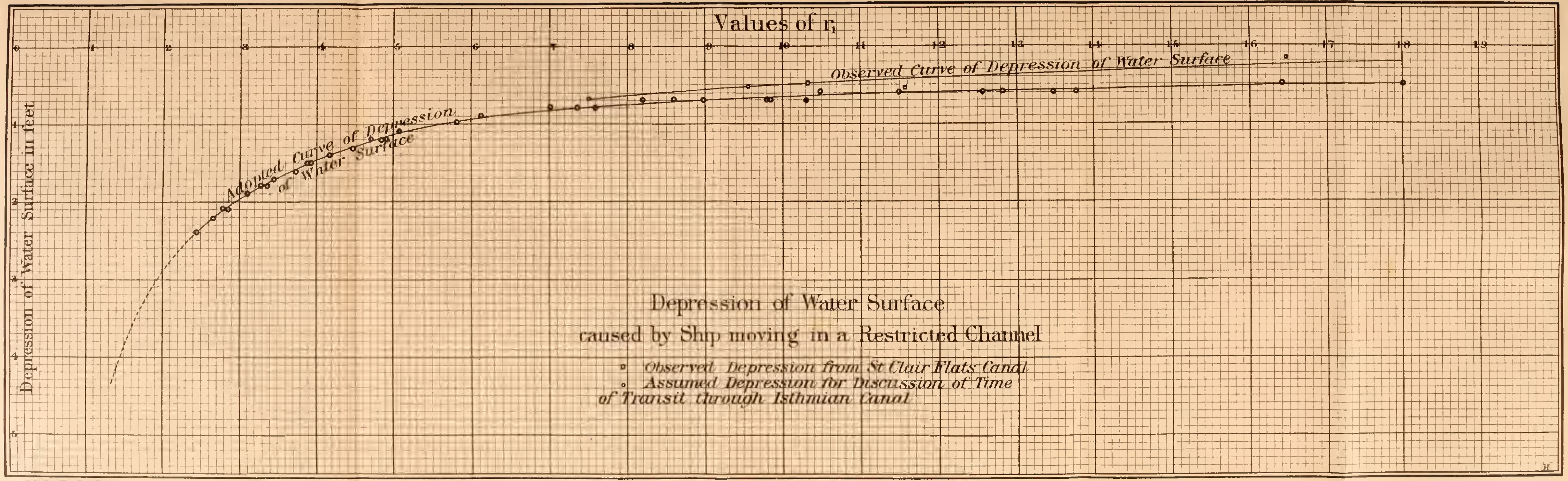
The several time intervals are summed up in the following table, giving the total time of transit by each route:

TABLE XXII.—*Time of transit across isthmus.*

[In hours.]

	Type A.	Type B.	Type C.	Type D.
Panama route.				
Time without allowance for lockage or meetings	6.02	6.71	7.49	8.80
Lockages	3.97	3.84	3.78	3.54
Meetings in canal section	.65	.77	.97	1.42
Meetings in channel in Panama Bay	.02	.02	.01	.00
Meetings at locks	.57	.55	.54	.51
Total time of transit	11.23	11.89	12.79	14.27
Nicaragua route.				
Time without allowance for lockage or meetings	20.58	22.81	24.69	27.61
Lockages	7.17	6.85	6.70	6.15
Meetings in canal sections	1.58	1.89	2.28	3.35
Meetings in channels in San Juan River and Lake Nicaragua	.20	.19	.11	.03
Meetings at locks	.58	.56	.57	.53
Total time of transit	30.11	32.30	34.35	37.67

These estimates are for ships having a sea speed of 12½ statute miles per hour. It is assumed that passing places, where ships can tie up, will be provided at intervals of 5 miles in all canal sections, and that the route will be so efficiently lighted, either by fixed lights along the route or by lights carried by the ships, or by both, as experience may indicate that navigation may be continued by night as well as by day. Should the ships be powered for a less sea speed the time of transit will not be increased in simple inverse proportion, nor could the time of transit be much reduced if the sea speed were considerably greater. If no provisions be made for passing places, or if the lighting be inadequate, the estimates do not apply.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1
2
3
4
5
6
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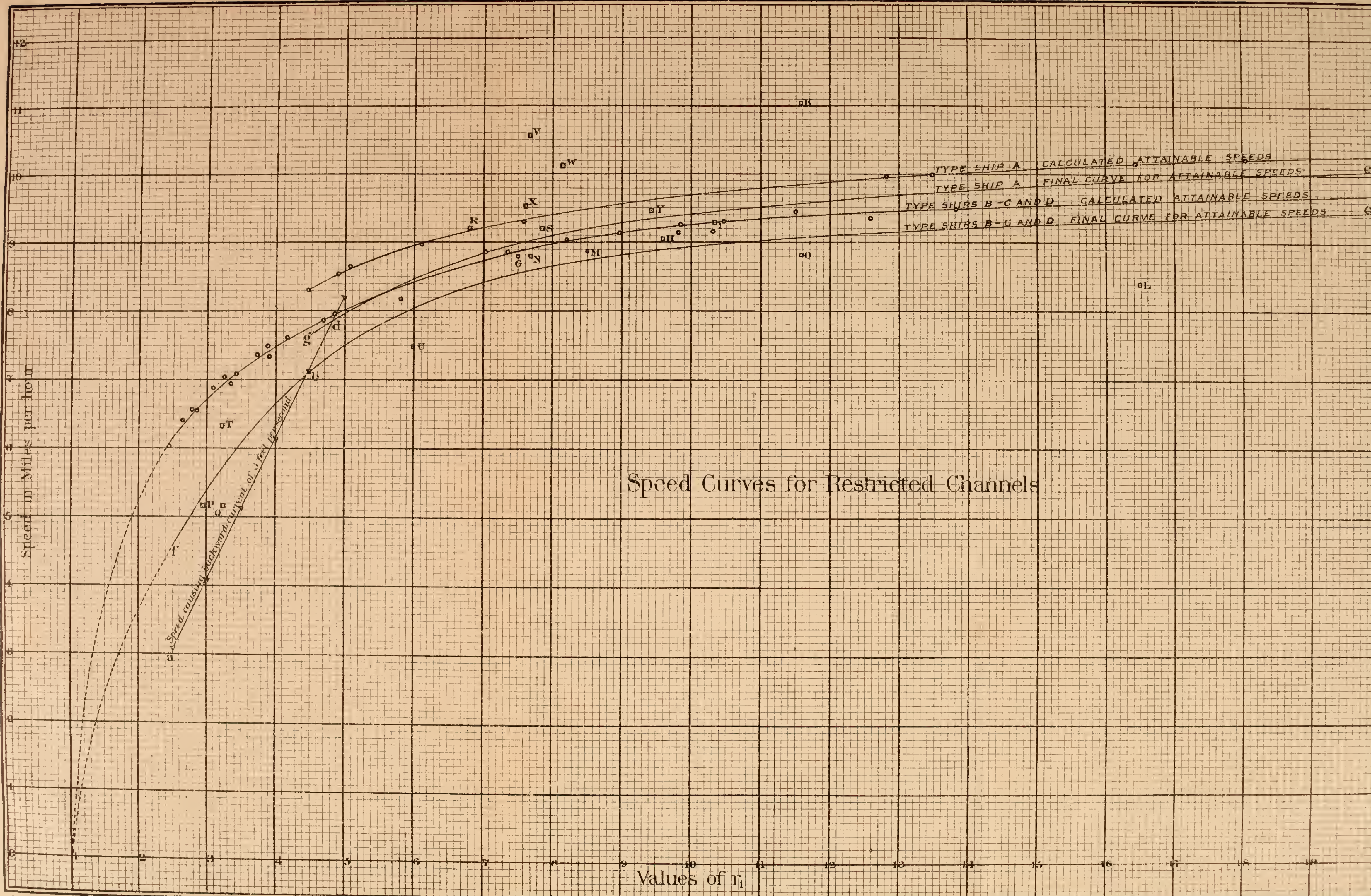
8
9
10
11
12
13
14
15
16
17
18
19
Depression of Water Surface in feet
Observed Curve of Depression of Water Surface
Adopted Curve of Depression of Water Surface
Depression of Water Surface
caused by Ship moving in a Restricted Channel
Observed Depression from St Clair Flats Canal
Assumed Depression for Discussion of Time of Transit through Isthmian Canal



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Appendix H.

DISCHARGE OF THE CANALIZED SAN JUAN RIVER.

The San Juan River flows with very little fall through a flat, swampy valley until the tributary, Rio Sabalos, is reached, about 26 miles from the lake. Within the next 18 miles, to the mouth of the Rio Machuca, the river descends the Toro, Castillo, and Machuca rapids, as well as several smaller ones. In the first 26 miles of its course the fall, at mean stages, is only about 4 feet, but in the next 18 miles the fall is about 45 feet. From the Rio Machuca to the mouth of the San Carlos, a distance of about 13 miles, the fall is very slight.

If the dam is built at Conchuda the water will be raised over the whole length of the river from that point to the lake, entirely drowning all the rapids and adding about 50 feet to the depth of the lower portion of the river, but only 4 or 5 to the upper portion. Therefore, when the canalized river is discharging, the condition of nature will be reversed and nearly all the slope will be found in the upper portion, where the cross section is changed but little. In the lower portion, where the cross section is increased from ten to twenty times, the slope will be very slight.

It is known from actual observations what the concurrent elevations of lake surface and discharges have been during the season of observation. It is also approximately known from rainfall and other observations in the drainage basin of the lake what discharges must be expected if the variation of the lake surface is to be regulated within the desired limits. In this investigation of the discharge of the San Juan River the problem has been so treated as to determine the hydraulic mean radius, the coefficient of roughness, and the slope for assumed discharges of 20,000, 30,000, 40,000, 50,000, 60,000, and 70,000 cubic feet per second for each elevation of lake surface 104, 106, 108, 110, and 112. In order to attain these ends the well-known Chezy's form of formula for mean velocity of discharge, with Kutter's coefficient, has been used. The following is its form:

$$v = \frac{\frac{1.811}{n} + 41.65 + \frac{.00281}{s}}{1 + \frac{n}{\sqrt{r}}\left(41.65 + \frac{.00281}{s}\right)} \sqrt{r\,s},$$

in which

$s =$ the sine of the inclination of the water surface to a horizontal.
$r =$ the hydraulic radius $=$ area of the normal water section divided by the wetted perimeter.
$n =$ coefficient of roughness.
$v =$ mean velocity in river.

In the present case, 0.024 was taken as the coefficient of roughness, n. The significance of this value will be discussed later.

To obtain r and v, 20 sections of the river valley were taken at various points between the lake and the site of the dam. The position of these sections is shown in figure 1.

Table 1 gives the distances of each section in feet from Fort San Carlos, measured along the present river channel.

TABLE 1.

Number of section.	Distance from lake.	Number of section.	Distance from lake.	Number of section.	Distance from lake.
	Feet.		*Feet.*		*Feet.*
1	0	8	153,000	15	228,000
2	23,500	9	177,000	16	239,000
3	42,500	10	183,000	17	259,000
4	65,000	11	191,000	18	269,000
5	70,500	12	193,500	19	283,000
6	86,000	13	206,000	20	300,500
7	137,000	14	212,000	Dam	326,500

These sections were all platted to a scale of 40 feet to an inch. In those sections in which excavation is required to give 35 feet draft with water at elevation + 104 the line of excavation was platted on the section. The wetted perimeters were then measured by a chartometer for elevations of water surface of 104, 106, 108, 110, and 112. Corresponding areas were then taken off by a planimeter. These areas, wetted perimeters, and the resulting hydraulic radii are given in Table 2.

There is considerable distance between sections Nos. 6 and 7. This portion of the river was studied some time ago quite thoroughly by Mr. A. P. Davis. He found that the river had a nearly uniform section, and as the average was almost exactly the same as at No. 4 that section was used for the length E, figure 1.

From the lake down to Rio Sabalos, where the river flows through extensive swamps, a rise of the water surface to elevation 104 will flood considerable area on both sides of the river and thereby add greatly to the cross section. This increased area will, however, be in swamps with dense vegetation, and in order that the capacity of the river may not be overestimated this overflow has not been considered. The cross section has been taken as though the banks were vertical at the side of the present river bed; but as the banks above the original surface under such a supposition are composed of water, those portions have not been added to the wetted perimeter, which, as will be seen in Table 2, has been taken as constant in sections Nos. 1, 2, 4, and 5 and equal to the actual earth perimeter between the present banks.

In figure 1 it is seen that there are three cut-off lines—San Francisco, Palo de Arco, and Santa Cruz. The combined discharge of a cut-off and the river bend or curve which is cut off will evidently be the total discharge of the river. The canal sections at these points are all alike and are called section No. 21, for which the areas for normal sections, wetted perimeters, and hydraulic radii are given in Table 2.

The river from the lake to the dam was divided into 10 short lengths, A, B, C, etc., as shown in figure 1. It was assumed that each of these lengths had a uniform section throughout, and that—

Section No. 1 is typical of length A.
Section No. 2 is typical of length B.
Section No. 4 is typical of length C.
Section No. 5 is typical of length D.
Section No. 6 is typical of length E.
Section No. 7 is typical of length F.
Section No. 9 is typical of length G.
Section No. 10 is typical of length H.
Section No. 14 is typical of length I.
Section No. 18 is typical of length K.

The next step was to find by Kutter's formula the slopes required at each section to give discharges of 20,000, 30,000, 40,000, 50,000, 60,000, and 70,000 second-feet, or cubic feet per second, for each of the following elevations of water surface at the sections 102, 104, 106, 108, 110, and 112. These slopes are given in Table 3. Having determined the slopes of Table 3, the curves of water surface of the San Juan River were plotted in figure 3 in the following manner:

The lengths A, B, C, etc., on that plate correspond to the divisions of the river in figure 1. The ordinates are elevations in feet above mean sea level. The abscissas of the curves of water surface are distances in feet from the lake, measured along the course of the river.

The slopes given in Table 3 are for elevations of water surface 104, 106, etc., only, but the water surface may be at any elevation. In order to obtain the slopes at any elevation, the curves p_1 p_5, p_6 p_{11}, etc., were constructed.

To illustrate the manner of obtaining all of these curves, the process will be followed through for the curves p_1 p_5 and p_6 p_{11}.

If the fourth slope, 0.0000195, Table 3, be multiplied by 10,000, the result, 0.195 feet, will be the amount that the river will fall in 10,000 feet of length A, if the mean elevation of water surface—i. e., the elevation of the midpoint of that length—is 112. The fall, 0.195 feet, is plotted as an abscissa from a b, the beginning of length A, at elevation 112 and the point p_1 obtained.

In the same way the slope for section No. 1, elevation 110, and a discharge of 70,000 second-feet, was multiplied by 10,000 and plotted at elevation 110 in the point p_2.

Points p_3, p_4, and p_5 were obtained in a similar manner. The curve p_1 p_2 was then drawn with a spline through these points. Any abscissa of this curve gives the fall that will occur in 10,000 feet of length A if the river is discharging 70,000 second-feet and the elevation of water surface at midpoint of that length is that at which the abscissa was measured.

Length B includes the San Francisco cut-off. The length, measured along the river, is 35,000 feet, and measured along the canal line is 27,000 feet.

It is assumed that the river has a uniform section—that of No. 2—throughout length B.

All the slopes for section No. 2, given in Table 3, were multiplied by 17,500, the half length of the river portion of length B. The results were plotted in the curves R_1, R_2, etc., fig. 2. As an example, the third slope, 0.0000185, given for an elevation of 112 feet for the midpoint of the length of section No. 2, for a discharge of 40,000 second-feet, was multiplied by 17,500. The product is 0.324, which is the fall in feet between the beginning and middle of the river portion of length B. This fall of 0.324 feet was plotted as an ordinate in point p_1, fig. 2. In a similar manner points p_2 and p_3 were plotted. The curve R_1 was then drawn with a spline through the points p_1, p_2, p_3 and made tangent to the horizontal axis of coordinates at the origin.

The ordinates to this curve give the fall for half the length of the river portion of length B for any discharge when the elevation of the water at the middle point is 112.

In the same way the slopes for section 21, in Table 3, were multiplied by 13,500 to obtain the ordinates for plotting curves C_1, C_2, etc.

Any horizontal line drawn like that through h_1 will indicate by the extremities of its intercept between the curves C_1 and R_1 the concurrent discharges of the canal and river portions, the fall of the mid-point of each portion below its beginning (or height above its ending) being given by the ordinate of the horizontal intercept. As an illustration, the horizontal intercept through h_1 is so drawn as to be bisected by the verticle ordinate erected at the discharge abscissa of 35,000 second-feet. Again, the horizontal intercept through h_2 is bisected by the vertical ordinate erected at the discharge abscissa of 30,000 second-feet, and similarly for all the others. The point of intersection of the horizontal intercept h_1 with the curve R_1 shows that the discharge of the river portion is 38,000 second-feet, while the point of intersection of the same line with the curve C_1 shows that the discharge of the canal portion is 32,000 second-feet. The combined discharge of the two portions is therefore 70,000 second-feet.

The measured ordinate of h_1 is 0.27 foot, the fall in half the length of both the cut-off canal line and the length B of the river, corresponding to the combined discharge of 70,000 second-feet, and to the elevation of water surface of 112 at the middle of both the cut-off line and the river portion. This fall of 0.27 foot was plotted as an abscissa in point p_6, figure 3.

In the same way p_7, p_8, etc., were obtained and the cure p_6p_{11} drawn. The abscissas measured from cd to this curve give the fall in half the length of either of the two channels of the San Francisco cut-off when the combined discharge is 70,000 second-feet and the elevation of the water surface at the midpoint of length of channel is that at which the abscissa was measured. Curves for discharges of 20,000, 30,000, 40,000, 50,000, and 60,000 cubic feet per second were obtained in a similar manner.

A set of curves for each of lengths C, E, F, H, I, and K were plotted in the same way as were those for length A. Curves for lengths D and G, the Palo de Arco and Santa Cruz cut-off lines, were obtained in the same manner as those for length B.

The method of obtaining the curves of water surface in figure 3 may be illustrated by taking curve X as an example. Remembering that the abscissas to the line p_1, p_3, p_5 are the falls of water surface for a length of 10,000 feet, while the latter is also the distance between two consecutive vertical lines on the diagram, a point o_1 was found with the dividers on the line ab such that o_1a_1 is equal to the abscissa o_1x_1. The length a_1o_1 was then measured down from elevation 110 on a line 10,000 feet downstream from ab and the point r_1 found. Points a_1 and r_1 were then connected by a straight line extended to r_2. This line, $a_1r_1r_2$, represents the water surface of the first 20,000 feet of the river when the lake is at elevation 110 and the river is discharging

70,000 second-feet, for the fall $n_1 r_1$ in 10,000 feet is the abscissa of the curve $p_1 p_5$ at elevation 109.68, which is the elevation at the middle point of $a_1 r_1 r_2$.

As the distance from r_2 to the beginning of length B is very small, the line was extended at the same slope to point a_2. In the same manner as before a point O_2 was found on line $c\ d$ such that $a_2\ o_2$ is equal to the abscissa $o_2\ x_2$. The distance $a_2\ o_2$ was then measured down from n_2, the same elevation as a_2 on $c_2\ d_2$, which is halfway between $c\ d$ and $e\ f$ and the point r_3 located, it being remembered that the abscissas of the curve $p_6\ p_{11}$ are the falls of water surface for half the length B. The line $a_2\ r_3$ was then drawn and extended to r_4. In the same manner the line was extended from length to length. And in the same way all the lines of water surface shown in figure 3 were constructed. All of this was done to a vertical scale on which hundredths of a foot could be easily read.

At the end of length K, at the extreme right-hand side of figure 3, are drawn curves, beginning on the vertical line drawn through the extremity of that length, representing the location of the Conchuda Dam. These curves are so drawn as to make their horizontal ordinates or abscissas represent the various discharges in cubic feet per second used in the preceding investigations. There is one such curve for each of the elevations of lake surface, represented by even numbers, from 106 to 112, both inclusive. The abscissas of each of these curves, therefore, represent the different discharges for the varying elevations (at which they are drawn) of the water surface at the dam, and corresponding to the elevation of water surface shown at the left side of the plate, there being one such elevation for each curve. There is thus given in this figure 3 all the information which is really required to determine the discharge of the canalized river for any elevation of lake surface or any elevation of water surface at the dam within the prescribed limits. It is convenient, however, to place this information regarding the discharges in a separate figure, and this is done in figure 4. The latter plate contains curves which show the elevation of water surface at the dam corresponding to any assumed discharge at a given elevation of water surface at the lake. The vertical ordinates of the curves are elevations of lake surface, while the abscissas of the same curves are the discharges in cubic feet per second, each curve corresponding to one of the given elevations at the dam, 102, 104, 106, and 108 feet. These two figures (3 and 4) exhibit complete information regarding discharges of the canalized river corresponding to elevations of surface either at the lake or at the dam.

It is evident that the minimum elevation of the water at the dam will be fixed by the elevation of the sills of Lock No. 4, and that at the time when the discharging capacity of the river is most desired, viz, at the time of flood, the water at the dam will always be held at the minimum elevation.

As low water in the summit level has been fixed by the Commission at elevation 104, the curve marked "elevation of water surface at dam 104," is of the greatest practical use. The other curves were developed to cover the field and show what might be accomplished in the way of increasing the discharge by depressing the summit level.

A set of curves, XX, XXI, XXII, XXIII, XXIV, XXV, figure 3, were constructed in the same manner as curves I, II, III, etc., except that they were drawn from right to left and starting from the dam at elevation 104.

The ordinates at the left-hand end of these curves should check with those of curve III, figure 4, which they do.

For any elevation of the lake the maximum discharge of the river may be read from curve III, figure 4.

A description of the use to which this curve was put will be found in Mr. Davis's report to the Commission.

The question now arises as to whether or not the velocities in the river at times of maximum discharge will be dangerous to navigation. To be on the safe side a discharge of 70,000 second-feet is assumed. It is evident from line XXII, figure 3, that the maximum velocity will occur in length F. The average elevation of water surface in the last 20,000 feet of this length at time of 70,000 second-feet discharge (see line XXII, figure 3) is about 106 and in table 3 it is seen that for that discharge at section No. 7 and an elevation of water surface of 106 the velocity is 4.2 feet per second. There is an apparent possibility that higher velocities might occur in one of three cut-off lines, but examination shows that they will not.

Many years of use has demonstrated that Kutter's formula expresses faily well the relation between the velocity, area of cross section, wetted perimeter, slope, and frictional resistance of a stream. The only point needing discussion is the value which was used for the coefficient of roughness n.

To test the correctness of 0.024 as a value of n the same process which has been described as applied to the canalized river was applied to the natural river and the results compared with known discharges and known elevations of water surface.

Table 4 shows the properties of the sections Nos. 1_a and 4_a, which are exactly the same as sections Nos. 1 and 4 of Table 2, except that they are sections of the natural instead of the canalized river. Sections Nos. 2 and 5 of Table 2, being at the cut-off lines, are already of the natural river. Table 5 gives the slopes for sections Nos. 1_a and 4_a, obtained by Kutter's formula, using 0.024 as the value of n. From slopes for the natural river sections, Nos. 1_a, 3, 4_a, and 5, the curves of water surface shown in figure 5 were obtained in exactly the same manner as those of figure 3.

In 1898 a gauging station was established near the mouth of the Rio Sabalos, and in 1899 another was established at Isla Grande. Daily readings of these gauges were made and a large number of current-meter observations of the discharge of the river were taken. As the curves of figure 5 were constructed for the same discharges and elevations of lake as those observed, they furnish a means of checking the accuracy of the method of investigation by observing the agreement of the elevation of water surface at the gauging stations given by the theoretical curves, based on Kutter's formula, with the actual observed elevation of water surface.

As an example, the mean elevation of lake from December 11 to 20, 1898, was 106.46 (see Report of Nicaragua Canal Commission, pp. 212, 219, 220), and the mean discharge of the river at that time was 26,230 second-feet. Curve 1, figure 5, was constructed for the above discharge, starting with elevation 106.46 at the lake, in the same way that the similar curves of figure 3 were constructed. At the Sabalos gauge the curve shows an elevation of water surface of 101.96. The mean of the actual observed elevations for that time was 101.88. In the same way the other curves were constructed and the comparisons made.

The agreement of the elevations given by the theoretical curves of water surface and the observed elevations is quite as close as could be expected, and it would seem that confidence can be placed in the accuracy of the curves of figures 3 and 4, although figure 5 does not cover quite so large a range as figure 3, either in length of river or in the elevation of water surface.

There will be practically no fall between Rio Sabalos and the dam, so that figure 5 covers all that part of the river that has much influence on the problem.

It is necessary, however, to make the assumption that the method of investigation applies with equal truth to the natural river and to the deeper canalized river. This assumption involves the general correctness of Kutter's formula, which is fairly well established.

The value which has been used for the coefficient of roughness, n, has been referred to as possibly needing some discussion. The value of the same coefficient for such rivers as the Mississippi, as well as some others of large mean radii, will be found given as about 0.032, although in other similar cases, like the Missouri River, values nearly or quite as low as 0.02 will be found. In the former of these sets of cases, however, there are some if not many instances where the slope or some other element of Kutter's formula is of uncertain value, involving a corresponding uncertainty in that of n.

The hydraulic mean radius of the San Juan, used in the preceding computations, is generally large, running from 9 or 10 feet to more than 50 feet. Finally, it is a river, on the whole, with not a very rough bed, although there are stretches where thick water grasses or other vegetation encroach upon its borders. The means taken to secure a correct value of n have already been described in this Appendix, and it will there be seen that the value used gives results when applied to the natural river which are closely confirmed by actual discharge gaugings.

It may still be thought that the value of n used, i. e., 0.024, is too small, and that it satisfies the conditions and checks with observations on the natural river so well in the foregoing investigation, because the sections used as typical may be smaller than the average section of the length for which they were assumed to be typical.

The question now arises: Has any material error been introduced into the results by the possible choice of too small sections for the computations?

As an illustration, let a rectangular section be taken 1,000 feet wide by 12 feet deep. With a slope of 0.00002 and a coefficient of roughness of 0.024, this section, by Kutter's formula, will discharge 20,750 second-feet. If this section were taken too small, and if it should be enough broader to have the same discharge (20,750 second-feet), with the same slope (0.00002), and a coefficient of roughness ($n=0.032$), then such a section would be 1,255 feet wide by 12 feet deep. The problem is: What will be the error in using the smaller section with the smaller coefficient ($n=0.024$) instead of the larger section with the larger coefficient ($n=0.032$) when the depth of water is, say, 20 feet instead of 12 feet?

With 20 feet depth of water in the smaller section, the sectional area is 2,000 square feet, the hydraulic radius is 19.23, and, by Kutter's formula, if $n=0.024$ and the slope is 0.00002 the discharge will be 50,400 second-feet.

With 20 feet depth of water in the larger section, the sectional area will be 25,100 square feet, the hydraulic radius will be 19.39, and, by Kutter's formula, if $n=0.032$ and the slope is 0.00002 the discharge will be 50,950 second-feet, or an error of less than 1 per cent on the safe side.

These hypothetical sections have about the same dimensions as the sections of the upper part of the river, and from this example it would seem that there can be no appreciable error in the final results, even if too small sections were taken, which is not probable.

TABLE 2.

Number of section.	Elevation of W. S. at section.	Sectional area.	Wetted perimeter.	Hydraulic radius.	Number of section.	Elevation of W. S. at section.	Sectional area.	Wetted perimeter.	Hydraulic radius.
1	112	24,540	1,060	23.15	9	106	15,790	504	21.22
1	110	22,480	1,060	21.19	9	104	14,790	504	39.30
1	108	20,420	1,060	19.25	9	102	13,790	504	27.30
1	106	18,360	1,060	17.31	10	112	....	....	....
1	104	16,300	1,060	15.37	10	110	20,790	604	34.36
2	112	14,540	645	22.50	10	108	19,670	596	33.00
2	110	13,280	645	20.59	10	106	18,550	588	31.50
2	108	12,020	645	18.64	10	104	17,430	580	30.06
2	106	10,760	645	16.68	10	102	16,360	576	28.36
2	104	9,490	645	14.72	12	110	37,260	1,341	27.77
2	102	8,230	645	12.75	12	108	34,700	1,314	26.52
2	100	7,110	605	11.76	12	106	32,180	1,287	25.00
3	110	12,840	780	16.46	12	104	29,700	1,260	23.55
3	108	11,320	770	14.70	13	110	40,350	1,470	27.42
3	106	9,800	760	12.90	13	108	37,470	1,447	25.91
3	104	8,280	710	11.66	13	106	34,590	1,417	24.40
4	112	20,060	720	27.80	13	104	31,710	1,400	22.65
4	110	18,540	720	25.75	14	112	29,480	848	34.70
4	108	17,020	720	23.62	14	110	27,930	828	33.75
4	106	15,500	720	21.55	14	108	26,370	808	32.60
4	104	13,980	720	19.42	14	106	24,810	788	31.50
4	102	12,620	720	17.50	14	104	23,250	768	30.30
5	112	16,230	820	19.90	14	102	21,790	744	29.25
5	110	14,610	820	17.81	15	110	51,240	1,399	36.60
5	108	12,990	820	15.85	15	104	43,260	1,360	31.80
5	106	11,370	820	13.86	16	110	40,560	1,083	37.40
5	104	9,750	820	11.89	16	104	34,380	1,032	33.30
5	102	8,650	815	10.62	17	110	44,880	779	57.50
5	100	7,050	811	8.70	17	104	40,260	752	53.60
6	110	15,370	801	19.20	18	112	32,980	696	47.40
6	108	13,830	794	17.41	18	110	31,720	683	46.48
6	106	12,290	787	15.61	18	108	30,460	670	45.50
6	104	10,750	780	13.79	18	106	29,180	657	44.35
7	112	....	....	....	18	104	27,930	644	43.36
7	110	19,380	740	26.20	18	102	26,750	630	42.45
7	108	17,960	736	24.41	19	110	32,610	630	51.75
7	106	16,540	732	22.55	19	104	39,250	600	48.75
7	104	15,120	728	20.76	20	110	47,310	925	51.16
7	102	14,100	724	19.45	20	104	42,150	880	47.85
8	110	27,560	943	29.71	21	112	9,406	316	29.80
8	108	25,730	931	27.70	21	110	8,840	310	28.56
8	106	23,920	925	25.68	21	108	8,282	304	27.25
8	104	22,130	916	23.75	21	106	7,732	298	25.94
9	112	18,880	504	37.40	21	104	7,190	292	24.63
9	110	17,840	504	35.35	21	102	6,656	286	23.26
9	108	16,800	504	33.30					

TABLE 3.

Section number.	Elevation W.S. at section.	Discharge, cubic feet per second.	Velocity, feet per second.	Slope n=.024.	Section number.	Elevation W.S. at section.	Discharge, cubic feet per second.	Velocity, feet per second.	Slope n=.024.
1	112	40,000	1.6030	0.00000325	1	110	50,000	2.2241	.0000108
		50,000	2.0375	.0000068			60,000	2.6690	.0000192
		60,000	2.4400	.000012			70,000	3.1137	.0000305
		70,000	2.8525	.0000195	1	108	20,000	.9795	.00000165
1	110	20,000	.8897	.0000011			30,000	1.4692	.00000403
		30,000	1.3345	.00000275			40,000	1.9580	.0000092
		40,000	1.7792	.0000055			50,000	2.4486	.0000185

TABLE 3—Continued.

Section number.	Elevation W. S. at section.	Discharge, cubic feet per second.	Velocity, feet per second.	Slope n=.024.
1	108	60,000	2.9382	0.000302
		70,000	3.4280	.0000465
1	106	20,000	1.0894	.0000027
		30,000	1.6340	.0000072
		40,000	2.1786	.0000168
		50,000	2.7234	.0000318
		60,000	3.2680	.000049
		70,000	3.8128	.000074
1	104	20,000	1.2270	.0000044
		30,000	1.8405	.000014
		40,000	2.4540	.0000292
		50,000	3.0675	.000051
		60,000	3.6810	.000083
		70,000	4.2945	.000118
2	112	20,000	1.3756	.0000026
		30,000	2.0633	.0000074
		40,000	2.7510	.0000185
2	110	20,000	1.5061	.00000308
		30,000	2.2591	.00000875
		40,000	3.0121	.0000235
		50,000	3.7650	.0000435
2	108	20,000	1.6639	.0000063
		30,000	2.4957	.0000215
		40,000	3.3277	.0000458
		50,000	4.1596	.0000812
2	106	20,000	1.8587	.0000113
		30,000	2.7880	.000035
		40,000	3.7174	.0000725
		50,000	4.6468	.000125
2	104	20,000	2.1075	.000022
		30,000	3.1612	.000065
		40,000	4.2148	.000122
		50,000	5.2688	.0002
2	102	20,000	2.4302	.0000405
		30,000	3.6452	.0001075
		40,000	4.8602	.000225
2	100	20,000	2.8128	.000067
		30,000	4.2192	.0001666
		40,000	5.6255	.00031
4	112	40,000	1.9940	.00000399
		50,000	2.4922	.0000077
		60,000	2.9910	.0000149
		70,000	3.4890	.000024
4	110	20,000	1.0787	.00000118
		30,000	1.6181	.0000025
		40,000	2.1575	.000006
		50,000	2.6968	.0000126
		60,000	3.2362	.0000227
		70,000	3.7756	.0000359
4	108	20,000	1.1751	.0000016
		30,000	1.7625	.00000404
		40,000	2.3501	.00000985
		50,000	2.9376	.0000204
		60,000	3.5251	.000035
		70,000	4.1130	.0000525
4	106	20,000	1.2903	.0000025
		30,000	1.9356	.00000675
		40,000	2.5806	.000017
		50,000	3.2258	.0000327
		60,000	3.8710	.0000526
		70,000	4.5160	.000079
4	104	20,000	1.4306	.0000039
		30,000	2.1460	.0000125
		40,000	2.8612	.000029
		50,000	3.5766	.000051
		60,000	4.2920	.0000825
		70,000	5.0071	.000119
4	102	20,000	1.5848	.0000063
		30,000	2.377	.0000212
		40,000	3.1695	.000045
		50,000	3.9618	.000079
5	112	40,000	2.4644	.0000175
		50,000	3.0806	.000033
		60,000	3.6970	.000053
		70,000	4.3130	.00008
5	110	20,000	1.4511	.0000048
		30,000	2.1767	.000016
		40,000	2.9021	.0000353
5	108	20,000	1.5396	.0000074
		30,000	2.3095	.000024
5	108	40,000	3.0794	0.000049
5	106	20,000	1.7590	.0000151
		30,000	2.6385	.0000425
		40,000	3.5178	.0000865
5	104	20,000	2.0514	.000031
		30,000	3.0770	.00008
		40,000	4.1026	.000154
5	102	20,000	2.3122	.000049
		30,000	3.4683	.000125
		40,000	4.6242	.000235
5	100	20,000	2.8370	.00011
		30,000	4.2551	.000257
		40,000	5.6737	.00045
7	112	40,000	1.9230	.0000036
		50,000	2.4040	.0000068
		60,000	2.8846	.000013
		70,000	3.3652	.000021
7	110	20,000	1.0526	.000001
		30,000	1.5788	.0000026
		40,000	2.1050	.0000053
		50,000	2.6314	.0000108
		60,000	3.1577	.00002
		70,000	3.6840	.0000318
7	108	20,000	1.1136	.0000014
		30,000	1.6703	.0000035
		40,000	2.2271	.0000066
		50,000	2.7839	.000016
		60,000	3.3408	.0000276
		70,000	3.8975	.0000425
7	106	20,000	1.2092	.00000195
		30,000	1.8138	.000005
		40,000	2.4184	.0000122
		50,000	3.0230	.000025
		60,000	3.6277	.000041
		70,000	4.2320	.0000615
7	104	20,000	1.3227	.0000027
		30,000	1.9840	.0000071
		40,000	2.6454	.0000176
		50,000	3.3067	.0000345
		60,000	3.9681	.0000555
		70,000	4.6295	.0000825
7	102	20,000	1.4185	.0000038
		30,000	2.1276	.0000125
		40,000	2.8368	.000029
		50,000	3.5460	.0000502
		60,000	4.2555	.000081
		70,000	4.9643	.0001175
9	112	40,000	2.1186	.0000024
		50,000	2.6482	.0000043
		60,000	3.1780	.000008
		70,000	3.7075	.0000142
9	110	20,000	1.1210	.00000062
		30,000	1.6816	.00000156
		40,000	2.2420	.00000325
		50,000	2.8025	.0000061
		60,000	3.3630	.0000118
		70,000	3.9235	.0000196
9	108	20,000	1.1905	.00000076
		30,000	1.7860	.000002
		40,000	2.3810	.0000041
		50,000	2.9760	.0000087
		60,000	3.5715	.0000168
		70,000	4.1665	.0000275
9	106	20,000	1.2667	.00000107
		30,000	1.9000	.00000277
		40,000	2.5330	.00000605
		50,000	3.1660	.000013
		60,000	3.8000	.0000242
		70,000	4.4330	.000038
9	104	20,000	1.3522	.00000142
		30,000	2.0285	.00000375
		40,000	2.7040	.0000089
		50,000	3.3806	.000019
		60,000	4.0570	.0000385
		70,000	4.7330	.0000526
9	102	20,000	1.4502	.00000195
		30,000	2.1756	.0000053
		40,000	2.9006	.000014
		50,000	3.6258	.0000276
		60,000	4.2511	.0000475

TABLE 3—Continued.

Section number.	Elevation W. S. at section.	Discharge, cubic feet per second.	Velocity, feet per second.	Slope n=.024.	Section number.	Elevation W. S. at section.	Discharge, cubic feet per second.	Velocity, feet per second.	Slope n=.024.
9	102	70,000	5.0762	0.000072	14	104	70,000	3.0108	0.000012
10	112	40,000	1.8256	.00000185	14	102	20,000	.9179	.0000005
		50,000	2.2820	.00000325			30,000	1.3768	.00000145
		60,000	2.7385	.0000055			40,000	1.8357	.000003
		70,000	3.1950	.0000092			50,000	2.2946	.0000052
10	110	20,000	.9620	.00000046			60,000	2.7536	.0000095
		30,000	1.4429	.00000125			70,000	3.2125	.0000168
		40,000	1.9239	.0000023	18	110	20,000	.6305	.00000011
		50,000	2.4050	.000004			30,000	.9458	.0000002
		60,000	2.8860	.0000072			40,000	1.2609	.00000039
		70,000	3.3670	.0000125			50,000	1.5762	.00000075
10	108	20,000	1.0168	.0000006			60,000	1.8915	.0000011
		30,000	1.5252	.00000145			70,000	2.2067	.0000016
		40,000	2.0335	.00000295	18	108	20,000	.6566	.00000012
		50,000	2.5420	.00000535			30,000	.9849	.00000025
		60,000	3.0504	.0000095			40,000	1.3132	.0000005
		70,000	3.5586	.0000172			50,000	1.6415	.0000009
10	106	20,000	1.4782	.00000074			60,000	1.9698	.0000014
		30,000	1.6173	.00000178			70,000	2.2981	.0000019
		40,000	2.1563	.0000037	18	106	20,000	.6854	.00000014
		50,000	2.6955	.00000725			30,000	1.0281	.00000028
		60,000	3.2347	.000014			40,000	1.3707	.00000055
		70,000	3.7737	.000023			50,000	1.7134	.000001
10	104	20,000	1.1475	.0000009			60,000	2.0562	.0000015
		30,000	1.7212	.00000245			70,000	2.3988	.0000025
		40,000	2.2949	.00000492	18	104	20,000	.7161	.00000018
10	104	50,000	2.8686	.00001			30,000	1.0741	.00000038
		60,000	3.4424	.000019			40,000	1.4321	.00000065
		70,000	4.0160	.0000308			50,000	1.7902	.00000102
10	102	20,000	1.2225	.00000122			60,000	2.1482	.0000016
		30,000	1.8336	.0000032			70,000	2.5061	.0000026
		40,000	2.4449	.000007	18	102	20,000	.7477	.0000002
		50,000	3.0561	.000015			30,000	1.1217	.00000045
		60,000	3.6675	.0000262			40,000	1.4953	.00000078
		70,000	4.2786	.0000418			50,000	1.8692	.0000014
14	112	40,000	1.3568	.000001			60,000	2.2431	.000002
		50,000	1.6960	.0000016			70,000	2.6170	.0000032
		60,000	2.0352	.0000025	21	112	20,000	2.1266	.000004
		70,000	2.3745	.00000375			30,000	3.1895	.000015
14	110	20,000	.7161	.00000023			40,000	4.2525	.0000375
		30,000	1.0741	.0000006			50,000	5.3160	.000072
		40,000	1.4321	.00000122	21	110	20,000	2.2625	.00000525
		50,000	1.7902	.00000198			30,000	3.3937	.0000202
		60,000	2.1482	.00000322			40,000	4.5248	.0000486
		70,000	2.5061	.00000495			50,000	5.6560	.000089
14	108	20,000	.7585	.00000028	21	108	20,000	2.4150	.0000074
		30,000	1.1376	.00000075			30,000	3.6224	.000028
		40,000	1.5168	.00000149			40,000	4.8295	.0000635
		50,000	1.8961	.0000025			50,000	6.0370	.0001135
		60,000	2.2754	.0000038	21	106	20,000	2.5868	.0000105
		70,000	2.6545	.00000635			30,000	3.8800	.0000378
14	106	20,000	.8062	.00000039			40,000	5.1731	.000086
		30,000	1.2092	.00000091			50,000	6.4670	.0001435
		40,000	1.6122	.00000178	21	104	20,000	2.7818	.0000158
		50,000	2.0152	.0000032			30,000	4.1725	.0000515
		60,000	2.4184	.00000508			40,000	5.5631	.0001068
		70,000	2.4214	.0000085			50,000	6.9540	.0001822
14	104	20,000	.8603	.00000018	21	102	20,000	3.0049	.0000225
		30,000	1.2903	.0000012			30,000	4.5074	.0000685
		40,000	1.7204	.0000023			40,000	6.0094	.000142
		50,000	2.1506	.0000039			50,000	7.5120	.0002325
		60,000	2.5806	.000007					

TABLE 4.

Number of section.	Elevation of W. S. at section.	Sectional area.	Wetted perimeter.	Hydraulic radius.	Number of section.	Elevation of W. S. at section.	Sectional area.	Wetted perimeter.	Hydraulic radius.
1_a	107	13,060	1,060	12.30	4_a	107	13,250	700	18.87
1_a	106	12,040	1,060	11.35	4_a	106	12,580	700	17.95
1_a	104	10,000	1,060	9.44	4_a	104	11,230	700	16.10
1_a	102	7,960	1,032	7.73	4_a	102	9,880	696	14.20
1_a	100	5,720	800	7.15	4_a	100	8,530	690	12.36

TABLE 5.

Number of section.	Elevation W.S. at section.	Discharge, cubic feet per second.	Velocity, feet per second.	Slope $n=.024$.
1_a	107	10,000	0.765	0.0000025
		20,000	1.530	.000014
		30,000	2.295	.000037
1_a	106	10,000	.830	.0000035
		20,000	1.661	.00002
		30,000	2.490	.0000525
		40,000	3.320	.000138
1_a	104	10,000	1.000	.0000082
		20,000	2.000	.0000425
		30,000	3.000	.00011
		40,000	4.000	.000225
1_a	102	10,000	1.256	.000024
		20,000	2.513	.000125
		30,000	3.770	.000237
1_a	100	10,000	1.750	.000052
		20,000	3.500	.0002225
4_a	107	10,000	.756	.000001
		20,000	1.511	.00000485
4_a	107	30,000	2.267	0.0000158
4_a	106	10,000	.795	.00000125
		20,000	1.590	.00000605
		30,000	2.385	.00002
		40,000	3.020	.000038
4_a	104	10,000	.890	.00000195
		20,000	1.770	.0000108
		30,000	2.670	.000034
		40,000	3.590	.000071
4_a	102	10,000	1.010	.0000034
		20,000	2.030	.000021
		30,000	3.030	0000575
		40,000	4.050	.0001175
4_a	100	10,000	1.172	.0000065
		20,000	2.345	.000039
		30,000	3.520	.00014

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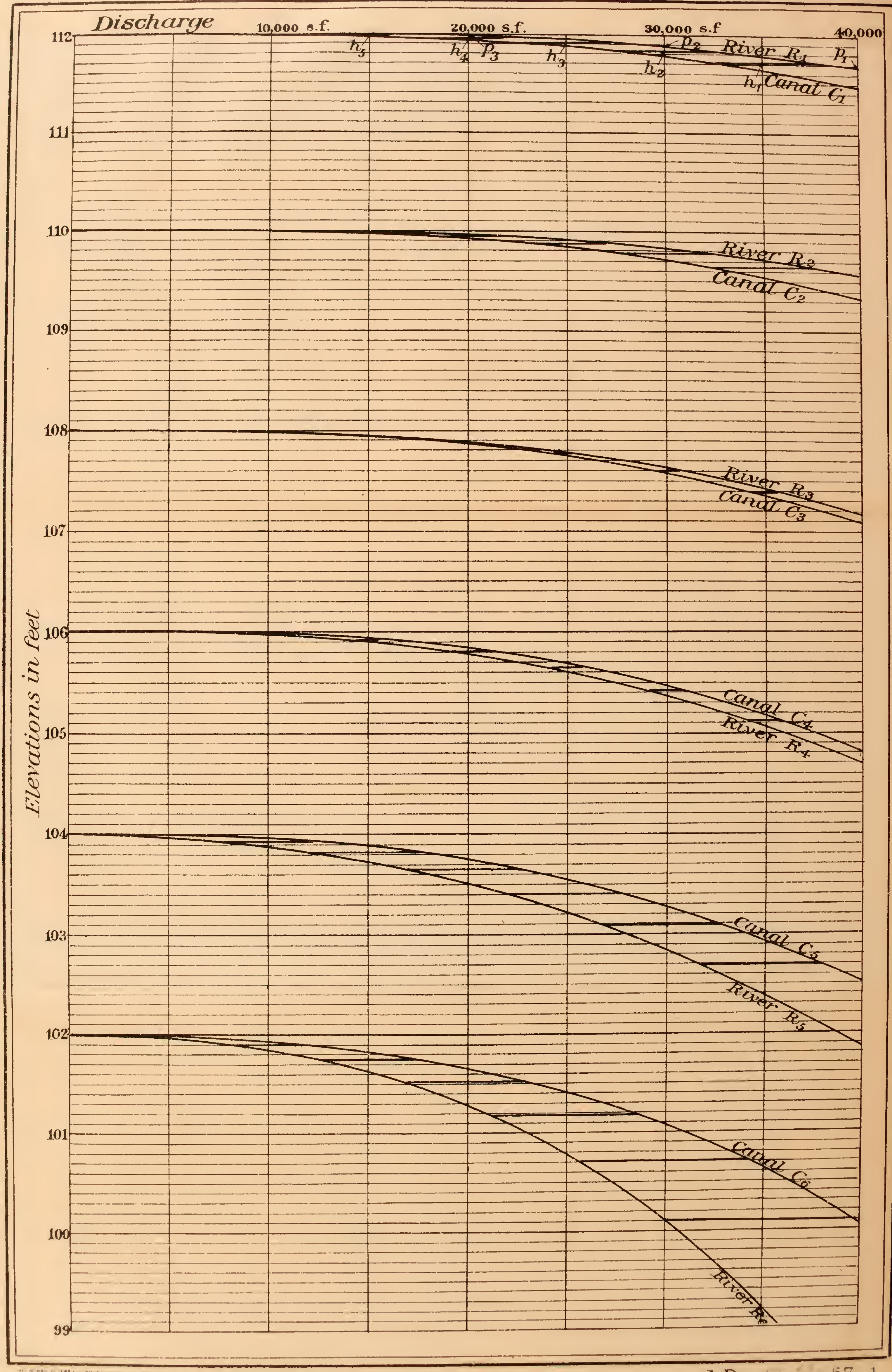
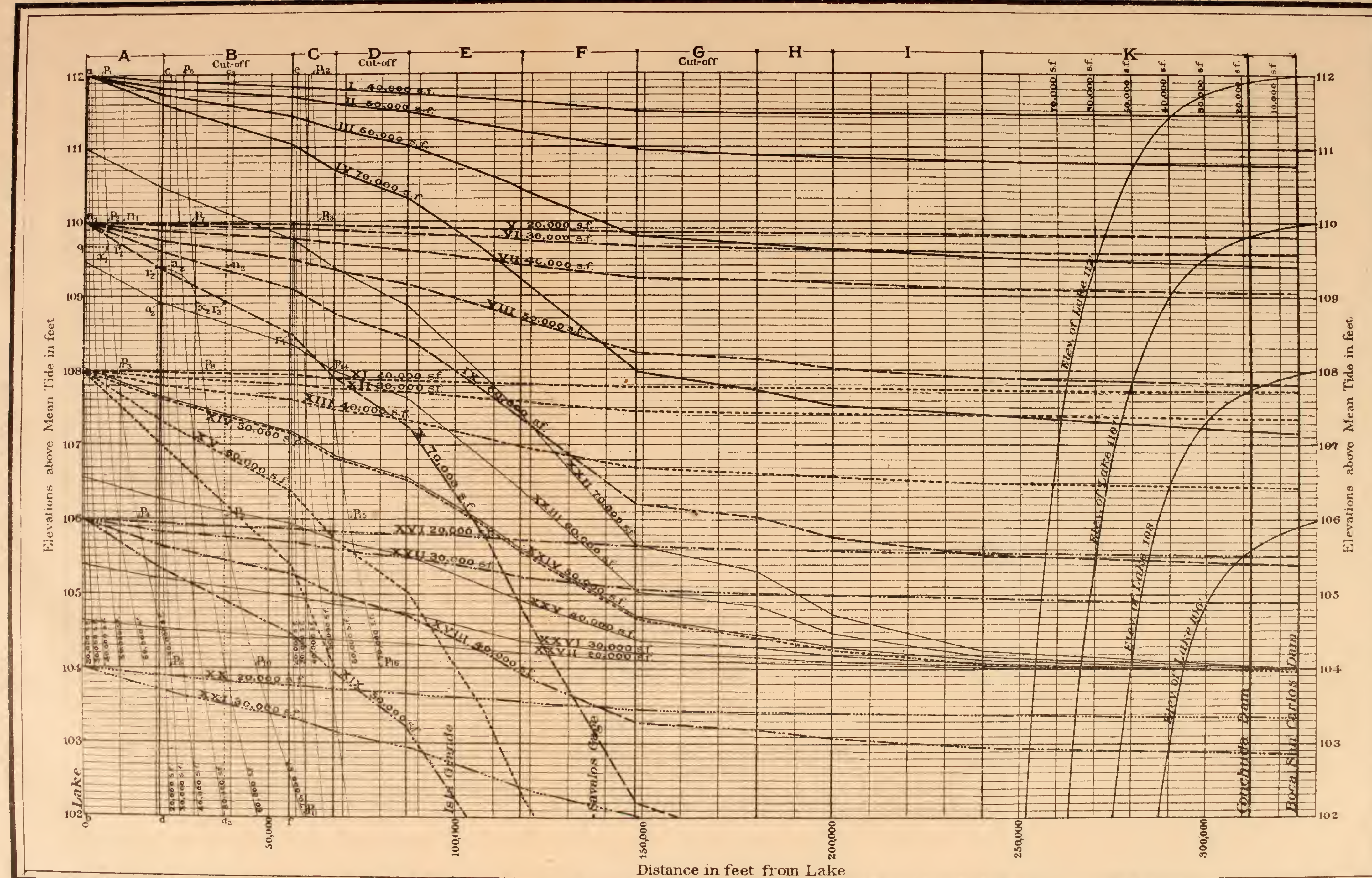
APPENDIX H, FIG, 2





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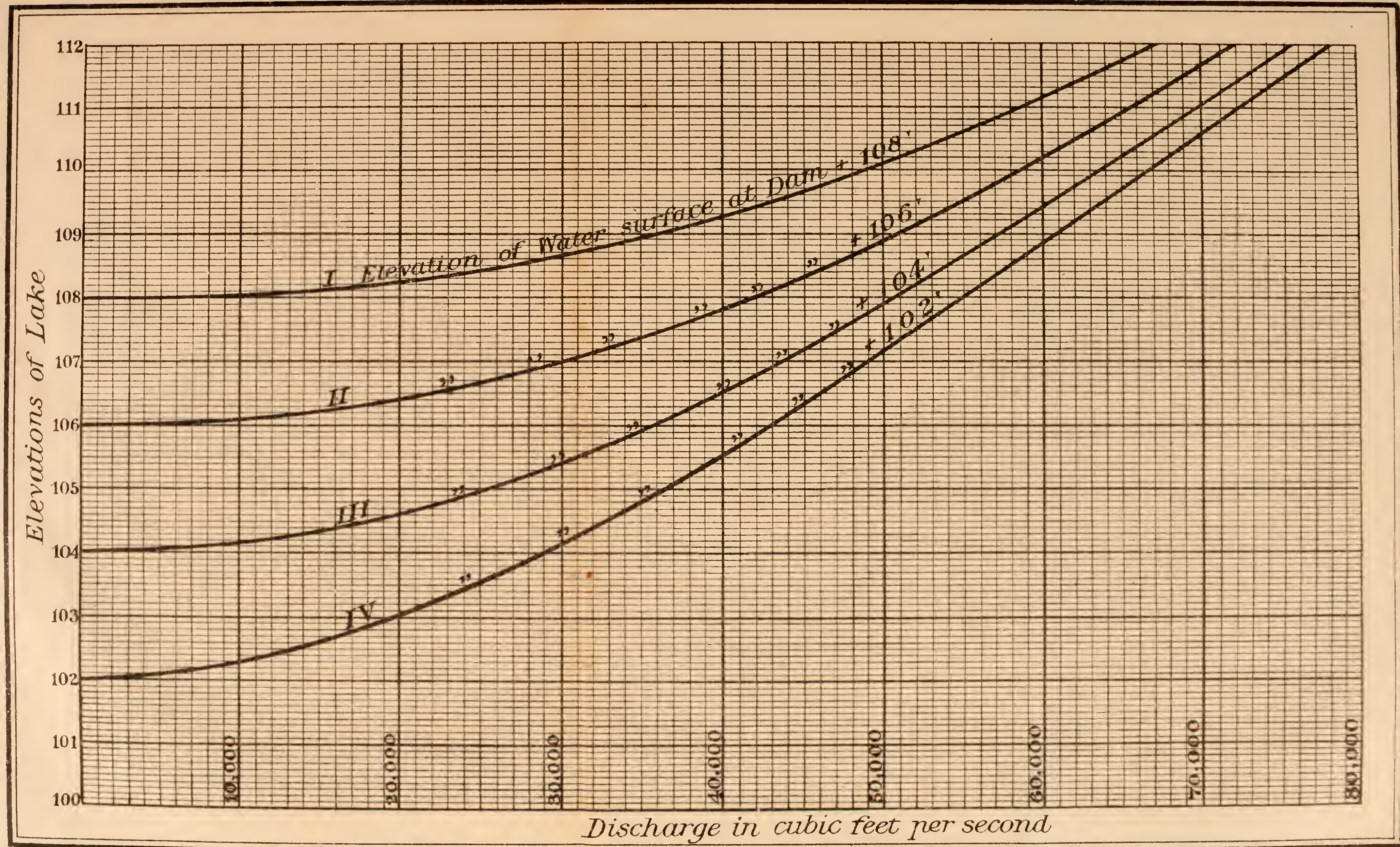

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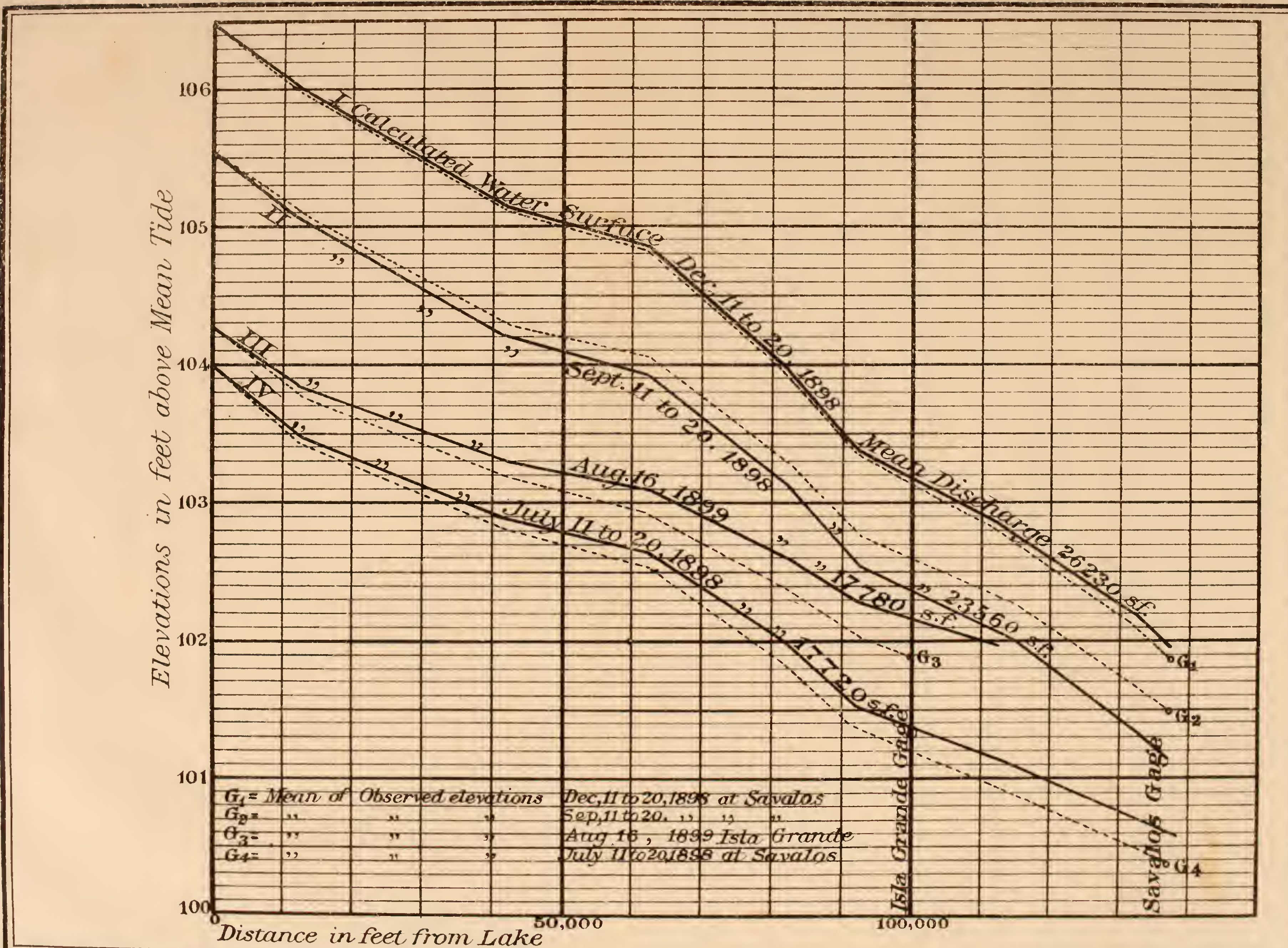

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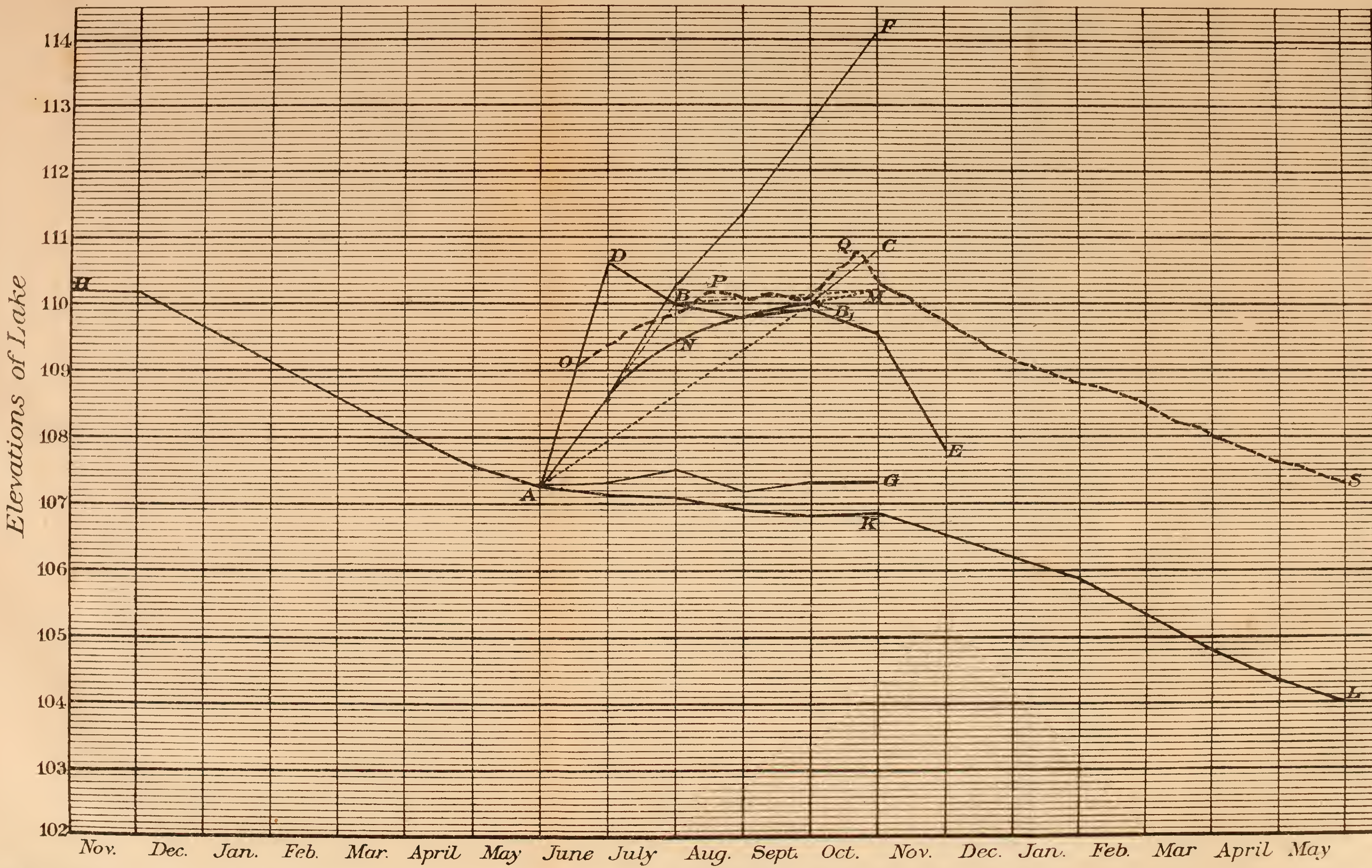

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APPENDIX I.

REPORT OF HYDROGRAPHIC INVESTIGATIONS IN NICARAGUA MADE FOR THE ISTHMIAN CANAL COMMISSION.

By ARTHUR P. DAVIS, *Chief Hydrographer*.

CONTENTS.

LIST OF ILLUSTRATIONS.

WASHINGTON, D. C., *March 25, 1901.*

SIR: I have the honor to transmit herewith a report on the hydrography of the Nicaragua Canal route. It includes a full account of the work prosecuted by me under your authority, and also the more important of the results of the hydraulic investigations made for the Nicaragua Canal Commission.

During a portion of the time covered by these investigations I was absent from Nicaragua on duties requiring my presence in Panama, Washington, and Paris. At such times the work was in the immediate charge of Mr. H. C. Hurd, until he was required for office work in Washington in November, 1900, since which date Mr. Fred Davis has had charge of fieldwork in Nicaragua. Acknowledgments are due to these gentlemen for their care and fidelity in the discharge of their duties.

Yours, with respect,

ARTHUR P. DAVIS,
Chief Hydrographer.

Rear-Admiral J. G. WALKER,
President Isthmian Canal Commission.

HYDROGRAPHY OF NICARAGUA CANAL ROUTE.

The hydrographic observations of the Isthmian Canal Commission consisted in the main of a continuation of those inaugurated by the Nicaragua Canal Commission, some extension of rainfall observations in the basin tributary to Lake Nicaragua being the principal difference.

The information required relates to the solution of four principal problems.

First. Water supply for the use of the canal and to replace loss by leakage and evaporation.

Second. The quantity of rainfall and volume of streams considered as obstacles to construction.

Third. The volume and habit of excessive floods with reference to their permanent control and discharge without injury to the canal or other property.

Fourth. The evaporation from Lake Nicaragua, this being the principal draft upon the water supply.

The desired information therefore required an investigation of the discharge of all streams of importance which it was proposed to control during construction or for which it was necessary to provide diversion channels or spillways; and measurements of rainfall at points as widely distributed as possible throughout the basin of Lake Nicaragua, San Juan River, and the adjacent region.

It also required an approximate determination of the rate of evaporation on Lake Nicaragua and some investigation of the sediment carried by the larger rivers.

STREAM MEASUREMENTS.

The general method used in observing the regimen and discharge of streams is substantially as follows:

A point is selected as near as may be to the location at which knowledge is desired, having reference to the condition of the stream itself, the aim being to secure high permanent banks on both sides of the river, a straight channel as uniform in depth and velocity as may be, and avoiding any location which is a short distance above an important tributary, and which for this reason might be affected in the matter of backwater by floods in that tributary. A gauge is placed in the stream near one bank, graduated to feet and tenths, and so situated, if possible, as to be read conveniently from the shore. It is usually possible to fasten such a gauge in deep water to the trunk of an overhanging tree and in a vertical position. The height of water indicated by this gauge is read and recorded usually twice every day and the mean of the two readings taken as the mean gauge height for that date. At various intervals, depending upon the facilities available and the change of gauge height, measurements of discharge are made with a current meter. Soundings are taken at known distances from an assumed initial point and the velocity measured by submerging an electric current meter at six-tenths of the measured depth and holding it in that position for a length of time sufficient to make a good determination of the velocity at that point, usually one hundred seconds or more. This operation is repeated at short intervals for the entire width of the stream, and from these observations the discharge in cubic feet per second is computed for each section by multiplying the depth, width, and measured velocity together. The discharge of the several sections being added together form a result for the discharge of the entire stream. At the beginning and end of the gauging a careful note is made of the stage of the water indicated on the river gauge, and the mean of those two observations is taken as the mean gauge height at the time of observation. It is the effort to have such observations well distributed with reference to the height of water in the river in order to show the relation of the indications of the gauge rod to the actual discharge of the stream. This relation is found to be reasonably definite and uniform for most of the streams, and by plotting the gauge heights as ordinates and the discharge results as abscissas their general relation is established and a curve is drawn, satisfying as nearly as possible all the observations made. Where no such relation could be established the measurements only are published.

PACIFIC SLOPE.

All streams with which the canal is concerned flow eventually into the Atlantic, except the Grande and its tributaries. This stream rises in the hills of the continental divide, and empties into the Pacific Ocean at Brito. The canal line follows its valley from the deep divide cut to the sea. The principal tributary is the Tola River, which enters from the north and which formerly, in common with the other headwaters of the Grande, flowed into Lake Nicaragua. The recession of the continental divide toward the lake turned them toward the Pacific, and the proposed canal cut through the divide is the site of the former stream bed of this drainage.

GRANDE AND TOLA RIVERS AT THEIR JUNCTION.

A gauge was kept on the Grande River a short distance below the junction of the Tola, and the latter river was observed about a mile above its mouth.

During a portion of the dry season the Grande is entirely dry above the mouth of the Tola, and the waters of the latter are ponded for some distance up the Grande.

A perceptible quantity of the water is lost by evaporation and seepage from this pond, so that for a time the discharge of the Tola at the station was slightly greater than that of the Grande below the mouth of the Tola.

The largest flood yet observed at this station occurred on the 22d day of October, 1900, when 5,450 cubic feet per second was flowing in the Grande below the Tola.

Daily gauge height of Grande River at Tola Gauge Station for 1899.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	1.55	1.45	2.42	2.46	17	1.50	1.51	2.08	2.02	2.02
2	......	1.52	1.50	2.29	2.34	18	1.52	1.52	1.69	2.02	2.01
3	......	1.51	1.50	2.21	2.30	19	1.58	1.64	1.55	2.02	2.00
4	......	1.51	1.50	2.16	2.25	20	1.52	1.55	1.60	2.01	2.00
5	......	1.64	1.46	2.15	2.14	21	1.52	1.53	1.60	2.06	1.97
6	......	1.79	1.49	2.13	2.14	22	1.51	1.51	1.86	2.03	1.96
7	......	1.59	1.52	2.13	2.11	23	1.50	1.50	1.91	2.04	1.99
8	......	1.55	1.83	2.10	2.11	24	1.53	1.51	1.97	2.02	1.99
9	......	1.53	1.59	2.20	2.10	25	1.60	1.51	2.79	2.03	1.98
10	......	1.54	1.51	2.20	2.08	26	1.88	1.52	4.60	2.02	1.97
11	......	1.53	1.52	2.10	2.11	27	1.65	1.49	7.65	2.06	1.97
12	......	1.52	1.51	2.08	2.08	28	1.57	1.50	4.42	2.10	1.95
13	1.50	1.51	1.55	2.08	2.08	29	1.56	1.47	3.38	3.10	1.95
14	1.51	1.50	1.76	2.06	2.08	30	2.14	1.46	2.77	3.30	1.95
15	1.52	1.52	1.63	2.06	2.07	31	2.06	......	2.60	......	1.94
16	1.50	1.53	1.70	2.04	2.04						

Daily gauge height of Grande River at Tola Gauge Station for 1900.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.95	1.86	1.71	1.62	1.58	1.91	2.65	2.27	2.09	6.00	3.76	2.93
2	1.95	1.86	1.71	1.62	1.58	1.79	2.30	2.22	2.05	4.20	3.67	2.91
3	1.95	1.86	1.71	1.62	1.58	1.75	2.99	2.22	2.01	4.35	3.60	2.90
4	1.93	1.85	1.71	1.62	1.58	1.92	2.51	2.19	2.08	4.30	3.57	2.88
5	1.93	1.84	1.71	1.62	1.57	1.84	2.64	2.18	2.16	4.05	3.52	2.85
6	1.93	1.84	1.71	1.62	1.57	2.09	4.37	2.18	2.11	5.07	3.46	2.84
7	1.93	1.84	1.71	1.62	1.56	4.32	2.58	2.16	4.87	3.95	3.37	2.82
8	1.92	1.82	1.70	1.62	1.56	3.61	2.45	2.13	3.87	3.88	3.34	2.80
9	1.92	1.82	1.70	1.62	1.56	2.62	2.46	2.14	3.07	5.67	3.32	2.78
10	1.92	1.81	1.70	1.62	1.55	2.54	3.75	2.12	2.83	3.80	3.30	2.77
11	1.92	1.81	1.70	1.62	1.54	2.34	4.84	2.10	2.67	3.77	3.27	2.75
12	1.92	1.80	1.70	1.62	1.54	2.09	3.95	2.11	2.58	3.74	3.21	2.75
13	1.95	1.81	1.70	1.61	1.67	2.05	3.13	2.14	2.51	3.62	3.19	2.75
14	1.94	1.80	1.70	1.61	1.63	2.14	2.76	2.14	2.45	3.63	3.17	2.72
15	1.91	1.78	1.70	1.61	1.77	2.01	2.63	2.12	2.39	3.47	3.13	2.70
16	1.93	1.78	1.70	1.60	1.67	2.02	2.60	2.10	2.80	3.50	3.13	2.70
17	1.92	1.79	1.70	1.60	1.68	2.13	2.42	2.07	3.32	3.55	3.11	2.70
18	1.92	1.78	1.70	1.60	1.63	2.00	2.49	2.05	2.81	3.50	3.08	2.69
19	1.91	1.78	1.70	1.60	2.23	1.96	2.43	2.05	4.05	3.65	3.08	2.68
20	1.89	1.76	1.70	1.59	1.87	2.05	2.39	2.11	3.28	4.64	3.07	2.68
21	1.89	1.75	1.69	1.58	3.02	2.54	2.34	2.10	3.02	8.00	3.07	2.67
22	1.88	1.75	1.68	1.58	1.89	2.15	2.51	2.12	3.52	8.90	3.06	2.66
23	1.88	1.74	1.68	1.58	1.79	2.12	2.45	2.11	4.52	7.15	3.04	2.64
24	1.87	1.73	1.67	1.58	2.04	2.63	2.38	2.15	4.35	6.12	3.03	2.63
25	1.87	1.73	1.67	1.58	2.12	2.07	2.35	2.12	3.47	5.90	3.01	2.60
26	1.87	1.72	1.67	1.58	2.04	2.04	2.31	2.14	3.77	4.89	2.99	2.59
27	1.87	1.72	1.66	1.58	2.15	2.04	2.29	2.13	3.24	4.64	2.96	2.58
28	1.87	1.71	1.65	1.58	1.95	2.49	2.30	2.09	3.09	4.32	2.94	2.57
29	1.87	......	1.65	1.58	1.98	2.13	2.29	2.08	5.45	4.20	2.94	2.57
30	1.87	......	1.64	1.58	1.90	2.47	2.27	2.07	6.00	3.99	2.94	2.54
31	1.87	......	1.63	......	2.59	......	2.33	2.08	......	3.81	......	2.53

Rating table for Grande River at Tola Gauge Station.

[This table is applicable only from August 13, to December 31, 1899, and May 19, 1900, to March 29, 1901.]

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
1.3	0	3.3	212	5.3	781	7.3	1,484
1.4	4	3.4	236	5.4	816	7.4	1,519
1.5	7	3.5	260	5.5	851	7.5	1,554
1.6	11	3.6	284	5.6	886	7.6	1,589
1.7	14	3.7	308	5.7	921	7.7	1,624
1.8	18	3.8	332	5.8	956	7.8	1,659
1.9	21	3.9	356	5.9	991	7.9	1,694
2.0	25	4.0	380	6.0	1,027	8.0	1,730
2.1	34	4.1	409	6.1	1,062	8.1	1,764
2.2	42	4.2	438	6.2	1,097	8.2	1,800
2.3	51	4.3	467	6.3	1,132	8.3	1,835
2.4	60	4.4	496	6.4	1,167	8.4	1,870
2.5	73	4.5	524	6.5	1,202	8.5	1,905
2.6	87	4.6	553	6.6	1,238	8.6	1,941
2.7	100	4.7	582	6.7	1,273	8.7	1,976
2.8	118	4.8	611	6.8	1,308	8.8	2,011
2.9	136	4.9	640	6.9	1,343	8.9	2,046
3.0	155	5.0	675	7.0	1,378	9.0	2,081
3.1	173	5.1	710	7.1	1,413	9.1	2,116
3.2	191	5.2	745	7.2	1,448	9.2	2,151

Estimated monthly discharge of Grande River below mouth of the Tola, 1898.

Months.	Discharge.			Total.	Months.	Discharge.			Total.
	Maximum.	Minimum.	Mean.			Maximum.	Minimum.	Mean.	
	Sec.feet.	*Sec.feet.*	*Sec.feet.*	*Acre-feet.*		*Sec.feet.*	*Sec.feet.*	*Sec.feet.*	*Acre-feet.*
January (6-31)	75	60	69	3,340	August	145	45	67	4,120
February	55	41	49	2,720	September	2,975	55	253	15,050
March	40	25	35	2,150	October	2,065	260	596	36,650
April	35	17	25	1,490	November	1,028	190	282	16,780
May	85	17	28	1,720	December	190	97	130	7,990
June	1,990	17	110	6,550					
July	2,030	55	121	7,440	Total	....	....	....	106,000

Estimated monthly discharge of Grande River at Tola gauge station.

Month.	Discharge.			Total.
	Maximum.	Minimum.	Mean.	
1899.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*
August 13–31	37	7	11	401
September	18	6	8	496
October	2,081	5	113	6,954
November	385	26	44	2,646
December	68	19	32	1,954
Total	2,081	5	44	12,451
1900.				
January	17	12	12	762
February	11	6	9	482
March	7	4	6	343
April	5	2	3	182
May	216	2	19	1,196
June	953	16	63	3,745
July	1,272	48	123	7,569
August	59	29	36	2,225
September	5,400	26	238	14,166
October	5,450	260	603	37,068
November	382	144	197	11,746
December	142	69	105	6,434
The year	5,450	2	119	85,918

Daily gauge height of Tola River, 1 mile above its mouth, for 1899.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	2.06	1.98	2.40	2.41
2	......	2.05	2.01	2.38	2.34
3	......	2.04	2.00	2.32	2.28
4	......	2.04	2.01	2.28	2.26
5	......	2.06	1.99	2.26	2.22
6	......	2.15	2.02	2.26	2.20
7	......	2.09	2.04	2.26	2.17
8	......	2.05	2.23	2.25	2.16
9	......	2.03	2.09	2.29	2.15
10	......	2.03	2.02	2.31	2.14
11	......	2.03	2.02	2.21	2.16
12	......	2.03	2.03	2.20	2.14
13	2.00	2.03	2.04	2.19	2.15
14	2.02	2.02	2.03	2.18	2.14
15	2.05	2.04	2.03	2.17	2.13
16	2.02	2.05	2.11	2.13	2.13
17	2.00	2.02	2.12	2.11	2.10
18	2.02	2.03	2.03	2.10	2.08
19	2.02	2.07	2.00	2.10	2.07
20	2.00	2.04	2.03	2.11	2.07
21	2.02	2.03	2.02	2.16	2.05
22	2.00	2.02	2.15	2.14	2.04
23	2.00	2.02	2.21	2.16	2.08
24	2.01	2.00	2.18	2.15	2.08
25	2.06	2.01	2.23	2.16	2.07
26	2.14	2.03	2.97	2.15	2.07
27	2.08	2.00	5.32	2.21	2.07
28	2.06	2.01	4.70	2.26	2.07
29	2.04	2.00	3.30	2.82	2.06
30	1.98	1.99	2.75	2.97	2.05
31	1.64	......	2.50	......	2.05

Daily gauge height of Tola River, 1 mile above its mouth, for 1900.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.04	1.96	1.89	1.80	1.76	1.84	2.75	2.26	2.07	5.00	3.31	2.16
2	2.04	1.96	1.89	1.80	1.76	1.86	2.31	2.19	2.06	4.42	3.24	2.13
3	2.04	1.95	1.89	1.80	1.76	1.83	2.29	2.21	2.04	3.67	3.17	2.12
4	2.04	1.95	1.89	1.80	1.76	2.02	2.42	2.20	2.08	4.30	3.05	2.09
5	2.03	1.91	1.88	1.80	1.75	1.95	2.55	2.18	2.15	3.90	2.99	2.08
6	2.03	1.93	1.88	1.80	1.75	2.20	2.48	2.19	2.09	4.42	2.91	2.06
7	2.02	1.93	1.88	1.80	1.74	2.19	2.36	2.21	2.80	4.20	2.85	2.04
8	2.02	1.91	1.88	1.80	1.74	3.18	2.30	2.16	2.55	3.78	2.77	2.04
9	2.02	1.91	1.87	1.80	1.74	2.39	2.30	2.14	2.35	3.65	2.70	2.03
10	2.01	1.91	1.87	1.79	1.74	2.17	2.52	2.09	2.30	3.61	2.70	2.03
11	2.01	1.91	1.87	1.79	1.74	2.24	2.66	2.10	2.33	3.54	2.66	2.02
12	2.01	1.91	1.87	1.79	1.73	2.10	2.27	2.07	2.30	3.49	2.61	2.01
13	2.03	1.91	1.87	1.79	1.82	2.05	2.55	2.07	2.28	3.46	2.55	2.00
14	2.03	1.91	1.86	1.79	1.82	2.12	2.53	2.22	2.25	3.44	2.54	1.99
15	2.02	1.91	1.86	1.79	1.95	2.02	2.60	2.08	2.20	3.24	2.52	1.98
16	2.03	1.90	1.86	1.78	1.83	2.00	2.47	2.03	2.72	3.09	2.52	1.98
17	2.01	1.90	1.86	1.78	1.84	2.07	2.39	2.02	2.88	3.34	2.52	1.97
18	2.01	1.90	1.86	1.78	1.80	2.02	2.46	2.00	2.64	3.22	2.47	1.96
19	2.01	1.90	1.86	1.78	2.02	1.99	2.43	1.99	3.47	3.62	2.47	1.95
20	2.00	1.90	1.86	1.77	1.93	2.11	2.42	2.08	3.07	3.60	2.41	1.95
21	1.99	1.90	1.86	1.77	2.00	2.40	2.39	2.06	2.91	5.53	2.40	1.93
22	1.98	1.90	1.86	1.77	1.83	2.21	2.58	2.11	3.04	10.82	2.37	1.93
23	1.98	1.90	1.86	1.77	1.81	2.14	2.50	2.09	3.62	6.09	2.32	1.91
24	1.98	1.90	1.85	1.77	2.67	2.35	2.44	2.26	3.57	5.24	2.29	1.88
25	1.98	1.89	1.85	1.77	2.18	2.11	2.40	2.12	3.20	4.72	2.28	1.87
26	1.98	1.89	1.85	1.77	1.99	2.08	2.35	2.16	3.13	4.30	2.24	1.84
27	1.97	1.89	1.84	1.77	1.96	2.08	2.31	2.14	3.05	4.06	2.22	1.84
28	1.97	1.89	1.84	1.76	1.92	2.51	2.31	2.07	2.95	3.85	2.20	1.83
29	1.97	......	1.83	1.76	1.91	2.14	2.30	2.07	4.92	3.70	2.19	1.81
30	1.97	......	1.82	1.76	1.89	2.60	2.29	2.06	5.00	3.55	2.18	1.78
31	1.97	......	1.81	......	1.95	......	2.34	2.08	......	3.50	......	1.78

Rating table for Tola River, 1 mile above its mouth.

[This table is applicable only from August 13, 1899, to April 30, 1900.]

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	*Sec. ft.*	*Feet.*	*Sec. ft.*	*Feet.*	*Sec. ft.*	*Feet.*	*Sec. ft.*
1.0	....	2.2	24	3.4	158	4.6	314
1.1	....	2.3	30	3.5	171	4.7	327
1.2	....	2.4	40	3.6	184	4.8	340
1.3	....	2.5	50	3.7	197	4.9	353
1.4	....	2.6	60	3.8	210	5.0	366
1.5	....	2.7	70	3.9	223	5.1	379
1.6	1	2.8	80	4.0	236	5.2	392
1.7	3	2.9	93	4.1	249	5.3	405
1.8	5	3.0	106	4.2	262	5.4	418
1.9	7	3.1	119	4.3	275	5.5	431
2.0	12	3.2	132	4.4	288	5.6	....
2.1	18	3.3	145	4.5	301	5.7	....

Rating table for Tola River.

[This table is applicable only from May 1, 1900, to October 20, 1900.]

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	....	2.3	49	3.6	225	4.9	433
1.1	....	2.4	59	3.7	241	5.0	449
1.2	....	2.5	70	3.8	257	5.1	465
1.3	....	2.6	81	3.9	273	5.2	481
1.4	....	2.7	93	4.0	289	5.3	497
1.5	....	2.8	105	4.1	305	5.4	513
1.6	....	2.9	118	4.2	321	5.5	529
1.7	10	3.0	131	4.3	337	5.6	545
1.8	14	3.1	145	4.4	353	5.7	561
1.9	19	3.2	161	4.5	369	5.8	577
2.0	25	3.3	177	4.6	385	5.9	593
2.1	32	3.4	193	4.7	401	6.0	609
2.2	40	3.5	209	4.8	417	6.1	....

Rating table for Tola River.

[This table is applicable only from October 21, 1900, to March 29, 1901.]

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	10	2.4	145	3.8	369	5.2	593
1.1	14	2.5	161	3.9	385	5.3	609
1.2	19	2.6	177	4.0	401	5.4	625
1.3	25	2.7	193	4.1	417	5.5	641
1.4	32	2.8	209	4.2	433	5.6	657
1.5	40	2.9	225	4.3	449	5.7	673
1.6	49	3.0	241	4.4	465	5.8	689
1.7	59	3.1	257	4.5	481	5.9	705
1.8	70	3.2	273	4.6	497	6.0	721
1.9	81	3.3	289	4.7	513	6.1	737
2.0	93	3.4	305	4.8	529	6.2	....
2.1	105	3.5	321	4.9	545	6.3	....
2.2	118	3.6	337	5.0	561	6.4	....
2.3	131	3.7	353	5.1	577	10.82	1,651

Estimated monthly discharge of Tola River 1 mile above its mouth, 1898.

Months.	Discharge. Maximum.	Discharge. Minimum.	Discharge. Mean.	Total.	Months.	Discharge. Maximum.	Discharge. Minimum.	Discharge. Mean.	Total.
	Sec.feet.	*Sec.feet.*	*Sec.feet.*	*Acre-feet.*		*Sec.feet.*	*Sec.feet.*	*Sec.feet.*	*Acre-feet.*
June (9-30)	355	12	53	2,310	November	270	100	160	9,520
July	163	21	46	2,830	December	100	65	79	4,860
August	57	20	30	1,840					
September	364	39	112	6,660	Total	452	12	106	43,145
October	452	130	246	15,125					

Estimated monthly discharge of Tola River at 1 mile above its mouth.

Months.	Discharge. Maximum.	Discharge. Minimum.	Discharge. Mean.	Total.	Months.	Discharge. Maximum.	Discharge. Minimum.	Discharge. Mean.	Total.
1899.	*Sec.feet.*	*Sec.feet.*	*Sec.feet.*	*Acre-feet.*	1900.	*Sec.feet.*	*Sec.feet.*	*Sec.feet.*	*Acre-feet.*
August (13-31)	26	2	13	496	April	5.3	4	5	276
September	17	8.5	14	841	May	89	11	19	1,182
October	408	8	49	2,993	June	187.3	15	40	2,384
November	173	18	30	1,759	July	99	28	62	3,840
December	41	15	20	1,256	August	47	24	34	2,023
					September	....	28	120	7,154
Total	408	2	26	7,345	October	3,047	145	370	22,765
1900.					November	291	111	179	10,679
					December	113	66	89	5,496
January	15.3	10	13	770					
February	11.7	7	8	428	The year	3,047	4	79	57,378
March	9.5	5	6	381					

LAKE NICARAGUA.

Lake Nicaragua is one of the notable fresh-water lakes of the world. It has an area of 2,975 square miles. It greatest length is from northwest to southeast, and is about 100 miles. Its extreme width is about 45 miles.

West of the center is an island occupied by the volcanoes Ometepe and Madera, which stand about 5,000 feet above the lake level, adding greatly to the scenic beauty.

Madera is the most southern of a line of volcanoes of comparatively recent origin, which extends in a northwesterly direction nearly to the Bay of Fonseca, including Ometepe, Zapatero, Mombacho, Chiltepe, Momotombo, and many others.

The prevailing easterly trade winds cause a moderately heavy surf to beat almost constantly on the western shore, causing the formation of a decided beach on that side, while on the eastern shore aquatic vegetation grows far out into the water. This shore is flat and muddy, with no well-marked beach.

Except in the southeastern portion the lake is deep, reaching at one point near the southern foot of Madera to a depth of 200 feet.

Lake Nicaragua receives the waters of a large number of tributaries, the most important being Rio Frio and Rio Pisote on the southern end, which rise in the high mountains of Costa Rica and maintain some flow throughout the dry season, and Malacatolla and Tipitapa on the northern end, the latter bringing the waters of Lake Managua. The drain-

FIG. 1.—MOMOTOMBO FROM THE WEST.

age area, as estimated from the best information obtainable, is as follows:

	Square miles.
Area of land surface draining directly to Lake Nicaragua	6,640
Area of Lake Nicaragua	2,975
Lake Managua and tributary basin	3,035
Total	12,450

VIEJO RIVER.

This stream rises in the neighborhood of Jinotega, and flows in a southerly direction to Lake Managua, being therefore in the basin of Lake Nicaragua.

The station on this river is about 500 yards above the ford known as Pasa Real, where the Matagalpa-Leon road crosses the stream. A record was kept for the Nicaragua Canal Commission from February 1, 1898, to January 22, 1899. The station was reestablished in August, 1899, and a record kept till the end of the year.

The observer at this station also made some observations of the discharge of the Nueva River, which approaches very near the Viejo at this point, but flows into the Atlantic.

Rating table for Viejo River, near crossing of Matagalpa-Leon road.

This table is applicable only from August 18, 1899, to January 22, 1900:

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.0	15	3.4	165	4.8	516	6.2	1,034
2.1	21	3.5	183	4.9	548	6.3	1,073
2.2	27	3.6	202	5.0	581	6.4	1,112
2.3	33	3.7	220	5.1	615	6.5	1,151
2.4	40	3.8	241	5.2	650	6.6	1,190
2.5	48	3.9	263	5.3	686	6.7	1,230
2.6	57	4.0	286	5.4	723	6.8	1,270
2.7	67	4.1	310	5.5	761	6.9	1,310
2.8	78	4.2	335	5.6	800	7.0	1,350
2.9	90	4.3	361	5.7	839	7.1	1,401
3.0	103	4.4	398	5.8	878	7.2	1,452
3.1	117	4.5	426	5.9	917	7.3	1,503
3.2	132	4.6	455	6.0	956	7.4	1,554
3.3	148	4.7	485	6 1	995	7.5	1,605

Estimated monthly discharge of Viejo River at crossing of Matagalpa-Leon road, 1898.

Months.	Discharge.			Total.	Months.	Discharge.			Total.
	Maximum.	Minimum.	Mean.			Maximum.	Minimum.	Mean.	
1898.	*Sec.feet.*	*Sec.feet.*	*Sec.feet.*	*Acre-feet.*	1898.	*Sec.feet.*	*Sec.feet.*	*Sec.feet.*	*Acre-feet.*
February	35	15	24.0	1,332	October	3,830	230	965.0	59,340
March	25	5	13.0	800	November	253	74	130.0	7,735
April	5	3	3.6	214	December	92	39	59.0	3,630
May	5,520	2	324.0	19,920					
June	15,600	50	2,170.0	129,120	1899.				
July	2,400	155	613.0	37,680	January	94	35	49.0	3,013
August	2,750	125	330.0	20,290					
September	9,745	220	1,765.0	105,025	The year	15,600	2	536.0	388,099

Estimated monthly discharge of Viejo River at crossing of Matagalpa-Leon Road.

Months.	Discharge.			Total.
	Maximum.	Minimum.	Mean.	
1899.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*
August 18–31	110	24	27.8	1,327
September	93	18	40.4	2,406
October	9,014	18	863.7	53,110
November	322	100	159.7	9,505
December	681	40	98.6	6,066
Total	9,014	18	268.0	72,414
1900.				
January	40	33	35.3	1,541

NUEVA RIVER.

This station is at the bend of the Nueva River, where it approaches nearest the Viejo, in the neighborhood of Paso Real, and was intended to throw light on the quantity of water that might be added to the supply for Lake Managua by diverting this river into it.

Measurements were made by wading at low water and by means of floats at high water. The stage of the river was ascertained by measuring downward with a tapeline from a nail driven in an overhanging trunk of a tree. These measurements were carried on by the same observer who had charge of the station on the Viejo.

Estimated monthly discharge of Nueva River near Viejo River.

Months.	Discharge.			Total.
	Maximum.	Minimum.	Mean.	
1899.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*
August 19–31	242	52.0	79.6	2,053
September	64	8.4	21.1	1,303
October	2,602	13.0	477.1	29,336
November	402	62.0	170.3	10,136
December	820	27.0	155.6	9,568
Total	2,602	8.4	196.0	52,396
1900.				
January 1–22	39	20.0	29.3	1,277

QUEBRADA HONDA.

This stream is tributary to the Viejo River about 2 miles below the station on the latter. A gauge was placed one-half mile above the wagon ford on the road from Leon to Matagalpa, and graduated to feet and tenths. At low water measurements were made by wading; at high water, by means of floats.

FIG. 2.—SAN JUAN RIVER ABOVE TORO RAPIDS.

Discharge measurements made on Quebrada Honda above crossing Matagalpa-Leon road.

[Hydrographer, Fred Davis. No flow from August 18 to October 10.]

Date.	Meter number.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.		*Feet.*	*Square ft.*	*Ft. per sec.*	*Square feet.*
October 10	7	3.78	3.70	0.52	1.92
October 15	7	3.72	2.15	.43	.92
October 17	7	4.40	28	1.70	47.72
October 20	7	4.20	19.50	1.14	22.20
October 26	([a])	13.30	535.60	4.28	2,293.4
October 29	([a])	7.30	169.50	3.01	510.7
November 8	7	4.70	24.50	.85	20.82
November 16	7	4.56	4.80	.52	2.49
November 23	7	4.50	3.90	.61	2.37
December 3	7	4.60	12.80	7.43	9.51
December 16	7	4.45	1.50	1.50	2.25
December 30	7	4.28	([b])	([b])	([b])
1900.					
January [b]					

[a] Floats. [b] No flow.

NOTE.—Seventy per cent of maximum surface velocity used in calculations.

TIPITAPA.

The gauge in this river is about 100 yards above Tipitapa Falls, and serves both to register the stage of the river and the height of Lake Managua, upon which the stage of the river depends. During low water the river was too sluggish above the falls for accurate measurements with current meter, and gaugings were made from the bridge below the falls. As the river rose it became very turbulent and swift at the bridge, but at the same time the velocity in the upper river increased and good measurements were made above the falls. Observations of rainfall and evaporation were also made at this point.

Lake Managua lies to the northwest of Lake Nicaragua and drains into the latter through Rio Tipitapa. Its area is about 438 square miles.

Reports of the discharge of Tipitapa River are conflicting. All agree that the stream goes dry in the latter part of every dry season. Some authorities assert that it has been dry for several years in succession, the inflow during the rainy season being insufficient to compensate for evaporation, while others maintain that there is more or less outflow every year in the rainy season. Investigations were therefore made to determine roughly the feasibility of diverting the Rio Nueva, which now drains into the Rio Grande into the Rio Viejo, and finally into Lake Managua. Near the station on Rio Viejo the two rivers approach within about a mile of each other and the intervening country is low and flat. The river channels are 30 to 40 feet deep, and a cut of this depth connecting the two could be made to conduct the waters of Rio Nueva into Rio Viejo, if a dam were built in Rio Nueva below the point of connection. There is rock on the bottom of Rio Nueva showing fairly good foundation for such a structure, but the excavation of the canal would be almost entirely alluvial earth.

Daily gauge height of Tipitapa River at Tipitapa, 1899.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	2.95	2.80	5.55	5.77	17	......	2.87	3.63	5.44	5.37
2	......	2.98	2.75	5.51	5.74	18	......	2.92	3.50	5.46	5.33
3	......	3.01	2.82	5.51	5.69	19	......	2.88	3.55	5.46	5.31
4	......	3.01	2.80	5.46	5.68	20	2.87	2.82	3.53	5.42	5.32
5	......	3.06	2.75	5.49	5.66	21	2.83	2.81	3.46	5.44	5.28
6	......	3.02	2.80	5.48	5.62	22	2.87	2.86	3.65	5.47	5.23
7	......	2.96	2.85	5.46	5.65	23	2.85	2.73	3.80	5.47	5.25
8	......	3.02	2.92	5.54	5.61	24	2.85	2.73	4.10	5.46	5.20
9	......	3.07	2.90	5.63	5.61	25	2.90	2.73	4.32	5.49	5.19
10	......	3.00	2.88	5.62	5.59	26	2.92	2.84	4.61	5.60	5.15
11	......	2.99	3.08	5.56	5.57	27	2.97	2.72	4.92	5.55	5.16
12	......	2.97	3.10	5.62	5.51	28	2.95	2.73	5.39	5.62	5.14
13	......	2.99	3.28	5.62	5.58	29	2.97	2.69	5.53	5.65	5.16
14	......	2.96	3.31	5.52	5.56	30	2.93	2.75	5.55	5.77	5.13
15	......	2.96	3.42	5.51	5.53	31	2.92	......	5.53	......	5.07
16	......	2.98	3.43	5.49	5.51						

Daily gauge height of Tipitapa River at Tipitapa, 1900.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	5.09	4.53	4.06	3.33	2.92	3.51	5.01	6.14	5.72	5.78
2	5.04	4.47	3.91	3.33	2.96	3.42	5.07	6.17	5.73	5.86
3	5.00	4.41	3.94	3.31	2.94	3.56	5.15	6.11	5.73	5.95
4	5.03	4.48	3.82	3.33	2.88	3.61	5.23	6.12	5.75	6.10
5	4.92	4.40	3.73	3.25	2.77	3.81	5.26	6.09	5.73	6.17
6	4.92	4.44	3.78	3.21	2.66	4.07	5.20	6.09	5.75	6.18
7	4.89	4.46	3.84	3.21	2.66	4.13	5.11	6.09	5.76	6.18
8	4.93	4.35	3.78	3.28	2.66	4.63	5.27	6.08	5.77	6.17
9	4.90	4.40	3.72	3.25	2.66	4.57	5.40	6.11	5.78	6.15
10	4.91	4.40	3.78	3.28	2.62	4.57	5.67	6.10	5.78	6.16
11	4.93	4.47	3.75	3.22	2.63	4.65	5.86	6.07	5.75	6.37
12	4.89	4.42	3.73	3.16	2.64	4.80	5.99	6.03	5.76	6.48
13	4.86	4.43	3.72	3.14	2.67	4.77	5.96	5.93	5.74	6.46
14	4.84	4.35	3.68	3.12	2.63	4.64	6.07	5.94	5.73	6.48
15	4.90	4.32	3.74	3.07	2.71	4.72	6.13	5.92	5.73	6.50
16	4.88	4.34	3.77	3.01	2.77	4.75	6.14	5.91	5.76	6.48
17	4.90	4.33	3.75	2.97	2.84	4.74	6.20	5.91	5.75	6.52
18	4.80	4.27	3.65	3.02	2.81	4.77	6.25	5.90	5.73	6.50
19	4.85	4.17	3.66	2.96	2.82	4.80	6.22	5.84	5.72	6.51
20	4.69	4.14	3.64	2.94	2.81	4.80	6.26	5.82	5.72	6.50
21	4.74	4.16	3.53	2.93	2.90	4.80	6.26	5.83	5.70	6.74
22	4.74	4.15	3.37	2.92	2.96	4.78	6.22	5.83	5.73	6.90
23	4.72	4.15	3.48	2.96	2.99	4.80	6.21	5.83	5.73	6.96
24	4.72	4.17	3.52	2.96	2.98	5.17	6.24	5.85	5.77	7.30
25	4.78	4.09	3.52	....	3.03	4.99	6.22	5.85	5.75	7.20
26	4.65	4.08	3.54	....	3.06	4.98	6.21	5.87	5.75	7.18
27	4.68	4.15	3.49	3.01	3.06	4.98	6.20	5.82	5.74	7.19
28	4.72	4.09	3.49	3.01	3.23	4.95	6.16	5.78	5.75	7.19
29	4.64	....	3.50	2.94	3.26	4.90	6.21	5.71	5.75	7.19
30	4.58	....	3.50	2.96	3.54	4.95	6.22	5.75	5.78	7.23
31	4.59	....	3.42	....	3.51	....	6.15	5.72	....	7.23

Rating table for Tipitapa River at Tipitapa.

[This table is applicable only from August 20, 1899, to October 30, 1900.]

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
2.6	1	3.8	30	5.0	280	6.2	1,200
2.7	2	3.9	39	5.1	320	6.3	1,287
2.8	3	4.0	48	5.2	375	6.4	1,375
2.9	4	4.1	60	5.3	440	6.5	1,462
3.0	6	4.2	72	5.4	500	6.6	1,550
3.1	8	4.3	90	5.5	587	6.7	1,637
3.2	10	4.4	110	5.6	675	6.8	1,725
3.3	12	4.5	130	5.7	762	6.9	1,812
3.4	14	4.6	153	5.8	850	7.0	1,900
3.5	16	4.7	180	5.9	937	7.1	1,987
3.6	18	4.8	210	6.0	1,025	7.2	2,075
3.7	24	4.9	245	6.1	1,112	7.3	2,162

Estimated monthly discharge of Tipitapa River at Tipitapa, 1898.

Months.	Discharge.			Total.	Months.	Discharge.			Total.
	Maximum.	Minimum.	Mean.			Maximum.	Minimum.	Mean.	
1898.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre ft.*	1898.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre ft.*
February	125	37	77.0	4,275	October	5,380	2,910	4,040.0	248,410
March	36	3	16.6	1,020	November	5,500	2,150	3,640.0	216,600
April	4	0	0.5	29	December	2,630	1,470	1,950.0	119,900
May	18	0	3.8	234					
June	700	13	121.0	7,200	1899.				
July	922	280	662.0	40,700	January (1–23)	1,470	950	1,210.0	55,200
August	930	487	626.0	38,490					
September	3,230	910	2,045.0	121,690	The year.	5,580	0	1,208.0	853,748

Estimated monthly discharge of Tipitapa River at Tipitapa.

Months.	Discharge.			Total.	Months.	Discharge.			Total.
	Maximum.	Minimum.	Mean.			Maximum.	Minimum.	Mean.	
1899.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*	1900.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-ft.*
August 20–31	5	3.0	4.0	97	March	55	5.7	25.0	1,515
September	7	2.0	4.5	266	April	13	.4	8.0	474
October	631	2.0	101.5	6,244	May	17	.2	5.0	309
November	824	517.0	612.7	36,459	June	358	12.0	173.0	10,277
December	824	308.0	545.0	33,505	July	1,275	284.0	919.0	56,500
					August	1,348	749.0	974.0	59,900
Total	824	2.0	291.0	76,571	September	866	762.0	801.0	47,667
					October	2,804	832.0	1,527.0	93,917
1900.									
January	316	148.0	223.0	13,724	Total	2,804	2.0	400.0	289,515
February	137	58.0	94.0	5,232					

REGIMEN OF LAKE NICARAGUA.

The rise and fall of the lake is the most important element in the measurement of the water supply to the summit level of the canal, the rate of inflow and of evaporation. To obtain this element with the greatest possible accuracy, four gauge rods were established at approximately equal intervals on the margin of the lake, at Sapoa, Granada, San Ubaldo, and Fort San Carlos, upon which daily observations were taken.

Daily elevation of Lake Nicaragua as indicated by the gauge rod at Sapoa, for the year 1899.

[Elevation of zero of rod, 100.02 feet.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	102.65	103.23	103.32	104.33	104.91
2	....	102.60	103.19	103.31	104.33	104.97
3	....	102.67	103.21	103.34	104.31	104.97
4	....	102.62	103.23	103.33	104.36	105.05
5	....	102.65	103.25	103.34	104.31	105.14
6	....	102.65	103.26	103.35	104.27	104.98
7	....	102.68	103.25	103.35	104.28	104.95
8	....	102.68	103.24	103.36	104.31	104.91
9	....	102.64	103.28	103.36	104.51	104.89
10	....	102.59	103.28	103.37	104.54	104.95
11	....	102.59	103.25	103.37	104.54	104.91
12	....	102.60	103.22	103.38	104.57	104.90
13	....	102.58	103.20	103.48	104.64	104.91
14	....	102.59	103.21	103.64	104.52	104.95
15	....	102.62	103.24	103.67	104.58	104.97
16	102.36	102.59	103.17	103.69	104.53	104.93
17	102.35	102.60	103.19	103.71	104.51	104.91
18	102.36	102.65	103.19	103.75	104.49	104.93
19	102.38	102.66	103.21	103.82	104.50	104.87
20	102.40	102.69	103.20	103.81	104.52	104.88
21	102.42	102.71	103.27	103.80	104.49	104.74
22	102.42	102.74	103.29	103.84	104.53	104.77
23	102.52	102.72	103.34	103.91	104.56	104.65
24	102.60	102.84	103.38	103.91	104.55	104.67
25	102.59	102.85	103.35	103.91	104.55	104.74
26	102.68	102.97	103.37	103.91	104.57	104.73
27	102.61	103.12	103.35	103.98	104.63	104.64
28	102.68	103.12	103.35	104.12	104.64	104.65
29	102.69	103.17	103.33	104.28	104.71	104.65
30	102.68	103.25	103.32	104.31	104.96	104.60
31	102.71	103.26	....	104.37	....	104.52

Daily elevation of Lake Nicaragua as indicated by the gauge rod at Sapoa for the year 1900.

[Elevation of zero of rod: January 1 to July 31, 100.02 feet; Aug. 1 to Dec. 31, 97.19 feet.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	104.49	104.08	103.26	102.46	101.57	102.03	102.65	104.04	104.59	105.53	107.39	106.83
2	104.47	104.06	103.25	102.53	101.55	102.10	102.67	104.07	104.56	105.76	107.39	106.77
3	104.52	103.96	103.28	102.33	101.55	102.05	102.66	104.08	104.58	105.76	107.37	106.77
4	104.54	103.89	103.31	102.28	101.53	102.08	102.71	104.18	104.66	105.95	107.35	106.75
5	104.52	103.83	103.24	103.28	101.55	102.08	102.74	104.17	104.73	105.95	107.27	106.75
6	104.51	103.92	103.17	102.30	101.62	102.11	102.83	104.22	104.68	105.99	107.29	106.76
7	104.47	103.82	103.11	102.25	101.61	102.02	102.81	104.25	104.63	106.17	107.31	106.75
8	104.42	103.76	103.13	102.18	101.41	102.22	102.86	104.28	104.66	106.19	107.31	106.77
9	104.39	103.80	103.11	102.18	101.53	102.28	102.99	104.31	104.72	106.17	107.33	106.79
10	104.33	103.77	103.00	102.16	101.37	102.28	103.04	104.37	104.64	106.23	107.37	106.84
11	104.29	103.76	102.93	102.17	101.40	102.34	103.16	104.38	104.70	106.27	107.46	106.79
12	104.29	103.68	102.92	102.13	101.35	102.35	103.28	104.39	104.76	106.28	107.38	106.77
13	104.35	103.71	102.83	102.08	101.28	102.35	103.44	104.34	104.73	106.32	107.37	106.78
14	104.38	103.70	102.81	102.06	101.34	102.43	103.46	104.40	104.74	106.32	107.31	106.73
15	104.31	103.57	102.75	102.00	101.20	102.46	103.58	104.47	104.72	106.34	107.28	106.72
16	104.26	103.57	102.73	102.00	101.21	102.45	103.67	104.43	104.78	106.35	107.23	106.74
17	104.26	103.56	102.70	101.95	101.23	102.48	103.69	104.38	104.86	106.51	107.23	106.70
18	104.26	103.59	102.76	101.95	101.25	102.46	103.54	104.40	104.88	106.48	107.13	106.74
19	104.23	103.72	102.75	101.89	101.31	102.46	103.88	104.32	105.01	106.50	107.06	106.73
20	104.23	103.62	102.71	101.87	101.35	102.50	103.90	104.38	104.95	106.55	107.03	106.77
21	104.30	103.42	102.79	101.84	101.33	102.46	103.97	104.34	104.92	106.61	107.01	106.75
22	104.18	103.40	102.74	101.82	101.41	102.48	103.98	104.41	104.96	106.90	107.03	106.66
23	104.14	103.42	102.72	101.77	101.33	102.49	103.81	104.46	104.97	107.17	106.99	106.66
24	104.10	103.32	102.57	101.75	101.38	102.57	103.77	104.55	105.11	107.35	106.91	106.64
25	104.10	103.36	102.55	101.62	101.46	102.53	103.98	104.56	105.09	107.42	106.92	106.68
26	104.10	103.34	102.50	101.64	101.58	102.52	103.95	104.60	105.11	107.38	106.98	106.67
27	104.04	103.42	102.48	101.63	101.60	102.49	104.00	104.56	105.14	107.36	107.01	106.57
28	104.01	103.29	102.47	101.64	101.72	102.60	103.93	104.55	105.16	107.35	106.97	106.58
29	103.94	....	102.41	101.60	101.79	102.59	103.97	104.56	105.26	107.38	106.92	106.55
30	103.87	....	102.46	101.60	101.98	102.59	103.99	104.56	105.51	107.36	106.93	106.53
31	103.90	....	102.51	....	102.13	....	103.99	104.57	....	107.36	....	106.47

Daily elevation of Lake Nicaragua as indicated by the gauge rod at Granada for the year 1899.

[Elevation of zero of rod, 100.37 feet.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1...	....	105.77	105.02	104.17	103.27	102.47	102.37	102.67	103.27	103.37	104.27	104.87
2...	....	105.77	104.87	104.07	103.27	102.47	102.37	102.77	103.27	103.32	104.27	105.07
3...	....	105.77	104.87	104.07	103.27	102.47	102.37	102.67	103.27	103.37	104.22	105.07
4...	....	105.87	104.87	104.07	103.17	102.37	102.47	102.67	103.27	103.32	104.17	104.97
5...	....	105.87	104.87	104.07	103.17	102.37	102.47	102.67	103.27	103.37	104.27	105.07
6...	....	105.77	104.87	104.07	103.17	102.47	102.37	102.67	103.32	103.37	104.27	105.02
7...	....	105.77	104.97	104.07	103.07	102.47	102.37	102.67	103.37	103.47	104.17	104.87
8...	....	105.67	104.87	104.07	103.07	102.47	102.37	102.57	103.22	103.52	104.27	104.82
9...	....	105.57	104.77	103.97	103.07	102.37	102.27	102.57	103.27	103.37	104.57	104.97
10...	....	105.57	104.67	103.97	102.97	102.47	102.27	102.57	103.17	103.42	104.57	104.97
11...	....	105.57	104.57	103.87	102.87	102.57	102.17	102.67	103.27	103.37	104.67	104.87
12...	....	105.57	104.57	103.77	102.87	102.57	102.07	102.67	103.22	103.42	104.62	104.77
13...	....	105.57	104.57	103.67	102.87	102.67	102.07	102.67	103.17	103.42	104.57	104.87
14...	....	105.47	104.57	103.67	102.82	102.47	102.17	102.57	103.17	103.67	104.62	104.87
15...	....	105.47	104.57	103.67	102.77	102.47	102.27	102.57	103.07	103.67	104.57	104.87
16...	....	105.47	104.57	103.57	102.77	102.47	102.27	102.57	103.07	103.67	104.47	105.07
17...	....	105.47	104.57	103.57	102.72	102.47	102.27	102.62	102.97	103.67	104.47	104.97
18...	....	105.37	104.57	103.57	102.67	102.57	102.27	102.57	103.07	103.67	104.47	104.97
19...	....	105.37	104.47	103.57	102.67	102.47	102.47	102.67	103.17	103.77	104.57	104.87
20...	....	105.47	104.47	103.52	102.67	102.67	102.37	102.57	103.62	103.67	104.47	104.87
21...	....	105.17	104.42	103.47	102.67	102.52	102.77	102.57	103.37	103.67	104.57	104.87
22...	....	105.17	104.37	103.57	102.67	102.47	102.67	102.57	103.37	103.87	104.57	104.77
23...	....	105.17	104.37	103.57	102.62	102.47	102.57	102.67	103.37	103.87	104 57	104.77
24...	105.67	105.17	104.32	103.57	102.57	102.47	102.37	102.67	103.32	103.97	104.57	104.77
25...	105.67	105.12	104.27	103.47	102.57	102.57	102.47	102.77	103.42	103.97	104.57	104.37
26...	105.67	105.12	104.27	103.37	102.57	102.47	102.57	103.07	103.47	104.07	104.57	104.57
27...	105.67	105.07	104.17	103.37	102.57	102.57	102.57	103.07	103.47	104.17	104.67	104.57
28...	105.67	104.97	104.17	103.37	102.47	102.47	102.67	103.07	103.52	104.27	104.67	104.57
29...	105.67	......	104.17	103.37	102.47	102.37	102.67	103.37	103.42	104.27	104.67	104.47
30...	105.77	....	104.17	103.32	102.47	102.37	102.67	103.37	103.37	104.27	104.87	104.47
31...	105.77	....	104.17	....	102.47	....	102.67	103.32	....	104.37	......	104.47

Daily elevation for Lake Nicaragua as indicated by the gauge rod at Granada for the year 1900.

[Elevation of zero of rod: January 1 to April 6, 100.37 feet; April 7, 98.44 feet.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1...	104.47	103.97	103.47	102.47	101.74	102.34	102.74	104.34	104.84	105.34	107.54	107.14
2...	104.47	103.97	103.47	102.47	101.74	102.34	102.74	104.34	104.94	105.49	107.54	107.14
3...	104.37	103.97	103.37	102.47	101.84	102.39	102.79	104.34	104.94	105.59	107.44	107.14
4...	104.37	103.97	103.27	102.37	101.84	102.24	102.84	104.34	104.84	105.69	107.44	107.14
5...	104.37	103.97	103.27	102.47	101.84	102.24	102.94	104.44	104.84	105.74	107.34	107.04
6...	104.47	103.97	103.37	102.47	101.94	102.19	102.94	104.44	104.84	105.94	107.34	107.04
7...	104.37	103.97	103.37	102.44	101.84	102.24	102.94	104.44	104.84	106.04	107.34	107.04
8...	104.37	103.97	103.37	102.44	101.84	102.14	102.94	104.44	104.84	106.04	107.44	106.94
9...	104.37	103.77	103.37	102.44	101.74	102.24	102.99	104.54	104.94	106.04	107.44	106.94
10...	104.37	103.77	103.37	102.34	101.74	102.54	103.24	104.64	104.94	106.14	107.44	106.94
11...	104.37	103.77	103.37	102.24	101.64	102.59	103.44	104.74	104.94	106.24	107.44	106.94
12...	104.37	103.77	103.37	102.24	101.64	102.54	103.49	104.74	104.94	106.44	107.54	106.94
13...	104.37	103.77	103.37	102.24	101.64	102.49	103.64	104.84	104.94	106.54	107.54	106.94
14...	104.37	103.77	103.37	102.24	101.44	102.54	103.64	104.84	104.94	106.54	107.74	106.94
15...	104.27	103.57	103.27	102.34	101.44	102.54	103.84	104.84	105.04	106.64	107.74	106.84
16...	104.27	103.47	103.17	102.34	101.41	102.54	103.84	104.84	105.04	106.74	107.64	106.74
17...	104.17	103.37	103.17	102.24	101.34	102.59	103.84	104.84	105.04	106.94	107.64	106.74
18...	104.17	103.37	103.17	102.14	101.34	102.59	103.94	104.94	105.04	107.04	107.74	106.74
19...	104.17	103.37	102.97	102.14	101.34	102.59	103.94	104.94	105.04	107.14	107.64	106.94
20...	104.17	103.37	102.77	102.04	101.39	102.64	103.94	104.94	105.14	107.24	107.64	106.94
21...	104.17	103.37	102.97	102.04	101.44	102.74	104.04	104.94	105.24	107.34	107.64	106.84
22...	104.17	103.47	102.87	102.04	101.54	102.74	104.04	105.04	105.24	107.34	107.54	106.84
23...	104.12	103.47	102.87	101.94	101.54	102.74	104.14	105.04	105.24	107.34	107.44	106.84
24...	104.17	103.47	102.77	101.94	101.59	102.79	104.14	105.04	105.24	107.34	107.44	106.84
25...	104.17	103.37	102.77	101.94	101.59	102.74	104.14	105.14	105.24	107.34	107.44	106.84
26...	104.17	103.37	102.87	101.94	101.94	102.74	104.14	105.14	105.24	107.34	107.44	106.84
27...	104.17	103.47	102.77	101.94	102.19	102.69	104.14	105.14	105.24	107.44	107.34	106.79
28...	104.07	103.37	102.57	101.84	102.14	102.74	104.14	105.04	105.24	107.44	107.34	106.79
29...	103.97	....	102.57	101.74	102.14	102.74	104.14	105.04	105.24	107.44	107.34	106.84
30...	103.97	....	102.57	101.74	102.19	102.74	104.24	105.04	105.34	107.44	107.14	106.84
31...	103.97	....	102.47	....	102.24	....	104.24	105.04	....	107.44	....	106.84

Daily elevation of Lake Nicaragua as indicated by the gauge rod at San Ubaldo for the year 1899.

[Elevation of zero of rod, 96.90 feet.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	102.35	102.78	103.37	103.49	104.37	105.11
2	....	102.45	102.73	103.34	103.45	104.42	105.10
3	....	102.40	102.68	103.35	103.46	104.38	105.15
4	....	102.47	102.67	103.34	103.52	104.37	105.02
5	....	102.37	102.72	103.35	103.51	104.40	104.94
6	....	102.38	102.71	103.31	103.55	104.42	104.93
7	....	102.33	102.72	103.33	103.54	104.44	104.92
8	....	102.32	102.72	103.41	103.54	104.45	104.95
9	....	102.27	102.67	103.36	103.54	104.60	104.95
10	....	102.30	102.65	103.37	103.49	104.60	104.93
11	....	102.40	102.70	103.33	103.61	104.57	104.88
12	....	102.28	102.70	103.29	103.62	104.50	104.95
13	....	102.32	102.67	103.30	103.69	104.51	104.90
14	....	102.35	102.67	103.34	103.74	104.33	104.93
15	....	102.37	102.66	103.27	103.91	104.49	104.88
16	....	102.43	102.66	103.25	103.95	104.49	104.83
17	....	102.38	102.65	103.25	103.86	104.54	104.78
18	102.50	102.40	102.70	103.24	103.87	104.61	104.74
19	102.35	102.47	102.67	103.20	103.89	104.63	104.67
20	102.65	102.40	102.68	103.26	103.84	104.61	104.70
21	102.50	102.47	102.77	103.34	103.94	104.62	104.71
22	102.55	102.53	102.70	103.35	103.99	104.68	104.72
23	102.40	102.70	102.73	103.36	104.10	104.68	104.71
24	102.58	102.65	102.84	103.40	104.20	104.68	104.68
25	102.45	102.67	102.83	103.42	104.35	104.76	104.72
26	102.48	102.63	103.09	103.44	104.28	104.73	104.70
27	102.38	102.70	103.21	103.49	104.35	104.78	104.61
28	102.27	102.63	103.23	103.42	104.40	104.82	104.55
29	102.45	102.73	103.23	103.45	104.40	104.88	104.58
30	102.55	102.70	103.31	103.45	104.39	105.14	104.53
31	....	102.72	103.35	....	104.41	....	104.55

Daily elevation of Lake Nicaragua as indicated by the gauge rod at San Ubaldo for the year 1900.

[Elevation of zero of rod: January 1 to June 12, 96.90 feet; June 13, 94.94 feet.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	104.56	103.97	103.18	102.36	101.81	102.18	102.71	104.04	104.70	105.59	107.40	106.85
2	104.56	103.93	103.12	102.33	101.78	102.15	102.71	104.02	104.69	105.79	107.32	106.85
3	104.40	103.95	103.14	102.30	101.70	102.05	102.78	103.96	104.70	105.86	107.33	106.81
4	104.29	104.89	103.10	102.41	101.69	102.08	102.75	104.03	104.77	105.84	107.33	106.81
5	104.43	103.00	103.04	102.37	101.62	102.13	102.79	104.10	104.80	105.94	107.32	106.74
6	104.37	103.85	103.12	102.25	101.58	102.22	102.77	104.20	104.83	105.99	107.32	106.73
7	104.41	103.83	103.13	102.32	101.58	102.31	102.93	104.30	104.80	106.17	107.31	106.72
8	104.41	103.87	103.03	102.29	101.57	102.30	102.99	104.34	104.81	106.23	107.25	106.67
9	104.43	103.80	102.94	102.29	101.58	102.43	103.08	104.33	104.82	106.26	107.18	106.66
10	104.41	103.78	102.92	102.25	101.41	102.48	103.18	104.30	104.83	106.28	107.17	106.69
11	104.42	103.80	102.98	102.18	101.45	102.45	103.25	104.30	104.85	106.29	107.16	106.64
12	104.41	103.73	102.88	102.11	101.58	102.47	103.43	104.28	104.84	106.33	107.18	106.65
13	104.39	103.68	102.97	102.07	101.44	102.51	103.15	104.41	104.83	106.39	107.13	106.71
14	104.32	103.68	102.93	102.11	101.64	102.51	103.56	104.33	104.83	106.36	107.12	106.75
15	104.31	103.67	102.93	102.12	101.43	102.45	103.62	104.34	104.79	106.41	107.17	106.71
16	104.32	103.68	102.91	102.06	101.46	102.49	103.58	104.33	104.93	106.44	107.14	106.71
17	104.35	103.65	102.83	102.00	101.38	102.48	103.70	104.41	104.90	106.48	107.12	106.73
18	104.32	103.60	102.79	101.99	101.39	102.55	103.83	104.43	104.93	106.59	107.12	106.70
19	104.30	103.40	102.77	101.98	101.41	102.55	103.91	104.43	104.97	106.47	107.11	106.69
20	104.27	103.40	102.75	101.99	101.39	102.56	103.90	104.44	104.95	106.64	107.09	106.69
21	104.18	103.46	102.65	101.94	101.43	102.59	103.91	104.45	104.96	106.79	107.09	106.68
22	104.19	103.48	102.56	101.94	101.49	102.62	103.93	104.51	104.97	106.98	107.11	106.68
23	104.20	103.45	102.61	101.94	101.46	102.62	104.01	104.53	105.05	107.18	107.11	106.67
24	104.22	103.45	102.62	101.90	101.51	102.63	103.99	104.51	105.13	107.30	107.06	106.64
25	104.20	103.40	102.62	101.88	101.60	102.63	104.02	104.51	105.16	107.33	107.02	106.60
26	104.15	103.25	102.65	101.95	101.69	102.65	104.02	104.52	105.18	107.37	106.97	106.60
27	104.11	103.26	102.61	101.88	101.77	102.64	104.00	104.57	105.18	107.40	106.91	106.57
28	104.10	103.28	102.62	101.78	101.81	102.65	103.98	104.63	105.21	107.37	106.88	106.58
29	104.08	....	102.55	101.80	101.93	102.60	104.03	104.68	105.34	107.41	106.87	106.66
30	104.03	....	102.52	101.85	102.06	102.64	104.06	104.65	105.39	107.37	106.90	106.66
31	103.99	....	102.12	....	102.06	....	104.05	104.68	....	107.34	....	106.51

STATION AT FORT SAN CARLOS.

A gauge was established at this point by Lieutenant Hanus, U. S. Navy, January 4, 1898. It was simply a graduated stick driven in the sand in shallow water and supported by two stakes in the form of braces. On March 13 a more substantial gauge was placed in deeper water and firmly fastened to the iron remains of an old wreck of a Vanderbilt steamer about a quarter of a mile north of the town of San Carlos. It was driven as far as possible into the mud and fastened with bolts and cable to the iron wreck.

Bench mark No. 1 is on the highest point of the shore end of the stranded boiler and is 12.933 feet above the zero of the gauge last described and 9.78 feet above the zero of gauge established by Lieutenant Hanus. From the 8th of March, when a special observer was stationed at San Carlos, rainfall, evaporation, temperature, and humidity observations were taken.

Daily elevation of Lake Nicaragua as indicated by the gauge rod at Fort San Carlos for the year 1899.

[Elevation of zero of rod = 96.436 feet.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1...	106.23	105.70	105.00	104.04	103.24	102.36	102.33	102.68	103.51	103.67	104.50	105.15
2...	106.08	105.64	104.88	103.99	103.32	102.42	102.22	102.65	103.51	103.54	104.37	105.06
3...	106.19	105.61	104.83	103.93	103.36	102.40	102.38	102.79	103.50	103.67	104.40	105.16
4...	105.97	105.48	104.94	103.79	103.21	102.34	102.37	102.67	103.41	103.59	104.41	104.90
5...	106.10	105.41	104.84	103.84	103.32	102.38	102.41	102.68	103.41	103.55	104.55	104.97
6...	106.15	105.59	104.70	103.96	102.87	102.49	102.37	102.75	103.37	103.57	104.51	105.03
7...	106.00	105.60	104.86	103.91	103.12	102.43	102.35	102.71	103.28	103.56	104.56	104.93
8...	106.05	105.65	104.59	103.82	103.05	102.60	102.40	102.55	103.40	103.47	104.59	104.98
9...	106.09	105.55	104.54	103.59	102.87	102.54	102.26	102.67	103.36	103.59	104.65	105.02
10...	106.06	105.59	104.65	103.76	102.82	102.50	102.36	102.76	103.35	103.66	164.57	105.00
11...	106.08	105.54	104.60	103.77	102.91	102.79	102.27	102.90	103.31	103.71	104.57	105.11
12...	106.04	105.64	104.51	103.62	102.89	102.38	102.29	102.69	103.32	103.79	104.63	105.00
13...	106.02	105.21	104.53	103.57	102.65	102.61	102.34	102.69	103.30	103.70	104.61	104.89
14...	106.00	105.03	104.56	103.72	102.66	102.57	102.55	102.70	103.26	103.87	104.60	104.91
15...	106.01	105.13	104.60	103.58	102.67	102.59	102.51	102.64	103.28	104.32	104.54	104.88
16...	105.92	105.34	104.41	103.61	102.67	102.65	102.44	102.72	103.13	104.19	104.48	104.80
17...	105.98	105.33	104.43	103.69	102.74	102.45	102.32	102.50	103.17	104.19	104.58	104.90
18...	106.09	105.24	104.50	103.69	102.78	102 62	102.42	102.58	103.16	103.92	104.61	104.82
19...	105.99	105.15	104.47	103.64	102.73	102.68	102.44	102.68	103.15	103.76	104.60	104.73
20...	106.04	105.17	104.52	103.63	102.55	102.84	102.46	102.77	103.35	104.05	104.72	104.82
21...	105.92	105.24	104.46	103.58	102.61	102.69	102.50	102.61	103.28	104.03	104.61	104.69
22...	105.93	105.16	104.32	103.35	102.54	102.49	102.50	102.75	103.32	104.10	104.61	104.62
23...	105.89	105.12	104.40	103.36	102.59	102.38	102.59	102.79	103.41	104.14	104.77	104.78
24...	105.88	105.20	104.32	103.24	102.55	102.41	102.62	102.87	103.42	104.22	104.80	104.73
25...	105.85	105.10	104.31	103.28	102.47	102.44	102.58	102.99	103.39	104.16	104.93	104.70
26...	105.81	105.26	104.22	103.29	102.54	102.42	102.52	103.16	103.51	104.29	104.82	104.61
27...	105.82	105.00	104.14	103.31	102.49	102.41	102.80	103.25	103.39	104.48	104.82	104.64
28...	105.82	104.82	104.22	103.28	102.68	102.34	102.79	103.23	103.34	104.69	105.02	104.61
29...	105.78	....	104.21	103.27	102.38	102.47	102.64	103.33	103.44	104.47	104.95	104.59
30...	105.65	....	104.18	103.16	102.40	102.39	102.80	103.31	103.54	104.56	104.97	104.46
31...	105.74	....	104.22	....	102.24	....	102.81	103.24	....	104.43	....	104.60

Daily elevation of Lake Nicaragua as indicated by the gauge rod at Fort San Carlos for the year 1900.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1...	104.68	103.81	103.22	102.38	101.88	102.02	102.54	104.07	104.70	105.51	107.35	106.95
2...	104.49	103.83	103.07	102.15	101.82	102.06	102.72	103.97	104.65	105.78	107.42	106.86
3...	104.55	103.76	103.13	102.22	101.66	102.17	102.95	104.06	104.79	105.89	107.37	106.78
4...	104.51	103.93	102.99	102.08	101.46	102.28	102.90	103.91	104.91	106.09	107.33	106.85
5...	104.45	103.87	102.81	102.15	101.34	102.23	102.44	104.18	104.96	106.00	107.52	106.82
6...	104.41	103.73	102.91	102.19	101.51	102.36	102.96	104.36	104.91	106.02	107.36	106.70
7...	104.34	103.77	102.88	102.08	101.19	102.25	103.11	104.32	104.88	106.41	....	106.81
8...	104.34	103.89	102.99	102.26	101.25	102.72	102.92	104.23	104.92	106.25	107.36	106.78
9...	104.47	103.84	102.96	102.10	101.40	102.66	103.08	104.26	104.92	106.24	107.31	106.59
10...	104.37	103.79	102.96	102.10	101.61	102.61	103.38	104.20	104.96	106.17	107.21	106.67
11...	104.51	103.64	102.85	102.10	101.50	102.55	103.47	104.29	104.82	106.43	107.32	106.78
12...	104.39	103.78	102.89	102.17	101.10	102.55	103.51	104.41	104.88	106.43	107.30	106.76
13...	104.49	103.62	102.87	101.99	101.52	102.45	103.47	104.25	104.85	106.49	107.26	106.78
14...	104.13	103.61	102.86	102.04	101.50	102.43	103.65	104.45	104.72	106.53	107.17	106.70
15...	104.40	103.61	102.94	101.94	101.67	102.36	103.72	104.26	104.99	106.49	107.09	106.74
16...	104.35	103.64	102.89	101.95	101.38	102.38	103.55	104.28	104.96	106.48	107.18	106.77
17...	104.30	103.55	102.85	101.55	101.58	102.47	103.87	104.44	104.86	106.58	107.19	106.66
18...	104.38	103.54	102.56	101.83	101.33	102.56	103.72	104.28	104.90	106.52	107.22	106.55
19...	104.29	103.23	102.58	101.89	101.34	102.63	103.84	104.24	104.76	106.65	107.27	106.69
20...	104.15	103.41	102.75	101.87	101.90	102.49	103.83	104.50	105.10	106.69	107.13	106.73
21...	104.15	103.55	102.36	101.94	101.43	102.62	103.95	104.52	105.13	107.05	107.13	106.64
22...	104.17	103.35	102.49	101.86	101.52	102.68	103.85	104.54	105.04	107.08	107.02	106.73
23...	104.20	103.39	102.46	101.93	101.51	102.67	104.13	104.58	105.09	107.25	107.10	106.67
24...	104.14	103.78	102.52	101.90	101.43	102.70	104.05	104.54	105.10	107.30	107.06	106.65
25...	104.24	103.50	102.53	101.97	101.67	102.54	103.98	104.29	105.18	107.40	107.10	106.65
26...	104.18	103.42	102.53	101.91	101.66	102.63	104.08	104.58	105.23	107.40	107.04	106.59
27...	104.14	103.25	102.57	101.94	101.93	102.56	104.02	104.53	105.16	107.46	106.96	106.53
28...	104.18	103.17	102.55	101.94	101.82	102.63	104.14	104.58	105.21	107.50	106.99	106.59
29...	104.01	....	102.52	101.85	102.12	102.63	104.02	104.62	105.43	107.39	107.01	106.50
30...	104.07	....	102.53	101.74	102.12	102.66	104.05	104.68	105.50	107.37	106.98	106.49
31...	104.08	....	102.42	....	102.04	....	104.08	104.72	....	107.41	....	106.54

Daily elevation of Lake Nicaragua, 1898.

[Computed from gauge-rod readings at Fort San Carlos, Jan. 4, 1898, to Dec. 31, 1898; Las Lajas, Feb. 8, 1898, to Dec. 31, 1898; Morrito, Apr. 9, 1898, to Sept. 21, 1898.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1...	....	104.49	103.86	103.02	102.29	102.48	103.50	104.56	104.96	105.66	106.41	106.64
2...	....	104.42	103.89	103.02	102.24	102.49	103.47	104.51	104.97	105.74	106.37	106.63
3...	....	104.52	103.82	102.98	102.23	102.44	103.55	104.51	104.95	105.76	106.31	106.59
4...	104.92	104.48	103.86	102.96	102.21	102.39	103.70	104.58	104.94	105.74	106.26	106.65
5...	104.96	104.51	103.78	102.92	102.20	102.42	103.62	104.61	104.97	105.75	106.22	106.67
6...	105.02	104.43	103.75	102.96	102.20	102.45	103.78	104.57	105.05	105.73	106.26	106.62
7...	104.93	104.43	103.76	102.92	102.14	102.52	103.79	104.60	105.02	105.75	106.22	106.64
8...	104.94	104.43	103.73	102.86	102.12	102.49	103.82	104.70	105.05	105.79	106.19	106.56
9...	104.88	104.42	103.72	102.83	102.11	102.48	103.90	104.67	105.05	105.73	106.22	106.55
10...	104.79	104.32	103.62	102.77	102.09	102.48	103.89	104.65	105.11	105.73	106.21	106.58
11...	104.85	104.30	103.64	102.81	102.08	102.48	103.96	104.65	105.19	105.71	106.26	106.57
12...	104.87	104.31	103.62	102.81	102.04	102.54	103.99	104.59	105.29	105.75	106.34	106.55
13...	104.80	104.41	103.61	102.76	101.96	102.51	103.98	104.74	105.44	105.75	106.46	106.49
14...	104.76	104.32	103.52	102.74	102.03	102.47	103.98	104.73	105.45	105.84	106.42	106.49
15...	104.75	104.29	103.57	102.69	101.97	102.48	104.03	104.78	105.48	105.88	106.47	106.47
16...	104.79	104.23	....	102.68	102.05	102.44	104.07	104.80	105.53	105.86	106.50	106.50
17...	104.78	104.21	....	102.68	102.01	102.47	104.04	104.83	105.58	105.92	106.50	106.44
18...	104.83	104.21	....	102.65	102.13	102.47	104.07	104.78	105.57	106.08	106.57	106.44
19...	104.84	104.16	103.26	102.61	102.10	102.59	104.10	104.78	105.57	106.14	106.51	106.39
20...	104.97	104.14	103.30	102.55	102.11	102.65	104.25	104.78	105.58	106.15	106.44	106.41
21...	104.90	104.08	103.33	102.59	102.15	102.70	104.17	104.82	105.65	106.13	106.62	106.37
22...	104.82	104.04	103.14	102.56	102.43	102.91	104.25	104.83	105.71	106.24	106.56	106.32
23...	104.73	104.00	103.27	102.53	102.40	102.97	104.23	104.77	105.66	106.28	....	106.37
24...	104.64	104.08	103.29	102.45	102.51	103.01	104.32	104.80	105.74	106.36	....	106.39
25...	104.71	104.04	103.30	102.43	102.57	103.09	104.33	104.81	105.72	106.35	....	106.35
26...	104.70	104.06	102.99	102.44	102.55	103.04	104.35	104.78	105.68	106.36	106.54	106.33
27...	104.69	103.94	103.19	102.42	102.59	103.16	104.39	104.83	105.63	106.38	106.59	106.29
28...	104.67	103.93	103.12	102.37	102.56	103.30	104.46	104.82	105.74	106.34	106.62	106.27
29...	104.52	....	103.09	102.33	102.46	103.42	104.38	104.91	105.76	106.41	106.63	106.38
30...	104.64	....	103.10	102.32	102.55	103.47	104.54	104.95	105.75	106.41	106.70	106.37
31...	104.57	....	102.97	....	102.50	....	104.51	104.96	....	106.38	....	106.44

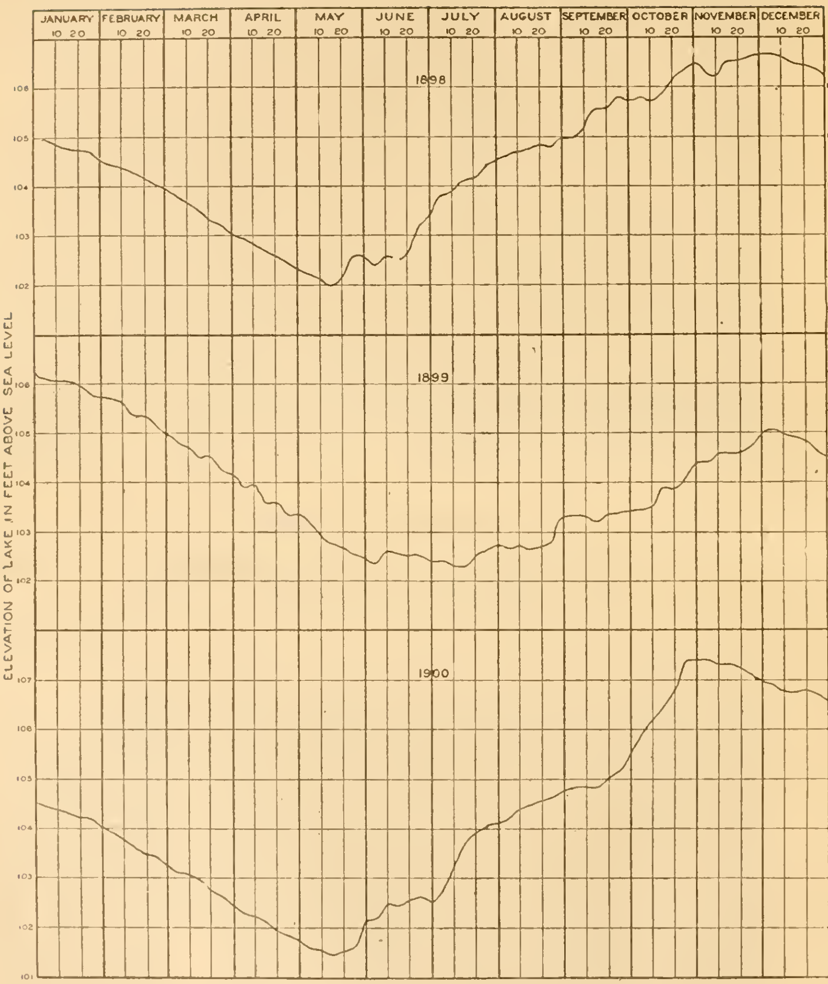

FIG. 3.—ELEVATION OF LAKE NICARAGUA.

Daily elevations of Lake Nicaragua, obtained by averaging the daily elevation as indicated by gauges at San Carlos, Granada, San Ubaldo, and Sapoa for the year 1899.[a]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1...	106.23	105.73	105.01	104.10	103.25	102.41	102.35	102.69	103.35	103.46	104.37	105.02
2...	106.08	105.70	104.88	104.03	103.29	102.45	102.35	102.69	103.33	103.41	104.35	105.05
3...	106.19	105.69	104.85	104.02	103.31	102.43	102.38	102.70	103.33	103.46	104.33	105.09
4...	105.97	105.68	104.90	103.93	103.19	102.35	102.44	102.66	103.31	103.44	104.33	105.01
5...	106.10	105.64	104.85	103.95	103.24	102.38	102.41	102.68	103.32	103.44	104.38	105.03
6...	106.15	105.68	104.79	104.01	103.02	102.48	102.37	102.69	103.32	103.46	104.37	104.99
7...	106.00	105.68	104.92	103.99	103.09	102.45	102.35	102.70	103.31	103.48	104.36	104.92
8...	106.05	105.66	104.73	103.94	103.06	102.53	102.36	102.63	103.32	103.47	104.41	104.91
9...	106.09	105.56	104.65	103.78	102.97	102.46	102.27	102.64	103.32	103.47	104.58	104.96
10...	106.06	105.58	104.66	103.86	102.89	102.48	102.31	102.64	103.29	103.48	104.57	104.96
11...	106.08	105.55	104.58	103.82	102.89	102.68	102.28	102.71	103.29	103.52	104.59	104.94
12...	106.04	105.61	104.54	103.69	102.88	102.47	102.21	102.67	103.26	103.55	104.58	104.90
13...	106.02	105.39	104.55	103.62	102.76	102.64	102.24	102.65	103.24	103.57	104.58	104.89
14...	106.00	105.25	104.57	103.70	102.74	102.52	102.36	102.63	103.25	103.73	104.54	104.91
15...	106.01	105.30	104.58	103.62	102.72	102.53	102.38	102.62	103.21	103.89	104.54	104.90
16...	105.92	105.40	104.49	103.59	102.72	102.56	102.38	102.63	103.15	103.88	104.49	104.91
17...	105.98	105.40	104.45	103.63	102.73	102.46	102.33	102.59	103.14	103.86	104.53	104.89
18...	106.09	105.30	104.53	103.63	102.72	102.56	102.36	102.63	103.17	103.80	104.54	104.86
19...	105.99	105.26	104.47	103.60	102.70	102.50	102.44	102.67	103.18	103.81	104.58	104.78
20...	106.04	105.32	104.50	103.57	102.61	102.75	102.41	102.68	103.36	103.84	104.58	104.82
21...	105.92	105.20	104.44	103.48	102.64	102.57	102.54	102.67	103.31	103.86	104.57	104.75
22...	105.93	105.17	104.34	103.46	102.61	102.50	102.53	102.69	103.33	103.95	104.60	104.72
23...	105.89	105.14	104.38	103.47	102.60	102.42	102.59	102.73	103.37	104.01	104.64	104.73
24...	105.78	105.18	194.32	103.40	102.56	102.49	102.56	102.80	103.38	104.07	104.65	104.71
25...	105.76	105.11	104.29	103.37	102.52	102.49	102.58	102.86	103.39	104.10	104.70	104.63
26...	105.74	105.19	104.23	103.33	102.56	102.46	102.60	103.07	103.45	104.14	104.67	104.65
27...	105.74	105.03	104.15	103.34	102.53	102.45	102.67	103.22	103.42	104.24	104.72	104.62
28...	105.75	104.89	104.20	103.32	102.57	102.36	102.69	103.22	103.41	104.37	104.79	104.59
29...	105.72	....	104.19	103.32	102.42	102.43	102.68	103.27	103.41	104.36	104.80	104.57
30...	105.71	....	104.17	103.24	102.43	102.44	102.71	103.31	103.42	104.38	104.98	104.52
31...	105.75	....	104.19	....	102.35	....	102.73	103,29	....	104.39	....	104.53

[a] Jan. 1–23; San Carlos gauge. Jan. 24–June 17, average of San Carlos and Granada gauges. June 18–July 15, average of gauges at San Carlos, Granada, and San Ubaldo. July 16–Dec. 31, averages of gauges at San Carlos, Granada, San Ubaldo, and Sapoa.

Daily elevation of Lake Nicaragua, obtained by averaging the daily elevations as indicated by gauges at San Carlos, Granada, San Ubaldo, and Sapoa for the year 1900.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1...	104.55	103.96	103.28	102.42	101.75	102.14	102.66	104.12	104.73	105.49	107.42	106.94
2...	104.50	103.95	103.23	102.37	101.72	102.16	102.71	104.10	104.71	105.70	107.42	106.90
3...	104.46	103.91	103.23	102.33	101.69	102.17	102.79	104.11	104.75	105.78	107.38	106.87
4...	104.43	103.92	103.17	102.28	101.63	102.17	102.80	104.11	104.79	105.89	107.36	106.89
5...	104.44	103.92	103.09	102.27	101.59	102.17	102.73	104.22	104.83	105.91	107.36	106.89
6...	104.44	103.87	103.14	102.30	101.66	102.22	102.87	104.31	104.82	105.98	107.33	106.81
7...	104.40	103.85	103.12	102.27	101.56	102.21	102.95	104.33	104.79	106.20	107.32	106.83
8...	104.38	103.87	103.13	102.29	101.52	102.32	102.93	104.32	104.81	106.18	107.34	106.79
9...	104.42	103.80	103.09	102.25	101.56	102.40	103.03	104.36	104.85	106.18	107.32	106.74
10...	104.37	103.78	103.06	102.21	101.53	102.48	103.21	104.38	104.84	106.20	107.30	106.78
11...	104.39	103.74	103.03	102.17	101.50	102.48	103.33	104.43	104.83	106.31	107.35	106.79
12...	104.37	103.74	103.00	102.16	101.42	102.48	103.43	104.45	104.85	106.37	107.35	106.78
13...	104.40	103.70	103.01	102.09	101.47	102.45	103.42	104.46	104.84	106.43	107.33	106.80
14...	104.30	103.69	102.99	102,11	101.48	102.48	103.58	104.51	104.81	106.44	107.34	106.78
15...	104.32	103.61	102.97	102.10	101.43	102.45	103.69	104.48	104.81	106.47	107.32	106.76
16...	104.30	103.59	102.92	102.09	101.37	102.47	103.66	104.47	104.89	106.50	107.30	106.76
17...	104.27	103.53	102.89	101.94	101.38	102.50	103.78	104.52	104.91	106.63	107.29	106.71
18...	104.28	103.52	102.82	101.98	101.33	102.54	103.78	104.51	104.94	106.66	107.30	106.68
19...	104.25	103.43	102.77	101.97	101.35	102.56	103.89	104.48	104.94	106.69	107.27	106.76
20...	104.21	103.45	102.77	101.94	101.51	102.55	103.89	104.57	105.03	106.75	107.22	106.77
21...	104.20	103.45	102.69	101.94	101.41	102.60	103.97	104.56	105.06	106.95	107.22	106.73
22...	104.18	103.42	102.67	101.91	101.49	102.63	103.95	104.62	105.05	107.07	107.17	106.73
23...	104.17	103.43	102.67	101.90	101.46	102.63	104.02	104.65	105.09	107.24	107.16	106.71
24...	104.16	103.51	102.62	101.87	101.48	102.67	103.99	104.66	105.14	107.32	107.12	106.69
25...	104.18	103.41	102.62	101.85	101.58	102.61	104.03	104.62	105.17	107.37	107.12	106.69
26...	104.15	103.29	102.66	101.86	101.72	102.63	104.05	104.71	105.19	107.37	107.11	106.67
27...	104.12	103.35	102.61	101.85	101.87	102.60	104.04	104.70	105.18	107.42	107.05	106.61
28...	104.10	103.28	102.73	101.80	101.87	102.65	104.05	104.70	105.20	107.41	107.05	106.63
29...	104.00	....	102.51	101.75	101.99	102.64	104.04	104.72	105.32	107.41	107.03	106.64
30...	103.90	....	102.52	101.75	102.09	102.53	104.09	104.73	105.43	107.39	106.99	106.63
31...	103.99	....	102.45	....	102.12	....	104.09	104.75	....	107.39	....	106.59

List of discharge measurements made on Frio River.

Date.	Hydrographer.	Meter number.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.			*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Sec. feet.*
Mar. 12	H. C. Hurd	B. B., No. 1	5.17	2,913	0.79	2,314
Mar. 18	....do	....do	5.75	2,320	.79	1,837
Mar. 27	R. H. Morrin	....do	4.75	1,690	.68	1,151
Apr. 4	....do	....do	4.32	1,788	.74	1,323
Apr. 15	....do	Ellis, No. 1	4.07	1,920	1.47	2,817
Apr. 27	....do	....do	3.71	1,704	.73	1,238
May 6	....do	....do	3.40	1,666	.42	707
May 17	....do	B. and B., No. 1	3.40	1,632	.74	1,202
May 18	C. Hayman	Price, No. 63	6.45	2,021	.67	1,364
June 16	A. Ahrling	Price, No. 93	2.16	2,638	1.33	3,503
July 10	....do	....do	2.02	2,013	1.35	2,716
Sept. 11	W. W. Schlecht	Price, No. 34	3.15	2,685	1.60	4,262
Sept. 17	....do	....do	5.80	2,647	1.61	4,264
Oct. 2	H. W. Durham	....do	10.00	2,658	2.00	5,312
Nov. 1	....do	....do	9.85	2,438	.90	2,203
Nov. 21	....do	....do	12.83	2,911	2.76	8,038
Dec. 12	H. G. Heisler	Price, No. 93	11.00	2,980	1.96	5,849
Dec. 15	....do	....do	10.81	2,960	1.71	5,468
Dec. 23	....do	....do	10.85	2,980	1.95	5,809
Dec. 31	....do	....do	10.89	2,980	2.20	6,584
1900.						
Jan. 2	H. G. Heisler	Price, No. 93	10.93	2,950	2.13	6,294
Jan. 18	H. S. Reed	Price, No. 63	9.85	2,658	1.58	4,213
Jan. 31	C. Hayman	....do	9.45	2,641	.87	2,299
Feb. 12	....do	....do	8.70	2,460	.60	1,478
Mar. 4	H. C. Hurd	Price, No. 34	8.20	2,174	.60	1,363
Mar. 10	C. Hayman	....do	7.82	2,286	.65	1,489
Mar. 24	....do	Price, No. 63	7.78	2,275	.72	1,645
Apr. 2	H. C. Hurd	Price, No. 35	7.45	2,187	.34	742
Apr. 10	C. Hayman	Price, No. 63	7.31	2,181	(a)	(a)
Apr. 17	....do	....do	6.54	2,040	.52	1,065
Apr. 30	....do	....do	6.79	2,092	(a)	(a)
May 12	....do	....do	6.58	2,075	.30	637
May 28	....do	....do	7.70	2,210	1.87	4,126
June 21	H. G. Heisler	B. and B., No. 1	8.45	2,383	1.57	3,757
July 13	....do	....do	9.64	2,818	1.82	5,140
July 29	....do	....do	11.52	2,918	2.44	7,145
Aug. 12	....do	....do	10.76	2,881	1.98	5,705
Aug. 26	....do	....do	10.42	2,792	1.78	5,018
Sept. 5	....do	....do	11.39	3,009	2.02	6,147

[a] No current.

List of discharge measurements to determine the dry season inflow to Lake Nicaragua, 1900.

[Made by J. Oscar Jones and Charles Hayman.]

	Date.	Area of section.	Mean velocity.	Discharge.
		Sq. ft.	*Ft. per sec.*	*Sec. ft.*
Canas River	Feb. 12	11	0.91	10
Do	Feb. 25	12	.83	9
Do	Mar. 14	8	1.16	10
Do	Mar. 17	8	1.14	9
Do	Mar. 30	6	1.06	6
Do	Apr. 3	6	1.16	7
Do	Apr. 14	5	1.17	6
Do	Apr. 18	5	1.17	6
Do	May 4	4	1.06	4
Do	May 12	5	1.13	6
Do	May 17	4	1.11	4
Do	May 31	58	2.07	121
Canitas River	Feb. 11	16	1.11	18
Do	Feb. 24	11	1.18	13
Do	Mar. 13	9	1.08	10
Do	Mar. 29	7	1.18	8
Do	Apr. 4	7	1.30	9
Do	Apr. 14	6	1.34	8
Do	Apr. 18	6	1.32	8
Do	May 3	6	1.07	6
Do	May 11	7	1.18	8
Do	May 17	6	1.16	7
Do	May 30	27	2.36	62
Guajinequil River	Feb. 11	5	.27	2
Do	Feb. 23	4	.29	1

List of discharge measurements to determine the dry season inflow to Lake Nicaragua, 1900—Continued.

	Date.	Area of section.	Mean velocity.	Discharge.
Guajinequil River—Continued.		*Sq. ft.*	*Ft. per sec.*	*Sec. ft.*
Do	Mar. 12	4	.44	2
Do	Mar. 18	4	.42	2
Do	Mar. 28	2	.52	1
Do	May 29	4	1.00	4
Las Haciendas River	Feb. 4	212	1.32	282
Do	Feb. 12	246	.85	209
Do	Feb. 18	166	1.16	193
Do	Mar. 12	129	1.07	138
Do	Mar. 14	116	1.16	134
Do	Mar. 30	73	1.26	93
Do	Mar. 30	67	1.16	78
Do	Mar. 30	73	1.10	81
Do	Apr. 3	83	1.56	129
Do	Apr. 15	52	1.27	67
Do	Apr. 17	52	1.24	65
Do	Apr. 22	57	1.35	76
Do	Apr. 24	62	1.37	85
Do	May 4	45	1.13	51
Do	May 15	94	1.66	156
Do	May 16	87	1.30	114
Do	May 16	81	1.22	99
Do	May 25	70	1.32	92
Do	May 31	193	2.16	417
Limon River	Feb. 9	4	.44	2
Do	Feb. 22	3	.40	1
Do	Feb. 28	....	0	0
Mataste River	Feb. 9	....	0	0
Mena River	Feb. 11	53	2.34	124
Do	Feb. 21	108	.46	50
Do	Feb. 26	49	2.40	117
Do	Mar. 13	30	2.35	71
Do	Mar. 17	27	2.30	61
Do	Mar. 29	17	2.02	35
Do	Apr. 4	38	1.46	55
Do	Apr. 14	35	1.39	49
Do	Apr. 18	34	1.42	49
Do	May 3	29	1.40	40
Do	May 11	33	1.39	46
Do	May 17	35	1.27	44
Do	May 30	81	2.34	190
Ochomogo River	Feb. 1	42	.95	40
Do	Feb. 4	40	.81	33
Do	Feb. 20	47	.82	39
Do	Feb. 21	40	.52	21
Do	Mar. 4	44	.77	34
Do	Mar. 7	42	.75	32
Do	Mar. 24	40	.75	30
Do	Apr. 9	38	.74	28
Do	Apr. 23	40	.72	29
Do	Apr. 27	40	.71	28
Do	May 23	56	1.70	95
Orosi River	Feb. 11	37	1.87	69
Do	Feb. 25	32	1.69	55
Do	Mar. 13	24	1.85	45
Do	Mar. 17	21	2.00	42
Do	Mar. 29	23	1.86	42
Do	Apr. 3	23	1.81	41
Do	Apr. 14	21	1.66	34
Do	Apr. 18	21	1.65	34
Do	May 4	15	1.61	24
Do	May 11	19	1.72	34
Do	May 17	16.	1.74	27
Do	May 31	92	2.84	262
Pisote River	Feb. 4	880	1.26	1,113
Do	Feb. 18	440	1.06	476
Do	Mar. 12	385	1.01	389
Do	Mar. 15	144.6	.65	941
Do	Mar. 30	337	.78	262
Do	....do...	1,119	.71	790
Do	Mar. 31	1,237	.72	893
Do	Apr. 22	1,047	.53	552
Do	Apr. 24	1,069	.50	539
Do	May 17	977	.69	674
Do	May 26	989	.98	966
Pueblo River	Feb. 11	24	.72	17
Do	Feb. 23	11	1.03	12
Do	Mar. 12	9	.53	5
Do	Mar. 18	7	.46	3
Do	Mar. 28	3	.57	2
Do	Apr. 4	3	.44	1
Do	Apr. 13	2	.38	.60
Do	May 2	4	.49	2
Do	May 29	19	1.11	21

List of discharge measurements to determine the dry season inflow to Lake Nicaragua, 1900—Continued.

	Date.	Area of section.	Mean velocity.	Discharge.
		Sq. ft.	*Ft. per sec.*	*Sec. ft.*
Sabalos River	Feb. 11	41	1.07	44
Do	Feb. 24	34	1.20	41
Do	Mar. 13	31	1.35	42
Do	Mar. 17	28	1.30	37
Do	Mar. 29	28	1.36	38
Do	Apr. 4	25	1.42	35
Do	Apr. 14	22	1.50	33
Do	Apr. 18	21	1.40	30
Do	May 3	21	1.50	31
Do	May 11	29	1.67	48
Do	May 17	24	1.22	30
Do	May 30	86	2.58	220
Sapoa River	Feb. 14	146	.54	79
Do	Feb. 27	99	.53	52
Do	Mar. 12	81	.66	53
Do	Mar. 19	75	.71	53
Do	Mar. 28	45	1.21	55
Do	Apr. 5	42	1.19	50
Do	Apr. 13	40	.22	48
Do	Apr. 19	39	1.24	49
Do	May 2	41	1.20	49
Do	May 10	40	1.20	48
Do	May 18	102	1.30	134
Do	May 29	276	2.34	660
Sardinas River	Feb. 12	9	.90	8
Do	Feb. 25	6	.65	4
Do	Mar. 13	5	.87	5
Do	Mar. 17	4	.83	4
Do	Mar. 30	4	.80	3
Do	Apr. 3	5	.87	4
Do	Apr. 14	4	.79	3
Do	Apr. 18	4	.77	3
Do	May 4	4	.74	3
Do	May 12	5	.92	4
Do	May 17	3	.87	3
Do	May 31	21	2.05	44
Tepenagua Sape River	Mar. 3	88	.32	28
Do	Mar. 21	55	.46	25
Do	Apr. 13	53	.30	16
Do	May 1	3	2.61	9
Do	May 22	159	.82	131
Tiruli River	Feb. 11	10	.71	7
Do	Feb. 24	9	.63	6
Do	Mar. 13	5	.39	2
Do	Mar. 18	12	.18	2
Do	Apr. 4	4	.44	2
Do	Apr. 14	4	.49	2
Do	Apr. 18	4	.49	2
Do	May 11	5	.64	4
Do	May 18	7	.79	5
Do	May 30	28	1.97	55
Tule River	Feb. 8	91	.52	47
Zapote River	Feb. 2	221	2.88	636
Do	Feb. 16	192	2.67	513
Do	Mar. 7	284	1.46	412
Do	Apr. 19	413	1.31	545
Do	Apr. 25	115	2.46	283
Do	Apr. 26	258	1.08	278
Do	Apr. 26	379	1.32	501
Do	May 13	162	3.07	496
Do	May 14	371	1.22	454
Do	May 15	268	1.33	357

Estimated monthly flow into Lake Nicaragua in excess of evaporation.

Months.	Stored in lake.	Outflow.	Total.	Net inflow.
1898.	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Sec. feet.*
January 4-31, inclusive	− 666,400	+ 1,032,100	+ 366,000	+ 6,590
February	−1,218,600	+ 923,800	− 291,800	− 5,310
March	−1,827,800	+ 863,600	− 964,200	−15,680
April	1,237,600	+ 724,100	− 513,500	− 8,630
May	+ 342,700	+ 723,300	+ 1,066,000	+17,340
June	+1,846,900	+ 841,600	+ 2,688,500	+45,200
July	+1,980,200	+ 1,190,900	+ 3,171,100	+51,570
August	+ 856,800	+ 1,202,200	+ 2,059,000	+33,490
September	+1,504,200	+ 1,313,600	+ 2,817,800	+47,350

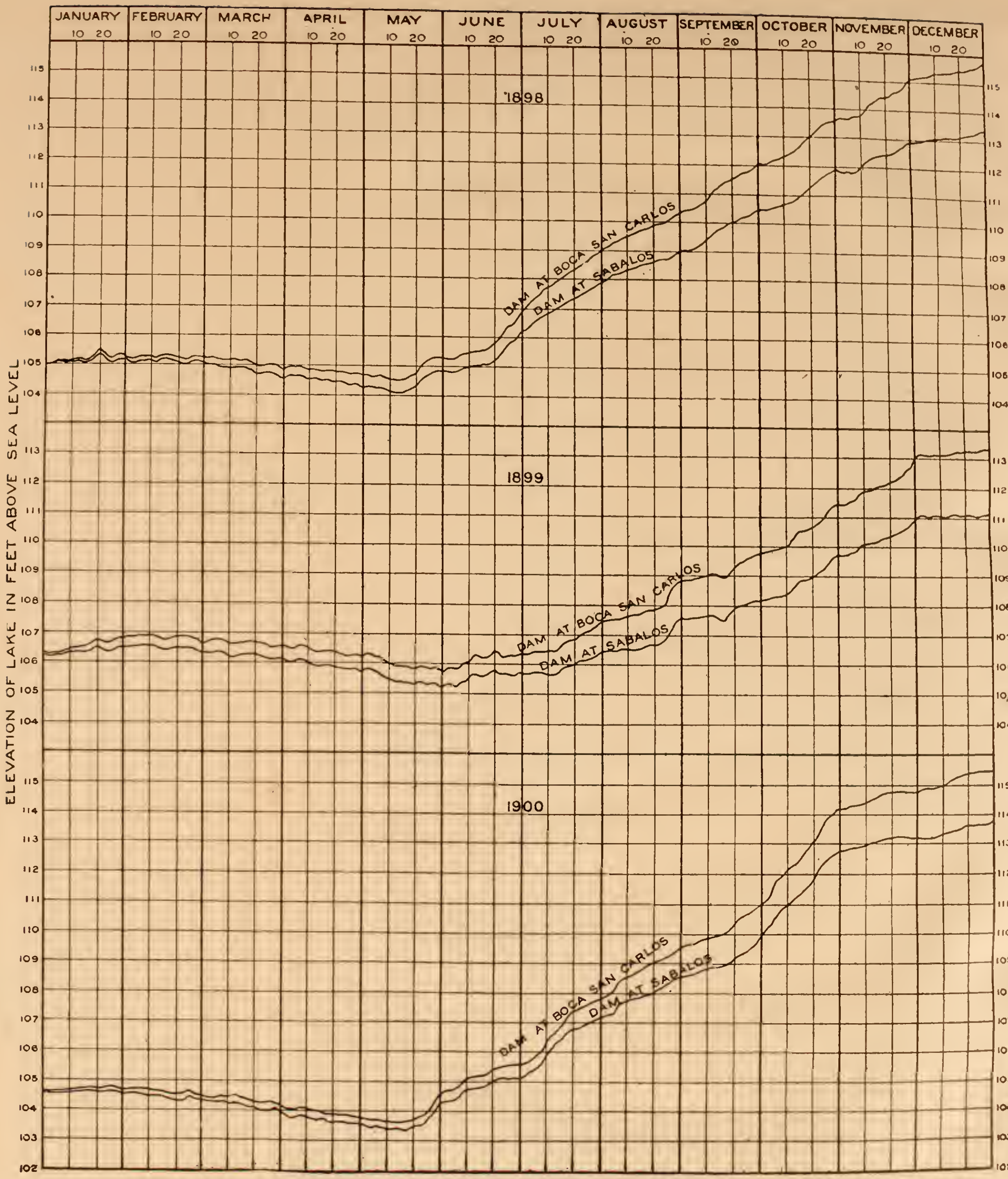

FIG. 4.—ELEVATION OF LAKE NICARAGUA IF ALL WATER HAD BEEN HELD BY A DAM.

Estimated monthly flow into Lake Nicaragua in excess of evaporation—Continued.

Month.	Stored in lake.	Outflow.	Total.	Net inflow.
1898.	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Sec. feet.*
October	+1,199,500	+ 1,440,600	+ 2,640,100	+42,960
November	+ 609,300	+ 1,512,000	+ 2,121,300	+35,650
December	− 495,000	+ 1,540,000	+ 1,045,000	+16,990
Total for 1898	+2,894,200	+13,308,100	+16,202,300	....
1899.				
January	−1,313,760	+ 1,443,254	+ 129,494	+ 2,106
February	−1,637,440	+ 1,154,774	− 482,666	− 8,691
March	−1,332,800	+ 1,103,500	− 229,300	− 3,729
April	−1,808,800	+ 896,008	− 912,792	−15,341
May	−1,694,560	+ 788,584	− 905,976	−14,735
June	+ 171,360	+ 765,329	+ 936,689	+15,743
July	+ 552,160	+ 881,716	+ 1,433,876	+23,319
August	+1,066,240	+ 944,463	+ 2,010,703	+32,537
September	+ 247,520	+ 1,021,693	+ 1,269,213	+21,331
October	+1,846,880	+ 1,115,681	+ 2,962,561	+48,179
November	+1,123,360	+ 1,211,088	+ 2,334,448	+39,234
December	− 856,800	+ 1,250,254	+ 393,454	+ 6,399
The year	−3,636,640	+12,576,344	+ 8,939,704	....
1900.				
January	−1,028,160	+ 1,083,292	+ 55,132	+ 897
February	−1,351,840	+ 836,958	− 514,882	− 9,270
March	−1,580,320	+ 755,503	− 824,817	−13,413
April	−1,332,800	+ 662,265	− 670,535	− 1,295
May	+ 704,480	+ 671,212	+ 1,375,692	+22,372
June	+ 780,640	+ 741,117	+ 1,521,757	+25,575
July	+2,970,240	+ 1,073,149	+ 4,043,389	+65,756
August	+1,256,640	+ 1,288,735	+ 2,545,375	+41,395
September	+1,294,720	+ 1,266,473	+ 2,561,193	+43,045
October	+3,731,840	+ 1,752,367	+ 5,484,207	+89,189
November	− 761,600	+ 1,679,231	+ 917,631	+15,422
December	− 761,600	+ 1,653,969	+ 892,369	+14,512
The year	+3,922,240	+13,464,271	+17,386,511	....

Elevation of Lake Nicaragua if all water had been held by a dam at Sabalos, 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1...	106.26	106.51	106.39	106.05	105.67	105.25	105.59	106.36	107.55	108.19	109.69	110.98
2...	106.13	106.50	106.28	106.00	105.73	105.30	105.61	106.38	107.55	108.16	109.69	111.03
3...	106.26	106.51	106.27	106.01	105.76	105.29	105.65	106.41	107.57	108.23	109.69	111.09
4...	106.07	106.52	106.34	105.93	105.65	105.22	105.72	106.39	107.57	108.23	109.71	111.03
5...	106.22	106.51	106.31	105.97	105.72	105.27	105.71	106.43	107.60	108.25	109.78	111.08
6...	106.29	106.57	106.27	106.05	105.51	105.38	105.68	106.46	107.61	108.28	109.79	111.06
7...	106.18	106.59	106.42	106.05	105.60	105.36	105.67	106.48	107.61	108.32	109.80	111.01
8...	106.25	106.60	106.25	106.01	105.59	105.45	105.69	106.43	107.63	108.33	109.87	111.02
9...	106.31	106.52	106.19	105.87	105.51	105.40	105.61	106.46	107.64	108.34	110.06	111.09
10...	106.31	106.56	106.22	105.96	105.44	105.43	105.67	106.47	107.63	108.37	110.08	111.11
11...	106.35	106.55	106.16	105.94	105.46	105.64	105.66	106.56	107.65	108.43	110.12	111.11
12...	106.34	106.63	106.14	105.83	105.46	105.45	105.61	106.53	107.64	108.48	110.13	111.10
13...	106.34	106.44	106.17	105.77	105.35	105.64	105.65	106.52	107.64	108.51	110.15	111.11
14...	106.35	106.32	106.21	105.87	105.34	105.53	105.78	106.52	107.67	108.69	110.13	111.15
15...	106.38	106.39	106.24	105.80	105.34	105.55	105.81	106.52	107.65	108.87	110.15	111.16
16...	106.32	106.51	106.17	105.79	105.35	105.60	105.83	106.54	107.60	108.88	110.13	111.19
17...	106.41	106.53	106.14	105.84	105.37	105.51	105.79	106.51	107.60	108.88	110.19	111.19
18...	106.55	106.45	106.24	105.86	105.38	105.62	105.83	106.57	107.65	108.84	110.22	111.18
19...	106.47	106.43	106.20	105.85	105.37	105.58	105.93	106.63	107.68	108.87	110.28	111.12
20...	106.54	106.61	106.25	105.84	105.29	105.85	105.92	106.66	107.88	108.92	110.30	111.19
21...	106.44	106.42	106.21	105.77	105.33	105.68	106.06	105.66	107.85	108.96	110.31	111.14
22...	106.48	106.41	106.12	105.76	105.31	105.62	106.07	106.70	107.89	109.07	110.36	111.13
23...	106.47	106.40	106.18	105.78	105.32	105.55	106.14	106.76	107.96	109.15	110.42	111.16
24...	106.38	106.46	106.14	105.72	105.29	105.63	106.13	106.85	107.99	109.23	110.46	111.16
25...	106.38	106.41	106.13	105.70	105.27	105.65	106.16	106.93	108.02	109.29	110.53	111.10
26...	106.38	106.51	106.08	105.68	105.32	105.63	106.20	107.16	108.10	109.34	110.52	111.14
27...	106.40	106.37	106.02	105.71	105.31	105.63	106.29	107.33	108.09	109.46	110.59	111.13
28...	106.44	106.25	106.09	105.70	105.36	105.56	106.33	107.35	108.09	109.61	110.68	111.12
29...	106.43	....	106.09	105.71	105.22	105.65	106.33	107.42	108.11	109.62	110.71	111.12
30...	106.44	....	106.09	105.65	105.24	105.67	106.38	107.48	108.13	109.66	110.91	111.09
31...	106.51	....	106.13	....	105.18	....	106.41	107.47	....	109.69	....	111.12

Elevation of Lake Nicaragua if all water had been held by a dam at Sabalos, 1900.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1...	104.57	104.55	104.31	103.83	103.52	104.25	105.16	107.19	108.48	109.90	112.76	113.16
2...	104.54	104.56	104.28	103.79	103.51	104.28	105.22	107.19	108.48	109.89	112.79	113.15
3...	104.52	104.54	104.30	103.76	103.49	104.30	105.31	107.22	108.54	110.14	112.78	113.15
4...	104.51	104.57	104.25	103.73	103.44	104.31	105.34	107.25	108.60	110.39	112.79	113.20
5...	104.54	104.59	104.18	103.73	103.41	104.32	105.29	107.39	108.66	110.44	112.82	113.23
6...	104.56	104.56	104.24	103.77	103.49	104.38	105.44	107.51	108.67	110.54	112.82	113.17
7...	104.54	104.55	104.23	103.75	103.40	104.38	105.54	107 55	108.66	110.79	112.84	113.22
8...	104.54	104.58	104.25	103.79	103.37	104.51	105.54	107.57	108.70	110.80	112.89	113.21
9...	104.60	104.52	104.22	103.76	103.42	104.61	105.65	107.63	108.76	110.83	112.90	113.19
10...	104.57	104.52	104.21	103.73	103.40	104.70	105.85	107.67	108.77	110.88	112.91	113.26
11...	104.61	104.50	104.20	103.70	103.38	104.71	105.99	107.74	108.78	111.02	112.99	113.30
12...	104.61	104.52	104.19	103.70	103.31	104.72	106.11	107.78	108.82	111.11	113.02	113.32
13...	104.65	104.50	104.21	103.64	103.37	104.70	106.12	107.81	108.83	111.20	113.03	113.37
14...	104.57	104.50	104.20	103.67	103.39	104.74	106.49	107.88	108.82	111.23	113.07	113.37
15...	104.61	104.43	104.19	103.68	103.35	104.72	106.43	107.87	108.84	111.28	113.08	113.39
16...	104.61	104.42	104.15	103.68	103.30	104.76	106.42	107.88	108.94	111.34	113.09	113.42
17...	104.60	104.37	104.13	103.54	103.32	104.81	106.56	107.95	108.98	111.50	113.11	113.40
18...	101.63	104.38	104.07	103.59	103.28	104.87	106.58	107.96	109.04	111.56	113.15	113.40
19...	104.61	104.31	104.03	103.59	103.31	104.91	106.71	107.95	109.07	111.62	113.15	113.50
20...	104.58	104.35	104.05	103.57	103.48	104.92	106.73	108.06	109.19	111.71	113.13	113.54
21...	104.59	104.37	103.98	103.58	103.39	104.98	106.83	108.07	109.24	111.95	113.16	113.53
22...	104.59	104.36	103.97	103.56	103.48	105.02	106.83	108.15	109.25	112.11	113.14	113.55
23...	104.60	104.38	103.98	103.56	103.46	105.03	106.92	108.20	109.31	112.31	113.16	113.56
24...	104.61	104.48	103.94	103.54	103.49	105.09	106.91	108.23	109.38	112.42	113.14	113.57
25...	104.65	104.39	103.95	103.53	103.60	105.04	107.03	108.21	109.44	112.50	113.17	113.59
26...	104.64	104.28	104.00	103.56	103.76	105.07	107.01	108.32	109.48	112.53	113.19	113.60
27...	104.63	104.35	103.97	103.57	103.92	105.05	107.01	108.34	109.49	112.61	113.16	113.57
28...	104.63	104.29	104.10	103.53	103.93	105.11	107.04	108.36	109.53	112.63	113.19	113.62
29...	104.55	....	103.89	103.49	104.06	105.11	107.05	108.40	109.68	112.66	113.19	113.65
30...	104.46	....	103.91	103.50	104.17	105.02	107.12	108.44	109.82	112.67	113.18	113.69
31...	104.56	....	103.85	....	104.22	....	107.14	108.48	....	112.70	....	113.65

SAN JUAN RIVER.

The San Juan River is the sole outlet of Lake Nicaragua and its tributary drainage basin. Its total length from the lake to the sea is 122 miles and it is usually navigable for light-draft river steamers. It leaves the lake at Fort San Carlos at an altitude varying from about 97 feet to about 110. Its course for a distance of 27 miles is through a low swampy country, relieved by occasional hills. Through this course the river is sluggish and receives several tributaries of small discharge, which, in the dry season, are practically still water. The principal of these are the Melchora, Medio Queso, Palo de Arco, and Negro. The first tributary of importance to the San Juan River is the Sabalos, which enters from the north and empties 27 miles east of Fort San Carlos. About half a mile below the mouth of the Sabalos are the first rapids, called "Toro Rapids." These rapids are caused by bowlders and gravel, probably brought into the river by the Sabalos in former times, but do not seriously obstruct navigation except in times of extremely low water. Below this point the San Juan receives the waters of a few streams, the principal of which are the Poco Sol and the Santa Cruz. Ten miles below Toro Rapids occur the largest rapids on the river, at Castillo Viejo. At this point the river falls about 5 feet in a few hundred feet, and steamers are seldom taken over the rapids except in high water. A railroad about 2,000 feet long is provided for the portage of freight and passengers on the right bank of the river.

Below Castillo are the Diamond, Balas, and Machuca rapids, the latter being 12 miles from Castillo. All of these rapids admit the passage of river steamers except at extreme low water. Below Machuca there are no more rapids. The river is deep and sluggish for a distance of about 15 miles to the point where it receives the waters and sediment of the San Carlos. This river is the largest tributary of the San Juan, rising far to the southward in the mountains of Costa Rica, and bearing such a volume of sediment that a delta has been built up at its mouth and from this point to the sea the San Juan is a shallow stream with sandy shifting bed. Twenty-five miles farther down the Sarapiqui empties into the San Juan from Costa Rica, being the tributary next in size to the San Carlos, and, like the latter, bearing large quantities of sediment in times of flood. Eight miles below the mouth of the Sarapiqui the San Juan assumes decidedly the character of a deltaic stream and sends out a small tributary known as the San Juanillo, which meanders through the swamps to the northward, and, after receiving the drainage of the Deseado, reenters the San Juan 4 miles above its mouth. Five miles below the exit of the San Juanillo, or 103 miles from Lake Nicaragua, the main stream of the San Juan separates into two large distributaries, the larger, called the Colorado, flowing eastward directly to the Caribbean, and the smaller, or lower San Juan, meandering to the northeast and finding its exit into the ocean at Greytown. Between the mouth of the Colorado and the lower San Juan another distributary, called the Taura, finds its way from the lower San Juan to the sea.

The principal obstructions to free navigation of light-draft river craft from Greytown to Fort San Carlos consist of the shoal character of the lower San Juan, especially in times of low water, and of the rapids lying between Machuca and the mouth of the Sabalos. For purposes of a ship canal the river also requires deepening below the mouth of the San Carlos and between the Sabalos and Fort San Carlos.

The only portion of the river which is suitable in its present state for a ship canal is the part from Machuca to a point a short distance above Boca San Carlos, or about 15 miles out of 122, and even here some dredging must be done and two sharp bends eliminated to permit the safe passage of the largest ships.

Rating table for San Juan River at Fort San Carlos.

Lake height.	Discharge.	Lake height.	Discharge.	Lake height.	Discharge.	Lake height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
96.0	3,000	98.9	6,630	101.8	11,150	104.7	18,350
96.1	3,115	99.0	6,770	101.9	11,325	104.8	18,675
96.2	3,230	99.1	6,910	102.0	11,500	104.9	19,000
96.3	3,345	99.2	7,050	102.1	11,675	105.0	19,325
96.4	3,460	99.3	7,190	102.2	11,850	105.1	19,650
96.5	3,575	99.4	7,330	102.3	12,025	105.2	19,980
96.6	3,690	99.5	7,475	102.4	12,215	105.3	20,310
96.7	3,810	99.6	7,620	102.5	12,400	105.4	20,680
96.8	3,930	99.7	7,770	102.6	12,590	105.5	21,055
96.9	4,050	99.8	7,920	102.7	12,780	105.6	21,435
97.0	4,170	99.9	8,070	102.8	13,000	105.7	21,815
97.1	4,290	100.0	8,220	102.9	13,220	105.8	22,195
97.2	4,410	100.1	8,375	103.0	13,450	105.9	22,595
97.3	4,535	100.2	8,530	103.1	13,680	106.0	22,995
97.4	4,660	100.3	8,685	103.2	13,910	106.1	23,395
97.5	4,785	100.4	8,840	103.3	14,140	106.2	23,795
97.6	4,910	100.5	8,995	103.4	14,410	106.3	24,195
97.7	5,035	100.6	9,155	103.5	14,680	106.4	24,790
97.8	5,160	100.7	9,315	103.6	14,950	106.5	25,490
97.9	5,290	100.8	9,475	103.7	15,220	106.6	26,290
98.0	5,420	100.9	9,635	103.8	15,490	106.7	27,600
98.1	5,550	101.0	9,795	103.9	15,760	106.8	27,920
98.2	5,680	101.1	9,958	104.0	16,080	106.9	28,240
98.3	5,810	101.2	10,115	104.1	16,400	107.0	28,560
98.4	5,945	101.3	10,280	104.2	16,725	106.1	28,880
98.5	6,080	101.4	10,450	104.3	17,050	107.2	29,200
98.6	6,215	101.5	10,625	104.4	17,375	107.3	29,550
98.7	6,350	101.6	10,800	104.5	17,700	107.4	29,900
98.8	6,490	101.7	10,975	104.6	18,025	107.5	30,250

SAN JUAN RIVER ABOVE LOS SABALOS.

A record has been kept of the discharge of the river at this point ever since January, 1898. The station used during 1898 and a portion of 1899 was found objectionable in some respects, especially showing evidence at times of being affected by high water in the Sabalos River, which enters the San Juan half a mile below. In October, 1899, a gauge was placed farther up the river at the mouth of an insignificant tributary called Farina. The discharge at this point is the same as at that previously occupied, there being no tributaries between. This gauge was connected with the bench mark of the precise levels showing the zero of the rod to be at elevation 90.794 feet above sea level..

In October, 1899, a gauge rod was placed on the right bank of the San Juan one-half mile below the east end of Isla Grande, near station 121 of the river survey. The zero of this is 95.29 feet above sea level. Occasional readings were taken of this gauge when convenient to compare with those observed at Los Sabalos for determining the slope of the river between the gauges. Eight cross sections were measured between these points at known gauge heights, by Mr. H. C. Hurd, showing the average cross section of 8,714 square feet with the Isla Grande gauge rod at 4.9. Cross section No. 3, which occurs just above Isla Chica, a mile below the upper slope rod, gives an area of 8,799 square feet.

Daily gauge height of San Juan River, Isla Grande, 1900.

Month.	Day.	Feet.	Month.	Day.	Feet.	Month.	Day.	Feet.
January	11	6.37	May	21	4.12	June	21	5.07
Do	20	6.20	Do	22	4.05	Do	22	5.15
February	4	5.99	Do	23	4.02	July	3	5.30
March	13	5.06	Do	25	4.22	Do	8	6.02
April	3	4.60	Do	26	4.28	Do	13	6.61
Do	4	4.65	Do	28	4.72	Do	14	6.32
Do	7	4.55	Do	29	4.90	Do	19	6.65
Do	10	4.50	Do	31	4.72	Do	20	6.44
Do	14	4.50	June	1	4.60	Do	24	6.41
Do	16	4.41	Do	2	4.71	Do	27	6.21
Do	17	4.25	Do	4	4.74	Do	31	6.52
Do	18	4.20	Do	5	4.90	August	3	6.95
May	2	4.28	Do	6	4.87	Do	8	7.06
Do	10	4.15	Do	7	4.90	Do	13	6.65
Do	11	4.05	Do	8	5.12	Do	16	6.61
Do	12	4.07	Do	9	5.09	Do	21	6.76
Do	14	4.15	Do	12	4.95	Do	31	6.87
Do	15	4.07	Do	13	4.98	September	4	6.85
Do	16	4.12	Do	14	4.93	October	4	8.25
Do	18	4.10	Do	15	4.92	December	3	8.45
Do	19	4.05						

Daily gauge height of San Juan River at Los Sabalos Station, 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	10.82	10.32	9.90	9.36	8.88	8.43	8.81	8.80	9.41	9.42	9.76	10.31
2....	10.79	10.31	9.90	9.30	8.88	8.45	8.98	9.00	9.37	9.58	9.77	10.27
3....	10.70	10.29	9.85	9.25	8.87	8.43	8.89	8.89	9.37	9.47	9.79	10.14
4....	10.71	10.26	9.85	9.17	8.90	8.43	8.90	8.85	9.33	9.51	9.84	10.20
5....	10.75	10.22	9.85	9.19	8.86	8.41	8.63	8.90	9.25	9.41	9.95	10.16
6....	10.75	10.27	9.80	9.22	8.78	8.46	8.53	8.90	9.22	9.37	10.16	10.15
7....	10.74	10.27	9.75	9.20	8.72	8.53	8.55	8.84	9.19	9.40	10.11	10.16
8....	10.71	10.25	9.70	9.17	8.72	8.56	8.51	8.93	9.19	9.32	10.08	10.14
9....	10.73	10.21	9.70	9.14	8.62	8.65	8.53	9.05	9.24	9.33	10.19	10.17
10....	10.79	10.21	9.65	9.12	8.62	8.78	8.61	8.91	9.24	9.35	10.13	10.19
11....	10.77	10.22	9.65	9.13	8.62	8.79	8.78	8.87	9.28	9.42	10.11	10.19
12....	10.83	10.26	9.65	9.11	8.60	8.78	8.83	8.83	9.30	9.56	10.16	10.15
13....	10.84	10.20	9.65	9.10	8.54	8.78	8.78	8.83	9.19	9.53	10.15	10.14
14....	10.76	10.07	9.65	9.11	8.57	8.69	9.10	8.85	9.15	9.75	10.07	10.12
15....	10.96	10.09	9.60	9.10	8.54	8.71	9.00	8.82	9.14	10.00	10.35	10.08
16....	10.78	10.09	9.60	9.07	8.54	8.68	8.77	8.91	9.08	9.75	10.13	10.04
17....	10.75	10.12	9.55	9.08	8.53	8.64	8.70	9.00	9.22	9.95	10.08	10.04
18....	10.71	10.19	9.55	9.09	8.55	8.65	8.70	9.40	9.39	9.72	10.06	10.04
19....	10.64	10.11	9.60	9.09	8.52	8.70	8.73	9.34	9.50	9.52	10.03	10.04
20....	10.59	10.11	9.60	9.04	8.52	8.81	8.76	9.06	9.70	9.49	10.08	10.05
21....	10.57	10.08	9.55	9.04	8.52	8.72	9.53	9.00	10.26	9.56	9.98	10.03
22....	10.58	10.04	9.55	8.98	8.45	8.63	9.42	9.10	10.85	9.65	10.08	9.99
23....	10.56	10.01	9.50	8.91	8.49	8.55	8.97	9.22	11.00	10.10	10.04	9.98
24....	10.54	10.00	9.45	8.85	8.51	8.55	9.05	9.49	9.69	10.11	10.05	9.98
25....	10.50	9.97	9.45	8.83	8.50	8.56	9.24	9.86	9.50	9.86	10.05	9.93
26....	10.45	9.98	9.45	8.88	8.48	8.55	9.46	9.98	9.49	9.79	10.07	9.87
27....	10.47	9.95	9.40	8.88	8.46	8.54	9.24	9.54	9.37	9.79	10.15	9.87
28....	10.43	9.90	9.40	8.87	8.45	8.68	9.03	9.49	9.34	9.84	10.11	9.88
29....	10.41	....	9.40	8.85	8.47	8.69	8.87	9.40	9.37	9.86	10.17	9.88
30....	10.39	....	9.35	8.82	8.44	8.58	8.89	9.35	9.35	9.84	10.24	9.85
31....	10.34	....	9.40	....	8.53	....	8.82	9.35	....	9.79	....	9.85

Daily gauge height of San Juan River at Los Sabalos Station, 1900.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	9.88	9.45	8.97	8.47	8.16	8.41	8.72	9.88	10.21	11.41	11.72	11.54
2....	9.85	9.43	8.90	8.40	8.18	8.46	8.81	9.85	10.20	11.68	11.74	11.45
3....	9.83	9.39	8.93	8.40	8.11	8.46	9.17	10.45	10.18	11.40	11.74	11.45
4....	9.84	9.43	8.84	8.37	7.99	8.51	9.07	10.78	10.16	11.39	11.71	11.48
5....	9.84	9.41	8.77	8.34	7.87	8.60	9.29	11.53	10.18	11.28	11.67	11.41
6....	9.80	9.35	8.76	8.31	7.86	8.61	8.99	10.87	10.20	11.20	11.68	11.37
7....	9.78	9.32	8.74	8.35	7.81	8.61	9.16	10.70	10.18	11.40	11.70	11.41
8....	9.78	9.32	8.77	8.37	7.86	8.81	9.71	10.46	10.15	11.76	11.72	11.40
9....	9.74	9.35	8.77	8.34	7.85	8.77	9.40	10.20	10.12	11.50	11.68	11.45
10....	9.72	9.25	8.80	8.27	7.95	8.76	9.65	10.20	10.14	11.44	11.69	11.39
11....	9.78	9.25	8.79	8.32	7.92	8.75	9.57	10.15	10.20	11.31	11.75	11.41
12....	9.78	9.26	8.77	8.33	7.93	8.72	9.60	10.10	10.19	11.27	11.67	11.65
13....	9.74	9.29	8.71	8.26	7.95	8.80	10.21	10.03	10.14	11.23	11.60	11.62
14....	9.70	9.24	8.75	8.24	8.02	8.66	9.81	10.26	10.11	11.21	11.56	11.51
15....	9.70	9.21	8.74	8.18	8.08	8.63	9.66	10.20	10.14	11.26	11.52	11.42
16....	9.68	9.24	8.73	8.19	8.00	8.66	10.61	10.03	10.35	11.28	11.52	11.38
17....	9.71	9.23	8.68	8.10	8.02	9.13	10.18	[illegible]	10.26	11.29	11.53	11.36
18....	9.67	9.19	8.63	8.09	7.96	9.31	10.07	9.97	10.22	11.32	11.52	11.35
19....	9.68	9.10	8.59	8.14	7.97	8.94	10.07	10.01	10.43	11.42	11.53	11.38
20....	9.64	9.12	8.68	8.15	7.97	8.82	9.88	10.02	10.39	11.58	11.53	11.36
21....	9.60	9.12	8.52	8.20	8.00	8.77	9.78	10.10	10.32	12.66	11.54	11.32
22....	9.61	9.10	8.51	8.13	8.00	8.77	9.79	10.24	10.52	12.75	11.58	11.29
23....	9.59	9.05	8.52	8.15	7.95	8.78	9.87	10.14	10.52	12.41	11.51	11.25
24....	9.60	9.13	8.60	8.11	8.01	8.75	9.85	10.14	10.51	12.21	11.48	11.22
25....	9.58	9.06	8.58	8.14	8.06	8.64	9.73	10.16	10.60	12.09	11.48	11.20
26....	9.58	9.01	8.58	8.23	8.16	8.63	9.71	10.36	10.59	11.96	11.44	11.14
27....	9.55	9.00	8.57	8.27	8.30	8.67	9.68	10.57	10.54	11.87	11.39	11.12
28....	9.57	8.95	8.53	8.17	8.44	8.68	9.72	10.45	10.50	11.81	11.36	11.10
29....	9.53	....	8.54	8.18	8.49	8.74	9.74	10.30	10.70	11.79	11.33	11.09
30....	9.50	....	8.52	8.08	8.47	8.73	9.72	10.29	11.14	11.77	11.36	11.05
31....	9.50	....	8.46	....	8.47	....	9.97	10.20	....	11.73	....	11.03

Rating table for San Juan River at Los Sabalos.

[This table is applicable only from January 1, 1898, to December 31, 1899, and from March 1, 1901, to April 30, 1901.]

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
8.0	11,130	9.0	14,710	10.0	20,010	11.0	25,310
8.1	11,320	9.1	15,240	10.1	20,540	11.1	25,840
8.2	11,530	9.2	15,770	10.2	21,070	11.2	26,370
8.3	11,760	9.3	16,300	10.3	21,600	11.3	26,900
8.4	12,040	9.4	16,830	10.4	22,130	11.4	27,430
8.5	12,380	9.5	17,360	10.5	22,660	11.5	27,960
8.6	12,760	9.6	17,890	10.6	23,190	11.6	28,190
8.7	13,200	9.7	18,420	10.7	23,720	11.7	29,020
8.8	13,680	9.8	18,950	10.8	24,250	11.8	29,550
8.9	14,180	9.9	19,480	10.9	24,780	11.9	30,080

[This table is applicable only from January 1, 1900, to February 28, 1901.]

7.7	10,400	8.8	12,720	9.9	18,840	11.0	25,000
7.8	10,490	8.9	13,250	10.0	19,400	11.1	25,560
7.9	10,600	9.0	13,800	10.1	19,960	11.2	26,120
8.0	10,740	9.1	14,360	10.2	20,520	11.3	26,680
8.1	10,890	9.2	14,920	10.3	21,080	11.4	27,240
8.2	11,050	9.3	15,480	10.4	21,640	11.5	27,800
8.3	11,220	9.4	16,040	10.5	22,200	11.6	28,360
8.4	11,400	9.5	16,600	10.6	22,760	11.7	28,920
8.5	11,600	9.6	17,160	10.7	23,320	11.8	29,480
8.6	11,900	9.7	17,720	10.8	23,880	11.9	30,040
8.7	12,280	9.8	18,280	10.9	24,440	12.0	30,600

Estimated monthly discharge of San Juan River at Station Sabalos.

Months.	Discharge.			Total.	Months.	Discharge.			Total.
	Maximum.	Minimum.	Mean.			Maximum.	Minimum.	Mean.	
1899.	*Sec. ft.*	*Sec. ft.*	*Sec. ft.*	*Acre-feet.*	1900.	*Sec. ft.*	*Sec. ft.*	*Sec. ft.*	*Acre-feet.*
January	25,100	21,810	23,472	1,443,254	January	18,943	16,600	17,618	1,083,292
February	21,720	19,480	20,792	1,154,771	February	16,320	13,800	15,070	836,958
March	19,180	16,560	17,946	1,103,500	March	13,635	11,520	12,287	755,503
April	16,618	13,780	15,658	896,008	April	11,540	10,407	11,128	662,265
May	14,421	12,176	12,825	788,584	May	12,588	10,263	10,916	671,212
June	13,730	11,942	12,862	765,329	June	15,536	11,420	12,455	741,117
July	17,519	12,418	14,193	881,716	July	22,816	12,368	17,453	1,073,149
August	19,904	13,680	15,360	914,463	August	27,968	17,649	20,959	1,288,735
September	25,310	15,134	17,170	1,021,693	September	25,784	19,338	21,283	1,266,473
October	20,593	15,469	18,144	1,115,681	October	34,800	23,466	28,499	1,752,367
November	21,865	16,135	20,353	1,211,088	November	29,200	25,345	28,220	1,679,231
December	21,653	17,213	20,333	1,250,254	December	28,640	25,168	26,915	1,653,969
The year.	25,310	11,942	17,370	12,576,341	The year.	34,800	10,263	18,600	13,461,271

CASTILLO STATION ON SAN JUAN RIVER.

Two gauges were placed in the San Juan River at Castillo, one above the falls and one below. The upper gauge was fastened to the downstream support of the first building below the steamboat wharf above the rapids. The lower gauge was fastened to the northeast corner of the wharf at the lower Bodega below the rapids. The zero of the upper gauge is 5.65 feet above the zero of the lower. Mr. John S. Augustine, the agent at Castillo, was employed to read the gauges, daily readings being taken of both. He also kept a record of rainfall.

Old residents testify that on August 30, 1892, the water reached an elevation which would correspond to a reading on the lower gauge of 11.1. This is marked on custom-house Bodega, with date.

One year later, November 20, 1893, the water came still higher, being about 4 inches over the floor of custom-house. This would make a rod reading of 12.3. These rod readings correspond to the lower gauge at the custom-house.

Daily gauge height of San Juan River at Castillo above falls, 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.80	3.50	3.10	2.80	2.40	2.20	2.40	2.50	3.10	3.05	3.00	3.50
2	3.80	3.50	3.10	2.80	2.20	2.20	2.80	2.90	3.00	3.00	3.00	3.50
3	3.80	3.50	3.10	2.70	2.20	2.20	2.80	2.85	3.00	3.00	3.00	3.55
4	3.90	3.50	3.00	2.70	2.20	2.20	2.80	2.85	2.90	3.30	3.10	3.40
5	4.00	3.40	3.00	2.65	2.20	2.10	2.60	2.90	2.80	3.10	3.40	3.40
6	4.30	3.40	3.00	2.70	2.20	2.10	2.50	2.75	2.70	2.95	3.70	3.30
7	4.20	3.40	3.00	2.80	2.20	2.10	2.00	2.80	2.70	2.90	3.60	3.35
8	4.20	3.30	2.90	2.80	2.20	2.50	2.10	2.70	2.35	2.90	3.60	3.40
9	4.90	3.30	2.90	2.80	2.20	2.50	2.15	2.70	2.30	2.90	3.60	3.45
10	4.30	3.30	2.90	2.80	2.20	3.00	2.70	2.90	2.30	2.90	3.80	3.50
11	4.10	3.30	2.90	2.70	2.20	2.50	3.40	2.60	2.45	2.90	3.80	3.50
12	5.00	3.50	2.90	2.80	2.20	3.00	3.00	2.55	2.90	3.10	3.30	3.45
13	5.00	3.50	2.90	2.70	2.00	2.60	2.80	2.50	2.80	3.00	3.80	3.40
14	4.80	3.50	2.90	2.70	2.00	2.10	3.70	2.60	2.80	3.55	3.80	3.35
15	4.20	3.50	2.90	2.60	2.20	2.10	2.30	2.60	2.60	3.80	3.80	3.30
16	4.00	3.40	3.80	2.55	2.20	2.00	2.30	2.60	2.60	3.30	3.70	3.20
17	4.10	3.30	3.80	2.40	2.20	2.00	2.30	2.80	2.70	3.30	3.70	3.20
18	4.00	3.30	3.80	2.40	2.20	2.00	2.75	3.30	3.20	3.20	3.65	3.20
19	3.80	3.30	3.80	2.40	2.20	2.10	2.75	3.60	3.20	3.00	3.65	3.60
20	3.80	3.20	2.90	2.40	2.20	2.10	2.75	2.95	3.50	2.95	3.60	3.50
21	3.70	3.20	2.90	2.40	2.20	2.10	4.00	2.90	4.50	3.00	3.60	3.40
22	3.70	3.20	2.90	2.40	2.20	2.10	3.80	3.20	5.70	3.00	3.55	3.40
23	3.70	3.30	2.90	2.40	2.20	2.10	3.50	3.10	5.55	3.90	3.45	3.35
24	3.80	3.30	2.90	2.40	2.20	2.10	2.50	3.50	3.80	3.80	2.40	3.30
25	3.80	3.30	2.90	2.40	2.20	2.10	2.70	4.00	3.50	3.25	3.40	3.25
26	3.80	3.30	2.80	2.40	2.20	2.10	4.00	3.60	3.40	3.10	3.35	3.20
27	3.80	3.30	2.80	2.40	2.20	2.10	3.35	3.60	3.35	3.10	3.30	3.20
28	3.70	3.00	2.80	2.40	2.20	2.50	2.50	3.30	3.30	3.05	3.30	3.20
29	3.70	......	2.80	2.40	2.20	2.40	2.50	3.20	3.30	3.05	3.40	3.20
30	3.70	......	2.80	2.40	2.20	2.60	2.50	3.10	3.30	3.05	3.40	3.00
31	3.50	......	2.80	......	2.20	......	2.45	3.50	......	3.05	......	3.00

Daily gauge height of San Juan River at Castillo, above falls, 1900.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.70	2.40	1.00	1.70	1.00	1.00	2.70	2.00	3.60	3.20	2.80
2	2.70	2.50	1.00	1.70	1.00	1.00	2.70	2.00	3.85	3.20	2.85
3	2.75	2.50	1.80	1.70	1.00	1.00	3.85	2.00	3.90	3.25	2.80
4	2.75	2.45	1.80	1.50	1.00	1.50	5.15	2.00	3.85	3.20	2.70
5	2.80	2.45	1.80	1.50	1.00	1.50	5.00	2.00	3.40	3.20	2.70
6	2.70	2.40	2.00	1.30	1.00	1.50	4.85	1.90	3.23	3.10	2.70
7	2.70	2.40	2.00	1.30	1.00	1.40	3.00	1.90	3.20	3.15	2.80
8	2.70	2.30	2.00	[a] .40	1.00	2.00	3.00	1.90	3.60	3.15	2.90
9	2.70	2.30	2.00	.40	1.00	2.00	3.00	1.90	3.30	3.10	2.90
10	2.70	2.30	2.00	.40	1.00	2.00	3.00	1.95	3.30	3.10	2.95
11	2.70	2.30	2.00	.60	1.00	2.00	3.00	2.20	3.20	3.10	3.15
12	2.70	2.30	2.00	.50	1.00	2.00	3.10	2.30	3.10	3.10	3.85
13	2.70	2.20	2.00	.50	1.00	2.80	3.80	2.35	3.10	3.10	3.90
14	2.60	2.15	2.00	.50	1.00	2.30	5.50	2.35	3.00	3.00	3.70
15	2.60	2.15	2.00	.55	1.00	1.70	3.40	2.30	2.85	3.10	3.55
16	2.60	2.15	1.90	.55	1.00	2.80	2.40	2.35	3.00	3.10	3.60
17	2.60	2.15	1.70	.55	2.10	2.80	2.25	2.65	3.00	3.10	3.50
18	2.50	2.15	1.80	.50	2.30	2.30	2.65	3.00	2.90	3.10	3.40
19	2.50	2.30	1.80	.50	1.40	2.30	2.65	3.10	3.00	3.10	3.10
20	2.50	2.30	1.80	.45	1.40	2.30	2.60	3.00	4.85	3.10	3.10
21	2.50	2.30	1.80	.45	1.00	2.10	2.80	3.00	5.10	3.10	3.00
22	2.50	2.20	1.80	.45	1.00	2.10	2.70	3.05	4.10	3.10	3.00
23	2.50	2.20	1.80	.45	1.00	2.00	2.30	3.05	4.00	3.00	3.00
24	2.50	2.20	1.80	.45	1.00	2.00	2.35	3.15	3.90	3.00	3.00
25	2.50	2.20	1.80	.50	1.00	2.00	2.40	3.25	4.00	3.00	3.00
26	2.40	2.00	2.00	.70	.95	1.95	2.45	3.35	4.00	3.00	3.00
27	2.45	1.80	2.00	.70	.95	1.95	4.25	3.35	4.00	2.90	3.00
28	2.40	1.75	1.80	1.30	.95	1.95	2.70	3.55	3.50	2.90	3.00
29	......	1.50	1.80	1.00	1.00	1.95	3.85	4.55	3.50	2.80	3.00
30	......	1.30	1.70	1.00	1.00	1.95	2.70	5.55	3.20	2.80	3.00
31	......	.80	......	1.00	......	1.95	2.60	......	3.30	......	3.00

[a] New rod; elevation of zero = 88.53 or 0.90 higher than old rod.

Daily gauge height of San Juan River at Castillo, below falls, 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.00	4.50	3.90	3.30	3.50	3.05	2.85	3.15	3.90	4.00	3.80	4.50
2	5.00	4.50	3.90	3.30	2.80	3.00	3.30	3.50	3.60	4.00	3.95	4.50
3	5.00	4.50	3.90	3.30	2.80	3.00	3.75	3.52	3.60	4.00	3.75	4.50
4	5.15	4.50	3.80	3.27	2.80	2.95	3.50	3.50	3.50	4.20	3.90	4.38
5	5.25	4.40	3.80	3.25	2.80	3.00	3.40	3.60	3.50	3.90	4.38	4.40
6	5.45	4.40	3.80	3.30	2.80	3.00	3.30	3.52	3.40	3.50	4.95	4.30
7	5.30	4.40	3.80	3.32	2.80	3.00	2.60	3.55	3.40	3.55	4.90	4.38
8	5.30	4.35	3.70	3.35	2.80	2.90	2.52	3.70	3.42	3.45	4.80	4.40
9	5.60	4.35	3.70	3.40	2.80	2.90	2.65	3.98	3.40	3.40	4.80	4.40
10	5.50	4.32	3.70	3.40	2.80	3.55	3.02	3.40	3.40	3.40	5.00	4.50
11	5.45	4.32	3.70	3.30	2.80	3.20	3.78	3.18	3.50	3.50	5.30	4.50
12	5.85	4.42	3.70	3.35	2.80	3.60	3.90	3.02	3.50	3.90	5.92	4.42
13	6.30	4.50	3.70	3.30	2.50	3.35	3.80	3.00	3.40	3.70	5.02	4.40
14	6.20	4.50	3.70	3.30	2.50	3.30	4.45	3.50	3.40	4.75	5.00	4.38
15	5.85	4.50	3.70	3.30	2.70	3.15	2.90	3.00	3.20	4.98	5.00	4.20
16	6.00	4.40	3.60	3.30	2.70	2.80	2.85	3.05	3.20	4.00	4.95	4.25
17	5.40	4.35	3.52	3.30	2.60	2.80	3.00	3.50	3.50	4.00	4.95	4.22
18	5.25	4.30	3.50	3.30	2.60	2.90	3.30	5.10	4.15	3.90	4.90	4.20
19	5.00	4.25	3.50	3.30	2.60	2.55	3.30	5.42	4.00	3.75	4.80	4.50
20	5.00	4.20	3.50	3.30	2.60	2.45	3.35	3.50	4.50	3.70	4.70	4.62
21	4.20	4.20	3.50	3.40	2.60	2.50	......	3.60	6.15	3.60	4.65	4.40
22	4.20	4.20	3.50	3.40	2.60	2.50	4.25	4.20	7.30	3.72	4.60	4.42
23	4.35	4.20	3.50	3.40	2.60	2.50	3.90	4.05	6.55	5.10	4.45	4.30
24	4.80	4.30	3.50	3.50	2.60	2.50	3.35	4.60	4.70	4.95	4.30	4.30
25	4.80	4.30	3.40	3.55	2.60	2.50	3.62	5.25	4.48	4.35	4.30	4.30
26	4.80	4.30	3.40	3.50	2.60	2.50	4.65	5.05	4.40	4.00	4.30	4.20
27	4.80	4.25	3.40	3.50	2.60	2.50	4.20	4.72	4.20	4.00	4.20	4.20
28	4.75	4.00	3.45	3.50	2.60	2.85	3.60	4.25	4.20	4.00	4.20	4.20
29	4.75	......	3.40	3.50	2.60	2.80	3.40	4.00	4.20	3.90	4.10	4.20
30	4.70	......	3.40	3.50	2.60	3.00	3.40	3.85	4.20	3.90	4.10	4.05
31	4.50	......	3.40	......	2.60	......	3.30	3.82	......	3.90	......	4.05

Daily gauge height of San Juan River at Castilio below falls, 1900.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.30	3.25	2.20	1.85	2.70	2.70	3.85	4.70	6.00	6.10	5.60
2	3.30	2.80	2.10	1.80	2.70	2.70	3.85	4.55	6.45	6.10	5.50
3	3.30	2.60	2.05	1.80	2.70	2.70	5.60	4.20	6.45	6.20	5.50
4	3.30	2.60	2.05	1.60	2.70	3.20	6.00	4.20	6.30	6.20	5.45
5	3.30	2.60	2.00	1.40	2.70	3.20	5.75	4.15	6.00	6.20	5.40
6	3.30	2.60	2.00	1.30	2.70	3.20	5.35	4.15	5.90	6.10	5.40
7	3.30	2.60	2.10	1.30	2.70	4.20	4.85	4.10	6.15	6.10	5.50
8	3.30	2.60	2.10	1.30	2.70	4.20	4.70	4.10	6.70	6.10	5.50
9	3.30	2.50	2.20	[a]1.65	2.70	4.20	4.70	4.10	6.30	6.10	5.70
10	3.30	2.50	2.20	1.95	2.70	4.20	4.70	4.00	6.30	6.10	5.70
11	3.30	2.50	2.10	1.75	2.70	4.20	4.80	4.30	6.15	6.10	5.85
12	3.30	2.50	2.00	1.70	2.70	5.50	4.80	4.30	5.80	6.10	6.30
13	3.30	2.45	1.90	1.70	2.70	4.60	5.10	4.35	5.80	6.10	6.70
14	3.30	2.40	1.90	1.80	2.70	4.00	6.75	4.35	5.55	6.00	6.60
15	3.30	2.40	1.90	1.85	2.70	5.50	4.36	4.40	5.70	6.10	6.40
16	3.30	2.40	1.90	1.85	2.70	5.50	4.45	4.45	5.60	6.10	6.40
17	3.30	2.40	1.80	1.80	3.00	4.60	4.50	4.60	5.60	6.10	6.40
18	3.30	2.30	1.80	1.80	4.70	4.60	4.90	4.90	5.50	6.10	6.30
19	3.20	2.40	1.70	1.75	3.00	4.60	4.60	4.05	5.60	5.90	6.20
20	3.20	2.40	1.70	1.75	3.00	4.40	4.40	5.05	6.35	5.80	6.20
21	3.20	2.40	1.70	1.75	2.70	4.40	4.50	4.80	7.00	5.80	6.00
22	3.30	2.30	1.90	1.75	2.70	4.60	4.65	4.80	6.70	6.00	6.00
23	3.30	2.30	1.90	1.75	2.70	4.20	4.65	5.00	6.40	5.80	6.00
24	3.30	2.30	1.90	1.80	2.70	4.20	4.55	5.02	6.30	5.80	6.00
25	3.25	2.30	1.90	2.00	2.70	4.20	4.60	5.35	6.50	5.80	6.00
26	3.25	2.30	2.00	2.20	2.65	3.95	4.80	5.45	6.60	5.60	6.00
27	3.25	2.30	2.00	2.90	2.65	3.95	5.15	5.45	6.50	5.50	6.00
28	3.25	2.20	1.80	2.70	2.70	3.95	5.35	5.70	6.40	5.50	5.90
29	......	2.20	1.80	2.70	2.70	3.95	4.90	7.90	6.40	5.50	5.90
30	......	2.10	1.70	2.70	2.70	3.95	4.80	7.90	6.20	5.50	5.90
31	......	2.10	.....	2.70	......	3.95	4.70	......	6.20	......	5.90

[a] New rod; elevation of zero = 81.59.

List of discharge measurements made on tributaries of San Juan River above Boca San Carlos.

MELCHORA RIVER.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.			*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Sec. feet.*
Oct. 3	H. W. Durham	Price No. 34	....	126	0.55	68
1900.						
Jan. 19	H. S. Reed	Price No. 63	....	166	.00	0
June 1	H. G. Heisler	B. & B. No. 1	....	270	.16	43
June 22	.....do	.....do	....	172	.17	28
July 14	.....do	.....do	....	374	.76	287
July 30	.....do	.....do	....	380	.26	96
Aug. 13	.....do	.....do	....	236	.35	83
Aug. 27	.....do	.....do	....	265	.64	172
Sept. 8	.....do	.....do	....	([a])	....	....
Sept. 21	.....do	.....do	....	([a])	....	....

MEDIO QUESO RIVER.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.						
Oct. 3	H. W. Durham	Price No. 34	....	1,114	0.77	856
Nov. 2	.....do	.....do	....	765	.27	206
Nov. 14	.....do	.....do	....	1,066	.42	455
1900.						
Jan. 19	H. S. Reed	Price No. 63	....	1,292	.18	231
June 1	H. G. Heisler	B. & B. No. 1	....	....	([a])	....
June 22	.....do	.....do	....	....	([a])	....
July 14	.....do	.....do	....	1,017	.80	816
July 30	.....do	.....do	....	1,087	.67	733
Aug. 13	.....do	.....do	....	1,147	1.01	1,160
Aug. 27	.....do	.....do	....	1,160	.68	800
Sept. 8	.....do	.....do	....	1,173	.41	487
Sept. 21	.....do	.....do	....	1,192	.46	554

PALO DE ARCO RIVER.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.						
Oct. 3	H. W. Durham	Price No. 34	....	220	0.44	97
1900.						
June 1	H. G. Heisler	B. & B. No. 1	....	107	.26	28
June 22	.....do	.....do	....	103	.31	32
July 14	.....do	.....do	....	395	.54	214
July 30	.....do	.....do	....	405	.56	227
Aug. 13	.....do	.....do	....	362	.23	86
Aug. 27	.....do	.....do	....	534	.40	214
Sept. 8	.....do	.....do	....	....	([a])	....
Sept. 21	.....do	.....do	....	190	.29	56

CAÑO CHICO.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.						
Oct. 4	H. W. Durham	Price No. 34	....	500	0.38	191
Nov. 23	.....do	.....do	....	460	.22	101
1900.						
Jan. 19	H. S. Reed	Price No. 63[a]	....	....	([a])	....
July 14	H. G. Heisler	B. & B. No 1	....	735	.65	478
July 30	.....do	.....do	....	587	.71	422
Aug. 13	.....do	.....do	....	829	.65	540
Sept. 8	.....do	.....do	....	....	([a])	....
Sept. 21	.....do	.....do	....	619	.33	206

[a] No current.

List of discharge measurements made on tributaries of San Juan River, etc.—Continued.

NEGRO RIVER (ABOVE LOS SABALOS).

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.			*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Sec. feet.*
Sept. 13	R. H. Morrin	Stackpole No. 1	3.61	90	1.05	95
Oct. 5	H. W. Durham	Price No. 34		437	.41	178
Oct. 12	do	do	3.54	139	.80	110
Oct. 27	do	do	3.72	130	.39	50
Nov. 8	do	do	3.03	163	.91	157
Nov. 16	do	do	1.97	189	1.20	227
Nov. 27	do	do	3.15	146	.65	96
1900.						
Jan. 15	H. W. Durham	B. & B. No. 1	4.05	64	.30	19
Feb. 4	T. F. Boltz	do	3.98	186	.21	39
Mar. 5	do	Haskell No. 2	3.10	38	.19	7
Mar. 12	do	do	3.05	35	.15	5
Mar. 19	do	do	3.00	22	.18	4
Mar. 26	do	do	2.88	31	.15	5
Apr. 2	do	do	2.78	25		0
Apr. 8	do	do	2.71			0
Apr. 17	do	do	2.50			0
Apr. 23	do	do	2.55			0
Apr. 30	do	do	2.46			0
May 14	do	do	2.60	27	.54	15
May 28	do	do	5.92	179	1.38	247
June 17	do	do	4.40	131	.98	129
June 26	do	do	3.15	145	.25	37
July 2	do	do	5.09	150	1.21	182
July 9	do	do	4.95	144	.98	141
July 16	do	do		605	2.11	1,277
July 23	do	do	6.24	188	1.34	252
July 29	do	do	4.55	134	.66	88
Aug. 6	do	do		592	1.26	745
Aug. 12	do	do	6.70	219	1.45	318
Aug. 21	do	do	6.00	188	1.21	226
Aug. 27	do	do	8.33	270	1.88	508
Sept. 3	do	do	4.90	186	.49	90
Sept. 11	do	do	4.67	87	.37	32
Sept. 26	do	do	5.27	155	.49	76
Oct. 1	do	do	6.32	188	.94	177
Oct. 8	do	do	7.70	231	1.28	296
Oct. 15	do	do	5.85	211	.25	54
Oct. 23	do	do		733	.95	697
Oct. 29	do	do	6.42	123	.48	59
Dec. 1	do	Price No. 68	6.61	195	.90	175
Dec. 9	do	do	6.88	214	1.11	239
Dec. 16	do	do	6.09	175	.44	77
Dec. 23	do	do	5.98	172	.52	89
1901.						
Jan. 6	do	do	2.45	158	.24	38

SABALOS RIVER.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899						
Jan. 3	R. H. Morrin	Stackpole No. 1	5.69	510	1.05	535
Jan. 19	do	do	5.51	467	.85	396
Feb. 4	do	do	4.98	336	.28	95
Feb. 14	do	do	4.81	354	.36	124
Feb. 21	do	do	4.85	340	.53	181
Feb. 25	do	do	4.68	320	.24	77
Mar. 6	S. Wilson	do	4.55	311	.24	76
Mar. 21	do	do	4.30	110	.90	100
Mar. 31	do	do	4.13	173	.42	76
Apr. 15	do	do	3.87	140	.63	89
Do	do	do	3.87	101	.80	81
Apr. 21	do	do	3,81	134	.49	67
Apr. 29	do	do	3.65	94	.40	37
Do	do	Stackpole No. 7	3.65	94	.34	32
Do	do	Stackpole No. 1	3.65	112	.37	41
Do	do	Stackpole No. 7	3.65	112	.34	38
May 12	do	Stackpole No. 1	3.55	105	.65	68
May 17	do	do	3.41	95	.46	44
May 23	do	do	3.30	86	.47	40
June 7	do	do	3.31	83	.83	69
June 16	do	do	3.70	316	.60	191
June 23	do	do	3.47	299	.25	75
Do	do	Stackpole No. 7	3.47	299	.30	90

List of discharge measurements made on tributaries of San Juan River, etc.—Continued.

SABALOS RIVER—Continued.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.			*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Sec. feet.*
July 5	S. Wilson	Stackpole No. 7	4.74	422	1.31	555
Aug. 2	do	Stackpole No. 1	6.02	581	2.32	1,349
Aug. 15	do	do	3.68	376	.65	246
Sept. 2	R. H. Morrin	do	4.25	423	.93	393
Sept. 15	do	do	3.97	412	.62	255
Sept. 23	do	do		2,618	4.63	[a] 12,134
Oct. 2	do	do	4.95	498	1.23	613
Oct. 5	do	do	4.72	459	1.05	484
Oct. 9	do	do	4.16	387	.64	246
Oct. 14	do	do	4.24	404	.71	298
Oct. 17	do	do	4.52	451	.78	354
Oct. 24	do	do	8.41	874	2.80	2,444
Oct. 30	do	do	4.69	427	.73	310
Nov. 3	do	do	3.40	402	.38	153
Nov. 7	do	do	5.55	569	1.49	851
Nov. 11	do	do	4.82	457	.70	319
Nov. 14	do	do	5.23	482	1.24	598
Nov. 17	do	do	5.13	494	1.04	512
Nov. 22	do	do	5.29	514	1.28	659
Dec. 4	do	do	4.89	475	.72	340
Dec. 12	H. W. Durham	B. and B. No. 1	4.78	517	.54	260
Dec. 16	do	do	4.75	510	.57	291
Dec. 22	do	do	4.70	490	.63	312
Dec. 29	do	do	4.50	451	.36	164
1900.						
Jan. 1	H. W. Durham	B. and B. No. 1	4.50	453	.33	149
Jan. 3	do	do	4.45	441	.29	128
Jan. 14	H. G. Heisler	do	4.35	129	1.19	154
Jan. 21	H. S. Reed	do		437	.26	114
Feb. 6	T. F. Boltz	do	3.90	126	.90	113
Feb. 9	do	do	3.95	126	.92	116
Mar. 4	do	do	3.61	114	.81	91
Mar. 10	do	do	3.60	111	.60	67
Mar. 17	do	do	6.57	110	.54	59
Mar. 24	do	do	6.48	106	.47	50
Mar. 31	do	do	6.38	103	.37	38
Apr. 7	do	do	6.29	100	.37	37
Apr. 14	do	do	6.20	99	.33	33
Apr. 21	do	do	6.14	98	.30	29
Apr. 28	do	do	6.11	97	.23	23
May 5	do	Haskell No. 2	5.94	85	.27	23
May 12	do	do	5.99	101	.40	41
May 27	do	do	6.30	112	.97	109
June 2	do	do	6.50	116	.79	92
June 11	do	do	6.63	104	.56	58
June 16	do	do	6.84	147	1.48	217
June 19	do	do	7.89	584	.99	577
June 23	do	do	6.99	488	.46	226
July 16	do	do		1,913	1.54	2,943
July 18	do	do	8.85	687	1.22	838
July 21	do	do	8.29	618	.85	528
July 25	do	do	8.12	609	.74	455
July 28	do	do	8.50	652	.99	648
Aug. 7	do	do	8.96	720	1.36	977
Aug. 7	do	do	11.72	2,034	1.36	2,775
Aug. 11	do	do	8.64	721	.90	649
Aug. 15	do	do	9.85	864	1.54	1,335
Aug. 19	do	do	8.54	699	.88	614
Aug. 22	do	do	9.08	760	1.12	853
Aug. 25	do	do	8.99	752	1.10	828
Aug. 29	do	do	8.88	722	1.02	732
Sept. 1	do	do	8.30	641	.54	348
Sept. 5	do	do	8.10	139	1.54	214
Sept. 8	do	do	8.05	136	1.39	190
Sept. 12	do	do	8.08	141	1.39	196
Sept. 15	do	do	8.17	625	.45	281
Sept. 19	do	do	9.11	761	1.10	839
Sept. 26	do	do	9.49	795	1.27	1,009
Sept. 29	do	do	8.82	706	.63	447
Oct. 2	do	do	10.27	867	1.29	1,117
Oct. 6	do	do	9.26	742	.67	499
Oct. 9	do	do	9.46	752	.61	455
Oct. 13	do	do	9.10	711	.38	270
Oct. 17	do	do	9.34	747	.64	480
Oct. 20	do	do	14.20	2,145	1.89	4,059
Oct. 23	do	do	11.20	2,082	.78	1,616
Oct. 27	do	do	9.80	790	.57	449

[a] Heavy flood. Gauging made one-half mile above mouth. River too swift to reach gauge rod.

List of discharge measurements made on tributaries of San Juan River, etc.—Continued.

SABALOS RIVER—Continued.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1900.			*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Sec. feet.*
Oct. 31	T. F. Boltz	Haskell No. 2	9.49	477	.49	333
Nov. 3	do	do	9.58	543	.67	366
Nov. 11	do	do	10.54	890	1.37	1,222
Nov. 14	do	do	9.39	747	.39	290
Nov. 17	do	do	9.46	752	.51	387
Nov. 22	do	Price No. 68	9.92	812	1.15	936
Nov. 24	do	do	9.34	739	.53	395
Nov. 28	do	do	9.12	165	1.17	194
Dec. 1	do	do	11.41	1,020	2.06	2,102
Dec. 5	do	do	9.63	770	.97	747
Dec. 8	do	do	9.63	773	1.03	796
Dec. 12	do	do	10.22	847	1.30	1,091
Dec. 15	do	do	9.32	730	.66	480
Dec. 19	do	do	9.74	789	1.12	886
Dec. 22	do	do	9.18	717	.53	381
Dec. 26	do	do	9.00	697	.35	244

POCO SOL RIVER.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.						
Oct. 5	H. W. Durham	Price No. 34	1.08	981	1.54	1,513
Nov. 2	do	do	.85	919	.66	611
Nov. 25	do	do	1.42	978	1.29	1,264
1900.						
Jan. 22	H. S. Reed	Price No. 63	.40	1,007	.55	556
Feb. 13	H. C. Hurd	Price No. 34	− .10	1,030	.20	204
Mar. 14	do	do	− .07	945	.15	142
Apr. 6	do	Price No. 35	−1.20	570	.29	167
Apr. 20	do	do	−1.35	336	.10	34
May 6	C. Hayman	Price No. 63	1.61	281	.35	99
June 2	H. G. Heisler	B. and B. No. 1	− .03	1,358	.92	1,258
June 25	do	do	− .50	751	.52	391
July 15	do	do	2.15	1,000	2.65	[a]2,651
July 26	do	do	1.97	1,110	2.11	[b]2,442
Aug. 14	do	do	3.90	1,212	1.89	2,303
Aug. 28	do	do	3.00	1,181	2.03	2,399
Sept. 8	do	do	1.25	846	1.04	886
Sept. 22	do	do	2.68	1,082	1.96	2,123

SANTA CRUZ RIVER.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.						
Oct. 5	H. W. Durham	Price No. 34	0.85	1,035	0.62	638
Nov. 4	do	do	.80	1,359	.26	347
Nov. 25	do	do	1.23	781	.30	237
1900.						
Feb. 13	H. C. Hurd	Price No. 34	.10	65	1.31	86
Mar. 14	do	do	.50	163	1.41	68
Apr. 6	do	Price No. 35	− .92	97	.37	36
Apr. 20	do	do		98	.17	47
May 7	C. Hayman	Price No. 63	1.34	165	.56	93
May 20	H. G. Heisler	B. and B. No. 1	−1.20	131	.31	41
June 2	do	do	− .04	382	.33	130
June 25	do	do	− .35	329	.36	121
July 15	do	do	1.02	488	.42	207
July 26	do	do	1.12	533	.64	342
Aug. 14	do	do	12.00	2,415	4.26	[c]10,301
Aug. 28	do	do	2.45	1,132	1.26	1,437
Sept. 8	do	do	1.20	886	.42	379
Sept. 22	do	do	2.10	989	.48	482

[a] Gauging made below gauge.
[b] Gauging made above gauge.
[c] Flood. Impossible to go to gauge. Elevation determined approximately August 28 by drift in branches of trees.

List of discharge measurements made on tributaries of San Juan River, etc.—Continued.

SANTA CRUZITA RIVER.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
			Feet.	*Sq. feet.*	*Ft. per sec.*	*Sec. feet.*
1900.						
Aug. 14	H. G. Heisler	B. and B., No. 1		345	1.80	623
Aug. 28	.....do	.....do		331	.71	237

BARTOLA RIVER.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.						
Oct. 6	H. W. Durham	Price, No. 34	0.95	412	0.59	245
Nov. 6	.....do	.....do	2.12	499	.57	286
Nov. 25	.....do	.....do	1.48	457	.39	179
Jan. 23	H. S. Reed	Price, No. 63	.83	471	.45	214
Feb. 14	H. C. Hurd	Price, No. 34	− .30	99	.25	60
Mch. 14	.....do	.....do	− .30	161	.91	66
Apr. 24	.....do	Price, No. 35	−1.00	88	.45	40
May 21	H. G. Heisler	B. and B., No. 1	− .06	145	.50	72
June 3	.....do	.....do	− .03	148	.43	63
June 26	.....do	.....do	− .20	217	.31	69
July 17	.....do	.....do	−3.20	567	1.39	792
July 31	.....do	.....do	1.63	483	.61	293
Aug. 15	.....do	.....do	2.99	640	.81	521
Aug. 29	.....do	.....do	4.50	860	2.83	[a] 2,437
Sept. 10	.....do	.....do	1.45	462	.37	176
Sept. 23	.....do	.....do	2.35	316	.64	204

INFIERNITO RIVER.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.						
Oct. 6	H. W. Durham	Price, No. 34	0.84	1,547	0.70	1,084
Nov. 6	.....do	.....do	3.68	1,283	1.91	2,449
Nov. 26	.....do	.....do	1.25	940	.80	753
1900.						
Jan. 23	H. S. Reed	Price, No. 63	.55	1,137	.60	683
Feb. 14	H. C. Hurd	Price, No. 34	− .10	556	.63	347
Mch. 15	.....do	.....do	− .60	674	.25	170
Apr. 24	.....do	.....do	−1.20	392	.20	80
May 31	H. G. Heisler	B. and B., No. 1	−1.03	929	.36	293
June 3	.....do	.....do	− .03	788	.67	528
June 26	.....do	.....do	− .40	781	.29	227
July 17	.....do	.....do	3.50	1,025	1.19	1,226
July 31	.....do	.....do	1.35	958	.66	637
Aug. 15	.....do	.....do	3.73	1,229	1.47	1,815
Aug. 29	.....do	.....do	3.80	1,440	1.17	1,689
Sept. 10	.....do	.....do	1.60	1,088	.80	873
Sept. 23	.....do	.....do	2.70	966	1.56	1,513

MACHUCA RIVER.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.						
Oct. 6	H. W. Durham	Price, No. 34		220	0.58	128
Nov. 6	.....do	.....do		316	.44	140
Nov. 26	.....do	.....do		253	.38	97
1900.						
Jan. 23	H. S. Reed	Price, No. 63		167	1.17	197
Feb. 14	H. C. Hurd	Price, No. 34		94	.54	51
Mar. 15	.....do	.....do		79	.63	50
Apr. 24	.....do	Price, No. 35		40	.66	27
May 21	H. G. Heisler	B. and B., No. 1		54	.52	28
June 3	.....do	.....do		109	.31	34
June 26	.....do	.....do		103	.47	48
July 17	.....do	.....po		314	.71	225
July 31	.....do	.....do		186	.52	97
Aug. 15	.....do	.....do		514	.66	339
Aug. 29	.....do	.....do		551	1.03	573
Sept. 10	.....do	.....do		255	.49	126
Sept. 23	.....do	.....do		176	.73	128
Dec. 14	E. W. F. Reed	Price, No. 65		511	.86	[b] 441

[a] Flood—falling rapidly from 5 feet to 4 feet while gauging one-half hour.
[b] Made 2 miles above mouth.

List of discharge measurements made on tributaries of San Juan River, etc.—Continued.

CRUCITA DEL NORTE RIVER.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.			*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Sec. feet.*
Oct. 7	H. W. Durham	Price, No. 34	....	200	0.13	27
1900.						
June 3	H. G. Heisler	B. and B., No. 1	....	....	([a])	....
Aug. 15	.....do	.....do	....	276	.21	59
Aug. 29	.....do	.....do	....	367	.29	108
Sept. 10	.....do	.....do	....	....	([a])	....
Dec. 14	E. W. F. Reed	Price, No. 65	....	....	([a])	....

LA CRUCITA DEL SUR RIVER.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1900.						
Aug. 15	H. G. Heisler	B. and B., No. 1	....	209	0.40	85
Aug. 29	.....do	.....do	....	307	.47	144
Dec. 14	E. W. F. Reed	Price, No. 65	....	310	.52	152

LA CRUZ DEL NORTE RIVER.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.						
Oct. 7	H. W. Durham	Price, No. 34	....	201	0.42	84
1900.						
Jan. 23	H. S. Reed	Price, No. 63	....	202	.16	32
Feb. 14	H. C. Hurd	Price, No. 34	....	124	.53	66
Mar. 15	.....do	.....do	....	73	.39	28
June 3	H. G. Heisler	B. and B., No. 1	....	188	.24	47
June 26	.....do	.....do	....	115	.24	29
July 17	.....do	.....do	....	335	.28	96
July 31	.....do	.....do	....	311	.35	111
Aug. 15	.....do	.....do	....	548	.50	293
Aug. 29	.....do	.....do	....	721	.38	280
Sept. 10	.....do	.....do	....	224	.37	86
Sept. 23	.....do	.....do	....	324	.29	97
Dec. 14	E. W. F. Reed	Price, No. 65	....	....	([b])	....

LA CRUZ DEL SUR RIVER.

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1899.						
Nov. 6	H. W. Durham	Price, No. 34	....	276	0.28	77
1900.						
Aug. 15	H. G. Heisler	B. and B., No. 1	....	....	([a])	....

EL JARDIN RIVER (NEAR CONCHUCA).

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1900.						
May 2	H. S. Reed	Price, No. 65	....	41	0.61	25
May 9	.....do	.....do	....	100	1.16	116
May 16	.....do	.....do	....	49	.85	42
May 22	.....do	.....do	....	59	1.39	83
May 30	.....do	.....do	....	105	.97	103
June 12	.....do	.....do	....	100	.52	53
June 23	.....do	.....do	....	86	.66	57
June 30	.....do	.....do	....	123	.62	76
July 11	.....do	.....do	....	157	.55	86
July 19	.....do	.....do	....	294	.39	115
July 25	.....do	.....do	....	222	.59	131
Aug. 9	.....do	.....do	....	309	1.50	463
Aug. 25	.....do	.....do	....	297	2.50	742
Aug. 31	.....do	.....do	....	278	.86	237
Sept. 7	.....do	.....do	....	178	.77	137
Sept. 20	.....do	.....do	....	241	.78	188
Oct. 1	.....do	.....do	....	399	.70	277
Oct. 9	.....do	.....do	....	346	.39	134
Oct. 13	.....do	.....do	....	287	.41	117
Oct. 30	.....do	.....do	....	297	.30	88
Nov. 27	E. W. F. Reed	.....do	....	248	.36	90
Dec. 13	.....do	.....do	....	469	.77	359
Dec. 31	.....do	.....do	....	192	.52	100

[a] No current. [b] Back water; no current.

FIG. 5.—MICA ISLAND, SAN JUAN RIVER.

List of discharge measurements made on tributaries of San Juan River, etc.—Continued

LA TIGRE RIVER (NEAR CONCHUCA).

Date.	Hydrographer.	Meter No.	Gauge height.	Area of section.	Mean velocity.	Discharge.
1900.			*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Sec. feet.*
May 2	H. S. Reed	Price, No. 65		39	0.44	17
May 9	do	do		34	1.22	41
May 16	do	do		50	.74	37
May 22	do	do		60	.37	22
May 30	do	do		115	.53	61
June 23	do	do		101	.32	33
June 30	do	do		143	.29	42
July 11	do	do		191	.22	43
July 19	do	do		239	.30	73
July 25	do	do		166	.42	70
Aug. 9	do	do		357	.70	249
Aug. 25	do	do		319	1.76	560
Aug. 31	do	do		226	.50	113
Sept. 7	do	do		177	.31	55
Sept. 20	do	do		259	.33	85
Oct. 1	do	do		269	.30	81
Oct. 9	do	do		232	.22	53
Oct. 13	do	do		182	.21	38
Oct. 30	do	do		183	.22	40
Nov. 27	E. W. F. Reed	do		142	.31	44
Dec. 13	do	do		334	.44	146
Dec. 31	do	do		131	.34	44

OCHOA STATION ON SAN JUAN RIVER.

A camp was continued at this point under charge of Mr. H. S. Reed, keeping rainfall and temperature records and rod readings on the river. Measurements of discharge were made from a boat, its position at each observation being determined by stadia from shore.

Records were also kept of gauge height, discharge, and rainfall at the station on San Carlos River.

From the time when the camp on the San Carlos was removed—August 31, 1898—to the present writing, daily trips were made to the San Carlos station, never omitting a day. Therefore, we have over three years' complete record of discharge for both the San Carlos near its mouth and the San Juan at Ochoa. By taking the difference between them we obtain the discharge of the San Juan above Boca San Carlos, and by deducting from this the discharge measured at Sabalos we obtain the discharge of the tributaries between Sabalos and Boca San Carlos. The comparative flow of the San Carlos and the San Juan at Ochoa and at Sabalos is shown in figure 8.

The bench mark at Ochoa is a standard United States Geological Survey copper tablet bench mark planted horizontally on top of a scarf cut into the inside larger root of a tree situated at the mouth of the first creek just above the camp, about 250 feet above the gauge. It is 28.10 above zero of rod and 74.33 feet above sea level.

The bench mark on San Carlos River is a large wrought-iron nail driven into the top of a scarf cut into the root on the river face of tree that acts as cable support. It is 31.67 above zero of rod and 81.13 feet above sea level.

At the Ochoa station two extra rods were placed in the river, one above and the other below the regular station, and were carefully connected by level lines, so that from synchroneous readings the slope of the surface of the river could be obtained. The indicated slope at each gauging taken is given in the table of discharge measurements on page 156.

The bench mark established for the upper-slope rod is one spike driven in center of a triangle of 40-penny nails midway of bottom of scarf made in root of large tree situated 86.4 feet south from gauge rod and is 22.42 above zero of that rod.

The bench mark established for the lower slope rod is one rod nail driven in advance of four 10-penny galvanized nails at point of scarf cut in root of large tree first on point of knoll bearing southwest 71 feet from rod and is 22.42 above zero of rod.

Upper rod is 2,273.4 feet above the regular rod at Ochoa and lower rod is 565.6 feet below, so that 2,839 feet is the total distance between rods.

For purposes of current meter measurements it was not permissible to extend a cable over the river at Ochoa on account of navigation. It was first intended to make measurements by means of a boat anchored to a small cable stretched across the river which should carry tags indicating distances from the initial point and which, when not in use, was to be held against the bottom of the river by means of sinkers. Experience on this line, however, soon demonstrated that it would be difficult, if not impracticable, to maintain a small cable in the position proposed on account of the large quantities of driftwood, leaves, and brush passing down the river, especially in times of flood, when the gauging apparatus would be most in demand. Another project was therefore inaugurated, which was the anchorage of a number of buoys at known distances from the initial point, said buoys to be constructed of "balsa," a very light, bulky, endogenous wood much used in the construction of rafts, etc. This method of marking distances from the initial point was successfully employed for several months during the season of low water, but as the rains increased and freshets began to come down the river the great quantity of leaves and brush carried by the water attached themselves to the buoys and their anchorages until they were either carried beneath the surface of the river or washed away entirely. The method permanently adopted required the employment of an additional instrument man to manipulate a telescope on shore and measure the distance of the boat during the process of gauging by means of a stadia rod.

The highest measurement of discharge yet made at this point was on November 17, 1898, at a gauge height of 17.43 feet, when the river was discharging 104,928 cubic feet per second. At this stage the river was about 8.5 feet below the flood plain at Ochoa, the formation of which indicates that it is sometimes overflowed.

Dr. C. W. Hayes, geologist, expresses the opinion that this flood plain is at intervals of ten to thirty years covered by the floods of San Juan River to a depth of more than 6 inches, but less than 3 feet. In other words, maximum gauge readings of 26.5 to 29 may be expected with moderate frequency at Ochoa station.

Plotting all observations of discharge, so far taken as abscissas, with corresponding gauge heights as ordinates, we obtain a curve indicating the relation of gauge height to discharge, showing that the ratio of discharge to increase of gauge height is not constant. The curve is concave downward, tending toward a horizontal position, showing that the increase of discharge for increase of gauge height is greater at high stages than at low stages, but above a medium stage of the river the line curves but slightly, and though the concavity is still downward the curve approaches a straight line, or, in other words, the ratio

FIG. 6.—SEDIMENT TRAP.

between gauge height and discharge approaches constancy. If we assume as constant the direction given to the line by the higher measurements, and continue it as a straight line, we obtain as the discharge corresponding to a gauge height of 28 feet about 200,000 cubic feet per second. If any curvature be given the extrapolated portion of the curve it will increase this amount.

If the same course of reasoning be applied to the flood-plain on the San Carlos River, we find that its maximum discharge must be about 100,000 cubic feet per second.

Similarly it may be shown by extrapolating the curve discharge of the San Juan River at Fort San Carlos that at the stage of 111 feet above sea level the lake must have discharged nearly 45,000 cubic feet per second.

When the measurement of November 17, 1898, that gave a discharge at Ochoa of 104,928 second-feet was made, the San Carlos River was discharging only 32,265, leaving 72,663 as the amount coming down the San Juan proper, of which probably not more than 28,663 were flowing from the lake, leaving 44,000 to be supplied by the small tributaries between the lake and Boca San Carlos. With such an indicated discharge it would not be excessive to assume a maximum for these tributaries of 55,000 cubic feet per second, and we have the maximum flood at Ochoa made up as follows:

	Second-feet.
Maximum, San Carlos River	100,000
Maximum discharge from lake	45,000
Maximum, small tributaries	55,000
Maximum at Ochoa	200,000

The highest observed discharge of the Sarapiqui is 62,000 cubic feet per second. It is probable that the extreme maximum is not less than 80,000 cubic feet per second. The Machado, San Francisco, Tamborcito, and San Juanillo, and a large number of lesser creeks contribute a large aggregate in time of flood, so that it is probable that at rare intervals the increment to the waters of the San Juan below Ochoa may amount to over 100,000 cubic feet per second. Such an occurrence coincident with extreme flood conditions above Ochoa would make a total of over 300,000 cubic feet per second discharging into the Caribbean through the various mouths of the San Juan.

FIG. 7.—Gauging San Juan River at Ochoa.

List of discharge measurements made on San Juan River at Ochoa by H. S. Reed with Price meter No. 65.

Date.	Gauge height.	Area of section.	Mean velocity.	Discharge.	Wetted perimeter.	Hydraulic radius.	Slope.	"N."
1899.	*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Sec. feet.*				
October 5	7.90	9,204	3.55	32,693	866	10.63	0.000187	0.029
October 6	7.31	8,713	3.41	29,731	865	10.07	.000190	.029
October 10	6.84	8,079	3.40	27,453	864	9.35	.000197	.028
October 28	7.21	8,554	3.46	29,633	865	9.89	.000206	.029
November 5	11.21	12,617	4.16	52,476	878	14.37	.000190	.030
November 6	13.38	15,301	4.63	70,870	886	17.27	.000192	.031
November 8	10.49	12,147	3.94	47,868	875	13.88	.000185	.031
November 15	14.31	16,678	4.50	74,882	896	18.63	.000160	.031
November 25	8.51	10,373	3.52	36,500	868	11.96	.000180	.031
December 1	10.97	12,964	3.86	50,057	875	14.82	.000183	.033
December 6	12.14	13,864	4.33	60,105	877	15.81	.000180	.030
December 12	9.24	11,006	3.64	40,020	863	12.74	.000178	.031
December 16	8.31	10,099	3.54	35,735	867	11.65	.000176	.030
1900.								
January 4	8.63	10,289	3.73	38,346	860	11.97	.000180	.029
January 6	11.28	12,742	4.10	52,194	876	14.55	.000173	.030
January 24	7.01	8,621	3.29	28,396	863	9.99	.000173	.029
January 27	7.17	8,721	3.42	29,824	863	10.11	.000180	.028
January 30	6.89	8,366	3.37	28,164	862	9.71	.000176	.028
February 15	5.81	7,219	3.15	22,746	862	8.37	.000183	.027
February 26	5.57	7,223	3.03	21,913	861	8.39	.000180	.028
March 9	5.16	6,926	2.98	20,647	857	8.08	.000182	.028
March 16	4.97	6,467	2.90	18,711	857	7.55	.000176	.027
March 30	4.63	6,317	2.86	18,085	855	7.39	.000166	.026
April 5	4.55	6,116	2.84	17,358	855	7.16	.000173	.026
April 12	4.36	5,930	2.77	16,551	853	6.95	.000173	.027
April 25	3.97	5,980	2.79	16,694	850	7.03	.000173	.027
April 28	4.02	5,622	2.77	15,550	851	6.61	.000169	.025
May 1	3.85	5,453	2.77	15,079	850	6.42	.000169	.025
May 5	3.48	5,048	2.69	13,560	847	5.96	.000176	.025
May 21	4.74	6,280	3.04	19,101	859	7.31	.000178	.025
May 28	8.60	10,000	3.59	35,880	860	11.64	.000173	.029
June 2	6.48	8,305	3.21	26,685	865	9.60	.000187	.030
June 11	6.07	7,872	3.16	24,843	863	9.12	.000187	.029
June 18	8.96	10,503	3.66	38,405	862	12.18	.000176	.030
June 21	6.40	7,994	3.16	25,272	864	9.24	.000183	.029
June 28	5.59	7,316	3.10	22,702	863	8.48	.000187	.028
July 2	6.79	8,629	3.41	29,407	867	9.96	.000187	.029
July 12	8.20	9,497	3.66	34,758	867	10.95	.000182	.028
July 14	9.47	10,473	3.90	40,800	865	12.11	.000173	.027
July 16	10.92	11,804	4.28	50,513	874	13.51	.000189	.028
August 4	12.47	13,923	4.38	61,026	879	15.84	.000190	.031
August 7	11.64	13,223	4.09	54,128	877	15.08	.000173	.030
August 12	10.97	12,142	4.11	49,880	875	13.87	.000190	.030
August 30	11.36	12,698	4.22	53,523	876	14.50	.000180	.029
September 4	8.60	10,169	3.55	36,064	860	11.82	.000183	.031
September 18	10.08	11,582	3.78	43,791	869	13.33	.000178	.031
September 21	9.00	10,475	3.60	37,709	862	12.15	.000185	.031
September 29	12.05	13,287	4.29	57,035	878	15.13	.000180	.030
September 30	14.83	16,501	4.69	77,429	897	18.40	.000169	.030
October 3	14.08	15,395	4.72	72,721	893	17.24	.000167	.028
October 10	13.05	14,333	4.35	62,427	884	16.21	.000183	.031
October 22	16.16	17,952	4.89	87,696	....	....	....	....
October 23	13.56	14,884	4.31	64,212	....	....	....	....
November 6	11.30	12,592	3.99	50,329	876	14.37	.000197	.033
November 24	10.23	11,926	3.69	41,038	870	13.71	.000185	.033
November 30	12.43	13,610	4.17	56,696	880	15.47	.000190	.032
December 9	19.56	20,141	5.02	101,135	....	....	....	....
December 10	16.12	17,140	4.49	77,042	....	....	....	....
December 12	14.90	15,723	4.48	70,442	880	17.87	.000164	.030
December 21	9.95	11,211	3.73	41,869	874	12.83	.000176	.031

FIG. 7.—GAGING SAN JUAN RIVER AT OCHOA.

Rating table for San Juan River at Ochoa.

[This table is applicable from April 1, 1899, to December 1, 1900.]

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	*Sec.feet.*	*Feet.*	*Sec.feet.*	*Feet.*	*Sec.feet.*	*Feet.*	*Sec.feet.*	*Feet.*	*Sec.feet.*
3.0	12,000	6.0	23,550	9.0	38,300	12.0	55,200	15.0	77,100
3.1	12,200	6.1	24,000	9.1	38,800	12.1	55,800	15.1	78,000
3.2	12,400	6.2	24,450	9.2	39,300	12.2	56,400	15.2	78,900
3.3	12,700	6.3	24,900	9.3	39,800	12.3	57,000	15.3	79,800
3.4	13,000	6.4	25,350	9.4	40,300	12.4	57,600	15.4	80,700
3.5	13,350	6.5	25,800	9.5	40,800	12.5	58,200	15.5	81,600
3.6	13,700	6.6	26,300	9.6	41,300	12.6	58,800	15.6	82,500
3.7	14,050	6.7	26,800	9.7	41,800	12.7	59,500	15.7	83,400
3.8	14,400	6.8	27,300	9.8	42,300	12.8	60,200	15.8	84,300
3.9	14,750	6.9	27,800	9.9	42,800	12.9	60,900	15.9	85,300
4.0	15,100	7.0	28,300	10.0	43,350	13.0	61,600	16.0	86,300
4.1	15,500	7.1	28,800	10.1	43,900	13.1	62,300	16.1	87,300
4.2	15,900	7.2	29,300	10.2	44,450	13.2	63,000	16.2	88,300
4.3	16,300	7.3	29,800	10.3	45,000	13.3	63,700	16.3	89,300
4.4	16,700	7.4	30,300	10.4	45,600	13.4	64,400	16.4	90,300
4.5	17,100	7.5	30,800	10.5	46,200	13.5	65,100	16.5	91,300
4.6	17,500	7.6	31,300	10.6	46,800	13.6	65,800	16.6	92,300
4.7	17,900	7.7	31,800	10.7	47,400	13.7	66,500	16.7	93,300
4.8	18,300	7.8	32,300	10.8	48,000	13.8	67,200	16.8	94,300
4.9	18,700	7.9	32,800	10.9	48,600	13.9	67,900	16.9	95,300
5.0	19,100	8.0	33,300	11.0	49,200	14.0	68,600	17.0	96,300
5.1	19,500	8.1	33,800	11.1	49,800	14.1	69,400	17.1	97,300
5.2	19,950	8.2	34,300	11.2	50,400	14.2	70,200	17.2	98,300
5.3	20,400	8.3	34,800	11.3	51,000	14.3	71,000	17.3	99,300
5.4	20,850	8.4	35,300	11.4	51,600	14.4	71,800	17.4	100,400
5.5	21,300	8.5	35,800	11.5	52,200	14.5	72,600	17.5	101,500
5.6	21,750	8.6	36,300	11.6	52,800	14.6	73,500	17.6	102,600
5.7	22,200	8.7	36,800	11.7	53,400	14.7	74,400	17.7	103,700
5.8	22,650	8.8	37,300	11.8	54,000	14.8	75,300	17.8	104,800
5.9	23,100	8.9	37,800	11.9	54,600	14.9	76,200	17.9	105,900

[This table is applicable only after December 1, 1900.]

7.0	28,300	9.8	42,300	12.6	57,650	15.4	73,600	18.2	91,900
7.1	28,800	9.9	42,800	12.7	58,200	15.5	74,250	18.3	92,600
7.2	29,300	10.0	43,350	12.8	58,750	15.6	74,900	18.4	93,300
7.3	29,800	10.1	43,900	12.9	59,300	15.7	75,550	18.5	94,000
7.4	30,300	10.2	44,450	13.0	59,850	15.8	76,200	18.6	94,700
7.5	30,800	10.3	45,000	13.1	60,400	15.9	76,850	18.7	95,400
7.6	31,300	10.4	45,550	13.2	60,950	16.0	77,500	18.8	96,100
7.7	31,800	10.5	46,100	13.3	61,500	16.1	78,150	18.9	96,800
7.8	32,300	10.6	46,650	13.4	62,050	16.2	78,800	19.0	97,500
7.9	32,800	10.7	47,200	13.5	62,600	16.3	79,450	19.1	98,200
8.0	33,300	10.8	47,750	13.6	63,150	16.4	80,100	19.2	98,900
8.1	33,800	10.9	48,300	13.7	63,700	16.5	80,750	19.3	99,600
8.2	34,300	11.0	48,850	13.8	64,250	16.6	81,400	19.4	100,300
8.3	34,800	11.1	49,400	13.9	64,800	16.7	82,050	19.5	101,000
8.4	35,300	11.2	49,950	14.0	65,350	16.8	82,700	19.6	101,700
8.5	35,800	11.3	50,500	14.1	65,900	16.9	83,350	19.7	102,400
8.6	36,300	11.4	51,050	14.2	66,450	17.0	84,000	19.8	103,100
8.7	36,800	11.5	51,600	14.3	67,000	17.1	84,650	19.9	103,800
8.8	37,300	11.6	52,150	14.4	67,550	17.2	85,300	20.0	104,500
8.9	37,800	11.7	52,700	14.5	68,100	17.3	85,950	20.1	105,250
9.0	38,300	11.8	53,250	14.6	68,650	17.4	86,600	20.2	106,000
9.1	38,800	11.9	53,800	14.7	69,200	17.5	87,250	20.3	106,750
9.2	39,300	12.0	54,350	14.8	69,800	17.6	87,900	20.4	107,500
9.3	39,800	12.1	54,900	14.9	70,400	17.7	88,550	20.5	108,250
9.4	40,300	12.2	55,450	15.0	71,000	17.8	89,200	20.6	109,000
9.5	40,800	12.3	56,000	15.1	71,650	17.9	89,850	20.7	109,750
9.6	41,300	12.4	56,550	15.2	72,300	18.0	90,500	20.8	110,500
9.7	41,800	12.5	57,100	15.3	72,950	18.1	91,200	20.9	111,250

Daily gauge height of San Juan River at Ochoa for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	8.60	7.60	7.22	5.85	4.80	5.45	6.95	9.12	8.00	8.30	7.01	11.29
2....	9.32	7.58	7.12	5.82	4.80	5.18	7.25	8.75	7.82	8.30	6.90	9.80
3....	9.85	7.47	7.02	5.75	4.80	5.02	7.80	8.48	7.67	7.85	6.92	9.41
4....	9.30	7.38	6.92	5.75	4.82	4.85	7.45	10.52	7.65	7.85	7.22	8.99
5....	9.55	7.30	6.88	5.55	4.88	4.75	7.30	10.02	7.30	7.45	11.26	9.58
6....	9.28	7.30	6.78	5.90	4.82	4.70	7.40	9.12	7.17	7.42	11.95	11.93
7....	8.92	7.50	6.78	5.95	5.15	5.10	7.28	8.65	7.05	7.35	12.05	13.37
8....	9.07	7.45	7.28	6.05	4.88	6.85	7.30	9.42	7.25	7.14	10.61	12.29
9....	8.92	7.30	7.40	6.48	4.70	6.92	9.15	10.12	7.10	6.89	11.35	11.48
10....	9.07	7.25	6.98	6.35	4.58	8.45	12.60	9.05	7.15	6.86	11.50	10.43
11....	8.97	7.25	6.75	6.90	4.50	7.42	15.25	8.22	7.52	6.81	11.76	9.69
12....	9.85	7.45	6.65	6.70	4.52	7.28	12.45	7.72	8.00	7.36	13.87	9.26
13....	10.37	8.38	6.60	6.30	4.58	7.02	11.65	7.78	7.57	7.58	13.41	9.02
14....	9.90	8.98	6.55	6.10	4.60	6.32	14.85	7.85	7.37	8.54	12.93	8.49
15....	9.97	8.15	6.52	5.88	4.50	6.40	12.68	7.90	7.17	9.14	14.30	8.56
16....	10.55	7.98	6.48	5.70	4.42	6.20	10.85	7.90	7.35	8.23	12.95	8.33
17....	9.95	7.90	6.35	5.58	4.42	6.15	9.85	8.25	7.60	8.12	11.90	8.61
18....	9.42	8.25	6.30	5.48	4.45	6.22	9.00	8.82	8.10	8.07	11.28	10.21
19....	9.17	8.20	6.28	5.48	4.62	6.25	9.10	9.58	8.20	7.57	10.65	10.37
20....	9.02	8.00	6.25	5.42	5.15	6.92	8.52	8.05	8.60	7.30	10.19	9.92
21....	8.75	8.22	6.22	5.32	4.80	6.75	9.62	8.65	9.87	7.21	9.80	9.93
22....	8.52	7.80	6.12	5.25	4.78	6.25	10.80	9.20	13.57	7.76	9.39	9.60
23....	8.45	8.10	6.02	5.15	5.10	6.00	8.55	8.88	14.05	9.04	9.02	9.06
24....	8.35	7.90	6.00	5.05	5.28	5.98	8.35	9.98	11.00	8.80	8.75	9.26
25....	8.35	7.70	5.98	5.00	5.55	6.02	9.35	10.42	9.47	8.03	8.50	9.22
26....	8.15	7.42	5.90	4.95	6.35	5.78	10.35	10.30	8.97	7.50	8.34	9.37
27....	8.02	7.50	5.82	4.95	6.60	5.82	11.32	10.05	8.82	7.24	8.55	9.44
28....	7.97	7.40	5.80	4.95	6.08	6.68	10.38	9.00	9.20	7.19	9.44	9.41
29....	7.82	....	5.80	4.92	6.42	6.92	9.52	8.42	8.85	7.26	9.08	9.20
30....	7.72	....	5.78	4.85	6.50	6.68	8.55	8.20	8.42	7.19	9.07	9.04
31....	7.65	....	5.70	....	5.90	....	9.30	8.05	....	7.17	....	9.83

Daily gauge height of San Juan River at Ochoa for 1900.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	9.48	6.61	5.67	4.55	3.83	7.60	7.13	8.58	10.00	12.95	10.91	12.97
2....	8.99	6.56	5.58	4.73	3.89	7.51	6.85	8.68	9.63	14.43	10.87	11.86
3....	8.54	6.59	5.55	5.15	3.77	6.72	6.77	9.61	9.03	13.79	11.14	11.06
4....	8.54	6.58	5.52	4.72	3.64	6.76	7.85	12.15	8.63	12.79	11.67	11.09
5....	11.68	6.41	5.64	4.53	3.47	7.06	7.37	14.93	8.39	12.38	11.63	11.23
6....	11.60	6.33	5.66	4.40	3.57	6.83	7.18	12.54	8.13	11.97	11.30	11.69
7....	10.27	6.20	5.37	4.37	4.04	6.35	7.43	11.73	8.38	12.21	10.84	13.82
8....	9.62	6.14	5.25	4.35	3.89	7.04	9.51	10.87	8.59	12.62	11.07	20.28
9....	9.13	6.15	5.18	4.33	3.83	6.76	8.91	10.52	8.58	11.87	13.99	19.15
10....	8.60	6.17	5.21	4.30	3.76	6.27	9.00	11.83	8.28	12.60	14.51	16.52
11....	8.32	6.02	5.17	4.30	4.44	6.09	8.83	11.67	8.55	11.84	14.41	14.74
12....	8.08	5.93	5.13	4.60	4.09	6.33	8.29	11.50	8.31	10.97	13.31	14.97
13....	8.00	5.90	5.15	4.92	4.11	6.45	9.79	10.91	8.19	10.55	12.25	13.79
14....	7.88	5.84	5.05	4.58	4.42	6.08	9.55	10.75	8.45	10.29	12.94	12.59
15....	7.70	5.81	5.01	4.35	4.36	5.70	8.56	11.02	8.35	10.20	12.88	11.76
16....	7.57	5.83	4.99	4.18	4.35	6.84	10.53	9.50	8.53	10.02	11.97	11.15
17....	7.38	5.83	4.92	4.17	4.10	8.22	11.65	9.36	9.45	9.93	11.33	10.83
18....	7.26	5.83	4.92	4.18	3.90	9.22	10.64	9.60	9.95	10.04	10.82	10.52
19....	7.12	5.75	4.82	4.31	3.80	7.52	11.66	10.16	9.97	10.36	10.54	10.69
20....	7.05	7.04	4.79	4.45	3.84	6.89	10.56	9.07	9.56	11.05	10.40	10.31
21....	6.95	7.20	4.81	4.34	4.61	6.51	9.79	9.13	9.05	13.95	10.34	10.00
22....	6.98	6.36	5.07	4.23	4.91	6.05	9.85	9.51	9.03	15.88	10.53	9.69
23....	7.04	6.04	5.19	4.10	4.45	5.96	10.63	9.24	9.79	13.76	10.80	9.50
24....	7.02	5.81	5.35	4.02	4.54	5.72	10.10	9.43	9.62	12.63	10.18	9.26
25....	6.91	5.76	5.24	3.96	4.73	5.66	9.13	10.34	9.83	12.75	9.85	9.12
26....	6.77	5.60	5.05	4.09	6.79	5.57	8.59	10.21	11.18	12.08	9.70	8.96
27....	7.12	5.85	4.90	4.07	8.19	5.40	8.57	10.78	11.37	11.86	9.60	8.83
28....	7.32	5.95	4.81	4.03	8.55	5.50	8.71	10.82	10.76	11.47	9.78	8.69
29....	7.68	....	4.69	4.05	7.18	6.17	8.65	11.95	11.95	11.09	10.52	8.61
30....	6.90	....	4.62	3.88	6.55	6.92	8.44	11.30	14.60	10.79	11.63	8.50
31....	6.70	....	4.53	....	7.29	....	8.64	10.45	....	10.89	....	8.40

Estimated monthly discharge of San Juan River at Ochoa.

	Discharge.			Total.
	Maximum.	Minimum.	Mean.	
1898.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*
January	75,200	32,240	15,250	2,782,000
February	58,530	26,080	35,400	1,966,000
March	30,650	20,140	23,800	1,463,400
April	40,380	17,290	21,150	1,258,510
May	34,880	16,300	19,640	1,207,600
June	60,180	18,890	33,140	1,971,970
July	78,050	35,540	46,810	2,878,200
August	54,100	32,020	37,230	2,289,200
September	54,100	30,920	39,530	2,352,200
October	67,625	34,600	42,200	2,594,800
November	107,000	37,080	51,890	3,087,670
December	65,000	32,790	40,850	2,511,770
The year	107,000	16,300	36,408	26,363,620
1899.				
January	49,100	32,000	39,665	2,438,900
February	41,120	29,840	32,540	1,807,180
March	31,300	23,900	26,940	1,656,480
April	28,831	18,500	21,987	1,308,222
May	27,291	16,780	19,533	1,201,079
June	36,399	17,900	24,624	1,465,351
July	80,626	28,050	42,783	2,630,645
August	58,624	31,900	37,931	2,332,348
September	77,321	29,050	35,963	2,139,978
October	39,000	27,350	31,769	1,953,350
November	74,882	27,800	46,133	2,746,154
December	64,190	34,950	42,763	2,629,458
The year	80,626	16,780	33,553	24,309,145
1900.				
January	53,280	27,150	33,968	2,089,746
February	29,300	21,750	24,235	1,345,993
March	22,065	17,220	19,664	1,209,122
April	19,725	14,680	16,469	979,978
May	36,050	13,245	18,413	1,132,212
June	39,400	20,850	26,386	1,570,119
July	53,100	29,200	38,494	2,366,930
August	76,470	36,050	47,131	2,898,042
September	77,429	33,950	41,039	2,442,026
October	87,696	42,965	55,259	3,298,815
November	72,680	41,300	51,838	3,084,600
December	106,600	35,300	52,889	3,252,047
The year	106,600	13,245	35,484	25,669,630

Daily gauge height of San Carlos River at station 3 miles above mouth, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	11.90	11.85	12.40	11.15	10.80	12.35	113.30	5.25	13.15	13.10	12.50	17.40
2	12.75	11.85	12.20	11.45	10.80	12.10	13.30	14.70	13.05	13.35	12.35	15.50
3	14.35	11.80	12.15	11.45	10.75	11.90	13.50	14.35	13.00	13.05	12.40	15.25
4	12.80	11.70	12.05	11.40	10.80	11.65	13.50	17.90	13.00	13.10	12.55	14.75
5	12.60	11.65	12.00	10.20	10.80	11.55	13.80	15.60	12.85	13.15	17.95	15.90
6	12.40	11.60	11.85	12.05	10.85	11.50	14.70	15.30	12.70	12.80	19.10	19.15
7	12.15	12.05	11.85	11.75	11.55	11.90	14.70	14.85	12.60	12.90	16.75	19.40
8	12.55	12.00	12.70	11.60	11.20	12.20	14.20	14.65	12.80	12.60	15.50	18.70
9	12.50	11.70	12.80	12.75	10.90	12.80	15.10	15.70	12.45	12.40	17.15	17.30
10	12.35	11.70	12.20	12.20	10.90	13.95	19.00	14.75	12.65	12.40	16.70	16.10
11	12.20	11.70	11.95	12.60	10.80	13.50	22.95	14.10	13.10	12.40	18.20	15.30
12	12.35	11.70	11.80	12.50	10.80	13.45	17.50	13.70	14.05	12.55	19.45	14.90
13	13.00	12.70	11.75	12.00	11.05	12.95	18.80	13.50	13.50	13.15	18.25	14.65
14	13.25	14.70	11.80	12.00	11.20	12.75	20.60	14.30	13.35	13.60	17.95	14.30
15	12.90	13.45	11.70	11.80	10.90	12.90	17.50	14.20	13.00	13.65	18.95	14.05
16	15.00	13.25	11.65	11.65	10.85	12.75	16.80	14.30	13.00	13.10	17.60	13.95
17	13.60	12.70	11.55	11.50	10.80	12.90	15.60	14.05	13.30	13.45	16.90	13.90
18	13.25	12.85	11.50	11.40	10.70	12.80	14.90	13.90	13.00	13.40	16.25	16.20
19	13.20	12.95	11.50	11.30	10.80	12.70	15.50	13.70	13.00	13.15	15.75	15.00
20	13.20	12.85	11.40	11.30	11.20	13.90	14.40	13.50	12.75	12.85	15.45	14.70
21	12.85	13.30	11.40	11.20	11.35	13.25	15.60	14.25	12.85	12.70	15.05	14.50
22	12.65	12.85	11.30	11.15	11.35	12.70	14.90	14.75	14.15	13.30	14.65	14.95
23	12.55	13.70	11.25	11.10	12.20	12.75	14.35	13.65	14.50	13.40	14.30	14.45
24	12.50	13.20	11.20	11.05	12.60	12.55	14.55	13.80	14.25	13.30	14.35	15.30
25	12.60	12.90	11.15	11.00	12.00	13.00	14.30	13.70	13.20	13.05	14.00	15.20
26	12.35	12.55	11.10	10.95	12.65	12.50	14.35	13.90	13.05	12.70	13.75	15.80
27	12.20	12.80	11.10	10.90	13.80	12.35	16.90	14.00	12.85	12.50	13.50	15.68
28	12.50	12.60	11.05	10.90	13.00	14.00	16.40	13.65	13.75	12.50	16.25	15.45
29	12.05	....	11.10	10.95	13.30	13.70	15.45	13.30	13.85	12.60	15.30	15.03
30	12.00	....	11.10	10.90	13.60	13.55	14.65	13.15	13.20	12.65	15.55	15.09
31	11.90	....	11.05	....	12.95	....	16.40	13.20	....	12.70	....	16.57

Daily gauge height of San Carlos River at station 3 miles above mouth, for 1900.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	16.09	12.57	11.98	11.18	10.97	14.12	14.17	14.56	15.26	17.70	15.70	18.42
2....	15.16	12.65	11.92	11.92	10.92	14.12	13.70	14.17	14.75	19.20	15.39	16.44
3....	14.63	12.47	11.78	12.53	10.84	14.23	13.62	14.[illegible]3	14.30	17.35	15.55	15.50
4....	14.91	12.37	11.82	11.60	10.84	14.27	13.91	15.97	13.98	16.76	16.31	15.11
5....	20.00	12.23	12.07	11.18	10.74	14.39	13.90	16.13	13.72	16.50	16.35	15.19
6....	18.26	12.15	12.15	11.34	10.73	14.11	14.19	15.25	13.50	16.83	16.14	14.90
7....	16.80	12.08	11.76	11.21	11.15	13.64	14.11	15.50	13.73	17.83	15.48	17.77
8....	16.06	12.00	11.62	11.19	11.36	14.80	15.45	14.73	14.24	17.75	16.40	27.70
9....	15.30	11.94	11.55	11.16	11.17	13.76	14.40	14.65	13.93	16.32	21.58	22.48
10....	14.76	12.00	11.61	11.18	11.16	13.16	14.62	15.63	13.79	18.95	19.77	20.53
11....	14.40	11.90	11.48	11.19	10.97	13.41	14.93	15.20	14.03	16.60	19.25	17.93
12....	14.12	11.79	11.54	12.23	11.20	13.41	14.61	15.67	13.62	15.82	18.23	17.69
13....	14.06	11.72	11.65	12.21	11.24	13.39	15.71	15.41	13.38	15.66	17.50	16.77
14....	13.84	11.70	11.41	11.73	11.85	13.12	15.00	14.57	13.65	15.00	18.60	15.98
15 ...	13.58	11.60	11.36	11.42	11.54	12.87	14.29	14.60	13.97	14.87	18.48	15.68
16....	13.43	11.62	11.29	11.26	11.65	13.63	14.35	14.11	13.75	14.65	16.96	15.25
17....	13.22	11.72	11.25	11.40	11.35	15.28	17.80	13.91	15.00	14.57	16.19	14.90
18....	13.09	11.70	11.22	11.48	11.23	13.97	16.53	13.90	15.58	15.07	15.57	14.68
19....	12.94	11.90	11.20	11.89	11.22	13.35	17.85	13.95	15.04	15.38	15.25	14.52
20....	12.86	14.00	11.15	11.92	11.44	13.41	16.27	13.59	14.62	17.03	15.04	14.38
21....	12.78	13.70	11.10	11.69	12.78	13.22	15.73	13.69	14.16	16.75	14.95	14.20
22....	12.70	12.60	11.21	11.46	12.58	12.92	15.29	13.95	14.10	18.23	15.20	14.02
23....	12.70	12.21	12.10	11.34	11.98	12.96	16.54	14.27	14.79	16.70	15.97	13.90
24....	12.80	12.00	12.15	11.25	12.24	12.65	15.44	14.43	14.48	16.44	14.75	13.70
25....	12.72	11.85	12.03	11.12	12.78	12.65	14.70	14.62	15.59	16.85	14.49	13.58
26....	12.54	11.75	11.71	11.24	14.73	12.70	14.23	14.27	17.07	16.23	14.28	13.46
27....	13.43	12.30	11.50	11.05	16.30	12.45	14.05	14.25	17.76	16.98	14.30	13.32
28....	13.63	12.52	11.36	11.16	14.90	13.82	14.57	14.81	16.46	15.87	14.68	13.23
29....	13.20	....	11.29	11.12	13.78	13.54	15.00	16.77	17.04	15.16	15.82	13.05
30....	13.00	....	11.20	11.00	13.18	14.10	14.20	16.85	20.72	14.95	17.95	13.02
31....	12.70	....	11.19	....	14.34	....	14.25	15.80	....	15.56	....	12.95

Rating table for San Carlos River at station 3 miles above mouth.

[This table is applicable only from April 1, 1899, to September 14, 1900.]

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
10.7	2,800	13.1	8,160	15.5	15,200	17.9	24,360	20.3	36,160
10.8	2,960	13.2	8,420	15.6	15,520	18.0	24,800	20.4	36,680
10.9	3,120	13.3	8,700	15.7	15,840	18.1	25,240	20.5	37,200
11.0	3,320	13.4	8,980	15.8	16,200	18.2	25,680	20.6	37,720
11.1	3,520	13.5	9,260	15.9	16,560	18.3	26,160	20.7	38,240
11.2	3,720	13.6	9,540	16.0	16,920	18.4	26,640	20.8	38,760
11.3	3,920	13.7	9,820	16.1	17,280	18.5	27,120	20.9	39,280
11.4	4,140	13.8	10,100	16.2	17,640	18.6	27,600	21.0	39,800
11.5	4,360	13.9	10,380	16.3	18,000	18.7	28,080	21.1	40,320
11.6	4,580	14.0	10,660	16.4	18,360	18.8	28,560	21.2	40,840
11.7	4,800	14.1	10,940	16.5	18,720	18.9	29,040	21.3	41,360
11.8	5,020	14.2	11,220	16.6	19,120	19.0	29,520	21.4	41,880
11.9	5,240	14.3	11,500	16.7	19,520	19.1	30,000	21.5	42,400
12.0	5,480	14.4	11,800	16.8	19,920	19.2	30,480	21.6	42,920
12.1	5,720	14.5	12,100	16.9	20,320	19.3	30,960	21.7	43,440
12.2	5,960	14.6	12,400	17.0	20,720	19.4	31,480	21.8	43,960
12.3	6,200	14.7	12,700	17.1	21,120	19.5	32,000	21.9	44,480
12.4	6,440	14.8	13,000	17.2	21,520	19.6	32,520	22.0	45,000
12.5	6,680	14.9	13,300	17.3	21,920	19.7	33,040	22.1	45,540
12.6	6,920	15.0	13,600	17.4	22,320	19.8	33,560	22.2	46,080
12.7	7,160	15.1	13,920	17.5	22,720	19.9	34,080	22.3	46,620
12.8	7,400	15.2	14,240	17.6	23,120	20.0	34,660	22.4	47,160
12.9	7,640	15.3	14,560	17.7	23,520	20.1	35,120	22.5	47,700
13.0	7,900	15.4	14,880	17.8	23,920	20.2	35,640	22.6	48,240

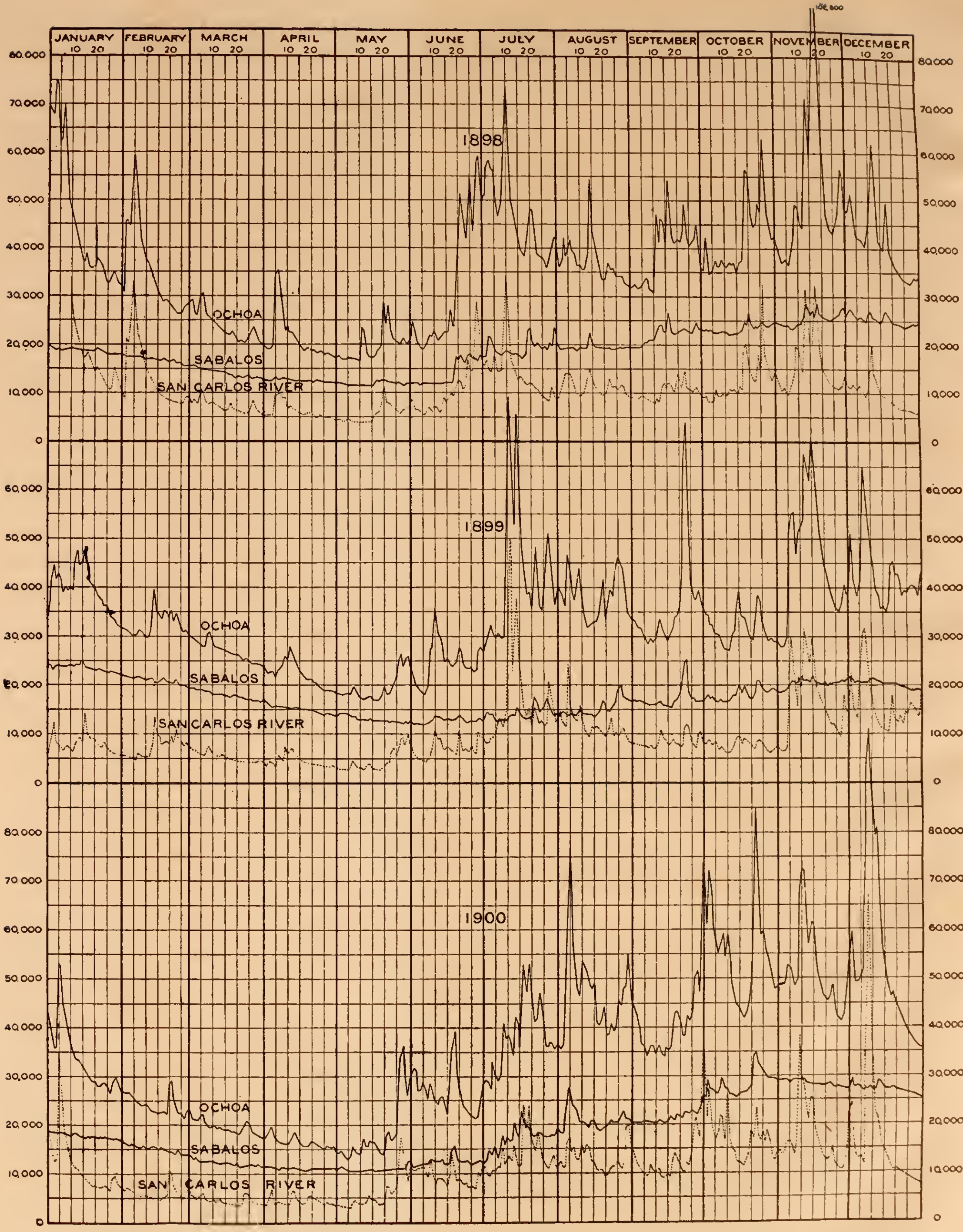

FIG. 8.—FLUCTUATIONS OF SAN JUAN RIVER AT SABALOS AND OCHOA AND OF THE SAN CARLOS NEAR ITS MOUTH.

Rating table for San Carlos River at station 3 miles above mouth—Continued.

[This table is applicable only from September 14, 1900, to December 31, 1900.]

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
12.7	....	14.8	11,920	16.9	18,520	19.0	26,960	21.1	36,460
12.8	....	14.9	12,200	17.0	18,880	19.1	27,400	21.2	36,920
12.9	7,200	15.0	12,480	17.1	19,240	19.2	27,840	21.3	37,380
13.0	7,440	15.1	12,760	17.2	19,600	19.3	28,280	21.4	37,840
13.1	7,680	15.2	13,040	17.3	19,960	19.4	28,720	21.5	38,300
13.2	7,920	15.3	13,320	17.4	20,320	19.5	29,160	21.6	38,760
13.3	8,160	15.4	13,600	17.5	20,680	19.6	29,600	21.7	39,220
13.4	8,400	15.5	13,920	17.6	21,040	19.7	30,040	21.8	39,680
13.5	8,640	15.6	14,240	17.7	21,440	19.8	30,480	21.9	40,140
13.6	8,880	15.7	14,560	17.8	21,840	19.9	30,940	22.0	40,600
13.7	9,120	15.8	14,880	17.9	22,240	20.0	31,400	22.1	41,060
13.8	9,360	15.9	15,200	18.0	22,640	20.1	31,860	22.2	41,520
13.9	9,600	16.0	15,520	18.1	23,040	20.2	32,320	22.3	41,980
14.0	9,840	16.1	15,840	18.2	23,440	20.3	32,780	22.4	42,440
14.1	10,080	16.2	16,160	18.3	23,880	20.4	33,240	22.5	42,900
14.2	10,320	16.3	16,480	18.4	24,320	20.5	33,700	22.6	43,360
14.3	10,560	16.4	16,800	18.5	24,760	20.6	34.160	22.7	43,820
14.4	10,800	16.5	17,120	18.6	25,200	20.7	34,620	22.8	44,280
14.5	11,080	16.6	17,440	18.7	25,640	20.8	35,080	22.9	44,740
14.6	11,360	16.7	17,800	18.8	26,080	20.9	35,540	23.0	45,200
14.7	11,640	16.8	18,160	18.9	26,520	21.0	36,000		

Estimated monthly discharge of San Carlos River 3 miles above its mouth.

[Drainage area 1,450 square miles, approximately.]

Month.	Discharge.			Total.	Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.	
1898.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*	*Sec. feet.*	*Inches.*	*Inches.*
January 10-31	28,000	10,560	16,055	700,582	11.10	9.09	....
February	34,300	7,400	13,530	751,380	9.30	9.68	....
March	11,341	5,140	7,030	432,260	4.80	5.53	7.52
April	10,080	4,220	6,038	359,285	4.20	4.69	11.66
May	11,880	4,100	5,560	341,870	3.80	4.38	20.12
June	32,250	5,200	10,720	637,880	7.40	8.26	20.79
July	41,600	8,400	14,094	866,605	9.70	11.18	18.26
August	15,730	8,800	10,990	675,750	7.60	8.76	11.68
September	14,200	7,420	10,319	614,023	7.10	7.92	....
October	32,500	8,180	12,880	791,960	8.90	10.26	....
November	32,260	9,680	15,440	918,750	10.60	11.88	....
December	19,920	5,850	9,290	571,220	6.40	7.38	....
The year	41,600	4,100	10,996	7,661,565	....	....	....
1899.							
January	14,200	5,720	7,865	483,600	5.42	6.25	....
February	17,340	4,940	7,360	408,750	5.08	5.29	....
March	8,060	4,300	5,400	332,030	3.72	4.29	....
April	7,280	3,120	4,410	262,457	3.04	3.39	....
May	10,100	2,800	4,559	280,308	3.14	3.62	....
June	12,314	4,360	7,381	439,206	5.09	5.68	....
July	50,130	8,700	16,909	1,039,701	11.66	13.44	....
August	24,360	8,290	11,678	718,067	8.05	9.28	....
September	12,100	6,560	8,467	500,829	5.84	6.52	....
October	9,757	6,440	7,808	480,701	5.38	6.20	[a] 6.03
November	34,737	6,320	17,106	1,027,893	11.79	13.15	20.32
December	31,480	10,380	16,057	991,347	11.07	12.76	16.03
The year	50,130	2,800	9,583	6,967,889	....	....	....
1900.							
January	35,457	6,776	11,670	717,543	8.05	9.28	8.79
February	10,783	4,580	5,946	330,249	4.10	4.27	4.96
March	5,840	3,520	4,525	278,257	3.05	3.52	6.56
April	6,752	3,320	4,316	256,835	2.98	3.32	3.00
May	18,000	2,848	5,844	369,353	4.03	4.65	15.42
June	14,496	6,560	9,530	567,079	6.57	7.33	11.26
July	26,074	9,596	13,665	840,358	9.42	10.86	15.53
August	20,120	9,512	13,187	817,815	9.10	10.49	22.72
September	34,608	8,924	12,936	769,784	8.92	9.95	21.36
October	27,840	11,276	17,202	1,057,745	11.86	13.67	6.45
November	38,432	10,524	17,380	1,034,237	11.98	13.36	16.56
December	66,820	7,320	16,256	999,545	11.21	13.02	24.69
The year	66,820	2,848	11,038	8,038,800	....	....	....

[a] From Oct. 12 to 31.

Estimated monthly discharge of San Juan River above the mouth of the San Carlos.

[This is obtained by subtracting the discharge of the San Carlos from that of the San Juan at Ochoa.]

Month.	Discharge.			Total.
	Maximum.	Minimum.	Mean.	
1898.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*
January, 10-31	23,270	19,500	21,030	917,650
February	34,900	18,500	22,080	1,226,260
March	22,000	14,600	16,850	1,036,070
April	25,800	12,900	15,120	899,700
May	19,200	11,700	14,130	868,820
June	39,200	13,000	22,410	1,333,500
July	43,100	26,200	32,720	2,011,870
August	38,400	23,000	26,170	1,609,130
September	41,300	22,800	29,210	1,738,120
October	37,600	24,700	29,320	1,802,820
November	70,500	26,800	36,460	2,169,520
December	41,800	26,300	31,570	1,941,160
The year	70,500	11,700	24,756	17,554,620
1899.				
January	38,900	26,300	31,800	1,955,300
February	28,200	23,100	25,180	1,398,430
March	23,100	19,600	21,540	1,324,450
April	20,880	15,388	17,575	1,045,777
May	16,740	13,390	14,981	920,979
June	30,580	13,540	17,229	1,025,231
July	38,030	17,000	25,777	1,586,005
August	35,900	21,050	26,253	1,614,281
September	56,900	21,250	27,472	1,634,741
October	29,320	20,910	25,548	1,471,747
November	41,720	21,460	28,959	1,723,175
December	32,710	23,450	26,706	1,642,110
The year	56,900	13,540	24,085	17,342,226
1900.				
January	26,854	19,640	21,994	1,352,370
February	19,832	16,597	18,292	1,025,925
March	16,633	13,520	15,133	930,495
April	13,620	11,122	12,186	725,127
May	22,750	10,188	12,569	772,860
June	22,060	11,144	16,524	983,237
July	34,730	17,554	24,496	1,406,242
August	59,082	23,770	33,946	2,087,339
September	38,892	24,628	28,156	1,675,415
October	61,528	30,512	37,999	2,336,492
November	43,820	30,098	34,277	2,039,652
December	55,742	27,980	36,633	2,252,502
The year	61,528	10,188	24,380	17,587,656

Estimated monthly discharge of tributaries to San Juan River between Boca San Carlos and Los Sabalos Station. Drainage area, 750 square miles (approximately).

[This is the difference between the discharge of the San Juan above Boca San Carlos and at Sabalos Station.]

Months.	Discharge.			Total.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1898.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*	*Sec. feet.*	*Inches.*
January (10-31)	5,100	900	2,630	114,770	3.51	2.87
February	17,600	2,700	5,450	302,680	7.27	7.57
March	6,600	1,300	2,820	173,400	3.76	4.34
April	12,700	1,100	2,960	176,130	3.95	4.40
May	7,000	500	2,380	146,340	3.17	3.66
June	21,000	1,000	8,270	492,100	11.03	12.31
July	21,600	7,800	13,350	820,860	17.80	20.52
August	16,100	3,400	6,580	404,590	8.77	10.11
September	15,900	2,600	7,140	424,860	9.52	10.62
October	11,900	2,000	6,050	373,000	8.04	9.30
November	45,000	2,800	11,080	659,360	14.76	16.47
December	15,600	2,900	6,540	402,150	8.72	10.05
The year	45,000	500	6,270	4,190,240		

FIG. 9.—HILL ON LEFT BANK OF SAN JUAN RIVER.

Estimated monthly discharge of tributaries to San Juan River between Boca San Carlos and Los Sabalos Station. Drainage area, 750 square miles (approximately)—Cont'd.

Months.	Discharge.			Total.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1899.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*	*Sec. feet.*	*Inches.*
January	14,400	4,300	8,330	512,190	11.10	12.80
February	7,100	3,200	4,390	243,810	5.85	6.09
March	4,400	2,800	3,590	220,750	4.80	5.53
April	5,481	1,600	2,517	149,772	3.36	3.75
May	5,773	972	2,156	132,573	2.87	3.31
June	11,446	1,296	4,367	259,862	5.82	6.49
July	22,970	4,430	11,585	712,309	15.45	17.81
August	15,833	7,067	10,892	669,818	14.52	16.74
September	31,590	5,795	10,362	616,619	13.82	15.42
October	9,704	3,048	5,790	356,056	7.72	8.90
November	19,855	2,008	8,604	511,967	11.47	12.80
December	11,853	3,604	6,373	391,649	8.50	9.80
The year	31,590	972	6,580	4,777,375	....	....
1900.						
January	8,574	2,977	4,574	281,262	6.10	7.03
February	5,008	2,517	3,186	176,984	4.25	4.43
March	4,010	2,000	2,845	164,965	3.79	4.37
April	2,258	446	1,124	66,877	1.50	1.67
May	11,270	90	1,886	116,025	2.51	2.89
June	8,884	2,124	4,214	250,778	5.62	6.26
July	11,914	2,802	7,365	452,885	9.82	11.32
August	31,114	5,042	12,983	798,317	17.31	19.96
September	14,574	4,170	6,922	411,870	9.23	10.30
October	26,728	2,320	9,559	587,739	12.75	14.70
November	14,620	3,524	6,234	370,954	8.31	9.27
December	28,222	2,712	9,715	597,335	12.96	14.83
The year	31,114	90	5,884	4,275,991	....	....

Estimated monthly discharge of Machado River.

Months.	Discharge.			Total.
	Maximum.	Minimum.	Mean.	
1899.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*
January	339	98	214	13,178
February	150	68	97	5,405
March	300	56	118	7,252
April	213	60	101	6,030
May	424	53	160	9,854
June	251	95	159	9,471
July	1,035	170	335	20,570
August	930	198	337	20,747
September	1,158	180	302	17,994
October	225	100	154	9,471
November	1,252	79	309	18,373
December	1,464	110	338	20,797
The year	1,464	53	219	159,142
1900.				
January	258	95	146	9,011
February	311	73	120	6,665
March	105	62	77	4,740
April	83	37	55	3,255
May	221	30	94	5,796
June	196	79	112	6,653
July	472	101	258	15,862
August	989	209	528	32,490
September	648	170	337	20,025
October	355	80	169	10,378
November	375	113	267	12,327
December	2,602	168	600	36,538
The year	2,602	30	230	163,740

SAN FRANCISCO RIVER.

The most important stream that will be intersected by a canal line from Boca San Carlos to Greytown, on the left bank of the San Juan, is the San Francisco. Its principal branch is the Chanchos. Above their junction measurements were made throughout 1898. The summary of monthly discharges of the river near its mouth is given in the table following. In 1899 and 1900 fifteen current meter measurements were made, which are also given below.

Estimated monthly discharge of San Francisco River at its mouth.

[Obtained by combining observations taken on the Upper San Francisco and Chanchos rivers and Nicholson Creek.]

Months.	Discharge.			Total.
	Maximum.	Minimum.	Mean.	
1898.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*
January	1,270	230	583	35,850
February	1,360	170	489	27,160
March	390	120	199	12,240
April	1,260	110	254	15,110
May	560	125	232	14,260
June	1,100	115	373	22,200
July	1,890	270	684	42,060
August	800	185	364	22,380
September	1,280	150	382	22,730
October	510	130	274	16,850
November	1,520	100	502	29,870
December	1,090	160	398	24,470
The year	1,890	100	394	285,180

Discharge measurements made on San Francisco River.

Date.	Hydrographer.	Meter No.	Area of section.	Mean velocity.	Discharge.
1899.			*Sq. feet.*	*Ft. per sec.*	*Sec. feet.*
Oct. 9	H. W. Durham	Price No. 34	491	0.52	256
Nov. 7	do	do	1,085	1.12	1,212
Nov. 28	do	do	834	.30	247
1900.					
Jan. 24	H. G. Heisler	Price No. 63	662	.64	429
Feb. 16	H. C. Hurd	Price No. 34	503	.26	131
Mar. 18	do	do	415	.36	148
Apr. 29	do	Price No. 35	270	.10	27
May 21	H. G. Heisler	B. & B. No. 1	348	.36	126
June 4	do	do	508	.64	326
June 27	do	do	417	.42	176
Aug. 1	do	do	810	.57	465
Aug. 16	do	do	842	1.15	968
Aug. 30	do	do	978	1.21	1,187
Sept. 11	do	do	625	.54	340
Sept. 24	do	do	751	.73	554

SARAPIQUI RIVER.

A station for the measurement of rainfall and discharge on the Sarapiqui was maintained about 6 miles above the mouth of that river from August, 1898, to the end of the year 1899, and the record is complete for that period. A native observer took rainfall and gauge-height observations throughout 1900, and approximate results for that year also are given.

FIG. 10.—HEAD OF SAN JUANILLO ON SAN JUAN RIVER.

Daily guage height of Sarapiqui River 5 miles above its mouth, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	7.30	7.33	8.53	6.90	6.27	9.20	9.13	11.28	9.74	9.74	8.82	12.60
2....	12.14	7.42	8.32	6.98	6.15	8.95	10.24	11.06	9.19	9.37	8.60	10.77
3....	10.00	7.26	8.15	8.63	6.11	8.49	9.73	10.75	9.11	10.04	8.42	10.76
4....	8.41	7.18	8.26	7.10	5.98	8.05	9.77	13.85	8.81	9.64	9.80	10.30
5....	9.60	7.08	7.90	7.56	6.00	8.37	14.23	11.81	8.61	9.79	13.62	15.63
6....	8.30	7.74	7.56	8.84	6.80	8.70	12.23	12.29	8.72	8.97	17.10	20.15
7....	8.55	7.90	7.52	7.80	6.72	9.83	14.25	11.42	8.73	9.26	13.61	18.40
8....	8.61	7.43	10.10	8.66	6.25	10.50	13.74	11.48	9.83	8.54	12.64	18.75
9....	8.66	7.14	8.86	9.37	6.02	10.75	15.86	13.51	9.02	8.50	16.80	15.17
10....	8.34	7.09	7.96	8.63	5.96	13.72	25.17	11.14	11.41	8.28	13.34	13.29
11....	8.08	7.06	7.55	9.58	6.10	11.68	24.80	10.61	12.66	8.07	16.58	12.17
12....	9.01	7.49	7.33	7.15	6.28	13.84	17.55	10.05	11.92	12.42	15.28	11.46
13....	11.63	14.40	7.41	7.97	7.20	10.87	19.40	9.63	10.46	9.55	14.67	10.92
14....	9.98	13.80	7.62	7.98	6.71	10.08	18.02	10.22	9.46	10.04	17.23	10.39
15....	9.88	9.58	7.84	7.37	6.26	10.61	14.68	10.58	10.00	10.40	17.03	10.27
16....	13.10	8.77	7.71	7.31	6.21	10.38	13.30	10.10	9.56	9.19	15.10	10.14
17....	10.70	8.18	7.32	7.03	6.09	9.68	12.12	9.97	9.42	9.81	13.75	11.12
18....	9.76	8.46	7.30	6.93	6.35	9.94	11.59	9.74	9.75	10.41	12.72	14.69
19....	10.16	8.30	7.15	7.04	9.37	9.15	12.04	9.47	9.31	9.05	12.52	11.93
20....	9.48	9.71	7.14	8.75	7.79	10.65	10.88	9.00	9.35	8.55	11.36	10.89
21....	8.98	8.71	6.93	7.01	8.10	9.82	10.94	9.87	9.47	8.39	10.80	12.07
22....	8.65	9.50	6.82	6.83	9.56	9.27	10.98	10.76	9.98	8.96	10.29	10.71
23....	8.39	9.84	6.75	6.65	11.24	9.16	10.75	9.47	11.65	10.29	9.92	10.66
24....	8.46	10.92	6.72	6.47	10.76	8.80	10.21	10.24	11.15	11.39	10.10	11.28
25....	8.72	9.76	6.75	6.38	9.30	8.79	10.20	10.15	10.33	9.85	9.79	11.56
26....	8.30	9.64	6.72	6.28	12.00	8.80	10.65	10.35	9.73	10.64	9.49	12.09
27....	8.10	9.64	7.05	6.28	14.09	8.72	14.70	14.50	9.37	9.00	10.08	11.11
28....	7.86	9.36	7.14	6.78	11.86	10.27	12.67	11.09	9.37	8.56	11.96	10.59
29....	7.65	....	9.27	7.00	11.83	9.94	11.00	10.13	9.78	9.74	10.34	10.55
30....	7.50	....	6.92	6.61	10.75	9.33	10.22	10.40	9.16	8.97	11.06	10.40
31....	7.35	....	6.75	....	9.82	....	14.59	9.71	....	9.81	....	....

Daily guage height of Sarapiqui River 5 miles above its mouth, for 1900.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	10.65	9.90	4.95	7.50	7.15	10.06	11.15	10.20	9.90	16.05	12.95	16.55
2....	9.90	9.75	4.90	14.00	6.80	11.74	9.95	10.00	9.55	17.45	11.20	13.15
3....	9.45	9.50	4.85	9.50	6.65	12.50	11.65	12.20	9.05	13.80	14.05	11.80
4....	13.25	9.50	4.95	7.95	6.45	11.15	11.40	16.65	8.75	13.20	12.90	11.70
5....	20.80	9.35	7.65	7.70	6.35	12.95	10.60	14.45	8.45	13.80	13.25	11.55
6....	15.50	9.20	5.25	7.20	6.30	12.50	11.40	12.65	8.35	13.00	12.05	12.35
7....	13.70	9.15	4.75	6.95	7.60	11.75	12.90	12.65	8.55	16.65	10.95	14.75
8....	13.30	9.05	4.50	7.35	7.40	10.65	13.20	11.35	8.95	13.15	13.10	30.25
9....	11.85	9.10	4.40	7.30	7.75	11.75	11.85	14.50	8.40	12.15	23.50	28.75
10....	10.95	9.35	5.00	6.90	7.15	9.80	12.65	16.15	8.05	15.35	18.25	21.65
11....	10.45	9.05	4.65	6.90	7.10	9.30	11.70	14.55	8.25	12.20	18.30	17.00
12....	9.95	6.85	4.60	12.65	7.25	9.40	11.00	16.60	9.30	11.45	16.30	15.75
13....	9.95	6.80	4.90	8.85	8.55	10.65	11.20	14.10	8.15	10.65	17.40	14.40
14....	9.80	6.85	4.60	7.80	9.75	9.60	11.10	12.40	8.25	10.20	17.20	13.00
15....	9.30	6.90	4.50	7.30	10.60	9.25	10.35	12.05	8.05	9.95	17.00	12.75
16....	9.00	6.90	4.45	7.15	9.30	9.00	11.15	11.00	9.65	9.60	14.45	12.05
17....	8.80	6.78	4.40	7.70	8.00	9.25	13.90	10.75	12.40	9.50	13.20	11.30
18....	8.55	6.90	4.40	8.10	7.60	11.10	12.30	10.10	12.45	9.60	12.10	10.85
19....	8.40	6.85	4.00	8.70	7.25	9.20	16.60	10.60	10.05	9.90	11.45	10.55
20....	8.30	10.55	4.00	9.20	9.85	8.90	14.60	10.10	9.50	10.70	11.10	10.15
21....	8.15	7.35	4.00	8.40	9.65	9.65	13.15	9.90	9.05	14.15	11.00	9.95
22....	8.00	5.75	4.75	8.88	8.70	9.90	12.30	9.75	9.20	13.60	10.90	9.70
23....	8.00	5.50	9.90	7.30	8.55	9.25	12.66	9.35	11.25	11.80	12.15	9.45
24....	8.20	4.85	7.75	8.65	9.50	8.80	12.70	10.45	9.65	11.25	10.65	9.35
25....	8.20	4.75	6.45	7.60	11.45	8.35	11.40	10.05	10.10	12.00	10.05	9.15
26....	7.95	4.75	8.45	7.15	14.20	8.90	10.65	10.05	14.10	12.00	9.80	8.90
27....	9.65	6.25	7.05	6.95	14.30	9.35	10.55	10.10	13.45	12.50	11.95	8.75
28....	9.00	5.50	6.80	7.35	13.20	8.65	10.15	10.95	13.55	11.80	13.15	8.70
29....	8.30	....	6.60	6.90	11.30	10.60	10.45	11.30	15.75	10.30	13.25	8.55
30....	8.00	....	6.50	6.95	10.15	11.60	10.65	11.75	19.25	9.95	15.00	8.45
31....	9.85	....	6.40	....	12.20	....	10.00	11.00	....	13.50	....	8.40

Rating table for Sarapiqui River 5 miles above its mouth.

[This table is applicable only from Apr. 1, 1899, to Dec. 31, 1900.]

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
4.0	800	6.4	2,022	11.5	9,290	19.0	28,000
4.2	860	6.6	2,200	12.0	10,190	20.0	31,000
4.4	920	6.8	2,400	12.5	11,100	21.0	34,000
4.6	980	7.0	2,600	13.0	12,090	22.0	37,000
4.8	1,040	7.5	3,100	13.5	13,110	23.0	40,000
5.0	1,100	8.0	3,690	14.0	14,180	24.0	43,000
5.2	1,188	8.5	4,320	14.5	15,300	25.0	46,000
5.4	1,276	9.0	5,020	15.0	16,500	26.0	49,000
5.6	1,398	9.5	5,800	15.5	17,800	27.0	52,000
5.8	1,554	10.0	6,630	16.0	19,200	28.0	55,000
6.0	1,710	10.5	7,510	17.0	22,000	29.0	58,000
6.2	1,866	11.0	8,390	18.0	25,000	30.0	61,000

Estimated monthly discharge of Sarapiqui River 5 miles above its mouth.

[Drainage area, 1,100 square miles, approximately.]

Month.	Discharge.			Total.
	Maximum.	Minimum.	Mean.	
1899.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*
January	22,077	3,000	5,420	333,260
February	27,100	2,710	5,200	288,800
March	8,972	2,240	3,350	205,980
April	6,481	1,928	3,173	188,835
May	18,054	1,694	4,357	267,905
June	16,766	3,753	6,553	399,916
July	61,479	5,223	14,173	871,488
August	23,347	5,020	8,094	497,708
September	15,076	4,474	6,418	381,931
October	15,670	3,778	5,920	363,982
November	26,678	4,219	11,605	691,724
December	42,110	6,876	11,512	685,012
The year	61,479	1,694	7,150	5,176,541
1900.				
January	33,637	3,631	7,458	458,575
February	7,598	1,025	3,598	199,828
March	6,464	800	1,726	106,119
April	14,180	2,500	4,055	241,065
May	14,852	1,944	5,472	336,441
June	11,991	4,530	7,041	418,997
July	27,038	6,547	9,880	607,532
August	21,077	5,566	10,257	630,690
September	28,946	3,753	7,652	455,340
October	23,498	5,800	11,094	682,211
November	41,808	6,298	14,258	848,406
December	62,236	4,194	13,624	837,713
The year	62,236	800	8,043	5,822,917

SAN JUANILLO RIVER.

Lull route, variants I, II, and III, all require that the San Juanillo River be diverted below the mouth of the Deseado River and conducted to the sea north of the canal line. To obtain data on this problem, a gauge was established on that river January 1, 1900. Daily readings of the gauge and occasional measurements of discharge were made, the results of which are as follows:

Daily gauge height of San Juanillo River below the mouth of Deseado, for 1900.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	8.82	6.87	5.40	3.15	2.35	4.80	5.92	7.35	9.30	9.20
2	8.82	6.51	5.90	3.12	2.32	....	6.75	9.00	8.50	9.45
3	8.57	6.41	6.00	3.20	2.30	....	7.50	9.40	8.50	9.40
4	8.41	6.36	6.25	3.22	2.20	....	7.00	9.90	8.45	9.60
5	9.14	6.10	6.20	3.00	2.15	....	7.15	10.10	8.30	9.80
6	9.56	5.93	6.25	2.90	2.10	....	7.10	10.50	8.20	9.00
7	9.71	5.62	5.90	2.81	5.65	....	7.10	10.30	7.95	8.80
8	9.67	5.32	5.90	2.75	6.00	....	7.05	10.00	7.80	8.55
9	9.40	5.22	5.58	2.70	6.40	....	7.00	9.70	7.55	8.20
10	9.09	5.11	5.50	2.65	6.20	5.20	6.95	9.67	7.25	7.90
11	8.79	5.30	4.90	2.60	6.70	5.00	6.70	9.90	7.05	7.70
12	8.45	5.20	4.90	2.70	6.80	4.85	6.50	10.05	6.90	7.55
13	8.10	4.75	4.90	4.00	6.75	4.75	6.35	10.30	6.75	7.40
14	7.79	4.44	4.80	4.00	6.70	4.60	6.20	10.25	6.80	7.35
15	7.60	4.29	4.50	4.00	6.60	4.45	6.20	10.00	7.70	7.35
16	7.42	4.23	4.50	3.45	7.30	4.30	6.40	9.80	7.80	7.20
17	7.08	4.50	3.50	3.10	7.00	4.40	6.70	9.67	7.90	7.05
18	6.74	4.51	3.20	2.90	6.30	4.80	7.30	9.50	8.20	7.00
19	6.39	4.32	3.55	2.90	5.90	5.00	7.25	9.40	8.60	6.90
20	6.17	5.69	3.40	2.90	5.10	4.90	7.40	9.55	9.05	7.50
21	5.89	5.60	3.80	2.90	5.00	4.90	7.75	9.40	9.50	....
22	6.16	7.92	3.93	2.90	4.95	4.80	8.35	9.10	9.00	9.20
23	6.92	7.68	4.55	2.90	4.70	4.75	8.60	9.00	....	9.45
24	7.45	7.22	4.68	2.80	4.55	....	8.43	8.90	....	9.60
25	7.31	7.00	4.49	2.70	4.15	....	8.10	9.25	....	....
26	6.95	6.30	4.15	2.60	3.90	....	8.10	9.35	....	....
27	7.65	6.00	4.00	2.45	3.90	4.40	8.05	9.40	....	....
28	7.70	5.66	3.60	2.40	4.20	3.90	8.20	9.40	9.70	....
29	7.81	....	3.39	2.40	4.50	4.20	8.50	9.60	9.60	....
30	7.60	....	3.25	2.40	4.65	4.00	8.65	9.60	9.50	....
31	7.24	....	3.15	....	4.80	....	8.70	9.45	....	8.32

Rating table for San Juanillo River, below the mouth of the Deseado.

[This table is applicable only from January 1, 1900, to December 31, 1900.]

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
2.0	240	4.2	501	6.4	1,097	8.6	1,849
2.1	245	4.3	522	6.5	1,131	8.7	1,883
2.2	250	4.4	544	6.6	1,165	8.8	1,918
2.3	255	4.5	566	6.7	1,199	8.9	1,952
2.4	260	4.6	588	6.8	1,234	9.0	1,986
2.5	265	4.7	611	6.9	1,268	9.1	2,020
2.6	270	4.8	634	7.0	1,302	9.2	2,054
2.7	280	4.9	657	7.1	1,336	9.3	2,089
2.8	290	5.0	680	7.2	1,370	9.4	2,123
2.9	300	5.1	704	7.3	1,405	9.5	2,157
3.0	310	5.2	729	7.4	1,439	9.6	2,191
3.1	320	5.3	755	7.5	1 473	9.7	2,225
3.2	330	5.4	782	7.6	1,507	9.8	2,260
3.3	340	5.5	810	7.7	1,541	9.9	2,294
3.4	355	5.6	838	7.8	1,576	10.0	2,328
3.5	370	5.7	867	7.9	1,610	10.1	2,362
3.6	385	5.8	897	8.0	1,644	10.2	2,396
3.7	400	5.9	928	8.1	1,678	10.3	2,431
3.8	420	6.0	960	8.2	1,712	10.4	2,465
3.9	440	6.1	994	8.3	1,747	10.5	2,500
4.0	460	6.2	1,028	8.4	1,781	10.6	....
4.1	480	6.3	1,062	8.5	1,815	10.7	....

Estimated monthly discharge of San Juanillo River below the mouth of the Deseado.

Month.	Discharge.			Total.
	Maximum.	Minimum.	Mean.	
1900.	*Second-feet.*	*Second-feet.*	*Second-ft.*	*Acre-feet.*
January	2,520	925	1,603	98,596
February	1,616	507	904	50,181
March	1,044	325	626	38,508
April	460	260	311	18,534
May	1,405	245	744	45,765
June	729	440	619	36,828
July	1,883	934	1,421	87,458
August	2,500	1,489	2,184	134,305
September	2,225	1,215	1,786	106,292
October	2,260	1,268	1,794	110,330
Ten months	2,520	245	1,211	726,797

Discharge measurements of tributaries and distributaries to San Juan River below Boca San Carlos, excepting Machado, San Francisco, and Sarapiqui.

River.	Date.	Hydrographer.	Meter.	Gauge height.	Area of section.	Mean velocity.	Discharge.
	1899.			*Feet.*	*Sq. ft.*	*Ft.p.sec.*	*Sec. ft.*
Cureño	Oct. 9	H. W. Durham	Price No. 34		369	0.41	153
Do	Nov. 7	do	do		739	1.09	808
Do	Nov. 28	do	do		548	.75	413
	1900.						
Do	Jan. 24	H. G. Heisler	Price No. 63		425	.67	285
Do	Feb. 16	H. C. Hurd	do		312	.30	93
Do	Mar. 18	do	Price No. 34		279	.28	78
Do	Apr. 29	do	Price No. 35		190	.23	43
Do	May 21	H. G. Heisler	B. and B. No. 1		264	.36	95
Do	June 4	do	do		455	.71	322
Do	June 27	do	do		349	.32	114
Do	July 18	do	do		644	.82	539
Do	Aug. 1	do	do		470	.85	403
Do	Aug. 10	do	do		571	2.00	1,145
Do	Aug. 30	do	do		734	1.02	735
Do	Sept. 10	do	do		526	.91	482
Do	Sept. 24	do	do		590	1.01	596
	1899.						
Danta	Oct. 9	H. W. Durham	Price No. 34		168	.41	69
Do	Nov. 7	do	do		437	.81	355
Do	Nov. 28	do	do		284	.24	69
	1900.						
Do	Jan. 24	H. G. Heisler	Price No. 63		206	.70	145
Do	Feb. 16	H. C. Hurd	Price No. 34		119	.24	28
Do	Mar. 18	do	do		61	.47	28
Do	Apr. 29	do	Price No. 35		38	.31	12
Do	May 21	H. G. Heisler	B. and B. No. 1		74	.32	24
Do	June 4	do	do		166	.82	137
Do	June 27	do	do		96	.54	52
Do	July 18	do	do		319	.61	197
Do	Aug. 1	do	do		224	.49	111
Do	Aug. 16	do	do		347	.96	335
Do	Aug. 30	do	do		430	.81	348
Do	Sept. 11	do	do		235	.61	142
Do	Sept. 24	do	do		318	.58	186
	1899.						
Tambor Grande	Oct. 9	H. W. Durham	Price No. 34		115	.24	27
Do	Nov. 7	do	do		256	.44	111
	1900.						
Do	Jan. 24	H. G. Heisler	Price No. 63		125	.23	30
Do	June 4	do	B. and B. No. 1		90	.15	13
Do	June 27	do	do		52	.17	9
Do	July 18	do	do		132	.21	29
Do	Aug. 1	do	do		177	.22	40
Do	Aug. 16	do	do		152	.33	51
Do	Aug. 30	do	do		177	.48	85
Do	Sept. 24	do	do		136	.25	34

Discharge measurements of tributaries and distributaries to San Juan River below Boca San Carlos, excepting Machado, San Francisco, and Sarapiqui—Continued.

River.	Date.	Hydrographer.	Meter.	Gauge height.	Area of section.	Mean velocity.	Discharge.
	1900.			*Feet.*	*Sq. ft.*	*Ft.p.sec.*	*Sec.ft.*
San Geronimo	Mar. 18	H. C. Hurd	B. and B. No. 1		16	1.04	17
Do	May 22	H. G. Heisler	do		12	.99	11
Do	June 4	do	do		20	.15	3
	1899.						
Tamborcito	Oct. 9	H. W. Durham	Price, No. 34		409	.66	272
Do	Nov. 7	do	do		797	.83	661
Do	Nov. 28	do	do		477	.61	295
	1900.						
Do	Feb. 16	H. C. Hurd	do		364	.27	97
Do	Mar. 18	do	do		270	.13	86
Do	Apr. 29	do	Price, No. 35		205	.08	17
Do	June 27	H. G. Heisler	B. and B., No. 1		290	.32	94
Do	July 18	do	do		660	.55	364
Do	Aug. 1	do	do		445	.59	263
Do	Aug. 16	do	do		576	1.08	626
Do	Aug. 30	do	do		723	.77	560
Do	Sept. 11	do	do		480	.62	304
Do	Sept. 24	do	do		553	.51	284
	1899.						
Copalchi	Oct. 9	H. W. Durham	Price, No. 34		143	1.40	201
Do	Nov. 7	do	do		455	1.69	769
Do	Nov. 28	do	do		224	.88	197
	1900.						
Do	Jan. 24	H. G. Heisler	Price, No. 63		145	1.13	165
Do	Feb. 16	H. C. Hurd	Price, No. 34		91	.62	57
Do	Mar. 18	do	do		50	1.31	66
Do	Apr. 29	do	Price, No. 35		46	.37	17
Do	June 4	H. G. Heisler	B. and B., No. 1		178	.65	117
Do	June 27	do	do		79	1.16	91
Do	July 18	do	do		278	1.08	300
Do	Aug. 1	do	do		206	.91	189
Do	Aug. 16	do	do		292	1.82	532
Do	Aug. 30	do	do		425	.97	413
Do	Sept. 11	do	do		210	.66	140
Do	Sept. 24	do	do		271	.88	240
	1899.						
Gausimo	Oct. 9	H. W. Durham	Price, No. 34		121	.44	54
Do	Nov. 7	do	do		431	.50	216
Do	Nov. 28	do	do		117	.31	36
	1900.						
Do	Jan. 24	H. G. Heisler	Price, No. 63		92	.79	74
Do	Feb. 16	do	Price, No. 34		49	.67	33
Do	Mar. 18	H. C. Hurd	do		27	1.22	33
Do	Apr. 29	do	Price, No. 35		115	1.23	14
Do	May 22	H. G. Heisler	B. and B., No. 1		49	.26	13
Do	June 4	do	do		74	.35	26
Do	June 27	do	do		38	.37	14
Do	July 18	do	do		89	.39	35
Do	Aug. 1	do	do		97	.48	47
Do	Aug. 16	do	do		177	.62	111
Do	Aug. 30	do	do		230	1.01	234
Do	Sept. 11	do	do		139	.40	56
Do	Sept. 24	do	do		201	.31	64
	1899.						
Caño de las Ceibas (near San Juan on Sarapiqui).	Sept. 21	T. F. Boltz	Price, No. 68		331	1.65	548
Do	Sept. 27	do	do		318	1.65	525
Do	Oct. 7	do	do		165	.91	151
Do	Oct. 17	do	do		288	.92	265
Do	Oct. 27	do	do		241	.86	208
Do	Nov. 7	do	do		592	2.22	1,312
Do	Nov. 19	do	do		468	1.02	477
Do	Nov. 27	do	do	5.60	261	.45	118
Do	Dec. 10	do	do	10.00	534	.98	522
Do	Dec. 16	do	do	6.39	307	.60	184
Do	Dec. 26	do	do	7.79	177	1.48	261
	1900.						
Do	July 19	H. G. Heisler	B. and B. No. 1		832	.88	733
Do	Aug. 2	do	do		295	1.21	356
Do	Aug. 17	do	do		325	.87	285
Do	Aug. 31	do	do		420	1.13	478
Do	Sept. 12	do	do		297	.33	99

Discharge measurements of tributaries and distributaries to San Juan River below Boca San Carlos, excepting Machado, San Francisco, and Sarapiqui—Continued.

River.	Date.	Hydrographer.	Meter.	Gauge height.	Area of section.	Mean velocity.	Discharge.
	1899.			*Feet.*	*Sq. ft.*	*Ft.p.sec.*	*Sec.ft.*
Caño Barbuda	Sept. 21	T. F. Boltz	Price, No. 68		133	1.25	167
Do	Sept. 27	do	do		123	.89	110
Do	Oct. 7	do	do		79	.53	42
Do	Oct. 17	do	do		109	.81	88
Do	Oct. 27	do	do		83	.40	33
Do	Nov. 7	do	do		250	.99	248
Do	Nov. 17	do	do		238	.55	131
Do	Nov. 27	do	do	5.37	96	.27	26
Do	Dec. 10	do	do	8.73	225	.60	135
Do	Dec. 17	do	do	7.88	184	1.87	343
Do	Dec. 27	do	do	7.79	177	1.48	261
Caño Maria	Oct. 14	H. W. Durham	Price, No. 34		233	.58	134
Do	Nov. 8	do	do		287	1.96	565
	1900.						
Do	Aug. 2	H. G. Heisler	B. and B., No. 1		238	.69	164
Do	Aug. 17	do	do		412	.51	212
Do	Aug. 31	do	do			([a])	
	1899.						
Sucio	Oct. 14	H. W. Durham	Price, No. 63		74	1.34	100
	1900.						
Do	Apr. 30	H. C. Hurd	Price, No. 34		8	.81	7
Do	May 23	H. G. Heisler	B. and B., No. 1		14	.27	4
Do	June 5	do	do		53	.21	11
Do	Aug. 2	do	do		91	.23	22
Do	Aug. 17	do	do		102	.31	32
Do	Aug. 31	do	do		126	.46	59
Do	Sept. 12	do	do		80	.18	14
	1899.						
La Tigre [b]	Oct. 14	H. W. Durham	Price, No. 34		363	1.08	392
Do	Nov. 8	do	do		767	1.17	894
Do	Dec. 2	do	do		676	.44	300
	1900.						
Do	Jan. 25	H. G. Heisler	do		381	.27	105
Do	Feb. 18	H. C. Hurd	do		96	.72	69
Do	Mar. 19	do	Price, No. 35		174	.63	110
Do	Apr. 30	do	do		74	.56	41
Do	May 23	H. G. Heisler	B. and B., No. 1		209	1.49	313
Do	June 5	do	do		428	.93	396
Do	June 28	do	do		280	.53	149
Do	July 19	do	do		798	.99	790
Do	Aug. 2	do	do		385	1.43	545
Do	Aug. 17	do	do		518	.78	406
Do	Aug. 31	do	do		678	.96	652
Do	Sept. 12	do	do		425	.40	172
Do	Sept. 24	do	do		565	.98	554
	1900.						
Negro	Feb. 18	H. C. Hurd	do		75	.46	75
Do	Feb. 25	do	Price, No. 34		112	1.02	119
Do	Mar. 19	do	do		95	.45	43
Do	Apr. 30	do	do		58	.40	24
Do	May 24	H. G. Heisler	B. and B., No. 1		65	.32	21
Do	June 5	do	do		87	.47	41
	1899.						
San Juanillo Distributary.	Oct. 14	H. W. Durham	Price, No. 34		68	.59	41
Do	Nov. 8	do	do		134	1.13	151
Do	Dec. 2	do	do		91	1.07	97
	1900.						
Do	Jan. 25	H. G. Heisler	Price, No. 63		63	.70	46
Do	Feb. 18	H. C. Hurd	Price, No. 34		23	.18	4
Do	June 5	H. G. Heisler	B. and B., No. 1		59	.71	42
Do	June 28	do	do		25	.47	12
Do	July 19	do	do		196	1.11	199
Do	Aug. 2	do	do		55	.82	45
Do	Aug. 17	do	do		105	.80	85
Do	Aug. 31	do	do		153	.98	151
Do	Sept. 12	do	do		80	.82	66
Do	Sept. 25	do	do		115	.82	95
	1900.						
Misteriosa	Jan. 11	T. F. Boltz	Price, No. 34	6.12	408	.26	102
Do	Feb. 11	H. G. Heisler	do	4.00	254	.03	78

[a] No current. [b] Below Sarapiqui.

FIG. 11—CASTILLO RAPIDS.

FIG 12.—SURF AT GREYTOWN.

Discharge measurements of tributaries and distributaries to San Juan River, below Boca San Carlos, excepting Machado, San Francisco, and Sarapiqui—Continued.

River.	Date.	Hydrographer.	Meter.	Gauge height.	Area of section.	Mean velocity.	Discharge.
	1900.			*Feet.*	*Sq. ft.*	*Ft.p.sec.*	*Sec. ft.*
Colorado (below San Juan).	May 24	Heisler & Reed ...	B. and B., No. 1..	....	9,030	2.47	22,336
Do	June 6	.....do	.....do	....	13,633	2.86	39,034
	1900.						
San Juan (below Colorado junction)	Mar. 21	H. C. Hurd	Price, No. 34	....	961	1.06	1,021
Do	Apr. 30	....do	Price, No. 35	....	761	.73	559
Do	May 24	H. G. Heisler	B. and B., No. 1..	....	944	1.84	[a] 1,741
Do	June 6	.....do	.....do	....	2,356	2.32	[b] 5,473
Do	June 28	.....do	.....do	....	1,225	1.77	[b] 2,168
Do	Aug. 2	.....do	.....do	....	2,402	2.62	[b] 6,310
Do	Aug. 17	.....do	.....do	....	2,948	2.25	[b] 6,637
Do	Sept. 21	.....do	.....do	....	2,201	2.13	[b] 4,695
Do	Sept. 25	.....do	.. ..do	....	2,744	2.29	[b] 6,273
	1899.						
The Parado	Oct. 14	H. W. Durham	Price No. 63	....	74	.72	54
Distributary	Nov. 8	.....do	.....do	....	154	1.40	215
Do	Dec. 2	.....do	.....do	....	105	1.53	162
	1900.						
Do	Jan. 25	H. G. Heisler	B. and B. No. 1..	....	76	.44	34
Do	June 6	.....do	.....do	....	90	.60	55
Do	July 19	.....do	.....do	....	170	1.56	265
Do	Aug. 2	.... do	.....do	....	85	.81	71
Do	Aug. 17	.....do	.....do	....	94	.98	93
Do	Aug. 31	.....do	.....do	....	152	1.36	208
Do	Sept. 12	.....do	.....do	....	76	.97	74
Do	Sept. 25	.....do	.....do	....	97	1.41	137
	1899.						
The Taura	Oct. 14	H. W. Durham	Price No. 34	....	333	1.53	509
Distributary	Nov. 8	.....do	.....do	....	740	2.26	1,669
Do	Dec. 2	.....do	.....do	....	632	1.92	1,218
	1900.						
Do	Jan. 25	H. G. Heisler	Price No. 63	....	256	1.52	391
Do	Mar. 19	H. C. Hurd	Price No. 34	....	64	.13	[c] 8
Do	Apr. 30	.....do	Price No. 35	....	4	.68	[c] 3
Do	June 6	H. G. Heisler	B. and B. No. 1 ..	....	285	1.20	344
Do	July 19	.....do	.....do	....	803	2.05	1,489
Do	Aug. 2	.....do	.....do	....	428	1.26	542
Do	Aug. 17	.....do	.....do	....	521	1.12	886
Do	Aug. 31	.....do	.....do	....	727	1.76	1,284
Do	Sept. 12	.....do	.....do	....	339	1.01	343
Do	Sept. 25	.....do	.....do	....	451	1.78	815
	1899.						
San Juanillo	Dec. 2	H. W. Durham	Price No. 34	....	1,393	.42	[d] 587
Tributary to Lower San Juan.	May 4	H. C. Hurd	Price No. 35	....	746	.51	[d] 380

[a] One mile below Boca Colorado.
[b] One-fourth mile below Taura.
[c] Discharging into San Juan
[d] These gaugings made short distance above mouth, and the discharge includes the discharge of Deseado and Silico Lagoon.

STATION ON NEGRO RIVER TRIBUTARY TO INDIO RIVER.

Surveys were made in 1899 to test the feasibility of the canal route from Machuca to the Caribbean by way of the Indio River. In this connection it was desirable to know something of the volume of the streams to be intercepted, and it was also desired to secure data as to the position and extent of the Greytown district of heavy rainfall. To attain these ends it was decided to establish a station on the Indio in October, 1899. In November the station was removed to the Negro River as being the branch most likely to be followed by a canal location. The station was discontinued September 26, 1900.

A vertical pine rod, marked in feet and tenths, was fastened to a tree on the right bank and observations taken twice daily of the height thereon, gaugings being made near the same point by means of a Price meter. As the supply of water became lower the stream at this point became too sluggish for accurate measurement and in April the station was moved to a point about 4 miles up, just below the entrance of a small tributary. Here the discharge was practically the same as at the first station, there being no tributaries between; but, the velocity being higher, measurements could be made with greater accuracy.

List of discharge measurements made on Negro River.

[12 miles above Indio River. S. H. Harris, hydrographer.]

Date.	Meter (Price) No.	Gauge height.	Area of section.	Mean velocity.	Discharge.	Remarks.
1899.		*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Sec. feet.*	
December 19	34	11.35	2,175	2.58	6,074	
December 27	34	8.85	1,830	.86	1,791	
1900.						
January 1	34	8.47	1,795	.67	1,370	
January 4	34	8.67	1,838	.41	876	
January 13	34	8.07	1,920	.41	929	
January 16	68	8.37	1,975	.48	1,124	
January 19	68	7.55	1,885	.47	1,038	
January 23	68	9.05	2,100	1.24	3,094	
January 26	68	7.55	1,890	.55	1,233	
January 29	68	7.92	1,923	.32	701	
February 9	68	8.32	1,965	.38	912	
February 10	68	7.92	1,940	.37	889	
February 12	68	8.25	1,970	.35	797	
February 14	68	7.40	1,873	.20	473	
February 17	68	7.52	1,880	.32	761	
March 24	68	8.00	1,193	.34	451	At new camp.
March 27	68	7.15	304	.50	174	Upper rod.
March 28	68	7.25	1,135	.23	316	New camp.
April 12	68	7.07	1,116	.22	308	Do.
April 13	68	6.90	280	.49	160	Upper rod.
April 16	68	6.60	1,072	.17	227	New camp.
April 17	68	6.45	257	.36	108	Upper rod.
April 20	68	7.10	1,106	.12	162	New camp.
April 24	68	6.80	1,087	.09	113	Do.
April 25	68	6.25	245	.39	114	Upper rod.
April 28	68	6.40	1,054	.10	117	New camp.
May 8	68	9.05	1,336	.58	832	Do.
May 9	68	8.60	386	.70	305	Upper rod.
May 12	68	8.60	1,300	.35	491	New camp.
May 15	68	11.25	1,553	1.30	2,224	Do.
May 17	68	8.07	376	.65	272	Upper rod.
May 18	68	6.67	1,069	.30	410	New camp.
May 28	68	6.55	1,049	.34	430	Do.
May 29	68	8.65	392	.77	333	Upper rod.
June 9	68	7.55	323	.59	221	Do.
June 15	68	8.10	350	.59	235	Do.
July 13	68	8.72	399	.87	386	Do.
July 14	68	6.55	1,082	.42	535	New camp.
July 17	68	13.75	983	1.81	1,999	Upper rod.
July 18	68	9.12	1,350	.86	1,250	New camp.
July 20	68	8.82	1,284	.96	1,355	Do.
July 24	68	7.82	1,200	.61	821	Do.
July 25	68	9.35	419	.81	369	Upper rod.
July 28	68	8.27	1,245	.51	704	New camp.
August 13	68	15.5	990	2.12	2,105	Upper rod.
August 15	68	15.6	2,190	1.77	3,896	New camp.
August 20	68	13.37	1,863	1.47	2,736	Do.

RAINFALL.

Observations of rainfall were made at each river station, the form of gauge used at most of the stations being a metal funnel which caught the rain and discharged it into a bottle, from which it was measured in a graduate bearing a known relation to the diameter of the funnel. The gauge was always placed in a position as exposed as possible, but nearly always this was a small clearing in the forest which was still well sheltered from the wind.

One of the most remarkable characteristics of Nicaragua is its rainfall, and the radical and striking differences in the climate of the east and west coasts with reference thereto.

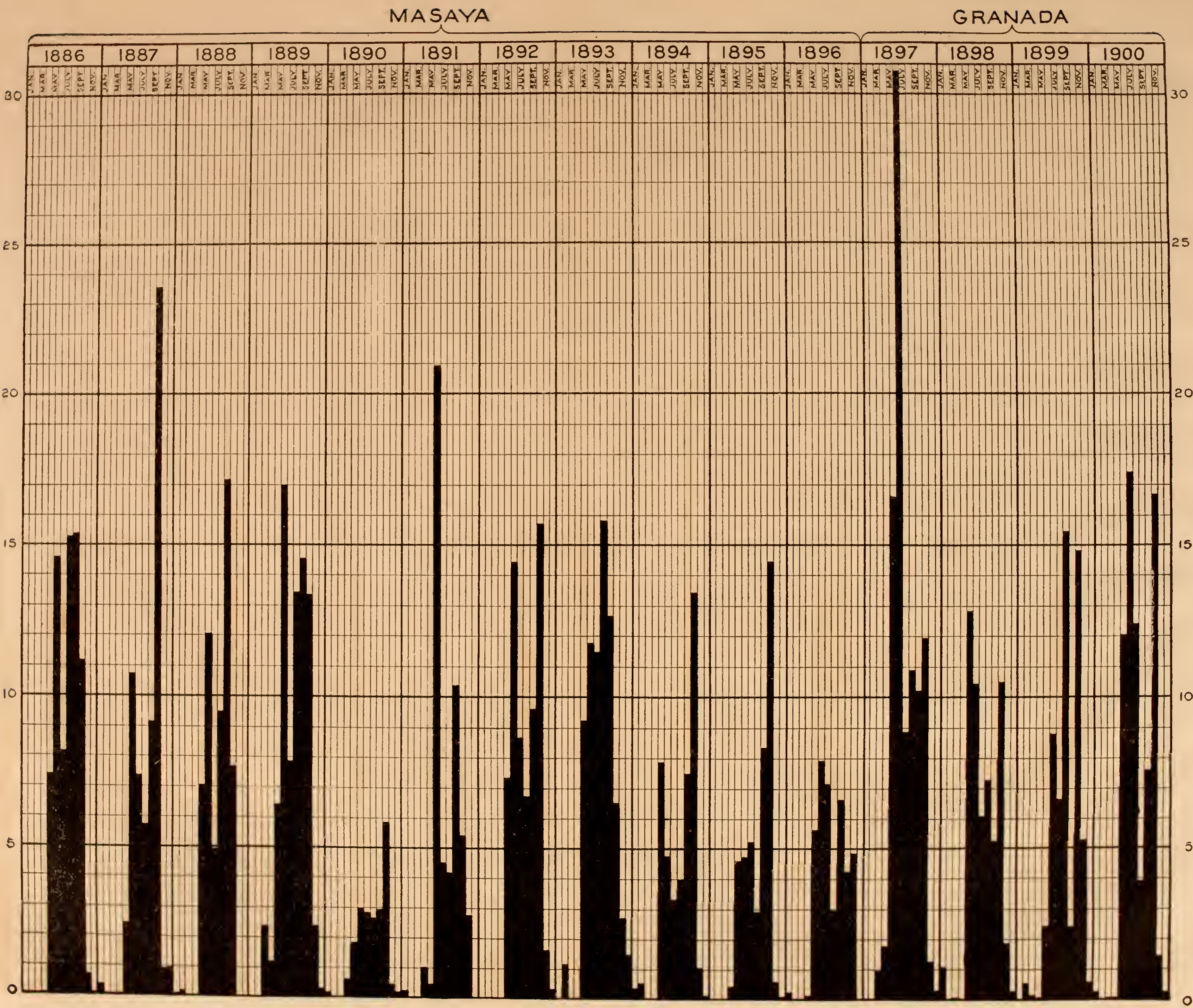

FIG. 13.—MONTHLY RAINFALL AT MASAYA AND GRANADA.

From the records it will be seen that there is no definite dry season on the eastern coast, but that rain may be expected any day in the year and the expectation will seldom be disappointed.

On the Pacific coast, on the contrary, there is little rain from the beginning of January till the middle of May, when the rainy season begins, but the region is subject to violent downpours during the rainy season, the precipitation for a single day being often several inches: Mr. William Climie reports a rainfall of 9 inches in 9 hours at Nandaime, a small town south of Granada.

No less remarkable is the excessive aggregate of rainfall in a limited district of which the nucleus seems to be in the vicinity of Greytown. The annual rainfall at this point, as deduced from the mean of six years' observation, is about 260 inches, while that at Bluefields is only about 105, at Port Limon somewhat less, and at San Jose de Costa Rica, about 70. While there is a slight increase of rainfall with altitude on the headwaters of the Deseado and Limpio, yet in general it may be said that the rainfall decreases as we pass up the San Juan.

So far as known no satisfactory theory has yet been advanced to account for this local phenomenon.

The heaviest fall of rain observed in Nicaragua was, on the report of Mr. Howard Scharschmidt, at Silico Station, on Lake Silico, November 4, 1899, 10.5 inches in six hours, or an average of 1¾ inches per hour. On the same date Mr. Charles D. Scott, at Greytown, observed 12.48 inches in twenty-four hours, of which 8 inches fell in about six hours. These are the heaviest falls for a single day yet observed. The heaviest monthly rainfall observed by this Commission was at Greytown for November, 1900, 55.39 inches.

The following records of heavy rainfall were compiled by the Nicaragua canal board of 1895, and are published in Appendix E of its report:

Large monthly rainfalls at Greytown.

Month.	Inches.	Month.	Inches.
November, 1889 (in 24 days)	50.70	December, 1890	41.65
December, 1889	64.39	December, 1891	32.74
June, 1890	41.56	May, 1892	50.88
July, 1890	52.59	July, 1892	38.96
August, 1890	36.61	November, 1892	36.93

Large daily rainfalls at Greytown.

July 1, 1890	4.20	May 1, 1892	5.08
July 2, 1890	4.31	May 2, 1892	4.95
July 11, 1890	4.18	May 3, 1892	4.57
July 12, 1890	2.19	May 4, 1892	1.62
July 13, 1890	5.02	May 5, 1892	5.10
July 14, 1890	4.66	May 6, 1892	5.80
July 15, 1890	2.57	May 7, 1892	4.10
September 7, 1890	4.05	May 8, 1892	4.20
October 9, 1890	4.00		
November 5, 1890	4.10	Total for 8 days	35.42
December 27, 1890	7.65	July 23, 1892	5.30
January 20, 1891	4.35	October 29, 1892	5.78
April 28, 1891	5.75	October 30, 1892	3.50
		October 31, 1892	8.02
June 5, 1891	3.83		
June 6, 1891	4.95	Total for 3 days	17.30
		November 20, 1892	5.12
Total for 2 days	8.78	December 5, 1892	8.95
June 22, 1891 (9 hours)	4.51	June 3, 1893	4.00
July 18, 1891 (9 hours)	8.17	June 19, 1893	5.00
December 8, 1891	4.05		

Large daily rainfalls at Camp No. 4.

Month.	Inches.	Month.	Inches.
July —, 1890	5.25	July 6, 1891	6.70
July 5, 1891	7.70		

Large daily rainfalls at Camp Carazo.

June 27, 1888	4.60	December 19, 1889	2.90
December 4, 1888	4.00	December 28, 1889	3.50
May 21, 1889	2.90	January 22, 1890	3.00
October 20, 1889	3.00		

Large daily rainfall at Silico Lake.

April —, 1890	7.12	....	....

Rainfall observations at Sapoa, Nicaragua, 1899.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	0.10	0.00	0.00	0.00	0.05	18	0.00	1.38	0.25	0.00	0.09	0.05
2	......	.07	.00	.00	.21	.42	19	.56	.14	.31	.17	.96	.34
3	......	1.41	.00	.00	.04	.01	20	.57	.95	.81	.86	.08	.01
4	......	.09	.00	.00	.35	.07	21	1.84	.47	.01	.00	.40	.03
5	......	.35	.00	.00	.24	.00	22	.17	.06	.44	.10	.11	.01
6	......	.10	.01	.03	.15	.00	23	.24	.31	.00	.14	.01	.00
7	......	.00	.19	.00	.33	.19	24	.22	.18	.02	.00	.19	.00
8	......	.00	.04	.43	.03	.02	25	.40	.26	.00	.39	.09	.00
9	......	.00	.02	.10	1.63	.49	26	.49	1.15	.00	.24	.00	.00
10	......	.00	.45	.05	.16	.08	27	.62	.37	.00	.99	.52	.02
11	......	.02	1.52	.10	.13	.02	28	.22	.06	.42	.71	.70	.00
12	......	.02	.00	.01	.00	.01	29	.00	.16	.48	.09	.62	.03
13	......	.03	.00	.23	.02	.04	30	.00	.35	.06	.00	1.19	.04
14	......	.09	.00	1.67	.11	.01	31	.07	.04	......	.00	......	.00
15	......	.51	.03	.02	.23	.04							
16	0.00	.00	.28	.10	.00	.00	Total	5.42	8.74	5.34	6.45	8.59	1.98
17	.02	.07	.00	.02	.00	.00							

Total, July 16 to December 31, 1899, — 36.52.

Rainfall observations at Sapoa and Tortuga, Nicaragua, 1900.

[July 16 to July 19 estimated. January 1 to July 15, Sapoa. July 20 to December 31, Tortuga.—H. C. Hogan, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.00	0.00	0.00	0.00	0.00	0.01	0.53	0.87	0.49	0.00	0.78	0.00
2	.02	.00	.00	.00	.00	.54	.04	.04	.00	2.43	.00	.00
3	.00	.03	.00	.00	.00	.42	1.94	.57	.00	.06	.20	.00
4	.00	.07	.00	.00	.00	.11	.22	.49	1.64	.52	.26	.00
5	.00	.01	.00	.00	.00	.11	1.23	.06	.03	.72	.20	.00
6	.03	.01	.18	.00	.00	1.80	2.65	.24	.04	6.43	.13	.00
7	.02	.17	.02	.00	.07	.10	.16	.05	.20	.02	.17	.00
8	.02	.01	.00	.00	.15	1.09	.53	.20	.00	.11	.13	.07
9	.00	.14	.02	.00	.02	.05	.56	.22	.00	.86	.00	.00
10	.04	.01	.00	.00	.12	.72	.15	.37	.00	.41	.00	.00
11	.24	.00	.02	.00	.54	.02	.30	.04	.00	.16	.00	.00
12	.04	.00	.00	.00	.55	.00	.31	.24	.00	.04	.00	.08
13	.09	.00	.00	.04	.22	.98	.43	.19	.92	.04	.02	.03
14	.11	.01	.00	.00	.04	1.36	.21	.18	.70	.00	.00	.00
15	.00	.00	.00	.00	.01	.32	.39	.35	1.64	1.20	.43	.12
16	.03	.00	.00	.00	.00	.57	.40	.03	1.85	.18	.53	.00
17	.06	.02	.02	.12	.00	.76	.10	.22	.98	.63	.00	.30
18	.01	.04	.11	.04	.00	.02	1.80	.00	1.54	.82	.05	.17
19	.01	.00	.01	.00	.09	.00	.25	.27	.91	1.12	.00	.17
20	.00	.00	.05	.02	.92	.00	.00	.39	.30	.85	.00	.41
21	.05	.00	.04	.20	.09	.11	.00	2.39	.05	1.54	.00	.19
22	.01	.00	.01	.09	.02	.01	.34	.02	2.11	2.65	.35	.04
23	.00	.05	.06	.01	.16	.07	.22	.09	2.69	.03	.00	.04
24	.00	.00	.01	.00	.08	.42	.12	.84	.96	.73	.00	.20
25	.05	.00	.00	.02	.60	.76	.12	.99	2.03	.09	.35	.00
26	.00	.00	.02	.00	1.34	.01	.19	.62	1.09	.20	.11	.06
27	.01	.00	.00	.00	.03	.00	.00	.46	.13	.04	.03	.38
28	.00	.00	.00	.00	1.02	.31	1.03	.15	.30	.00	.00	.02
29	.00	......	.06	.00	1.17	.78	.27	.02	.78	.00	.00	.03
30	.02	......	.00	.00	1.55	1.40	.35	.10	2.37	.00	.17	.00
31	.25	......	.00	......	1.42	......	.10	.00	......	.40	......	.00
Total.	1.11	.57	.63	.54	10.21	12.85	14.74	10.70	23 75	22.28	3.51	2.31

Total from January 1 to December 31, 1900=103.60 inches.

Rainfall observations at Rivas, Nicaragua, 1899.

[Dr. Earl Flint, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
2	.00	.02	.00	.00	.00	.00	.93	.00	.00	.00	.00	.04
3	.00	.00	.00	.00	.00	.00	.08	.01	.00	.00	.00	.00
4	.12	.00	.00	.00	.00	.00	.00	.19	.00	.84	.32	.00
5	.00	.00	.00	.00	.00	.06	.00	.02	.93	.00	.00	.00
6	.03	.00	.00	.00	.90	.99	.00	.02	1.93	.65	.00	.00
7	.00	.00	.05	.00	.00	.00	.00	.00	.00	.20	.00	.00
8	.00	.00	.00	.00	.00	1.15	.00	.00	.00	.95	.30	.00
9	.00	.52	.00	.00	.00	.62	.04	.00	.00	.07	1.07	.02
10	.00	.00	.00	.00	.00	2.76	.00	.00	.06	.00	.10	.04
11	.00	.00	.00	.00	.00	.00	.00	.03	.05	.10	.00	.24
12	.16	.33	.00	.00	.00	.45	.11	.00	.00	.36	.00	.00
13	.00	.00	.00	.00	.00	.13	.00	.00	.00	1.99	.00	.00
14	.43	.00	.00	.00	.00	.00	.16	.17	.00	.65	.31	.02
15	.00	.00	.00	.00	.00	.00	.20	.58	.08	.07	.04	.00
16	.00	.00	.00	.00	.00	.00	.70	.03	.21	.50	.00	.01
17	.00	.69	.00	.00	.04	.00	.00	.04	.00	.22	.00	.00
18	.00	.02	.00	.00	.00	.34	.00	.01	.00	.01	.00	.00
19	.00	.12	.00	.00	.00	.31	.00	1.20	.57	.09	.00	.20
20	.00	.00	.00	.00	.00	.35	.20	.20	.04	.00	.00	.00
21	.01	.00	.00	.00	.00	.00	2.09	.46	.51	1.07	.26	.00
22	.00	.00	.00	.00	.00	.00	2.32	.06	.00	.40	.10	.06
23	.00	.00	.00	.00	.00	.00	.00	.00	.08	.01	.36	.23
24	.00	.00	.00	.00	.00	.00	.40	.95	.00	.10	.00	.00
25	.00	.00	.00	.00	.00	.32	.83	.34	.00	1.01	.38	.00
26	.00	.00	.00	.00	.58	.00	1.80	2.22	.00	2.84	.00	.00
27	.00	.00	.00	.00	.00	.00	.71	1.04	.00	4.21	.44	.00
28	.00	.00	.00	.00	.00	.06	.00	.00	.00	1.70	.53	.00
29	.00	......	.00	.00	.10	.00	.00	.07	.69	.80	3.15	.00
30	.00	......	.09	.00	.00	.00	.10	1.40	.00	.00	1.70	.00
31	.00	......	.51	.00	.00	......	.02	.22	......	1.55	......	.00
Total.	.85	1.70	.65	.00	1.62	7.53	10.69	9.26	5.15	20.39	9.06	.92

Total January 1 to December 31, 1899=66.35 inches.

Rainfall at Masaya, Nicaragua.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1886....	([a])	......	......	......	......	......	8.23	15.26	15.34	11.19	0.69	0.02	72.70
1887....	0.30	0.00	0.00	0.00	2.42	10.73	7.39	5.74	9.15	23.56	.94	.99	61.22
1888....	.05	.14	.00	.00	7.09	12.09	4.95	9.50	17.21	7.67	.00	.00	58.70
1889....	.00	.00	2.39	1.18	6.43	17.00	7.87	13.43	14.53	13.36	2.34	.25	78.78
1890....	.14	.00	.00	.60	1.82	3.00	2.86	2.66	2.95	5.89	.42	.18	20.52
1891....	.19	.00	.00	1.02	.48	20.94	4.52	4.20	10.40	5.45	2.78	.00	49.98
1892....	.00	.00	.00	.00	7.36	14.42	8.70	6.75	9.64	15.71	1.66	.30	64.54
1893....	.00	1.15	.00	.00	9.26	11.78	11.47	15.82	12.67	6.51	2.70	1.50	72.86
1894....	.32	.50	.00	.00	7.87	4.77	3.32	4.00	7.49	13.42	1.08	.11	42.88
1895....	.00	.00	.00	.41	4.57	4.71	5.22	2.90	8.36	14.46	.57	.06	41.26
1896....	.23	.00	.00	.09	5.62	7.90	7.13	2.98	6.62	4.22	4.85	.00	39.64
1897....	......	......	......	......	......	......	......	......	......	......	......	......	......
1898....	......	......	......	.28	5.30	9.36	7.06	3.27	9.03	13.71	2.19	.53	50.73
1899....	.50	.48	.07	.00	2.02	8.62	4.19	9.47	2.80	10.35	5.54	1.20	45.24
1900....	.00	.00	.00	.00	8.66	15.52	10.27	4.70	7.23	11.24	1.91	.22	59.75
Mean.	.14	.19	.20	.28	5.30	10.83	6.66	7.19	9.53	11.17	1.98	.38	54.20

[a] Estimated rainfall January to June, 1886, inclusive, is 21.97 inches.

Rainfall observations at Granada, Nicaragua, 1899.

[Observer, S. Vargas.]

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	0.00	0.00	0.00	0.00	0.00	0.01	0.31	0.06	0.66	0.00	0.00
2	......	.05	.00	.00	.00	.00	.00	.00	.00	.15	.00	.36
3	......	.00	.00	.00	.00	.00	.00	.02	.00	.00	.00	.00
4	......	.00	.00	.00	.00	.01	.01	.20	.00	.00	.00	.00
5	......	.00	.00	.00	2.23	.00	.00	.02	.13	.00	.00	.00
6	......	.00	.00	.00	.00	1.64	.00	.00	.00	.10	.00	.00
7	......	.00	.03	.00	.00	.35	.00	.00	.28	1.56	.10	.00
8	......	.04	.00	.02	.00	1.84	.00	.00	.52	.31	.03	.00
9	......	.00	.00	.00	.00	.78	.00	.00	.73	.02	.75	.00
10	......	.00	.00	.00	.00	.76	.00	.00	.00	.00	.06	.08
11	......	.00	.00	.00	.00	.39	.00	.00	.00	.65	.00	.13
12	......	.00	.00	.00	.00	.22	.62	.00	.00	.00	.00	.00
13	......	.00	.00	.00	.00	.00	.00	.00	.00	.46	.00	.00
14	......	.00	.00	.00	.00	.26	.00	.00	.00	.51	.00	.00
15	......	.00	.00	.00	.00	.04	.14	.40	.17	1.48	.06	.00
16	......	.00	.00	.00	.00	.00	.00	.30	.12	1.07	1.00	.00
17	......	.00	.00	.00	.00	.00	.00	.02	.00	.00	.00	.00
18	......	.43	.00	.00	.00	.17	.00	1.21	.00	.00	.04	.00
19	......	.00	.00	.00	.00	.50	.00	1.51	.00	.00	.08	.00
20	......	.00	.00	.00	.00	.32	.51	.11	.07	.16	.00	.00
21	......	.00	.01	.00	.00	.22	2.34	.03	.00	.39	.00	.00
22	......	.00	.00	.00	.00	.00	.00	.39	.00	1.80	.18	.00
23	......	.00	.00	.00	.00	.05	.00	.39	.00	.07	.15	.00
24	......	.00	.00	.00	.00	.00	.00	.25	.00	.78	.00	.00
25	0.00	.00	.00	.00	.00	.48	1.30	.51	.00	.07	.00	.00
26	.00	.00	.00	.00	.07	.17	.87	8.25	.31	.36	.00	.00
27	.00	.00	.00	.00	.04	.58	.06	1.50	.00	.60	.19	.00
28	.00	.00	.00	.00	.00	.00	.53	.02	.00	2.03	.38	.00
29	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00	.39	.00
30	.00	.00	.07	.00	.08	.00	.00	.20	.00	.00	1.83	.00
31	.00	.00	.00	.00	.00	....	.06	.00	....	1.56	....	.00
Total...	.00	.52	.11	.02	2.43	8.78	6.64	15.44	2.39	14.79	5.24	.57

Total from January 25 to December 31, 1899=56.93 inches.

Rainfall observations at Granada, 1900.

[Stephen Vargas, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.10	0.00	2.25	0.00	0.00
2	.00	.00	.03	.00	.00	.42	.60	.00	.00	.00	.14	.00
3	.00	.00	.00	.00	.00	.12	.35	.12	.14	.55	.00	.00
4	.00	.00	.00	.00	.00	.08	.10	.00	.00	.00	.00	.00
5	.00	.00	.00	.00	.06	.00	.36	.18	.00	.00	.00	.00
6	.00	.00	.00	.00	.00	2.85	.45	.00	.00	1.95	.10	.00
7	.00	.00	.00	.00	.00	.06	48	.00	1.45	.00	.00	.00
8	.00	.00	.00	.00	.00	3.62	.42	.00	.00	1.73	.00	.00
9	.00	.00	.00	.00	.00	.70	.37	.00	.00	.00	.00	.00
10	.00	.00	.00	.00	.00	.25	.80	.20	.00	.00	.00	.00
11	.00	.00	.00	.00	.00	.21	.00	.00	.00	1.04	.00	.05
12	.00	.00	.00	.00	.00	.07	2.47	.00	1.88	.54	.00	.00
13	.00	.00	.00	.00	.00	1.45	.00	.00	.15	1.97	.00	.00
14	.00	.00	.00	.00	.00	.75	.00	.00	.00	.00	.00	.00
15	.03	.00	.00	.00	.00	.00	.00	.15	.00	.00	.00	.00
16	.00	.00	.00	.00	.40	.00	2.15	.00	.00	1.68	.00	.00
17	.00	.00	.00	.00	.00	.25	.23	.10	.00	.00	1.05	.00
18	.00	.00	.00	.00	.00	2.05	.03	.00	.87	.00	.13	.00
19	.00	.00	.00	.00	.00	.10	.00	.00	1.35	.00	.00	.00
20	.00	.00	.00	.00	.09	.00	.80	.00	.80	.00	.00	.00
21	.23	.00	.00	.00	.02	.12	.00	.00	.00	1.73	.00	.00
22	.00	.00	.00	.00	.00	.00	1.29	.00	.00	.00	.00	.00
23	.00	.00	.00	.02	.68	.90	.00	.00	.56	2.73	.00	.00
24	.00	.00	.00	.00	3.55	2.47	.25	.00	.00	.00	.00	.00
25	.00	.00	.00	.00	.00	.00	.00	.00	.21	.34	.00	.00
26	.00	.00	.00	.00	1.79	.11	.00	.00	.00	.00	.00	.00
27	.00	.00	.00	.00	2.89	.00	.00	2.75	.00	.00	.00	.00
28	.00	.00	.00	.00	.90	1.05	.00	.00	.00	.00	.00	.00
29	.00	......	.00	.00	.00	.00	.30	.33	.19	.00	.00	.00
30	.00	......	.00	.00	.54	.00	.38	.33	.00	.19	.00	.00
31	.00	......	.00	......	1.14	......	.35	.00	......	.00	......	.00
Total.	.26	.00	.03	.02	12.06	17.63	12.40	3.93	7.60	16.70	1.42	.05

Total for the year, 72.10.

Rainfall at Granada, Nicaragua.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1876	......	......	......	......	5.77	13.65	26.61	4.96	......	......	......	......	....
1877	0.00	0.00	0.00	.00	11.57	10.24	10.12	5.32	17.36	5.27	0.87	0.59	61.34
1883	.35	.00	.00	.18	.28	5.20	2.66	5.47	9.74	19.91	3.64	.00	47.43
1884	.00	.00	.00	.00	.00	8.25	3.99	3.75	8.82	8.63	2.28	.26	35.98
1897	.00	.00	.97	1.77	16.63	30.79	8.88	10.87	10.21	11.97	1.25	.28	93.62
1898	1.07	.00	.02	.00	12.82	10.44	6.09	7.30	5.25	10.49	1.87	.24	55.59
1899	.00	.52	.11	.02	2.43	8.78	6.64	15.44	2.39	14.79	5.24	.57	56.93
1900	.26	.00	.03	.02	12.06	17.43	12.40	3.93	7.60	16.70	1.42	.22	72.10
Mean.	.24	.07	.16	.28	7.70	13.10	9.67	7.13	8.77	12.51	2.37	.31	60.42

1876, Ramon Espinola; 1877, Dr. Earl Flint; 1883–4, National Institute; 1897–98, William Climie; 1899–1900, Stephen Vargas.

Rainfall observations at San Ubaldo, Nicaragua, 1899.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	0.01	0.31	0.00	0.56	0.00	0.01
2	....	.30	.30	.04	.00	.00	.00
3	....	.76	.12	.10	.36	.00	.00
4	....	.35	.01	1.53	.10	.10	.00
5	....	.02	.84	.00	.29	.00	.00
6	....	.00	.00	.23	.00	.03	.00
7	....	.00	.00	.11	.02	.04	.00
8	....	.00	.00	1.18	.20	.03	.00
9	....	.06	.00	.93	.05	.00	.02
10	....	.02	.00	.17	.07	.00	.42
11	....	.00	.07	.00	.09	.00	1.22
12	....	.23	.00	.00	.54	.00	.01
13	....	.01	.04	.00	.01	.00	.00
14	....	.31	.20	.00	.77	.10	.00
15	....	.41	.30	.00	1.79	.83	.00
16	....	.11	.49	.36	.08	.02	.00
17	....	.00	.10	.00	.07	.00	.00
18	....	.10	.53	.00	.38	.00	.01
19	....	.47	.08	.25	.05	.01	.01
20	....	.12	.03	.58	.32	.39	.00
21	0.01	.04	.00	.05	.16	.33	.00
22	.00	.05	.18	.02	.21	.00	.06
23	.00	.30	.49	.12	1.22	.00	.00
24	.05	.27	.53	.09	.04	.10	.00
25	.00	.00	1.52	.03	.50	.91	.00
26	.10	.22	2.27	.00	.96	.93	.00
27	.60	.01	.03	.00	1.58	1.31	.00
28	.01	.00	.16	.35	.63	.09	.00
29	.17	.05	.21	.04	.00	3.49	.00
30	.86	.00	.19	.04	.03	.60	.11
31	....	.08	.45	....	.02	....	.00
Total	1.80	4.30	9.45	6.22	11.10	9.31	1.87

Total, June 21 to December 31, 1899, 44.05.

Rainfall observations at San Ubaldo, 1900.

[G. C. W. Magruder, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.00	0.00	0.00	0.00	0.00	0.00	2.53	0.43	0.07	0.20	0.23	0.08
2	.05	.02	.02	.00	.00	.47	.75	.00	.00	.90	.17	.00
3	.00	.00	.03	.00	.00	.97	.24	.06	.01	.81	.00	.02
4	.00	.00	.00	.00	.00	.28	2.40	.39	2.52	.00	.00	.09
5	.00	.00	.02	.00	.00	.05	1.60	.11	.56	.00	.00	.16
6	.00	.00	.00	.00	.00	.14	.36	.02	.13	.00	.01	.00
7	.00	.03	.00	.00	.03	.09	.00	.08	.01	.01	.00	.00
8	.03	.00	.06	.00	.00	2.27	3.17	.15	.00	.00	.01	.00
9	.07	.00	.07	.00	.01	.00	1.65	.22	.00	.16	.02	.00
10	.01	.07	.01	.00	.00	.00	3.53	.00	.23	.03	.00	.00
11	.00	.00	.00	.00	.00	.69	1.34	.00	.01	.00	.00	.00
12	.65	.00	.00	.00	.00	.20	.12	.00	.23	.11	.25	.00
13	.06	.00	.00	.00	.07	1.72	2.88	.00	.00	.00	.00	.00
14	.01	.00	.00	.00	.02	.22	.12	.13	.06	.43	.00	.00
15	.00	.03	.00	.00	.73	.00	.00	.21	.87	.06	.04	.05
16	.03	.00	.00	.00	.00	.00	.72	.01	1.99	.34	.11	.04
17	.00	.02	.00	.00	.05	1.01	.28	.00	.19	.00	.02	.00
18	.00	.00	.01	.00	.01	.46	.02	.00	.14	.20	.04	.03
19	.15	.00	.00	.00	.98	.62	.04	.00	.32	.12	.17	.00
20	.00	.00	.01	.00	2.08	.05	1.75	.20	.69	2.95	.01	.00
21	.01	.00	.00	.07	.01	.12	.53	.12	.06	.48	.00	.00
22	.00	.00	.01	.00	.01	.05	.10	.31	1.43	1.70	.00	.06
23	.00	.00	.00	.00	.00	.01	.03	.29	.09	.04	.12	.00
24	.00	.00	.00	.00	.26	.00	.06	.75	.47	.35	.09	.00
25	.00	.02	.00	.00	.60	.07	.06	.16	.19	.00	.00	.00
26	.00	.00	.00	.00	.36	.00	.00	.88	.00	.00	.00	.02
27	.00	.00	.00	.00	.28	.07	.00	.08	2.69	.00	.00	.00
28	.00	.00	.00	.00	.15	.23	.00	.12	.63	.02	.00	.00
29	.00	.00	.00	.00	.01	.05	.59	.00	.07	.00	.00	.00
30	.14	......	.00	.02	1.69	.01	.04	.01	.42	.00	.14	.00
31	.01	......	.00	......	.09	....	.00	.29	....	.00	....	.00
Total.	1.22	.19	.27	.09	7.41	9.85	24.91	5.32	14.08	8.91	1.43	.55

Total for the year, 74.26.

Daily rainfall at Solentiname Island, Lake Nicaragua, Nicaragua, 1900.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.04	0.00	0.06	0.00	0.00	0.13	0.00	1.30	0.11	0.02	0.13	0.14
2	.00	.48	.02	.02	.00	.25	.22	.17	.00	.05	.22	.23
3	.04	.64	.32	.00	.00	.25	.13	1.60	.00	.70	.07	.20
4	.00	.00	.15	.00	.00	.07	.58	1.67	.00	.42	.10	.10
5	.03	.10	.02	.00	.03	.00	.04	.19	1.10	.90	.09	.11
6	.17	.01	.12	.00	.12	.00	.79	.45	.43	.40	.12	.09
7	.07	.00	.05	.00	.08	.06	.36	.25	.10	.60	.04	.12
8	.18	.00	.00	.00	.16	.16	.11	.02	.13	.45	.56	.07
9	.01	.22	.00	.00	.00	.00	.38	.50	.14	.50	.23	.10
10	.31	.00	.03	.05	.00	.00	.72	.10	.36	.00	.12	.23
11	.00	.00	.00	.05	.04	.02	.11	.47	.56	.00	.08	.31
12	.02	.01	.00	.00	.01	.00	.24	.50	.17	.00	.17	.12
13	.13	.00	.00	.00	.00	.00	.50	.06	.30	1.02	.03	.06
14	.05	.00	.00	.00	.00	1.05	.02	1.05	.20	.00	.05	.10
15	.05	.00	.00	.00	.00	.15	.10	.45	.30	.51	.66	.22
16	.01	.02	.00	.00	.00	.24	.94	.08	.50	.05	.31	.18
17	.05	.06	.02	.00	.00	1.52	.40	.33	.10	.32	.04	.10
18	.03	.00	.03	.00	.00	.02	.46	.46	.11	.60	.02	.14
19	.04	.20	.01	.00	1.00	.00	.37	.00	1.12	.40	.00	.05
20	.00	.04	.04	.00	.30	.10	.00	1.30	.88	.32	.05	.06
21	.03	.02	.19	.08	2.40	.51	.05	.00	.10	.09	.10	.10
22	.05	.00	.00	.17	.04	.02	.15	.18	.11	3.00	.13	.11
23	.05	.00	.00	.00	.10	.00	.06	.12	.40	3.85	.19	.18
24	.00	.00	.00	.00	.05	.00	.05	.25	.42	.15	.11	.00
25	.00	.04	.04	.00	.99	.00	.21	.32	1.62	.30	.00	.00
26	.00	.00	.00	.00	2.00	.12	.00	.83	.60	.08	.05	.02
27	.18	.09	.00	.00	.15	.21	.19	.42	1.06	.03	.00	.45
28	.00	.02	.00	.00	.70	.43	.06	.72	1.50	.04	.01	.00
29	.08	......	.00	1.03	.71	.00	.36	.10	.71	.01	.06	.00
30	.04	......	.00	.00	3.34	.00	.70	.02	2.30	.00	.30	.00
31	.00	......	.00	......	.25	.00	.33	.30	......	.08	......	.00
Total.	1.66	1.95	1.10	1.40	12.47	5.31	8.63	14.21	15.43	14.89	4.04	3.59

Total for the year, 84.68 inches.

Rainfall observations at Fort San Carlos, Nicaragua, 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..........	0.35	0.00	0.06	0.00	0.00	0.00	0.21	0.10	0.01	2.74	0.00	0.01
2..........	.00	.15	.00	.00	.00	.00	.71	.00	.00	.00	.03	.40
3..........	.74	.00	.06	.00	.00	.00	.54	.00	.00	.09	.81	.02
4..........	......	.10	.00	.00	.00	.00	.07	.18	.20	.12	.41	.10
5..........	.17	.00	.00	.02	.00	.00	.01	.02	.07	1.09	.72	.11
6..........	.00	.24	.12	.32	.67	.00	.00	.00	.12	.22	1.11	.01
7..........	.03	.00	.04	.04	.00	.28	.04	.12	.07	.10	.28	.07
8..........	.06	.00	.21	.09	.00	.95	.33	.42	.16	.01	.19	.00
9..........	.38	.00	.00	.29	.00	1.20	.00	.02	.12	.17	.48	.95
10..........	.17	.00	.00	.40	.10	2.10	.08	.00	.06	.40	.06	.02
11..........	.05	.54	.00	.22	.00	1.06	.76	.00	.03	.12	.00	.11
12..........	.47	.08	.04	.10	.15	.31	.07	.00	.06	.92	.14	.06
13..........	.05	.00	.00	.00	.00	.00	.86	.59	.00	.00	.01	.12
14..........	.58	.13	.00	.00	.02	.51	.43	.16	.21	3.88	.06	.31
15..........	......	.11	.10	.00	.00	.03	.00	.18	.92	.07	.70	.02
16..........	.53	.59	.00	.00	.00	.35	.00	.01	1.44	.05	.06	.06
17..........	......	.08	.00	.00	.00	.81	.00	.62	.05	.05	.81	.02
18..........	.26	.32	.00	.00	.05	.18	.00	.93	.21	.04	.29	.15
19..........	.05	.00	.00	.00	.22	.54	.52	.08	.41	.03	.12	......
20..........	.00	.05	.00	.00	.05	.21	.06	.33	2.33	.29	.00	.22
21..........	.22	.00	.00	.00	.03	.02	1.19	.20	1.00	.00	.01	.12
22..........	.08	.05	.00	.00	.02	.04	.00	.41	1.39	.04	.07	.03
23..........	.05	.00	.00	.00	.05	.00	1.08	.71	.03	.00	.72	.00
24..........	.25	.00	.00	.00	.00	.32	.44	.69	.08	.00	.13	.08
25..........	.05	.10	.00	.00	.20	.01	.26	.92	.12	.00	.07	.10
26..........	.10	.25	.00	.00	.30	.17	.72	.88	.00	.00	.06	.03
27..........	.05	.00	.00	.00	.00	1.42	.15	.60	.15	.13	.34	.01
28..........	.00	.00	.00	.00	.50	.14	.36	.10	.80	.09	.09	.05
29..........	.10	......	.00	.00	.76	.15	.37	.09	.07	.00	.32	.02
30..........	.00	......	.00	.00	.04	.44	.02	.03	.56	.00	.73	.00
31..........	.20	......	.42	......	.02	......	.00	.84	......	......	......	.00
Total.	4.99	2.79	1.05	1.48	3.18	11.24	9.28	9.23	10.67	10.66	9.43	3.20

Total, January 1 to December 31, 1899, 77.20.

Rainfall observations at Fort San Carlos, Nicaragua, 1900.

[Fred Davis, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.00	0.09	0.00	0.02	0.00	0.02	0.96	0.96	0.61	2.28	0.26	0.23
2	.00	.54	.01	.07	.00	.21	.01	.38	.01	.48	.11	.07
3	.02	.54	.31	.00	.00	.15	.51	1.19	.00	.74	.05	.57
4	.00	.00	.02	.00	.00	.27	.59	1.20	.00	.46	.06	.08
5	.03	.08	.05	.01	.00	.11	.53	.37	1.14	.17	.20	.03
6	.61	.03	.06	.00	.07	.01	.40	2.59	.00	.59	.00	.44
7	.06	.00	.00	.00	.58	.13	.00	.47	.08	.75	.62	.23
8	.23	.00	.01	.01	.10	.06	.17	.77	.00	.00	.78	.53
9	.00	.62	.01	.00	.26	.00	.79	.01	.00	.35	.50	.16
10	.04	.01	.00	.03	.00	.00	.70	.19	.30	.00	.00	.21
11	.00	.00	.00	.09	.52	.05	.10	.14	.87	.06	.00	.90
12	.64	.00	.00	.04	.19	.00	.27	.05	.46	.00	.08	.37
13	.22	.00	.00	.04	.00	.07	1.51	.02	.18	.29	.00	.20
14	.01	.09	.00	.00	.01	.30	.27	1.08	.12	.06	.00	.20
15	.29	.13	.00	.00	.01	.15	.05	.39	.00	.21	.31	.17
16	.03	.16	.00	.00	.00	.45	2.92	.12	.94	.68	.16	.38
17	.08	.01	.00	.06	.00	1.25	.49	.20	.60	.18	.00	.11
18	.00	.00	.00	.01	.15	.86	2.14	.46	.19	.95	.00	.52
19	.00	.10	.08	.03	1.80	.09	.09	.03	1.34	.15	.09	.07
20	.00	.14	.06	.00	1.62	.01	.31	.71	.07	1.45	.20	.07
21	.02	.01	.19	.00	.64	.00	.01	.12	.08	.03	.34	.39
22	.03	.02	.00	.00	.45	.01	.26	.23	.02	1.96	.17	.03
23	.08	.00	.01	.00	.00	.00	.22	.32	2.33	.40	.10	.06
24	.00	.00	.00	.00	.08	.00	.10	.52	.72	.81	.39	.01
25	.06	.00	.00	.00	.68	.28	.04	.41	.05	.12	.07	.00
26	.00	.00	.00	.00	2.02	.03	.01	.50	.03	.21	.25	.00
27	.21	.09	.00	.00	.36	.00	.41	.85	1.80	.00	.01	.25
28	.00	.00	.00	.00	.94	1.03	.36	.13	.52	.00	.00	.05
29	.18	......	.00	.00	.95	.32	.48	.24	1.02	.05	.01	.02
30	.22	......	.00	.00	2.08	.18	.66	.59	1.54	.00	.66	.00
31	.03	......	.00	......	.68	......	.08	.05	......	.16	......	.03
Total.	3.09	2.66	.81	.41	14.19	6.04	15.44	15.29	15.02	13.59	5.42	6.38

Total for the year, 98.34.

Rainfall observations at Ochoa, San Juan River, 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.17	0.37	0.25	0.37	0.00	0.26	0.24	0.23	0.20	0.43	0.02	0.02
2	1.83	.11	.01	.09	.00	.03	1.03	.66	.00	.01	.16	.19
3	.58	.08	.14	.35	.00	.00	.44	.03	.55	.33	.83	.16
4	.84	.01	.05	.17	.00	.00	.69	2.36	.00	.93	3.29	.42
5	1.31	.18	.00	.65	.17	.00	.03	.08	.00	.03	.51	.83
6	.05	.22	.02	.71	.07	.00	1.10	.06	.26	.17	.98	.85
7	.67	.00	1.36	.01	.00	1.26	.93	.79	.09	.01	.30	1.94
8	.25	.00	2.51	1.60	.00	3.24	1.16	2.21	.55	.55	.48	1.54
9	.17	.11	.06	1.17	.00	.20	6.90	.07	.06	.02	.77	.28
10	.22	.17	.00	.43	.24	2.51	2.81	.00	.79	T. [a]	.84	.01
11	.54	.08	.05	.51	.31	.21	.67	.00	.31	.49	1.97	.31
12	1.28	.99	.03	.47	.15	.19	.43	.00	.00	.01	2.64	.19
13	.24	.49	.35	.27	.00	.02	3.31	1.18	.00	.02	2.00	.31
14	.24	.01	.26	.08	.19	.18	1.07	.01	.05	.90	1.45	.16
15	1.49	.13	.24	.00	.32	.44	.04	.74	.00	.11	.94	.21
16	.80	.58	.09	.00	.01	.09	.19	.05	1.31	.69	.30	.13
17	.01	.33	.09	.00	.41	.65	.15	.90	.02	.36	.36	3.20
18	.43	.95	.01	.00	.69	1.11	.41	.31	.44	.00	.47	1.41
19	.16	1.15	.00	.00	.31	.26	.07	.05	.01	.11	.52	.94
20	.22	.27	.00	.00	1.57	.33	.53	.71	1.52	.35	.02	2.69
21	.54	.33	.02	.00	.39	.00	1.00	2.20	1.38	.01	.00	.83
22	.44	.09	.00	.00	.13	.29	.70	.20	4.24	.89	.00	.09
23	.04	.16	.00	.00	.04	.00	.08	.45	1.72	.48	.00	.58
24	.34	.06	.00	.06	.18	2.41	.01	1.75	.19	.24	.05	.15
25	.03	.05	.00	.00	2.44	.04	1.19	1.02	.57	.60	.42	.04
26	.04	.06	.00	.15	2.03	.03	2.18	.62	.00	.01	.00	.88
27	.01	.33	.01	.00	1.75	.72	.47	.11	.81	.00	.20	1.30
28	.00	.35	.02	.00	.10	.79	.78	.13	.34	.00	.04	.66
29	.02	......	.00	.00	.85	.24	.20	.05	.03	.00	.26	.50
30	.00	......	.01	.00	.21	.19	.00	.38	.00	.00	.76	.80
31	.05	......	.22	......	.04	......	1.09	.12	......	.10	.00	.09
Total.	14.02	7.96	5.80	7.09	12.60	15.69	30.20	17.50	15.49	7.85	20.58	22.13

Total, from January 1 to December 31, 1899, 176.91.

[a] Trace.

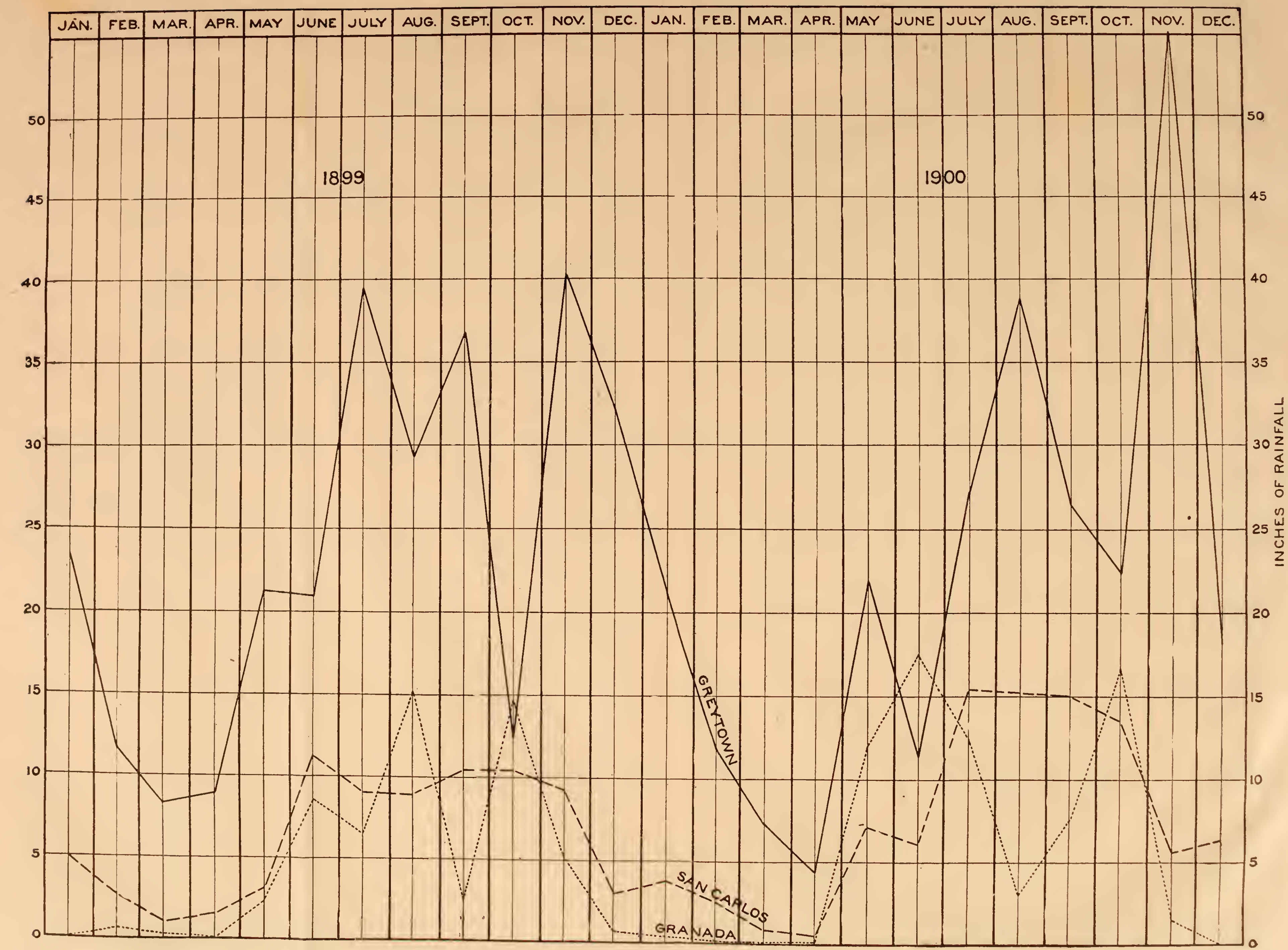

FIG. 14.—COMPARATIVE MONTHLY RAINFALL AT GREYTOWN, SAN CARLOS, AND GRANADA.

Rainfall observations at Ochoa, 1900.

[H. S. Reed, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.00	0.15	0.00	0.51	0.00	0.04	0.37	0.28	1.06	0.27	0.06	0.23
2	.06	.13	.78	.12	.00	.22	.01	1.40	.01	.07	.57	.03
3	.23	.54	.54	.01	.00	.97	.03	.30	.00	.02	.25	.65
4	.34	.02	.73	.14	.00	.61	1.74	2.56	.00	.47	1.65	.68
5	1.10	.12	.49	.00	.04	.10	.04	.61	.00	.03	.14	1.94
6	.40	.13	.02	.00	1.52	.02	.53	.31	.70	.00	.03	2.68
7	.30	.28	.00	.00	1.92	.23	.23	.83	1.60	.06	.16	4.87
8	.10	.02	.00	.04	.19	.00	.65	.46	.04	.01	.47	5.96
9	.00	.56	.17	.00	1.62	.00	2.55	1.66	.03	.01	1.61	1.23
10	.37	.00	.42	.10	.01	.00	.13	1.68	.00	.06	.27	.31
11	.00	.02	.38	.79	.55	.14	.21	1.48	.71	.00	1.03	.92
12	.13	.02	.16	1.33	.07	1.52	.08	2.75	.00	.01	.02	2.22
13	.23	T.	.00	.20	.87	.73	.52	.01	.31	.06	.20	.09
14	.09	.06	.00	.01	.33	.23	.49	.32	3.20	.59	1.46	.29
15	.45	.28	.00	.00	.20	.05	.01	.62	.01	.02	.56	.11
16	.05	.05	.00	.05	.00	2.75	2.16	.11	.21	.00	.26	.19
17	.02	.13	.00	.00	.00	1.45	.06	.83	.25	.12	.25	.33
18	.01	.33	.94	.00	.00	.09	.53	1.38	2.20	.00	.01	.19
19	.60	1.29	.00	.01	.19	.03	.54	1.24	.53	.15	.13	.13
20	.09	.11	.43	.00	.24	.42	.13	.07	.35	.08	.33	1.03
21	.50	.00	.43	.00	.39	.01	.10	.04	.07	2.52	.19	.01
22	1.34	.00	1.68	.19	.10	.00	2.40	.02	.19	.17	1.23	.30
23	.68	.00	.12	.00	.34	.00	.14	.18	.23	.36	.09	.00
24	.01	.00	.16	.00	.30	.09	.08	.18	.16	.89	.15	.02
25	.02	.00	.08	.00	.08	.06	.12	3.23	.14	.66	.07	.34
26	.00	.19	.03	.68	1.11	.05	.00	.89	.77	.76	.54	.02
27	.87	.06	.00	.00	1.09	.00	1.67	.60	.16	.36	.28	.10
28	.35	.00	.00	.10	1.35	.27	.51	.57	.16	.01	.02	.00
29	.38	......	.00	.00	.02	.14	.14	1.54	.82	.14	1.59	.09
30	.31	......	.00	.01	.50	1.02	.28	.03	2.75	.60	2.07	.00
31	.09	......	.02	......	.33	......	.00	.28	......	.03	......	.00
Total.	9.12	4.49	7.58	4.29	13.36	11.24	16.45	26.46	16.66	8.53	15.69	24.96

Total, from January 1 to December 31, 1900, 158.83.

Rainfall observations at Greytown, Nicaragua, 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.44	0.08	0.52	0.27	0.00	0.35	2.46	0.30	0.00	0.10	0.41	0.00
2	.80	1.00	.00	.03	.00	.00	2.14	.67	.00	.00	.00	.49
3	.92	.00	.03	.28	.00	.00	1.05	.00	.00	.00	.18	.40
4	.27	.47	.00	.40	.00	2.15	.40	5.70	.00	.00	12.48	2.60
5	.50	.25	.00	.30	.00	.11	.10	.07	.00	.00	.78	1.23
6	.59	.02	.00	.12	4.43	.46	.45	.70	.30	.00	.00	.70
7	1.61	.45	1.00	.00	.30	.00	2.14	.36	.85	.00	.00	1.58
8	.67	.00	.45	2.35	.00	.16	.46	1.40	.98	1.21	.14	.35
9	1.17	.00	.00	1.57	.00	.00	3.05	.09	.00	.00	3.24	.38
10	1.91	.02	.03	1.36	.69	.06	3.08	.00	1.73	.00	4.90	.00
11	2.08	.30	.01	.48	.57	.00	4.89	.00	5.60	.00	4.35	.00
12	2.46	2.45	.06	1.36	.03	.06	.06	.00	1.26	.26	2.40	.00
13	.49	.10	.02	.37	.00	.47	3.63	1.06	.53	.00	.70	1.30
14	.46	.04	.55	.00	.00	.22	.67	.28	1.05	1.76	.38	2.33
15	2.50	1.51	.30	.08	.11	.00	.36	4.23	.06	.00	1.84	.00
16	1.32	.45	.05	.00	.00	1.12	.28	.23	3.23	.00	1.09	1.10
17	.01	1.06	2.19	.00	1.46	2.40	.34	4.04	.00	.97	.59	2.12
18	2.21	1.23	.03	.00	1.00	3.07	.71	1.36	1.25	.00	1.38	2.82
19	.19	.87	.00	.05	1.02	.14	.06	.86	.15	1.12	1.25	.93
20	.29	.45	.00	.00	.40	.00	1.92	.08	6.10	4.69	.00	2.03
21	.49	.13	.00	.02	.20	.30	1.90	.80	.65	.00	.00	.93
22	.19	.00	.00	.00	.27	.00	.49	.27	3.52	.88	.00	.87
23	.12	.00	.04	.00	.00	5.25	1.02	.60	.71	.00	.00	2.10
24	.56	.38	.25	.00	.28	.21	1.03	1.97	1.20	.00	.00	.57
25	.00	.01	.02	.00	1.23	.22	1.07	.20	3.15	.60	.00	.97
26	.11	.00	.09	.05	4.00	.67	2.24	1.75	.00	.00	.65	1.83
27	.00	.23	.08	.00	.52	1.85	2.17	.16	2.23	.00	2.20	1.04
28	.00	.19	.25	.00	.35	.80	.00	.68	2.40	.00	.00	.52
29	.05	.00	.00	.00	2.85	.80	.00	.00	.00	.00	.00	.15
30	.02	......	.00	.00	1.16	.10	.12	1.58	.00	.00	1.40	2.53
31	.06	......	1.36	......	.37	......	1.33	.06	......	.85	......	.38
Total.	23.49	11.69	8.33	9.09	21.24	20.97	39.62	29.50	36.95	12.44	40.36	32.25

Total, January 1 to December 31, 1899, 285.93.

Rainfall observations at Greytown, Nicaragua, 1900.

[Charles D. Scott, observer.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.05	0.00	0.20	0.00	0.00	0.00	1.45	1.68	0.30	0.00	2.43	0.16
2	.75	.54	2.25	.27	.00	.00	.00	1.30	.00	.00	7.40	1.63
3	.10	1.04	1.25	.00	.00	1.40	.64	.41	.00	1.00	8.76	.91
4	3.15	.10	.22	.24	.00	.00	2.07	4.40	.00	.22	5.70	.63
5	4.16	.00	.65	.00	.30	.68	1.74	3.10	.00	1.77	.42	1.60
6	1.40	.58	.11	.00	5.60	.18	.64	.92	.00	.00	1.81	1.47
7	.86	.05	.00	.44	2.79	.48	.64	.98	.71	.00	1.34	2.60
8	.73	.00	.00	.11	.42	.00	.00	1.50	.00	.21	4.83	.00
9	.12	.63	.00	.00	.60	.00	.00	.53	.00	1.13	1.83	.82
10	.00	.00	.24	.00	5.08	.00	.00	3.68	.00	2.30	.54	.32
11	.00	.00	1.23	.30	2.10	.28	.22	3.29	.16	.00	.83	1.10
12	.80	.08	.00	.22	.00	.32	.12	.58	.00	.00	.98	.53
13	.57	.00	.00	.00	.00	.40	.18	1.18	2.06	.00	.32	.58
14	.00	.18	.00	.00	.18	.52	.00	3.68	6.29	.00	.32	.00
15	.80	.15	.00	.00	1.38	1.28	.13	.24	.00	2.03	1.43	.00
16	.25	1.23	.00	.00	.00	.29	1.58	.30	.00	.00	.00	.76
17	.00	.50	.00	.00	.00	.13	1.98	.20	.00	.00	.10	.75
18	.00	.00	.18	.59	.00	.00	1.59	1.26	.68	1.30	.06	1.46
19	.32	.95	.00	.00	.00	.00	1.08	.90	1.41	1.28	.15	.42
20	.18	2.58	.00	.00	.00	.13	.48	1.36	.00	4.97	.67	.00
21	.49	.00	.75	.00	.00	.00	1.08	.56	.28	1.45	1.60	.32
22	1.00	.00	.00	.23	.00	.00	3.20	.91	1.86	.00	.57	.92
23	1.38	.00	.39	1.81	.58	.20	.00	.46	.98	.39	.00	.12
24	.00	.00	.00	.00	.00	.00	.10	.56	2.12	1.30	.00	.00
25	.00	.00	.00	.00	.00	2.28	.20	1.40	2.43	.80	.53	.38
26	.18	.48	.00	.00	.00	.10	.29	1.46	1.40	.42	3.32	.58
27	1.42	1.15	.00	.00	.00	.00	3.95	.56	.58	.00	2.68	.00
28	.86	.48	.00	.00	.86	.10	.41	.12	3.41	.00	3.03	.00
29	.10	......	.00	.00	.29	2.42	.10	1.18	.58	.00	2.20	.00
30	.19	......	.00	.41	.76	.24	3.26	.26	1.20	.93	1.53	.18
31	.34	......	.00	......	1.12	......	.00	.00	......	.94	......	.00
Total.	21.20	10.72	7.47	4.62	22.06	11.43	27.13	38.96	26.45	22.44	55.38	18.24

Total, from January 1 to December 31, 1900, 266.10.

Rainfall at Greytown, Nicaragua.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1890	26.80	6.36	5.93	18.11	4.93	46.84	52.55	35.72	8.14	24.36	25.55	41.65	296.94
1891	20.30	2.57	1.95	10.40	13.78	26.95	23.57	19.49	14.16	20.21	28.15	32.74	214.27
1892	28.57	11.38	4.98	18.38	50.88	13.42	38.96	23.63	11.47	27.95	36.93	24.65	291.20
1893	17.70	7.53	3.93	9.99	2.77	......	......	......	......	......	......	......	......
1898	19.44	25.17	10.16	7.82	9.37	19.52	24.63	16.38	7.24	12.50	32.35	17.06	201.64
1899	23.49	11.69	8.33	9.09	21.24	20.97	39.62	29.50	36.95	12.44	40.36	32.25	285.93
1900	21.20	10.72	7.47	4.62	22.06	11.43	27.13	38.96	26.45	22.44	55.38	18.24	266.10
Mean	22.50	10.77	6.11	11.20	17.86	23.19	34.41	27.28	17.40	19.98	36.45	27.76	259.35

Monthly rainfall of Nicaragua, 1898.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Brito and Tola	0.25	0.00	0.08	0.08	11.30	14.86	11.42	6.17	16.60	25.70	6.01	2.41	94.88
Rivas	1.07	.12	.10	.00	16.17	18.95	13.65	11.85	13.99	20.83	8.19	3.11	108.06
Las Lajas	.25	.05	1.34	.28	10.60	13.50	10.64	8.44	6.79	16.19	4.41	2.26	74.75
Rio Viejo	......	.01	.66	.00	13.78	13.45	4.01	11.66	7.28	8.99	.61	.17	60.62
Tipitapa	......	.00	.26	.00	8.56	16.88	6.24	7.82	11.25	7.12	.93	.17	59.23
Morrito	......	......	......	.07	8.92	14.05	13.84	10.20	......	......	......	......	......
Fort San Carlos	......	......	1.21	3.00	8.22	15.56	13.35	8.00	10.56	8.93	9.86	5.62	84.31
Sabalos	......	......	2.10	6.00	11.69	17.13	20.69	11.33	11.42	11.81	12.17	10.20	114.51
Castillo	......	......	......	......	......	......	18.92	11.46	16.22	4.64	14.04	11.64	......
Machuca	......	......	......	......	......	......	......	6.52	12.86	9.83	15.65	6.75	......
Rio San Carlos	......	......	7.52	11.66	20.12	20.79	18.26	11.68	......	......	......	......	......
Ochoa	13.07	14.08	8.04	12.23	15.25	21.47	21.60	12.08	15.12	8.02	21.50	8.38	170.84
San Francisco [a]	15.33	18.43	8.72	11.25	13.87	18.87	19.22	13.45	10.95	9.09	22.28	10.61	172.17
Sarapiqui	......	......	......	......	......	......	......	......	11.19	11.35	18.63	7.12	......
Deseado [b]	21.92	26.98	11.76	8.83	14.84	18.66	26.86	13.31	5.23	11.92	29.25	21.07	210.63
Greytown	19.44	25.17	10.16	7.82	9.37	19.52	21.63	16.38	7.24	12.50	32.35	17.06	201.64

[a] Record incomplete from January 1–5, inclusive, and from December 29–31, inclusive; so the rainfall at Ochoa for those days is added.

[b] Rainfall not observed from December 25–31, 1898; so the record was completed by including the corresponding days of 1897.

Rainfall in Nicaragua and Costa Rica during 1899, in inches.

Location.	Observer.	Total.	Jan.	Feb.	Mar.	Apr.
Acoyapa	Modesto Cuadra					
Basillas	Sherwood Wilson					
Bluefields	T. W. Waters					
Castillo	John Augustine	114.50	10.32	6.47	2.02	2,21
Chichigalpa	S. H. Young	58.20	.00	.00	.00	.60
Colorado	H. Scharschmidt			10.72	11.83	13.17
Granada	S. Vargas	56.93	.00	.52	.11	.02
Do	Nicaragua Sugar Estates	60.33	.36	.43	.00	.00
Greytown	Chas. D. Scott	285.93	23.49	11.69	8.33	9.09
Indio (Negro)	S. H. Harris					
Javali mine	W. H. S. Grigsby					
Juigalpa	J. J. Sequeira					
La Libertad	Pelayo Porto					
Machuca	A. Faris	93.08	12.96	4.61	1.65	5.61
Managua	T. Bird					
Masaya	J. Weist	45.24	.50	.48	.07	.00
Matagalpa	W. K. Henley					
Momotombo	A. Peterson					
Moyogalpa	K. B. Luna					
Ochoa	H. S. Reed	176.91	14.02	7.96	5.80	7.09
Penon	Fernando Loredo					
Rama	T. W. White					
Rivas	Earl Flint	67.82	.85	1.70	.65	.00
Do	J. O. Jones					
Rio Frio	Sherwood Wilson					
Rio San Carlos	H. S. Reed					
Sabalos	R. H. Morrin	98.55	9.82	4.33	2.73	2.65
San Antonio plantation	Nicaragua Sugar Estates	67.22	.00	.44	.00	.00
San Carlos	E. Humphreys	77.20	4.99	2.79	1.05	1.48
San Francisco	T. Merriman					
San Miguelito	S. F. Cuadra					
San Ubaldo	Frank Trap					
Sapoa	M. C. Hogan					
Sarapiqui	T. F. Boltz et al	190.40	16.57	7.77	5.67	9.13
Sardinas	T. Montiel					
Sucia (Boca)						
Tipitapa	F. Davis et al		.26			
Tola gauge station	J. O. Jones					
Valle Menier	V. Gavinet					
Veijo	Fred Favls					
Zapote	J. C. Kennedy					
Do	G. B. Zampieri					

Location.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Established.
Acoyapa				9.60	3.30	15.32	8.95	1.20	Aug. 10
Basillas					.49	5.95	9.22	1.96	Sept. 26
Bluefields				2.18	29.11	8.10	9.55	9.75	Aug. 26
Castillo	5.90	9.29	18.11	17.73	12.01	8.21	15.33	6.90	
Chichigalpa	.88	4.56	5.13	6.88	4.06	32.29	3.80	.00	
Colorado	19.11		43.99	29.78		11.92			
Granada	2.43	8.78	6.64	15.44	2.39	14.79	5.24	.57	Jan. 25
Do	2.48	10.19	7.47	14.77	3.78	15.13	4.85	.87	
Greytown	21.24	20.97	39.62	29.50	36.95	12.44	40.36	32.25	
Indio (Negro)						.25	18.55	18.65	Oct. 27
Javali mine					5.60	8.81	7.65	4.78	Sept. 17
Juigalpa				4.25	.83	12.97	10.26	.60	Aug. 19
La Libertad				7.05	2.85	8.33	9.12	5.46	Aug. 16
Machuca	7.08	8.58	18.33	18.79	5.69	1.91	4.09	3.78	
Managua					2.21	18.59	2.79	.11	Sept. 16
Masaya	2.02	8.62	4.19	9.47	2.80	10.35	5.54	1.20	
Matagalpa					1.43	15.88	5.29	1.18	Sept. 12
Momotombo					.97	26.55	5.30	.62	Sept. 16
Moyogalpa					3.08	18.32	5.99	7.03	Sept. 1
Ochoa	12.60	15.69	30.20	17.50	15.49	7.85	20.58	22.13	
Penon					4.94	9.11	5.24	2.02	Sept. 13
Rama				2.65	11.58	10.90	13.42	8.33	Aug. 18
Rivas	1.62	7.53	10.69	9.26	5.15	20.39	9.06	.92	
Do							5.91	.57	Nov. 7
Rio Frio						.90	8.36	3.53	Oct. 21
Rio San Carlos						6.03	20.32	18.03	Oct. 12
Sabalas	5.50	11.31	15.87	12,15	14.70	6.67	8.09	4.73	
San Antonio plantation	2.12	9.82	8.08	9.60	5.50	26.85	4.81	.00	
San Carlos	3.18	11.24	9.28	9.23	10.67	10.66	9.43	3.20	
San Francisco					.82	1.60	6.82	3.00	Sept. 23
San Miguelito						8.13	6.95	2.78	Oct. 5
San Ubaldo		1.80	4.30	9.45	6.22	11.10	9.31	1.87	June 21
Sapoa			5.42	8.74	5.34	6.45	8.59	1.98	July 16
Sarapiqui	14.78	12.90	24.89	21.05	17.05	10.55	29.29	20.75	
Sardinas							11.59	1.71	Nov. 1

Rainfall in Nicaragua and Costa Rica during 1899, in inches—Continued.

Location.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Established.
Sucia (Boca)	....	....	....	....	13.72	13.95	30.32	19.88	Sept. 17
Tipitapa	....	....	....	2.22	2.57	11.69	5.42	.44	([a])
Tola gauge station	....	....	....	4.81	3.35	29.49	5.48	.52	Aug. 13
Valle Menier	....	....	....	....	2.04	15.95	6.11	.00	Sept. 2
Veijo	....	....	....	1.39	2.27	16.91	2.29	.08	Aug. 18
Zapote	....	....	12.33	11.63	9.45	8.04	16.23	6.18	July 3
Do	....	....	....	....	....	10.57	14.78	7.09	Oct. 3

[a] Discontinued January 24; reestablished August 20.

Rainfall in Nicaragua and Costa Rica during the year 1900, in inches.

Location.	Observer.	Total.	Jan.	Feb.	Mar.	Apr.
Acoyapa, Nicaragua	Modesto Cuadra	65.04	0.58	0.21	0.22	0.16
Arenal, Costa Rica [a]	Godfrey Hahn	121.70	4.45	2.73	3.18	4.25
Basillas Island, Nicaragua	S. Wilson et al	77.10	1.78	1.04	.52	.34
Boca Sucia, Costa Rica	....	....	9.65	.80	....	....
Bluefields, Nicaragua	Thomas W. Waters	127.63	5.70	6.95	3.55	1.05
Castillo, Nicaragua	John Augustine	....	....	4.37	2.22	2.32
Frio (5 miles up), Costa Rica.	Fred Davis	102.66	3.17	2.31	.92	.75
Granada Wharf, Nicaragua	Stephen Vargas	72.10	.26	.00	.03	.02
Granada City, Nicaragua	Nicaragua Sugar Estates	82.46	.45	.00	.00	.10
Greytown, Nicaragua	Charles D. Scott	266.10	21.20	10.72	7.47	4.62
Juigalpa, Nicaragua	J. Jesus Sequeira	37.73	.05	.12	.18	.22
Las Haciendas, Nicaragua	R. de Hennin	....	....	....	....	....
Machuca, Nicaragua	J. S. Martinez et al	137.88	1.37	1.67	2.05	2.39
Managua, Nicaragua	T. Bird	53.55	.00	.00	.00	.00
Masaya, Nicaragua	J. Wiest	59.70	.00	.00	.00	.00
Matagalpa, Nicaragua	W. K. Henley et al	85.68	.24	.36	.87	1.09
Momotombo, Nicaragua	A. Peterson	55.21	.00	.00	.00	.00
Moyogalpa, Nicaragua	K. B. Luna	71.70	.13	.03	.22	.05
Negro (Indio), Nicaragua	S. H. Harris	....	12.32	12.69	5.50	2.51
Ochoa, Costa Rica	H. S. Reed	158.83	9.12	4.49	7.58	4.29
Palo Seco, Costa Rica [b]	A. Quintania	....	....	4.37	5.47	3.62
Rama, Nicaragua	G. W. White et al	110.35	2.52	3.31	3.20	1.48
Rivas, Nicaragua	Earl Flint	94.68	.19	.02	.11	.02
Rivas, Nicaragua [c]	Charles Hayman	....	....	....	....	....
Sabalos, Nicaragua	Thomas F. Boltz	107.34	3.19	3.84	1.69	.64
San Antonio plantation, Nicaragua.	....	95.68	.00	.00	.55	1.02
San Carlos River, Costa Rica.	H. S. Reed	157.30	8.79	4.96	6.56	3.00
San Carlos, Nicaragua	Fred Davis et al	98.34	3.09	2.66	.81	.41
San Juanillo, Nicaragua	Fred Appleby	249.20	18.79	11.79	7.18	2.28
San Miguelito, Nicaragua	J. F. Cuadra	81.11	1.38	1.02	.49	1.40
San Ubaldo, Nicaragua	G. C. W. Magruder	74.26	1.22	.19	.27	.09
Sapoa, Nicaragua [d]	M. C. Hogan	103.60	1.11	.57	.63	.54
Silico, Nicaragua [e]	E. A. Keys	....	....	....	1,08	2.69
Sarapiqui, Costa Rica	Paulino Gonzalez	151.48	9.65	5.00	10.76	2.63
Sardinas, Nicaragua	Tomas Montiel	....	1.89	2.73	.61	.20
Solentiname, Nicaragua [f]	J. M. Boniche	84.68	1.66	1.95	1.10	1.40
Tipitapa, Nicaragua [g]	L. Roy Cannon	....	.00	.02	.00	.15
Tola gauge station, Nicaragua.	J. O. Jones	90.04	.17	.00	.01	.33
Valle Menier, Nicaragua	V. Gavinet (Nandaime)	....	.00	.00	.00	.31
Zapote (Upper), Costa Rica	G. B. Zampieri	128.64	4.09	2.62	2.29	1.44

Location.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Acoyapa, Nicaragua	11.31	10.19	12.91	4.76	9.36	12.96	1.12	1.26
Arenal, Costa Rica [a]	17.35	7.11	15.95	13.71	15.42	11.61	13.64	12.30
Basillas Island, Nicaragua	9.54	4.49	10.67	14.05	12.48	14.45	2.97	4.77
Boca Sucia, Costa Rica	....	....	....	....	....	....	....	....
Bluefields, Nicaragua	10.40	8.90	14.60	23.55	11.20	12.32	14.90	14.51
Castillo, Nicaragua	18.01	9.82	18.42	33.83	15.24	21.38	6.86	16.93
Frio (5 miles up), Costa Rica.	13.61	11.68	13.29	12.21	11.76	20.15	6.19	6.62
Granada Wharf, Nicaragua	12.06	17.63	12.40	3.93	7.60	16.70	1.42	.05
Granada City, Nicaragua	16.01	19.74	13.40	5.58	9.46	15.90	1.60	.22
Greytown, Nicaragua	22.06	11.43	27.13	38.96	26.45	22.44	55.38	18.24
Juigalpa, Nicaragua	6.49	2.05	3.42	3.77	9.79	10.56	.63	.45

[a] Upper San Carlos River.
[b] Established February 7.
[c] Established June 15.
[d] Removed to Tortuga July 16.
[e] Established March 22. Discontinued July 6.
[f] Isla Venado, Lake Nicaragua.
[g] Discontinued October 30.

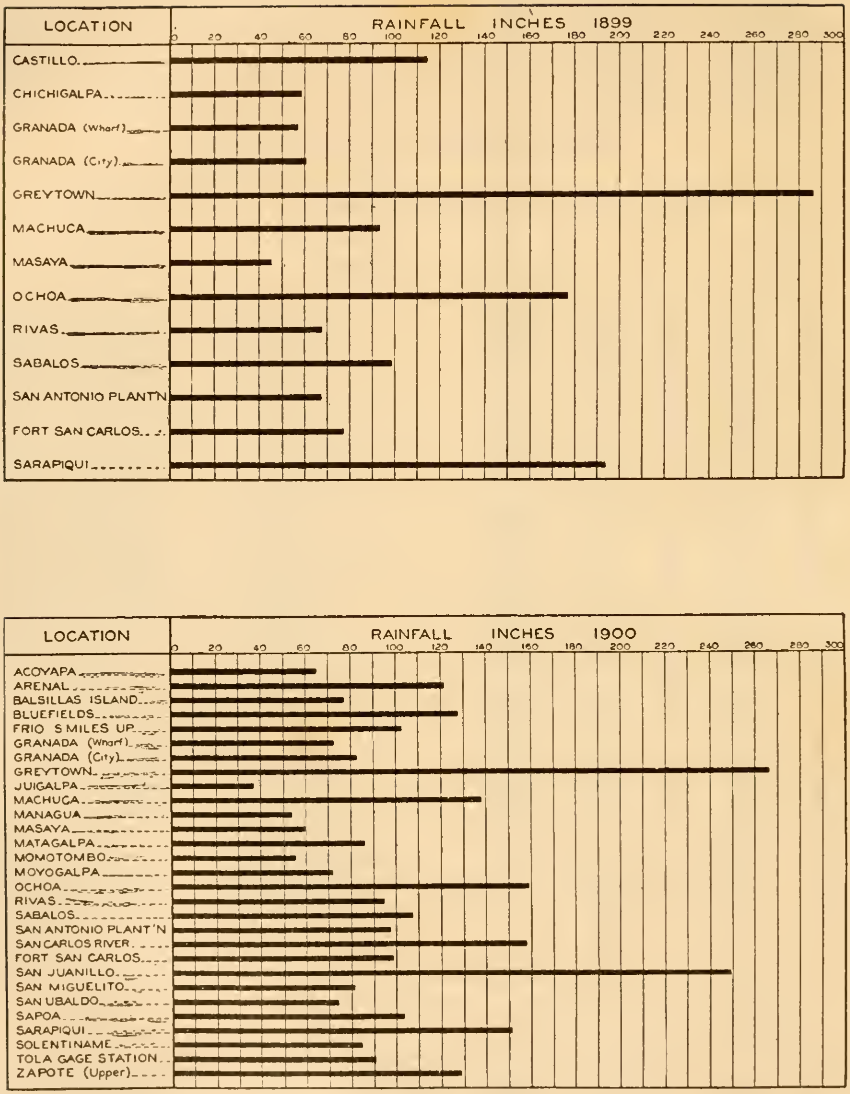

FIG. 15 —COMPARATIVE RAINFALL AT ALL STATIONS.

Rainfall in Nicaragua and Costa Rica during the year 1900, in inches—Continued.

Location.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Las Haciendas, Nicaragua	8.95	7.58	16.45	12.05	20.61	22.14	5.58	....
Machuca, Nicaragua	17.70	7.46	22.65	25.80	18.20	10.68	12.35	15.56
Managua, Nicaragua	6.62	8.54	7.97	3.83	7.57	17.48	1.37	.17
Masaya, Nicaragua	8.66	15.52	10.27	4.70	7.23	11.24	1.91	(17)
Matagalpa, Nicaragua	16.06	14.49	13.13	5.12	10.40	17.35	4.27	2.30
Momotombo, Nicaragua	6.67	13.48	6.96	.90	5.63	18.78	2.06	.73
Moyogalpa, Nicaragua	13.59	11.46	8.28	7.95	12.44	15.63	1.58	.34
Negro (Indio), Nicaragua	18.13	10.41	12.67	40.15	12.85	....	....	....
Ochoa, Costa Rica	13.36	11.24	16.45	26.46	16.66	8.53	15.69	24.96
Palo Seco, Costa Rica [b]	16.01	13.98	15.15	24.96	18.34	11.18	18.12	25.80
Rama, Nicaragua	12.70	6.73	16.30	19.56	19.58	10.97	7.61	6.39
Rivas, Nicaragua	11.19	16.38	10.61	9.16	22.58	21.93	1.18	1.31
Rivas, Nicaragua [c]	....	5.07	6.93	6.82	16.86	18.12	.87	.62
Sabalos, Nicaragua	8.57	8.37	16.89	20.40	11.24	16.34	6.72	9.45
San Antonio Plantation, Nicaragua	6.05	22.46	18.81	6.80	13.69	24.45	1.85	.00
San Carlos River, Costa Rica	15.42	11.26	15.53	22.72	21.36	6.45	16.56	24.69
San Carlos, Nicaragua	14.19	6.04	15.44	15.29	15.02	13.59	5.42	6.38
San Juanillo, Nicaragua	17.18	6.53	22.66	41.01	28.18	24.84	43.34	25.42
San Miguelito, Nicaragua	13.58	10.19	15.83	8.46	7.20	13.41	4.71	3.44
San Ubaldo, Nicaragua	7.44	9.85	24.91	5.32	14.08	8.91	1.43	.55
Sapoa, Nicaragua [d]	10.21	12.85	14.74	10.70	23.75	22.28	3.91	2.31
Silico, Nicaragua [e]	15.81	8.72	6.28	....	....	....	....	....
Sarapiqui, Costa Rica	10.54	9.84	22.24	23.48	6.99	11.08	24.86	24.86
Sardinas, Nicaragua	....	....	....	....	....	....	....	....
Solentiname, Nicaragua [f]	12.47	5.31	8.63	14.21	15.43	14.89	4.04	3.59
Tipitapa, Nicaragua [g]	13.53	12.60	12.58	6.04	8.32	15.00	....	....
Tola Gauge Station, Nicaragua	12.91	12.29	15.67	4.53	24.15	18.46	.87	.65
Valle Menier, Nicaragua	10.36	11.00	9.94	4.64	11.54	17.46	....	....
Zapote (Upper), Costa Rica	12.13	7.11	17.55	14.50	23.93	18.22	13.43	11.33

Rainfall.

SAN ANTONIO PLANTATION.

[Latitude, 12° 32′ N.; longitude, 86° 59′ W.; elevation, 66 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1895	0.00	0.00	0.00	......	7.98	6.29	3.36	5.07	21.68	21.71	3.42	0.32	69.83
1896	.00	.00	.00	.20	12.20	10.50	7.54	4.71	13.39	11.22	4.76	.98	65.50
1897	.00	.00	1.26	.59	18.23	14.53	6.81	13.86	10.94	31.06	.98	.00	98.26
1898	.24	.00	.00	.00	16.00	11.60	8.37	14.85	16.71	7.60	5.64	.04	81.05
1899	.00	.44	.00	.00	2.12	9.82	8.08	9.60	5.50	26.85	4.81	.00	67.22
1900	.00	.00	.55	1.02	6.05	22.46	18.81	6.80	13.69	24.45	1.85	.00	95.68

VALLE MENIER.

[Latitude, 11° 46′ N.; longitude, 85° 57′ W.; elevation, 492 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1880	0.00	0.00	0.00	0.00	13.48	9.92	2.24	9.96	6.77	13.46	2.72	0.00	58.55
1881	.55	.00	.00	.00	9.94	12.88	7.52	8.86	9.10	22.68	9.33	.98	81.84
1882	.00	.00	.00	.00	1.93	12.87		6.30	4.92	19.13	2.76	.00	47.91
1883	.00	.00	.00	.00	1.35	7.44	3.94	....	....	....	....	....	....
1899	.00	.00	.00	.00	....	....	....	....	2.04	15.95	6.11	.00	....
1900	.00	.00	.00	.31	10.36	11.00	9.94	4.64	11.54	17.46	....	....	....

MANAGUA.

[Latitude, 12° 7′ N.; longitude, 86° 16′ W.; elevation, 148 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891	0.00	0.00	0.00	0.00	1.08	14.00	5.04	3.04	8.43	9.64	7.24	0.43	48.90
1892	.00	.00	.00	.00	8.58	11.34	6.35	7.98	9.24	20.55	3.09	....	67.13
1899	....	....	....	....	....	....	....	....	2.21	18.59	2.79	.11	....
1900	.00	.00	.00	.00	6.62	8.54	7.97	3.83	7.57	17.48	1.37	.17	53.55

EVAPORATION.

The observation of evaporation by means of pans floating in the water was carried on under both the Nicaragua and Isthmian Canal commissions.

The inherent obstacles to accurate work by this method are great at all times, and, as might be expected, results are rather discordant. They are summarized in the tables following:

Monthly evaporation of Lake Nicaragua.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1898.												
San Ubaldo	......	......	......	6.42	6.26	5.19	5.08	4.87	......	......	......	......
Las Lajas	......	......	5.77	8.13	5.98	4.35	3.38	3.41	2.73	2.73	3.00	3.01
Fort San Carlos	......	......	4.74	4.92	4.56	4.20	3.84	3.69	3.54	4.09	3.39	4.03
Mean	......	......	5.25	6.49	5.60	4.58	4.10	3.99	3.13	3.41	3.20	3.52
1899.												
Las Lajas	3.40	3.39	4.25	......			......	......	......	......	......	......
Fort San Carlos	3.72	3.28	4.34	5.01	4.65	3.60	......	......	2.02	2.85	2.23	2.70
San Ubaldo	......	......	......	......	......	......	3.87	3.87	3.78	4.40	3.72	3.71
Sapoa	......	......	......	......	......	......	......	......	......	3.56	3.24	3.91
Tipitapa	......	......	......	......	......	......	......	......	5.58	5.42	3.97	5.79
Mean	......	......	......	......	......	......	......	......	3.79	4.06	3.29	4.03
1900.												
San Carlos	2.89	3.16	4.36	4.62	4.31	3.93	2.63	2.24	3.24	2.35	3.39	3.04
San Ubaldo	4.57	4.24	5.47	5.79	7.59	4.95	5.46	5.05	4.74	4.64	3.90	4.03
Sapoa	4.36	5.40	6.33	6.41	5.12	3.19	2.54	2.30	3.36	......	......	......
Tipitapa	3.28	4.02	5.89	6.66	7.28	5.16	4.49	4.25	4.89	5.18	......	......
Mean	3.78	4.21	5.61	5.87	6.08	4.31	3.78	3.46	4.06	4.06	3.64	3.53

Allowance must be made in the use of these results for the fact that the conditions prevalent on the lake can not be duplicated in the evaporating pan. During the greater part of the year the trade winds blow strongly from the eastern side of the lake to the western. Except along the eastern shore the surface of the lake is blown into billows, the waves often attaining a considerable height and being crowned with whitecaps, and the total water surface in contact with the wind is much greater than the level surface of the lake. Most of the lake surface must therefore lose by evaporation a greater depth of water than the pan.

The rate of evaporation during the dry season was obtainable by another method. The fluctuations of the lake were observed, and by applying to this the observations of rainfall upon the lake, the inflow from streams, and the discharge of San Juan River we obtain the evaporation actually taking place upon the lake. During April, 1898, the evaporation was found by this method to be 6.12 inches. The results for 1900 are given in the following table:

Evaporation from Lake Nicaragua—Dry season of 1900.

[Evaporation = fall of lake + rainfall + inflow − outflow.]

	Fall of lake.	Rainfall on surface of lake.	Inflow.	Total.	Outflow.	Evaporation.	Inches per day.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Ft. In.*	
February	0.71	0.08	0.11	0.93	0.44	0.49=5.88	0.21
March	.83	.04	.10	.97	.40	.57=6.84	.22
April	.70	.04	.07	.81	.35	.46=5.52	.18
May 1-15	.32	.08	.03	.43	.17	.26=3.12	.21

Area of lake, 1,904,000 acres. Rainfall on surface of lake is an average of the rainfall at Basillas, Granada, Moyogalpa, San Carlos, San Miguelito, San Ubaldo, Sapoa, and Solentiname.

FIG. 16.—LOWERING SEDIMENT TRAP ON SARAPIQUI.

REGULATION OF LAKE NICARAGUA.

Lake Nicaragua being the summit level upon which the water supply for the canal depends, and from which the surplus water must be discharged, its history, and especially the extreme variations of its supply, are important. Its fluctuation depends upon four factors:

1. The inflow, which is a function of the amount and character of rainfall in the basin.
2. The storage capacity of the lake.
3. The evaporation, which varies with the seasons.
4. The outflow, which varies with the elevation of the lake.

The problem of the storage capacity is simple, and its solution is known with all desirable accuracy. The area of the lake is 2,975 square miles, or 1,904,000 acres.

The evaporation from the lake has been fairly well determined and can be allowed for without important error. It is given in the table, page 186.

The outflow was observed during 1898, 1899, and 1900 at Camp Farina, above Rio Sabalos, which is the first important tributary to the river.

The inflow has been observed by noting the fluctuation of the lake surface at four stations—San Carlos, San Ubaldo, Granada, and Sapoa. This, after allowing for evaporation and outflow, gives the inflow.

It has not been possible to fix with certainty the limits of the natural fluctuation of Lake Nicaragua, but the best information obtainable indicates that the range is about 14 feet, from 97 as the minimum to 111 as the maximum.

The maximum stage was estimated as follows:

All the oldest inhabitants in the vicinity of the lake agree that a stage attained in 1861 was higher than any since reached. No more definite statement could be established than that it was "nearly up to the top of the wharf at Granada." The top of the wharf, in the lowest place, is at an elevation of 111.24 feet above sea level. If the mean lake level was within half a foot of the top of the wharf during the customary breeze in that region, it is probable that the waves would wash over the wharf, and the report would be that the water was over the top of the wharf. It is thought that the facts indicate 111 as about the elevation of the stage reported, as nearly as it can be determined.

The low-water limit of 97 feet is taken on the information of Mr. William Climie, who testifies that the lake was lower in 1886 than it has been since, and all obtainable evidence on the subject is to the effect that no lower stage has occurred within the memory of persons now living.

All available testimony, and especially that of the engineman on the steamer *Victoria*, who has been in continuous service for sixteen years, is to the effect that the steamer *Victoria* has in that period always been able to discharge her cargo directly upon the wharf, but at times of extreme low water, occurring at very rare intervals, she could not come alongside, but had to lie off the end of the wharf, touching only her bow. This was the condition in May, 1897. A diagram of the whart is shown in the sketch, figure 17. At the time it was made the water stood at 5.8 reading on the gauge-rod, or 104.24 feet above sea level. It shows the bottom of the lake to be at an elevation of about 93 feet near the end of the wharf, and somewhat lower, say

92 feet, off the end, where the steamer lay at low water. The boat draws from 4 feet of water, when empty, to 7 feet when fully loaded.

Allowing her 6 feet of water in May, 1897, the stage of the lake was about 98 feet above sea level, or at least it could not have been lower than this.

If the lake were 1 foot lower than this in 1886, it would give a stage of 97, and this is probably near the true minimum.

These data fix the natural limit of fluctuation at 14 feet, though no fluctuation approaching this amount occurs in any one year, nor even in any two. The low water of 1886 was preceded by three successive years of low rainfall, as shown by the Granada record for 1883 and 1884, and by the Rivas record for 1885, the latter being the lowest in the Rivas record of twenty years, with one exception. A study of the rainfall tables indicates another stage of extremely low lake just before the rainy season of 1897; this being preceded by three years of less than normal rainfall. This indication is confirmed by popular reports of an extremely low lake level at that time, and accounts for the fact that the heaviest rainfall of the record, 1897, did not produce as high a lake as had occurred in other years. Though no observations of the lake were made in 1897, those of 1898, considered with the rainfall record of 1897, indicate that the lake did not reach stage 107. (See diagram, figure 21.) Its stage at the end of 1897 is known to have been about 105, by observations of the Nicaragua Canal Commission.

Judging from the table of rainfall, considered in the light of known facts, the lake has passed through minimum stages in May of the years 1886, 1891, and 1897; and maximum in the autumns of 1889, 1893, 1900. None of these stages is exactly known except that of 1900, in which year the lake reached a maximum stage of 107.42 feet on the 27th day of October, and maintained about the same elevation for one week.

In this discussion we are concerned mainly with the years of maximum and minimum rainfall, as giving the extreme conditions under which Lake Nicaragua must be controlled. All the records and traditions at hand indicate that the year 1897 was the year of greatest precipitation in this vicinity ever recorded. Dr. Flint gives for Rivas a total for that year of 123.43 inches, a rainfall over 15 inches greater than any other in his record, while the report of Mr. Climie, for Granada, substantially confirmed by that of the sugar company, gives 93.62 inches for that year, being greater than any other year in either Granada or Masaya records. It may therefore be taken as the year of maximum rainfall within the range of the records. It is fortunate that this is the case, for we then have direct comparison by the same observer of the rainfall for 1897 with that for the three years covered by the observations of the fluctuations of Lake Nicaragua by this Commission. The year of minimum rainfall occurs in the Masaya record for 1890, being only 20.52 inches, and being but little more than half of that for 1896, which is the next driest year in the Masaya record. The year is also the year of smallest precipitation in Dr. Flint's record at Rivas, and gives very much less rainfall than he gives for any other year covered by the Masaya record. It seems safe to conclude, therefore, that 1890 was actually the year of smallest precipitation within the records.

The Rivas record is the longest and most continuous, and is nearly

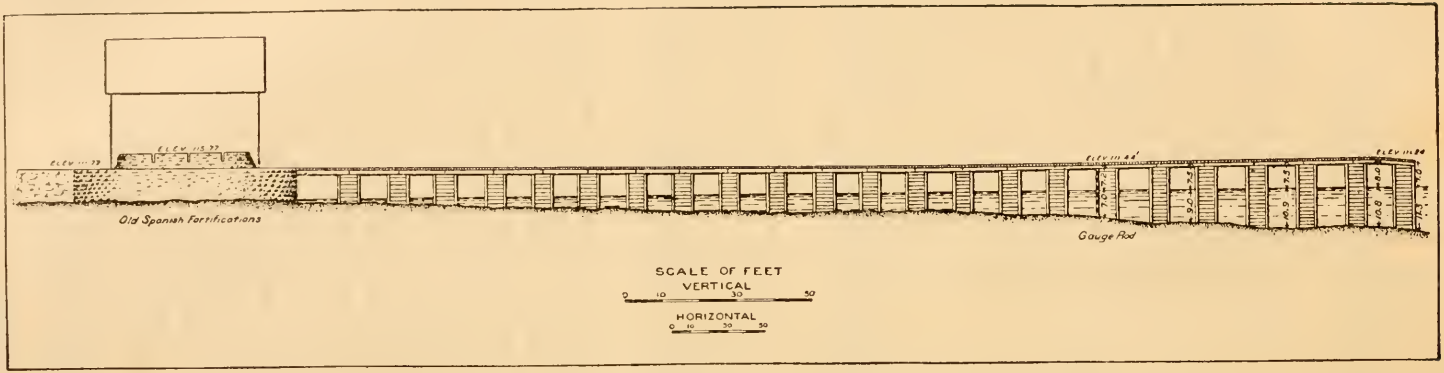

FIG. 17.—WHARF AT GRANADA.

on the canal line and nearly on the lake shore. In all these respects it promises very desirable and valuable information, completely covering the period from 1880 to date. An examination of this record, however, is somewhat disappointing. During the year 1898 Mr. J. A. Bull, an observer of the Nicaragua Canal Commission, was stationed at Las Lajas, near the point where the canal leaves the shore of the lake. This point is only about 5 miles from Rivas, not greatly different in elevation or surrounding conditions that might affect the rainfall, and yet the precipitation recorded at Rivas exceeded that observed at Las Lajas by the percentages shown in the following table:

	Las Lajas.	Rivas.	Excess.		Las Lajas.	Rivas.	Excess.
	Inches.	*Inches.*	*Per cent.*		*Inches.*	*Inches.*	*Per cent.*
May	10.60	16.17	52.5	October	16.19	20.83	28.7
June	13.50	18.95	40.4	November	4.41	8.19	85.7
July	10.64	13.65	28.3	December	2.26	3.14	38.9
August	8.44	11.85	40.4				
September	6.79	13.99	106.03	Total	72.83	106.77	46.6

This table indicates that the Rivas record is too large. Comparing it year by year with the recent records at Granada and Masaya also tends to confirm the result indicated above.

	Granada.	Masaya.	Rivas.	Excess.		Granada.	Masaya.	Rivas.	Excess.
	Inches.	*Inches.*	*Inches.*	*Per cent.*		*Inches.*	*Inches.*	*Inches.*	*Per cent.*
1890	....	20.50	31.81	50.3	1896	....	39.64	47.80	20.6
1891	....	49.98	66.03	32.1	1897	93.62	....	123.43	31.8
1892	....	64.54	78.27	21.3	1898	55.59	....	108.06	94.4
1893	....	72.86	106.13	45.7	1899	56.93	....	67.82	19.10
1894	....	42.88	47.32	10.3	1900	72.10	....	94.68	31.3
1895	....	41.26	47.68	15.56					

While Granada and Masaya are at considerable distance from Rivas and under somewhat different topographic conditions, there is no obvious reason why they should have less rainfall; and this evidence, so far as it goes, tends to confirm the indication of the Las Lajas record, that the record at Rivas is too large. A similar result is obtained by a comparison of the Rivas record with the movements of Lake Nicaragua. Many months occur in which the rise of the lake, if all water had been held by a dam on the Rio San Juan and evaporation eliminated, would have been much less than the reported rainfall at Rivas, proving that the rainfall on the surface of Lake Nicaragua is less than recorded at Rivas.

These facts, coupled with the great importance of the accuracy of any record on which estimates are to depend, led to the establishment, in June, 1900, of a rainfall observer in Rivas, whose gauge is located not more than 300 yards from that upon which the long record has been taken. The observer employed by the Commission was Mr. Charles Hayman, who thoroughly understood the work and who was cautioned to be extremely careful. The comparison of the observations is given below. It shows that the record of Dr. Flint exceeded that taken by Mr. Hayman in every month, and seems to establish the fact that the results reported by Dr. Flint are too large.

Comparison of rainfall observations made at Rivas, Nicaragua, by Dr. Earl Flint and the observer of the Isthmian Canal Commission, June 15 to November 30, 1900.

Day.	June.		July.		August.		September.		October.		November.	
	Dr. Flint.	Commission.	Dr. Flint.	Commission.	Dr. Flint.	Commission.	Dr. Flint.	Commission.	Dr. Flint.	Commission.	Dr. Flint.	Commission.
1	......	......	0.99	0.79	0.18	0.04	0.75	0.01	0.17	0.10	0.00	0.00
2	......	......	.00	.00	.00	.00	.00	.00	1.30	.98	.00	.03
3	......	......	.20	1.01	.60	.47	.00	.00	1.50	1.26	.05	.09
4	......	......	1.55	.15	.40	.24	.71	.52	1.30	1.20	.00	.00
5	......	......	.85	.38	.14	.35	.14	.21	.92	.27	.00	.00
6	......	......	.55	.35	.46	.10	.00	.03	1.29	1.43	.00	.00
7	......	......	.20	.15	.07	.02	2.70	2.53	2.00	.98	.06	.00
8	......	......	.26	.35	.00	T.	.63	.37	.13	.07	.08	.05
9	......	......	.66	.36	.48	.35	.16	T.	.00	.00	.08	.06
10	......	......	.21	.28	.00	.02	.40	.17	.00	.02	.00	.00
11	......	......	.87	.45	.02	.20	.09	.00	.00	.01	.00	.02
12	......	......	.30	1.07	.30	T.	.74	.69	.50	.39	.02	.00
13	......	......	1.49	.04	.00	.00	.20	.03	.11	.11	.08	.00
14	......	......	.07	.06	1.60	1.10	.06	.00	.33	.11	.00	.00
15	0.00	0.01	.00	.17	.13	.02	.00	.98	.02	.04	.00	.04
16	.70	.04	.40	.16	.03	.01	1.70	.44	.31	.17	.30	.39
17	.60	.99	.20	.16	.00	T.	.40	.13	.80	.60	.28	.00
18	.60	.01	.80	.44	.00	.00	.07	.00	.30	.44	.04	.01
19	.00	.00	.30	.10	.00	.15	1.97	1.95	.79	.33	.00	.01
20	1.26	.92	.05	.01	.10	.20	.50	.00	.01	1.95	.08	.04
21	1.50	1.18	.00	.02	.49	.02	.00	.00	3.15	3.50	.00	.00
22	.00	.18	.10	.00	1.61	.34	1.70	1.42	4.80	2.71	.00	.00
23	.30	T.	.07	.00	.50	1.35	1.42	1.07	.31	.19	.00	.00
24	1.48	1.19	.04	.10	.90	.59	.57	.37	.90	.65	.00	.00
25	.00	.01	.00	.00	.02	.01	.00	.01	.99	.61	.01	.00
26	.00	.00	.00	.00	.43	.70	.08	.05	.00	.00	.00	.00
27	.00	.00	.00	.00	.70	.13	.00	.00	.00	.00	.11	.06
28	.07	.03	.00	.18	.00	.00	.00	.00	.00	.00	.00	.00
29	.00	.00	.37	.02	.00	.00	4.18	3.40	.00	.00	.00	.00
30	.75	.51	.08	.06	.00	.00	3.41	2.48	.00	.00	.00	.07
31	......	......	.00	.07	.00	.43	......	......	.00	.00	......	......
	7.26	5.07	10.61	6.93	9.16	6.84	22.58	16.86	21.93	18.12	1.19	.87
Excess	43 *P. ct.*		53 *P. ct.*		34 *P. ct.*		34 *P. ct.*		21 *P. ct.*		37 *P. ct.*	

These comparisons show that the record of Dr. Flint exceeded that taken for the Commission in every month, the average excess being about 37 per cent, confirming the indications previously referred to.

For these reasons it is deemed safer at present to eliminate the Rivas records from consideration in estimating the probable relation between the recorded rainfall and the action of Lake Nicaragua. We have then left available for comparison only those records for Masaya and Granada. Some of these are published in the report of the Nicaragua Canal Commission, pages 280 and 281, and comprise a complete record at Granada for 1877 taken by Dr. Flint, and complete records for 1883–1884 observed by the National Institute at Granada. From the end of 1884 to the beginning of 1897 we have no records for Granada, but for 1887 to 1896, inclusive, we have a complete record for the town of Masaya, taken by Mr. William Climie. This record is believed to be entirely reliable, but is not coincident with any observations of Lake Nicaragua. Early in 1897 Mr. Climie removed his gauge to Granada, and gives the record for 1897 and 1898 at that place. The rainfall was also observed in 1897 by the officials of the Nicaragua sugar estates in the city of Granada, and their record continues up to the present time. It gives about 2 per cent less rainfall for 1897 than that of Mr. Climie, but the results are sufficiently accordant to confirm the substantial accuracy of both. During 1899 and 1900 a guage was maintained by this Commission at Granada, and these observations also serve to con-

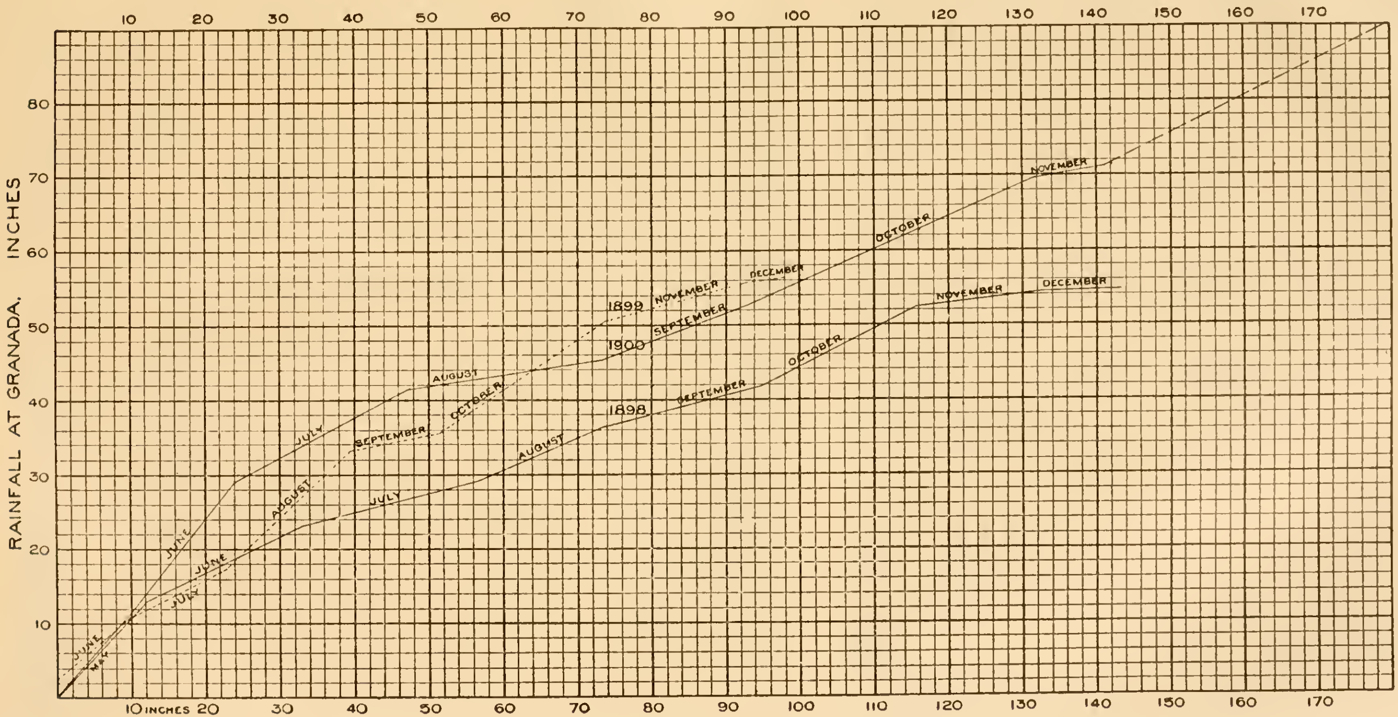

FIG. 18.—RISE OF LAKE, WITH NO OUTFLOW NOR EVAPORATION, COMPARED WITH RAINFALL AT GRANADA.

firm the substantial accuracy of those furnished by the Sugar company. We therefore have a continuous record from 1887 to date, the worst feature of which is that during the first ten years it was taken at Masaya and the last four years at Granada. Masaya is at an elevation of nearly 600 feet above Granada and is not on the drainage of Lake Nicaragua, but lies in a small basin which drains into Lake Masaya. Observations taken under the direction of Mr. Jacob Wiest in Masaya are at hand covering the period from June 11, 1898, to November 30, 1900, which includes the major portion of three rainy seasons coincident with observations taken in Granada. The distance from Masaya to Granada is about 10 miles, which precludes comparison day by day, but a monthly comparison is shown below, which shows considerable difference from the precipitation observed at Granada, that at Masaya being less.

Comparison of Granada and Masaya rainfall records, 1899 and 1900.

Months.	Granada.	Masaya.	Differences.	Months.	Granada.	Masaya.	Differences.
1899.				1900.			
January 25–31	0.00	0.50	0.50	January	0.26	0.00	0.26
February	.52	.48	.04	February	.00	.00	.00
March	.11	.07	.04	March	.03	.00	.03
April	.02	.00	.02	April	.02	.00	.02
May	2.43	2.02	.41	May	12.06	8.66	3.40
June	8.78	8.62	.16	June	17.63	15.52	2.11
July	6.64	4.19	2.45	July	12.40	10.27	2.13
August	15.54	9.47	5.97	August	3.93	4.70	.77
September	2.39	2.80	.41	September	7.60	7.23	.37
October	14.79	10.35	4.44	October	16.70	11.24	5.46
November	5.24	5.54	.30	November	1.42	1.91	.49
December	.57	1.20	.63	December	.05	([a])	([a])
Total	56.93	45.24	11.69	Total	72.10	59.53	12.57

[a] No record.

MAXIMUM SUPPLY TO LAKE NICARAGUA.

To obtain the probable inflow to the lake during the season of greatest rainfall, 1897, we compare the rainfall at Granada for that year with the rainfall at the same place for some year during which the behavior of Lake Nicaragua was observed. For the purpose of this comparison the diagram, figure 18, has been prepared. It shows three lines, each of which represents the relation of Granada rainfall to the run-off from the basin for one rainy season, the lines being plotted with the Granada rainfull as ordinates and the fluctuation of Lake Nicaragua that would have occurred if there had been neither outflow nor evaporation as abscissæ. This diagram is essentially accurate, involving no errors excepting those of observation. Apparently the two years of observation most suitable for comparing with 1897 are the years of 1898 and 1900, these being the years of greatest rainfall of the three observed. A diagram was plotted in which the line for 1898 was used as the basis for estimating the run-off corresponding to rainfalls observed in 1897. On this basis the fluctuation of the lake in 1897 would, if all water had been held, have amounted to nearly 14 feet, bringing the elevation of the lake in the spring of 1897 below 92 feet. There is abundant evidence that this stage of lake did not occur, and that the indication of the observations of 1898 is therefore erroneous, giving a much greater fluctuation than really occurred.

This could only be the case if the rainfall for 1898 was lower in proportion to the run-off of the basin than that of 1897. That this was really the case is indicated by an examination of the annual total rainfalls for Granada and Rivas on page 189. These show that whereas the record for Granada exceeded that for Rivas by 32 per cent in 1897, 19 per cent in 1899, and 31 per cent in 1900, in 1898 the excess was 94.4 per cent. Though the rainfall record of Rivas is rejected as inaccurate, the above indication is significant when taken in connection with the known facts of the fluctuation of Lake Nicaragua.

The estimate of run-off for 1897 was next made, using the observations of 1900 as the basis. The results were obtained by months, taking the run-off indicated by the given rainfall from the 1900 line on the diagram (fig. 18), and adding thereto the evaporation corresponding to the period covered. The result is taken as the fluctuation of the lake due to the rainfall and considered with evaporation in full play and with a dam in the river preventing outflow. This result is shown by the continuous line in the diagram (fig. 21). The dotted line in the same diagram shows the fluctuation of the lake on the assumption that the outflow to the San Juan River was that occurring in the state of nature due to the altitude of the lake. It therefore represents the actual changes that took place in the lake surface during 1897 as inferred from the observations of 1898 and 1900.

The rainfall in 1897 was greater than that for 1900, and it was necessary to extrapolate the line indicated in figure 18 for 1900. This is shown by the discontinuous line on the diagram for 1900.

The fluctuation of the lake as indicated by this method is about 10 feet in the aggregate, or a little over 8 feet net. The stage of January 4, 1898, having been observed by the Nicaragua Canal Commission, it is known that the lake stood at about 105 at the end of December, 1897. The elevation indicated for May, 1897, 96.7, is somewhat lower than that indicated by the estimate on page 187 and by reports of people who were in Nicaragua at that time, notably Mr. William Climie. But if this is the case, the errors are on the side of safety and the indications of the diagram may safely be taken as correct.

THE SEASON OF MINIMUM SUPPLY.

To obtain the probable fluctuation of the lake during nineteen months ending May, 1891, which, as has been shown, includes two dry seasons, and the driest rainy season in all the records at hand, comparison is made between the rainfall for that period at Masaya and the rainfall for 1900 at the same place when the behavior of the lake was observed. The only two years available for this comparison are 1899 and 1900, the former being not quite complete. The relation of rainfall at Masaya and the fluctuation of the lake is shown in fig. 19, page 193, two lines being plotted, for 1899 and 1900 respectively, as indicated, on the same basis as figure 18, already described.

It will be seen from the diagram that by taking 1900 as the basis of comparison we obtain more conservative results than if 1899 were used; that is, a given rainfall at Masaya corresponds to less inflow to the lake than in 1899, this difference being for a dry season on the side of safety.

On both diagrams it will be noticed that in the latter part of the year the line tends to approach a horizontal position, there being a

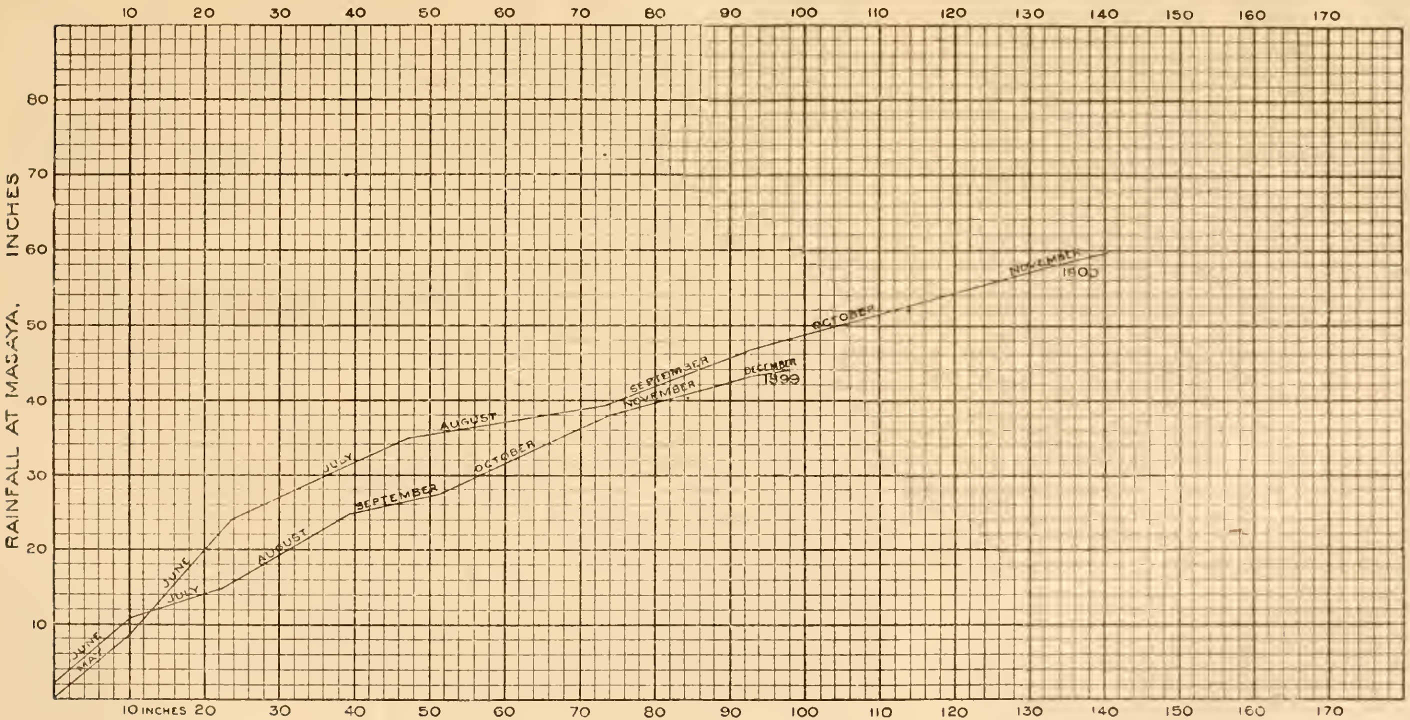

FIG. 19.—RISE OF LAKE, WITH NO OUTFLOW NOR EVAPORATION, COMPARED WITH RAINFALL AT MASAYA.

considerable run-off during the months of November and December with little or no rainfall, this, of course, being due to the rainfall of previous months. During 1890 there were only 20.52 inches of rainfall at Masaya, and this quantity corresponds to the rainfall plotted in the diagram before the end of June at a time when the rainy season had only endured a little over a month and when considerable rain had fallen that had not yet reached the lake, but which did so later on. This introduces an actual error into the assumption which may be important, but the magnitude of which can not be accurately estimated. Against this error must be placed the well-known fact that for a large rainfall the percentage of run-off is greater than for a small one on an average, or, in other words, the ratio of run-off to rainfall in 1900 was in the aggregate greater than in 1890. How far these two errors balance each other can not, of course, be known, but it is practically certain that their resultant is to an important degree an error on the side of safety.

The result is shown in figure 22, and indicates the fall of the lake from the 1st of November, 1889, to the end of May, 1891, the driest consecutive period of nineteen months of which we have record. It indicates that if all water had been held by a dam at the outlet of the lake, and 1,000 cubic feet per second had been used for canal purposes throughout that period, the surface of the lake would have declined 6.2 feet. No resistance can be offered to the decline of the lake during a dry period, except to keep all sluices closed, and therefore we may expect an unavoidable decline under extreme conditions of 6.2 feet in nineteen months.

The rise of the lake in seasons of excessive rainfall can be combated by the discharge of water through the dam at Boca San Carlos and into the valley of Grande River on the west side.

It is not permissible to use the latter outlet extensively, owing to the danger of carrying to the sea an excessive quantity of detritus and thereby obstructing the harbor at Brito. It is necessary, therefore, that the surplus waters be discharged to the eastward through the San Juan River.

If adjustable sluices be provided at Boca San Carlos, to discharge any desired quantity of water, the problem resolves itself into the estimation of the capacity of the canalized San Juan River. This is a function of the cross section, roughness, and slope, the latter depending upon the stage of the lake.

To determine the coefficient of roughness, computations were made of the value of the factor "*n*" in Kutter's formula, using measured slope, velocity, cross section, and discharge of the San Juan River. These computations, which were exceedingly laborious, were made by Mr. S. H. Woodard, and the resulting mean values of "*n*" varied from 0.022 to 0.024. Applying the latter value to the canalized river, its discharging capacity was computed for the various elevations at the lake and at Boca San Carlos. The accompanying diagram (fig. 20) has been constructed by Mr. Woodard, showing his results. It shows that with water at the dam held at 104 the discharging capacity varies from zero to 63,000 cubic feet per second, while the lake level rises from 104 to 110.

Applying these facts to the lake supply shown in figures 18 and 19, we obtain results shown in figure 22.

That is, if the canal had been constructed and the lake surface at

107.3 on the 1st of June, 1897, the lake would have risen to 110.6 by the end of June, in spite of the discharge through the river with sluices left open, holding the water level at 104 at the dam. During July and August the discharge would have been greater than the inflow, and the lake might have been drawn down to 109.8. It would have risen slightly in September, and receded again in October. But after June the discharge would have been checked, because it is necessary to hold the lake at 110.2 at the end of October to provide against exceptional drought. The aim would have been, therefore, for obvious reasons, to hold the lake as nearly as possidle to the line A B C, and after the end of June this could have been accomplished.

If, instead of the very wet year 1897, the driest year in the record, 1890, had occurred, the sluices would have remained closed, and the lake surface would have declined 3.3 feet under the combined influence of inflow, evaporation, and the consumption of 1,000 cubic feet per second, from 107.3 to 104, by the opening of the following rainy season, when the lake may be expected to rise.

If the elevation of 104 feet be adopted as the minimum summit level to be permitted, the lake must be at a stage not lower than 107.3 feet at the beginning of the rainy season, as it may be a season of minimum precipitation, so that the lake will decline 3.3 feet in the ensuing twelve months. To do this, each rainy season must be closed with the lake at 110.2 as the unavoidable loss during the dry season is 2.9 feet, as shown by figure 22. Should the following wet season be one of heavy rainfall like 1897, the lake will rise to about 110.6 in spite of all the discharge of which the river is capable. If, instead of a very wet season, the rainfall should be slight, like that of 1890, the lake would decline to 104 by the opening of the next rainy season, with all the sluices closed.

Our present information indicates, therefore, that the lake can be kept within limits of 6.6 feet, provided two minimum years do not occur in succession, which seems to be a safe assumption.

As neither the maximum nor minimum years have been actually observed, there is necessarily some uncertainty in any estimates that can be made for such years. It has been the effort to make the estimates conservative, as indicated in the discussion. If actual conditions should occur which are more extreme than those we have considered, it might be necessary to allow a greater fluctuation than 6.6 feet. If a season of greater inflow than that estimated for 1897 should occur, it would be necessary to allow the lake to stand temporarily at a higher level than 110.6. If experience should show a season of less inflow than that estimated for 1890, it would be necessary to begin each rainy season with the lake surface higher than 107.3 and to close it with the lake above 110.2 in order to prevent its decline below 104. A very slight increase in the upper limit allowed is a great relief to the conditions, since this not only increases the allowable fluctuations, but also increases the discharge capacity of the river. If the lake should reach a height of 111 feet, it would only be repeating the conditions that have probably occurred in its natural state. The water might rise to a height of 112 feet, or even higher, without doing any great amount of damage, and it is probable that permission to allow this could without difficulty be included in the concession. We could then begin each month of June with the lake at elevation 108; if the rainy season should furnish 20 per cent more water than that estimated for 1897, we could still control the lake within the 112-foot

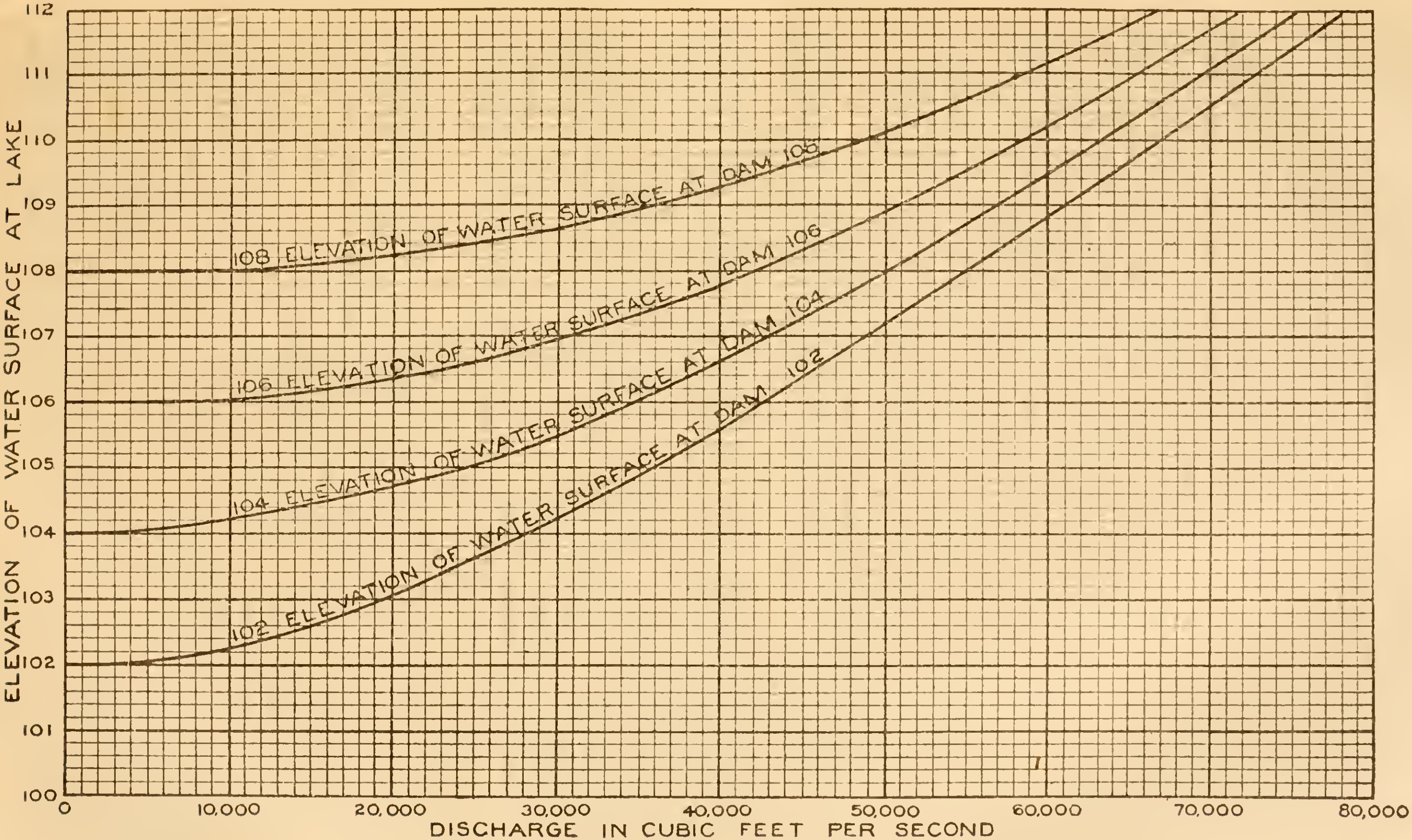

FIG. 20.—DISCHARGE CAPACITY OF CANALIZED SAN JUAN RIVER.

limit. If, instead, the rainy season should furnish only one-half the supply estimated for 1890, the lake would fall to just 104 by the opening of the next rainy season. This is certainly a very wide margin of safety.

TEMPERATURE AND RELATIVE HUMIDITY.

The temperature of Nicaragua is remarkably uniform. While some of the higher mountain regions have a rather cool climate, there is never any frost, and in general it may be said that in the inhabited portion of the country the temperature seldom exceeds 95° or falls belows 70°, and in any given locality the annual fluctuation is usually still less. The relative humidity is high, except during the dry season on the west side of the isthmus.

Temperature and relative humidity at Tola gauge station, Nicaragua.

Months.	Temperature.			Mean relative humidity.	Months.	Temperature.			Mean relative humidity.
	Maximum.	Minimum.	Mean.			Maximum.	Minimum.	Mean.	
1900.					1900.				
January	85.0	74.0	79.0	81.0	July	87.0	73.0	78.9	89.4
February	86.5	73.0	81.0	79.6	August	88.0	75.5	80.6	93.2
March	91.5	73.0	82.5	78.2	September	90.0	72.5	80.6	94.0
April	94.0	75.5	84.8	79.0	October	88.0	72.0	79.0	95.2
May	93.0	73.5	82.0	88.2	November	87.0	72.0	79.6	88.6
June	86.5	72.0	80.5	86.2	December	88.0	74.0	79.8	88.6

Temperature and relative humidity.

SAPOA, NICARAGUA.

Months.	Temperature.			Mean relative humidity.
	Maximum.	Minimum.	Mean.	
1899.				
August	87.0	72.0	79.6	87.8
September	96.0	70.0	80.5	89.0
October	94.0	71.0	78.9	89.4
November	86.0	70.0	78.5	89.8
December	84.0	72.0	80.3	87.0
1900.				
January	84.5	73.0	77.9	88.6
February	86.0	73.0	79.0	87.8
March	89.0	73.0	80.3	85.0
April	94.0	75.0	80.4	82.6
May	93.5	75.0	82.8	84.6
June	91.5	72.0	81.3	88.4
July	89.5	74.0	79.9	89.8
August	87.5	74.0	80.8	90.0
September	88.0	74.0	79.8	92.0
October	86.0	71.0	78.9	94.0
November	86.0	71.0	78.9	91.8
December	86.0	72.0	79.1	91.4

RIVAS, NICARAGUA.

1900.				
January	78.0	75.0	76.2	86.2
February	79.0	73.0	77.4	80.8
March	81.5	74.0	78.5	78.6
April	83.0	79.0	81.0	80.8
May	83.5	77.0	80.0	85.4
June	81.0	75.0	78.6	89.8
July	80.5	75.0	77.8	89.4
August	81.0	76.0	79.0	86.2
September	80.5	76.0	77.8	90.2
October	79.0	74.0	77.0	91.0
November	80.0	73.0	77.4	89.0
December	79.2	72.0	77.7	82.6

Temperature and relative humidity—Continued.

SAN UBALDO, NICARAGUA.

Months.	Temperature.			Mean relative humidity
	Maximum.	Minimum.	Mean.	
1899.				
September	95.0	72.0	81.7	88.0
October	91.0	72.0	79.8	91.0
November	91.0	72.0	80.0	88.6
December	88.0	67.0	78.5	84.6
1900.				
January	92.0	69.0	79.6	81.8
February	93.0	69.0	80.7	79.4
March	99.0	68.0	82.9	76.8
April	98.0	72.0	86.3	73.8
May	101.0	75.0	85.8	79.4
June	94.0	75.0	82.9	88.8
July	92.0	71.0	81.4	87.2
August	93.0	73.0	83.0	84.0
September	93.0	73.0	83.1	84.2
October	91.0	70.0	80.6	92.4
November	90.0	71.0	80.3	85.4
December	91.0	70.0	81.2	79.2

FORT SAN CARLOS, NICARAGUA.

1899.				
January	84.0	69.0	75.9	90.5
February	85.0	66.0	76.9	87.5
March	90.0	70.0	77.6	83.7
April	93.0	69.0	79.6	80.2
May	93.0	71.0	80.4	82.2
June	....	....	....	....
July	86.0	73.0	78.6	91.4
August	87.5	72.0	78.0	90.6
September	89.0	73.0	79.1	89.4
October	86.5	73.0	79.2	90.6
November	84.0	72.0	77.7	89.4
December	84.0	69.0	76.5	91.4
1900.				
January	85.0	72.0	77.6	90.2
February	85.5	70.5	76.9	93.0

CAMP SABALOS, NICARAGUA.

1899.				
January	86.0	66.0	75.2	90.7
February	86.0	64.0	76.0	87.6
March	90.0	68.0	77.1	85.0
April	91.0	67.5	78.2	83.0
May	92.0	70.0	79.4	83.4
June	....	....	....	....
July	88.0	74.0	78.3	91.0
August	92.0	71.5	77.8	91.0
September	91.0	71.5	78.4	89.9
October	91.0	71.0	78.9	89.9
November	87.0	71.0	77.2	87.0
December	84.0	66.0	75.1	91.0
1900.				
January	85.0	66.5	75.3	88.8
February	87.0	68.0	76.0	85.0
March	89.0	67.0	76.8	85.0
April	96.0	67.5	79.5	80.6
May	95.5	72.0	80.4	83.2
June	90.0	71.0	79.0	87.6
July	87.0	72.0	77.0	91.4
August	86.5	72.5	77.0	91.4
September	92.0	72.0	78.7	88.8
October	89.0	71.0	77.8	91.8
November	86.0	68.5	74.6	91.4
December	85.0	68.5	76.4	88.2

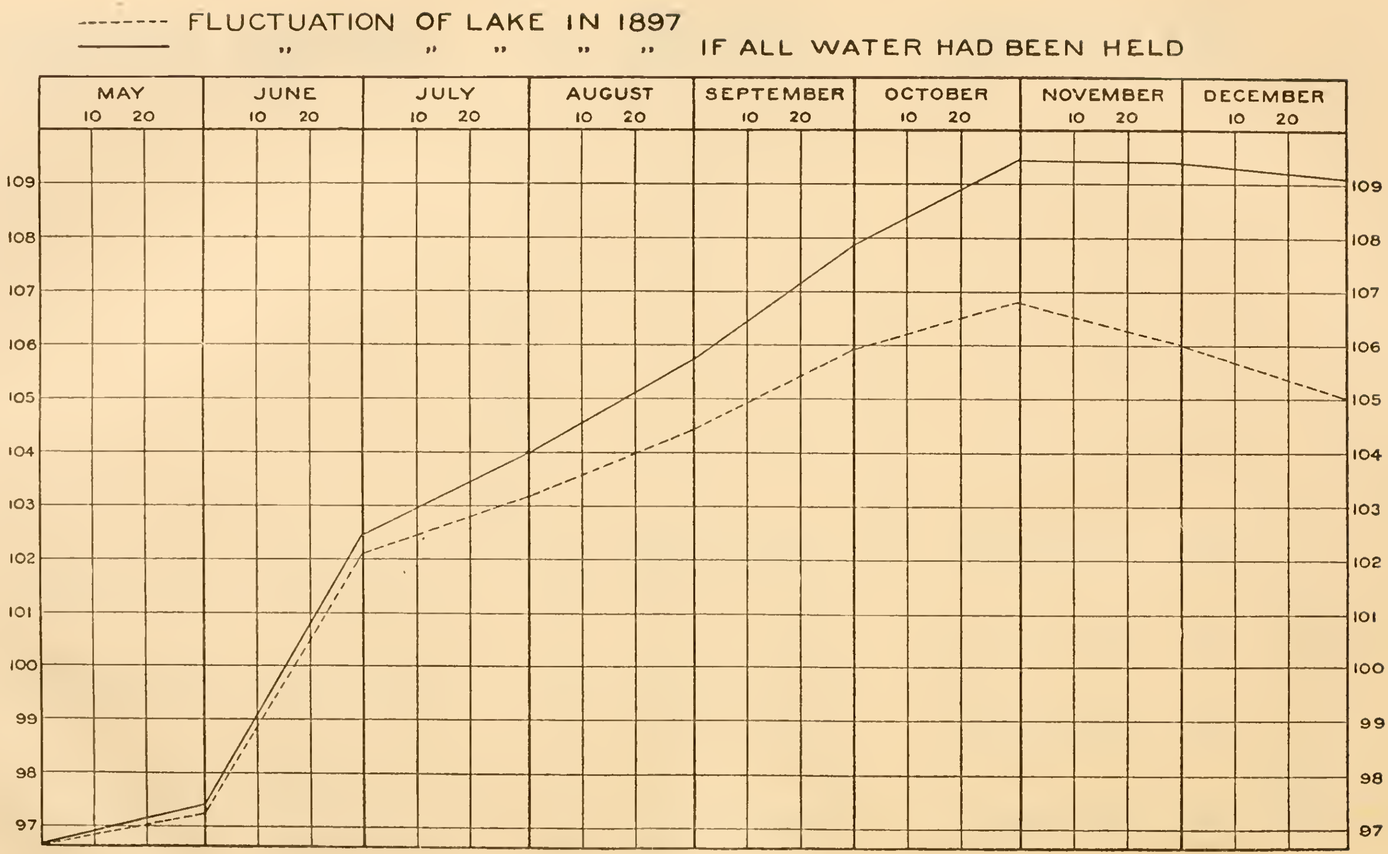

FIG. 21.—ESTIMATED INFLOW OF LAKE DURING 1897, BASED ON OBSERVATIONS OF 1900.

Temperature and relative humidity—Continued.

OCHOA, COSTA RICA.

Months.	Temperature.			Mean relative humidity.
	Maximum.	Minimum.	Mean.	
1899.				
January	84.5	67.0	74.8	93.2
February	86.0	68.0	75.3	91.9
March	91.0	67.0	75.6	89.7
April	88.5	68.0	76.6	87.0
May	89.5	70.0	77.9	90.6
June	86.0	72.0	77.7	90.2
July	85.5	72.5	77.3	92.6
August	86.0	71.5	77.5	92.2
September	90.0	72.0	78.4	89.8
October	88.5	72.5	79.0	89.0
November	87.0	72.0	77.4	91.4
December	84.5	68.0	75.1	92.6
1900.				
January	83.5	70.0	75.7	90.6
February	87.0	70.0	76.6	87.8
March	87.0	69.0	77.1	87.0
April	93.5	69.0	79.8	85.4
May	92.5	74.0	80.4	87.0
June	91.0	73.0	79.6	88.6
July	87.0	71.5	78.0	90.6
August	86.0	73.5	77.9	92.6
September	92.5	73.0	80.0	87.0
October	87.5	72.5	78.6	89.8
November	86.0	70.5	77.0	91.0
December	85.0	70.5	76.8	90.6

GREYTOWN, NICARAGUA.

1899.				
January	86.0	69.0	77.8	87.3
February	88.0	66.0	77.2	87.7
March	90.0	72.0	79.7	80.9
April	92.0	70.0	80.6	78.0
May	98.0	72.0	81.0	84.0
June	89.0	74.0	79.5	85.4
July	88.0	73.0	78.7	86.2
August	88.0	72.0	78.0	87.4
September	90.0	73.0	79.3	86.6
October	88.0	72.0	80.3	84.2
November	88.0	73.0	78.2	88.6
December	85.0	70.0	76.0	88.2
1900.				
January	87.0	71.0	77.4	87.0
February	89.0	71.0	78.6	85.0
March	89.0	71.0	78.3	83.0
April	94.0	70.0	81.7	80.8
May	93.0	74.0	81.2	85.6
June	92.0	75.0	81.1	83.2
July	91.0	73.0	78.6	87.8
August	89.0	75.0	80.0	86.2
September	92.0	74.0	80.9	84.8
October	91.0	73.0	79.3	87.8
November	88.0	72.0	77.2	89.8
December	86.0	71.0	78.6	84.2

SEDIMENT OBSERVATIONS.

Any proposition for a ship canal which involves the use of the San Juan River below the mouth of the San Carlos requires for its intelligent consideration some idea of the quantity of sediment carried by that stream, and if the San Juan is to be used below the mouth of the Sarapiqui the sediment carried by that stream becomes also an important factor. To determine these quantities samples of water were taken daily, allowed to settle, and the sediment measured. The samples were taken at not less than a dozen places in the river, the water taken aggregating several gallons, and representing approximately the average of the various parts of the current. The samples were thoroughly mixed, and one sample of 100 cubic centimeters taken from the mixture and the rest rejected. The sample taken was allowed to settle for twenty-four hours, the clear water poured off, and another sample added to the remainder, the clear water was decanted, the next day another sample added, and so on, accumulating any sediment that remained until it became a measurable quantity, when its depth was read on the graduated glass in which the settlement was made. This reading gives, of course, only the bulk of the loose mud, and not the dry solid matter. The relation between the mud and dry matter as determined by a series of experiments for a similar purpose made on sediment from the Gila River, Arizona, was five parts of mud to one of dry material. This factor has, therefore, been used in reducing the results.

The taking of water samples and measurement of sediment therein would not furnish all the required data, as these streams roll large quantities of sand and gravel along their beds, which could not be taken in water samples. So far as could be learned, no attempt at such measurements had ever been made, and it was recognized as a task of difficulty. The method devised was as follows:

A galvanized sheet-iron pan was provided (fig. 6, p. 155), 1 meter square and 8 inches deep, with one side hinged so that it could be opened to lie in the same plane as the bottom of the pan, and a weight and stays were provided to hold it in this horizontal position. Four chains, attached one to each corner of the top of the pan, met about 4 feet above the pan and united in a ring, and the whole was suspended from a cable stretched across the river, with the door open upstream. An anchor was thrown about 100 feet upstream to hold the pan firmly in position, while it was gently lowered from the cable by means of a rope from shore working in tackle blocks. The pan was allowed to settle firmly on the bottom and to remain for a limited time, usually one hour. The attempt is to cause the minimum disturbance of natural conditions in the stream, and to intercept and hold in the pan the sediment traveling along the bottom in the section it occupies. When it is desired to close the observation, a small copper wire which has been fastened to the open door and passed through the ring above the pan is stoutly pulled until it raises the lid from the bottom of the stream, whereupon the current catches and slams the lid shut, where it is automatically fastened by a latch on each side. Then, by means of a windlass on shore, the pan is hoisted and brought to land and the entrapped sediment measured.

There is nothing about this operation to increase the motion of sediment along the bottom into the pan, so it is thought that results can never be too large. On the other hand, some sand may pass under the edge of the lid when the bottom of the river at this point is marred with local inequalities. This is supposed to be one cause of the small results on certain days, when other observations immediately before or after give large results. Another persistent source of error of unknown magnitude is the washing out of the sediment by the current over the weir formed by the back of the pan. To test the importance of this theoretical possibility a temporary partition was placed in the pan perpendicular to the current, and nearly as high as the sides of the

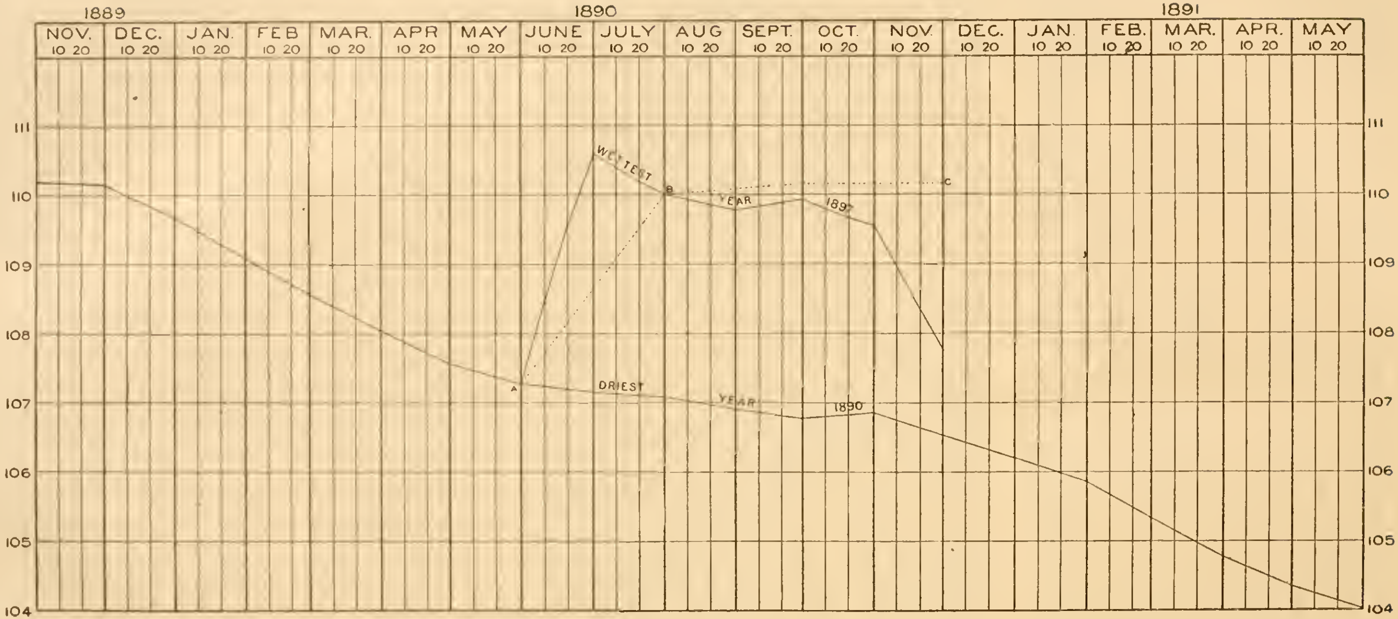

FIG. 22.—FLUCTUATION OF LAKE DURING DRIEST AND WETTEST YEARS, BASED ON RUN-OFF OF 1900.

pan, the theory being that if all sediment were stopped by the partition and deposited in front of it that would be good evidence that in the absence of the partition all would be stopped by the back of the pan and none lost. In the first experiment more sediment was deposited behind than in front of the partition, and the quantity that passed out of the pan is unknown. This result was essentially repeated for most of the experiments, showing conclusively that more or less sediment is carried out over the back of the pan by the scour which it occasions. It is important to bear this fact in mind when studying the results, for it is certain that the results are quantitatively too small, and should be regarded as showing that large quantities of sediment are traveling on the bed of the stream, and as roughly indicating the relative amount.

Sediment by water samples from San Juan River at Sabalos Station.

[Five cubic yards of mud are assumed equal to 1 cubic yard of solid matter.]

Months.	Mud.	Solid matter.	Months.	Mud.	Solid matter.
1900.	*Cubic yds.*	*Cubic yds.*	1900.	*Cubic yds.*	*Cubic yds.*
January	1,224,120	244,824	July	1,038,808	207,762
February	677,936	135,587	August	831,234	166,247
March	609,691	121,938	September	612,973	122,595
April	641,073	128,215	October	566,014	113,203
May	758,470	151,694	November	542,392	108,478
June	717,401	143,480	December	534,232	106,846

Sediment, by water samples, from San Juan River at Ochoa.

Months.	1899.		1900.	
	Mud.	Solid matter.	Mud.	Solid matter.
	Cubic yards.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*
January	1,139,623	227,925	1,348,513	269,703
February	860,125	172,025	651,461	130,292
March	765,275	153,055	585,215	117,043
April	1,055,212	211,042	474,309	94,862
May	1,162,524	232,505	913,695	182,739
June	709,230	141,846	1,267,086	253,417
July	2,969,998	594,000	1,526,670	305,334
August	2,257,480	451,496	1,869,237	373,847
September	3,107,248	621,450	2,759,489	551,898
October	1,260,497	252,099	3,727,661	745,532
November	2,658,002	531,600	2,498,526	499,705
December	1,696,789	339,358	2,097,570	419,514

NOTE.—Five cubic yards of mud are assumed equal to 1 cubic yard of solid matter.

Sediment rolled on bottom of San Carlos River.

COSTA RICA.

Date.	Gauge height.	Amount collected per hour.	Total for river.	Mean for month.	Total for month.	Remarks.
1899.		*Cubic centimeters.*	*Cu. yards per hour.*	*Cu. yards per hour.*	*Cubic yards.*	
April 18	11.40	27,124	7.10			Gravel and sand.
April 24	11.05	950	.25			Do.
April 29	10.95	9,954	2.60	3.32	2,390	Do.
May 11	10.80	53,088	13.89			Do.
May 22	11.40	34,400	9			Do.
May 26	12.80	44,993	11.17	11.55	8,593	Do.
June 5	11.55	28,203	7.38			Do.
June 13	12.90	34,839	9.11			Do.
June 27	12 75	94,563	24.74	41.23	29,686	Do.

Sediment rolled on bottom of San Carlos River—Continued.

COSTA RICA—Continued.

Date.	Gauge height.	Amount collected per hour.	Total for river.	Mean for month.	Total for month.	Remarks.
		Cubic centimeters.	*Cu. yards per hour.*	*Cu. yards per hour.*	*Cubic yards.*	
1899.						
July 19	15.40	101,200	26.47	26.47	19,694	Gravel and sand.
August 2	14.80	115,530	30.22			Do.
August 12	13.70	46,752	12.23			Do.
August 18	13.86	105,660	27.64			Do.
August 25	14.45	78,555	20.55			Do.
August 28	13.60	51,615	13.50	20.83	15,498	Do.
October 7	13.00	102,465	26.80			Do.
October 30	12.70	29,100	7.61			Do.
October 31	12.80	41,940	10.97	15.13	11,257	Do.
November 4	12.50	41,300	10.80	10.80	7,776	Do.
December 4	14.72	11,500	3.01	3.01	2,239	Do.
1900.						
March 15	11.36	6,300	1.65			Do.
March 21	11.10	4,400	1.15			Do.
March 23	12.13	21,350	5.59	2.80	2,083	Do.
May 14	11.70	36,900	9.65	9.65	7,180	Do.
June 27	12.41	31,080	8.13			Do.
June 29	14.16	16,537	4.33	6.23	4,486	Do.
August 29	14.37	5,124	1.34	1.34	997	Do.
September 6	13.50	64,075	16.76			Do.
September 8	14.50	65,700	17.19	16.97	12,218	Do.

Sediment rolled on bottom of Sarapiqui River.

COSTA RICA.

Date.	Gauge height.	Amount collected per hour.	Total for river.	Mean for month.	Total for month.	Remarks.
		Cubic centimeters.	*Cu. yards per hour.*	*Cu. yards per hour.*	*Cubic yards.*	
1899.						
March 2	8.3	6,500	0.84			Sand and gravel.
March 9	8.9	10,000	1.30			Do.
March 14	7.6	1,500	.20	1.17	870	Do.
April 5	7.6	15,500	2.01			Do.
April 7	7.8	40,000	5.20			Do.
April 12	7.1	41,000	5.33			Do.
April 22	6.8	4,000	.52	3.26	2,347	Do.
May 5	6.0	1,000	.13			Do.
May 15	6.3	2,060	.27			Do.
May 24	10.8	7,400	.96			Do.
May 29	11.8	5,000	.65	.50	372	Do.
June 7	9.8	7,000	.91			Do.
June 15	10.6	31,500	4.09			Do.
June 20	10.6	32,500	4.22			Do.
June 27	8.7	3,200	.42	2.41		Do.
July 2	10.2	10,600	1.38			Do.
July 8	13.7	29,500	3.83			Do.
July 20	10.9	36,000	4.68			Do.
July 29	11.00	4,000	.52	2.60	1,735	Do.
August 1	11.3	60,000	7.80			Do.
August 10	11.1	118,500	15.40			Do.
August 23	9.5	71,000	9.23			Do.
August 26	10.3	20,000	2.60	8.76	6,517	Do.

WIND MOVEMENT.

One point of interest in the consideration of the isthmian canal is the strength and persistence of winds, considered as motive force for sailing vessels and as annoyance to the navigation of the canal and to ships entering and leaving port.

The persistence of the trade winds has frequently been mentioned in discussions of the Nicaragua Canal route. In 1898, it being necessary to take gauge readings at Las Lajas, on the western margin of the lake, for transferring the level line across the lake, a camp with an observer was established here, who observed the gauge height of the lake at the hours of 6 and 9 a. m., 12 noon, 3 and 6 p. m. Note of the condition of the lake surface was made at each observation, and from January 19, 1898, when the observations began, until the 1st of May a heavy surf was beating on the beach at this point at every observation, due to the persistence of the trade winds. A few days of calm occurred in May and at later periods during the rainy season.

On May 16, 1900, an anemometer was installed at Greytown and observed at 8 a. m., 12 noon, and 6 p. m. each day, and the record was kept practically continuous to the end of the year. In all this time not a single day occurred without wind movement. The highest velocity recorded was something over 40 miles per hour, and this only occurred on one day, November 13, the mean for that day being 24.5. The results of the observations are shown in the following table:

Anemometer record, Greytown, Nicaragua.

Day.	Anemometer readings.			Miles.		Day.	Anemometer readings.			Miles.	
	8 a. m.	12 m.	6 p. m.	Per day.	Per hour.		8 a. m.	12 m.	6 p. m.	Per day.	Per hour.
May 16	78.0	93.6	117.2	68.7	2.9	July 14	310.1	349.2	395.0	153.9	6.5
May 17	146.7	178.0	212.1	99.4	4.1	July 15	464.0	478.0	502.5	108.2	4.5
May 18	246.1	271.0	313.6	127.1	5.3	July 16	572.2	590.0	664.5	145.8	6.1
May 19	373.2	399.0	403.3	62.3	2.6	July 17	718.0	733.0	761.5	102.2	4.3
May 20	435.5	450.3	497.5	97.6	4.1	July 18	820.2	860.1	895.0	142.8	5.9
May 21	533.1	553.4	589.0	85.2	3.6	July 19	963.0	991.5	47.0	121.6	5.1
May 22	618.3	639.3	688.6	105.0	4.4	July 20	84.6	91.2	116.0	62.5	2.6
May 23	723.3	755.5	801.2	99.9	4.2	July 21	147.1	166.5	182.3	84.4	3.5
May 24	823.2	869.0	916.1	119.8	5.0	July 22	231.5	246.2	276.0	73.6	3.1
May 25	943.0	984.1	41.7	139.5	5.8	July 23	305.1	330.0	363.2	83.4	3.5
May 26	82.5	95.5	130.9	91.1	3.8	July 24	388.5	406.5	438.0	83.5	3.5
May 27	173.6	195.2	226.0	115.2	4.8	July 25	472.0	490.1	543.2	107.0	4.4
May 28	288.8	317.8	353.5	129.8	5.8	July 26	579.0	602.1	650.8	134.0	5.6
May 29	418.6	438.8	467.7	84.7	3.5	July 27	713.0	725.8	758.0	81.0	3.4
May 30	503.3	521.1	549.1	101.7	4.2	July 28	794.0	836.0	889.2	135.0	5.6
May 31	605.0	626.2	652.1	72.4	3.0	July 29	929.0	941.3	994.0	84.5	3.5
June 1	677.4	786.1	754.5	127.4	5.3	July 30	13.5	24.1	55.2	76.0	3.2
June 2	804.5	922.9	980.9	121.8	5.1	July 31	89.5	102.3	156.2	110.5	4.0
June 3	926.3	950.8	3.2	118.8	4.5	Aug. 1	200.0	215.8	250.0	127.2	5.3
June 4	45.1	81.5	100.4	154.9	6.5	Aug. 2	327.2	339.3	381.2	93.8	3.9
June 5	200.0	222.8	278.9	195.7	8.2	Aug. 3	421.0	433.6	552.7	230.5	9.6
June 6	395.7	413.5	431.0	94.5	3.5	Aug. 4	651.5	663.7	700.0	71.6	3.0
June 7	490.2	525.0	562.4	133.5	5.6	Aug. 5	723.1	732.4	778.3	85.9	3.6
June 8	623.7	659.1	694.0	106.3	4.4	Aug. 6	809.0	838.7	874.0	104.2	4.4
June 9	730.0	754.0	801.0	102.1	4.3	Aug. 7	913.2	924.2	950.0	86.8	3.6
June 10	832.1	835.0	842.5	99.4	4.2	Aug. 8	1,000.0	9.2	29.0	120.7	5.0
June 11	931.5	973.1	19.0	123.8	5.1	Aug. 9	120.7	141.9	196.0	119.5	5.0
June 12	55.3	111.0	133.0	114.7	4.9	Aug. 10	240.2	252.1	284.8	148.8	6.2
June 13	170.0	193.2	221.5	81.0	3.4	Aug. 11	389.0	415.0	487.6	215.5	8.9
June 14	251.0	283.0	315.2	101.1	4.2	Aug. 12	604.5	612.0	625.2	74.2	3.1
June 15	352.1	370.7	416.3	97.7	4.1	Aug. 13	678.7	700.2	734.5	48.0	2.0
June 16	449.8	473.1	499.0	75.8	3.2	Aug. 14	726.7	820.0	867.5	216.7	9.0
June 17	525.6	554.1	569.0	78.4	3.3	Aug. 15	943.4	975.0	32.5	118.9	4.9
June 18	604.0	620.2	653.6	128.0	5.3	Aug. 16	62.3	79.6	116.1	93.3	3.9
June 19	732.0	751.6	784.1	93.7	3.9	Aug. 17	155.6	182.3	246.8	141.4	5.9
June 20	825.7	837.2	855.2	79.3	3.3	Aug. 18	297.0	312.4	349.5	101.1	4.2
June 21	905.0	832.0	953.2	82.1	3.4	Aug. 19	398.1	416.2	446.7	97.1	4.0
June 22	987.1	10.7	45.2	78.7	3.3	Aug. 20	495.2	506.4	549.0	102.1	4.3
June 23	65.8	81.2	186.7	146.3	6.1	Aug. 21	597.3	646.6	680.0	102.0	4.2
June 24	212.1	237.3	307.2	117.0	4.8	Aug. 22	699.3	718.7	743.2	75.8	3.2
June 25	329.1	343.3	378.8	72.5	3.0	Aug. 23	775.1	787.4	818.1	78.6	3.3
June 26	401.6	419.1	470.0	98.4	4.1	Aug. 24	853.7	877.4	944.2	138.6	5.8
June 27	500.0	515.5	567.2	103.0	4.3	Aug. 25	992.3	18.7	65.5	114.3	4.3
June 28	603.0	624.2	664.0	129.0	5.4	Aug. 26	106.6	117.8	141.2	84.2	3.5
June 29	732.0	744.2	822.5	147.0	6.1	Aug. 27	190.8	214.6	261.0	137.2	5.7
June 30	879.0	897.6	967.0	155.1	6.5	Aug. 28	328.0	346.2	409.0	138.1	5.8
July 1	34.1	50.0	69.1	77.8	3.2	Aug. 29	466.1	424.5	511.9	74.9	3.2
July 2	111.9	152.2	172.4	97.1	4.1	Aug. 30	541.0	552.7	536.2	140.0	5.8
July 3	209.0	219.1	235.8	54.2	2.3	Aug. 31	681.0	698.3	739.6	87.4	3.6
July 4	263.2	281.0	328.4	113.9	4.7	Sept. 1	768.4	782.0	799.3	70.7	2.9
July 5	377.1	397.4	463.5	140.9	5.9	Sept. 2	839.1	848.3	890.1	81.4	3.4
July 6	518.0	532.1	568.9	99.0	4.2	Sept. 3	920.5	947.2	999.0	79.5	3.3
July 7	617.0	625.1	683.1	167.8	7.0	Sept. 4	1,000.0	19.9	76.5	102.0	4.3
July 8	784.8	806.1	843.2	88.4	3.7	Sept. 5	102.0	120.2	163.8	97.2	4.1
July 9	873.2	890.5	920.1	94.8	3.9	Sept. 6	199.2	211.1	250.4	108.2	4.5
July 10	968.0	995.2	62.5	102.0	4.3	Sept. 7	307.4	326.4	369.0	89.6	3.7
July 11	70.0	83.2	105.2	58.1	2.4	Sept. 8	397.0	411.5	461.0	89.7	3.8
July 12	128.1	140.2	169.7	85.7	3.6	Sept. 9	486.7	507.2	553.6	114.7	4.8
July 13	213.8	230.0	275.5	96.3	4.1	Sept. 10	601.4	621.0	673.1	99.9	4.2

Anemometer record, Greytown, Nicaragua—Continued.

Day.	Anemometer readings.			Miles.		Day.	Anemometer readings.			Miles.	
	8 a. m.	12 m.	6 p. m.	Per day.	Per hour.		8 a. m.	12 m.	6 p. m.	Per day.	Per hour.
Sept. 11	701.3	719.5	763.3	101.8	4.2	Nov. 9	663.6	694.0	747.8	197.1	8.2
Sept. 12	803.1	815.7	845.0	57.6	2.4	Nov. 10	860.7	907.1	955.2	236.4	9.9
Sept. 13	860.7	873.4	911.6	81.0	3.4	Nov. 11	97.1	145.3	136.6	148.9	6.2
Sept. 14	941.7	953.1	1,000.0	95.5	4.0	Nov. 12	246.0	234.6	227.9	178.2	7.4
Sept. 15	37.2	52.1	102.3	109.5	4.5	Nov. 13	424.2	608.5	870.0	588.6	24.5
Sept. 16	146.7	160.5	223.2	145.5	6.1	Nov. 14	12.8	81.1	87.4	71.5	3.0
Sept. 17	292.2	321.6	401.3	159.8	6.6	Nov. 15	84.3	94.7	135.7	210.4	8.8
Sept. 18	452.0	472.1	501.3	71.0	3.0	Nov. 16	294.7	213.6	355.2	63.9	2.7
Sept. 19	523.0	540.8	601.2	91.2	3.8	Nov. 17	358.6	411.0	428.2	79.3	3.3
Sept. 20	614.2	632.4	681.1	150.9	6.3	Nov. 18	437.9	490.4	499.0	125.1	5.3
Sept. 21	765.1	783.9	830.5	119.6	5.0	Nov. 19	563.0	592.8	640.7	139.5	5.8
Sept. 22	884.7	899.0	948.9	111.3	4.6	Nov. 20	702.5	740.6	794.3	157.6	6.6
Sept. 23	996.0	15.6	49.5	86.3	3.6	Nov. 21	860.1	878.0	921.6	78.8	3.3
Sept. 24	82.3	100.2	161.1	149.2	6.2	Nov. 22	938.9	963.4	986.0	55.3	2.3
Sept. 25	231.5	243.5	299.4	105.9	4.4	Nov. 23	994.2	14.8	132.5	196.8	8.3
Sept. 26	337.4	361.2	433.1	197.3	8.2	Nov. 24	191.0	214.6	384.0	313.2	13.0
Sept. 27	534.7	553.1	612.2	140.8	5.9	Nov. 25	504.2	524.0	557.7	116.7	4.9
Sept. 28	675.5	693.3	759.1	125.8	5.2	Nov. 26	620.9	769.8	798.3	199.5	8.3
Sept. 29	801.3	824.4	900.0	184.7	7.7	Nov. 27	820.4	846.2	910.1	115.8	4.8
Sept. 30	986.0	20.1	97.3	141.8	5.9	Nov. 28	936.2	958.7	971.6	55.8	2.3
Oct. 1	127.8	162.2	203.7	108.5	4.5	Nov. 29	992.0	210.5	401.6	466.6	19.4
Oct. 2	236.3	251.2	300.0	96.7	4.0	Nov. 30	458.6	521.4	539.0	151.9	6.3
Oct. 3	333.0	347.1	406.4	114.2	4.3	Dec. 1	610.5	674.2	760.1	....	.....
Oct. 4	447.2	472.3	557.9	150.9	6.3	Dec. 2	....	....	....	....	.....
Oct. 5	598.1	623.0	693.2	131.2	5.4	Dec. 3	835.1	866.4	902.8	128.3	5.3
Oct. 6	729.3	747.8	795.9	101.8	4.2	Dec. 4	963.4	21.0	49.2	143.4	6.0
Oct. 7	831.1	846.2	880.0	70.1	2.9	Dec. 5	106.8	150.1	187.6	155.2	6.5
Oct. 8	901.2	923.6	1,000.0	130.1	5.4	Dec. 6	261.0	296.5	330.0	249.0	10.4
Oct. 9	31.3	57.6	111.1	85.8	3.6	Dec. 7	510.0	646.3	741.0	288.4	12.0
Oct. 10	117.1	122.5	202.6	111.9	4.7	Dec. 8	798.4	824.0	866.2	95.6	4.0
Oct. 11	229.0	246.4	273.1	69.4	2.9	Dec. 9	894.0	976.5	997.0	198.3	8.3
Oct. 12	298.4	316.2	359.6	87.6	3.6	Dec. 10	92.3	141.6	188.9	117.2	4.9
Oct. 13	386.0	399.4	427.1	52.6	2.2	Dec. 11	209.5	261.2	278.6	85.2	3.6
Oct. 14	438.6	463.1	556.9	152.5	6.4	Dec. 12	294.7	312.1	329.6	106.5	4.4
Oct. 15	591.1	608.7	648.6	87.9	3.6	Dec. 13	401.2	419.5	439.2	64.9	2.7
Oct. 16	679.0	699.3	753.2	118.3	4.9	Dec. 14	466.1	484.6	504.9	70.0	2.9
Oct. 17	797.3	812.5	860.0	104.7	4.4	Dec. 15	536.1	581.2	601.4	95.4	4.0
Oct. 18	902.0	912.3	995.1	115.3	4.8	Dec. 16	631.5	649.0	684.0	130.3	5.4
Oct. 19	17.3	38.2	76.1	92.0	3.8	Dec. 17	761.8	794.0	822.6	132.2	5.5
Oct. 20	109.3	125.2	198.6	107.8	4.5	Dec. 18	894.0	931.4	962.0	103.1	4.3
Oct. 21	217.1	232.0	275.4	104.0	4.3	Dec. 19	997.1	42.4	87.6	145.8	6.1
Oct. 22	321.1	339.2	381.2	122.2	5.1	Dec. 20	142.9	186.1	241.0	153.4	6.4
Oct. 23	443.3	477.0	488.2	51.4	2.1	Dec. 21	296.3	361.2	398.0	183.9	7.7
Oct. 24	494.7	516.2	578.3	117.3	4.9	Dec. 22	480.2	511.2	531.4	118.4	4.9
Oct. 25	612.0	650.0	700.3	157.4	6.6	Dec. 23	598.6	623.9	641.7	94.4	3.9
Oct. 26[a]	769.4	805.1	867.4	....	.....	Dec. 24	693.0	768.2	802.0	167.1	7.0
Nov. 1	319.5	326.1	515.2	255.0	10.6	Dec. 25	860.1	....	....	....	.....
Nov. 2	574.5	593.0	631.9	119.2	5.0	Dec. 26	....	978.0	61.7	....	.....
Nov. 3	693.7	716.5	694.0	113.6	4.7	Dec. 27	92.8	111.4	137.5	75.4	3.1
Nov. 4	807.3	912.0	980.9	201.4	8.4	Dec. 28	168.2	179.0	191.7	53.2	2.2
Nov. 5	8.7	25.8	125.6	84.2	3.5	Dec. 29	221.4	236.0	252.3	68.2	2.8
Nov. 6	92.9	74.5	118.2	....	.....	Dec. 30	289.6	302.5	319.8	48.6	2.0
Nov. 7	....	....	....	....	.....	Dec. 31	338.2	356.4	379.6	74.2	3.1
Nov. 8	453.0	403.0	480.5	210.6	8.8						

[a] No record for Oct. 27–31.

Observations of wind velocity at Ochoa station.

[Representing estimated mean velocity of wind, in miles per hour, for daytime only.]

1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7	3	5	8	3	4	8	7	3	4	3	3
2	16	8	3	13	5	3	5	2	4	3	3	0
3	11	5	3	7	3	5	5	7	3	5	0	3
4	7	13	5	7	3	5	8	0	3	4	0	3
5	5	8	5	8	5	3	8	3	4	4	3	......
6	5	7	5	5	3	8	3	3	4	3	0	......
7	8	7	13	5	5	5	8	4	5	7	3	......
8	3	8	13	1	8	3	3	0	5	5	3	0
9	3	8	13	3	11	2	0	0	7	3	5	0
10	3	3	13	5	11	0	0	5	5	5	0	5
11	0	3	11	5	5	1	0	5	3	3	3	4
12	3	5	5	3	5	1	3	4	3	5	8	3
13	7	13	8	3	13	3	0	4	4	7	0	8
14	3	5	7	5	23	3	0	4	4	4	18	7
15	8	3	3	5	5	5	3	0	5	3	13	8
16	5	3	11	7	13	5	5	3	0	5	3	11
17	0	5	13	8	3	8	8	5	8	5	0	5
18	0	3	8	5	22	0	3	0	3	8	3	0
19	4	8	8	5	0	3	4	7	7	3	4	8
20	3	5	5	8	5	3	7	5	1	3	4	8
21	8	11	3	8	3	7	2	3	0	7	5	7
22	8	11	5	8	10	8	3	5	0	13	4	9
23	5	5	5	8	13	8	0	4	3	0	3	18
24	7	4	5	13	0	3	13	5	0	3	1	0
25	5	7	8	8	0	0	......	8	3	13	0	7
26	7	5	8	8	13	0	......	3	5	7	5	38
27	3	8	5	8	22	5	3	1	0	7	0	0
28	5	8	4	8	4	5	3	4	0	4	5	18
29	8	......	5	8	3	8	8	3	3	3	0	7
30	8	......	8	5	5	5	7	1	3	0	0	4
31	3	......	5	......	3	......	5	0	......	3	......	7

1900.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7	8	7	7	8	8	0	0	0	0	28	3
2	11	7	0	13	7	5	4	0	1	0	0	3
3	7	5	8	13	0	8	0	0	3	7	5	3
4	3	7	18	5	13	5	4	0	4	7	0	3
5	0	5	4	13	8	0	0	3	0	5	4	4
6	8	13	18	13	0	5	8	0	3	8	5	3
7	7	3	13	3	8	4	4	3	5	13	0	3
8	7	13	13	8	0	4	8	0	3	7	0	0
9	18	5	3	8	3	3	4	0	5	5	4	3
10	7	7	0	0	7	0	4	3	4	0	5	1
11	4	18	3	0	3	8	0	0	0	0	11	0
12	3	13	5	5	5	5	4	0	5	5	3	1
13	11	18	7	13	0	0	0	3	5	0	4	5
14	18	13	0	13	8	7	3	3	3	2	7	1
15	4	3	5	18	8	4	0	5	4	0	5	3
16	7	11	3	16	8	0	3	8	7	3	11	5
17	3	11	13	18	8	0	3	5	0	4	7	8
18	4	8	18	11	5	0	0	4	0	3	8	0
19	7	0	18	22	13	0	8	3	3	4	7	11
20	7	3	18	5	7	0	7	5	7	6	7	5
21	7	8	18	13	0	3	3	7	4	0	4	7
22	0	8	18	8	15	1	0	0	7	0	5	3
23	0	5	8	4	1	5	0	6	0	0	3	5
24	4	5	3	0	4	5	4	8	7	2	0	0
25	4	8	8	0	2	7	5	7	4	2	3	7
26	4	0	7	0	......	8	3	3	8	7	4	7
27	0	8	0	8	......	5	0	8	4	0	3	5
28	7	8	5	5	0	8	0	0	7	0	7	11
29	3	......	8	3	2	4	3	7	15	11	4	5
30	3	......	8	8	0	9	0	0	0	8	7	7
31	8	......	5	......	5	......	0	3	......	......	......	5

Appendix J.

SURVEYS OF UPPER SAN JUAN TO HEADWATERS OF THE INDIO.

By A. B. Nichols, *Division Engineer.*

Concerning the surveys made to determine the practicability of a route for the Nicaragua Canal from some point on the upper portion of the Rio San Juan to the Caribbean Sea by way of the Rio Indio or its tributaries, I have the honor to report:

That, for the purpose above mentioned, examinations were made of Rios Bartola, Machuca, and La Cruz del Norte, tributaries of the San Juan, and of the Rio Negro, one of the two streams which unite to form the Indio proper, and of a portion of the Rio Salvador, a branch of the Negro.

The waters flowing into Lake Nicaragua and the San Juan from the northeast are separated from those flowing eastwardly into the Caribbean Sea by the Chontales, a ridge which rises from the swamps back of Greytown, runs nearly due west to a point in the vicinity of Conchuda and about 4 miles directly east from the mouth of La Cruz del Norte, and thence strikes nearly northwest, rising gradually with more or less uniformity.

The surveys were made to determine whether there is in this ridge a place low enough, and where the headwaters of the streams on each side are sufficiently near together, to afford a more desirable route for the canal than that projected by way of the lower San Juan.

RIO BARTOLA SURVEY.

This survey was made by Mr. M. W. Tenny, assistant engineer. The stream rises in the Chontales and flows into the San Juan about 5 miles below Castillo. It consists of two main branches which come together 7.3 miles (by the stream) from the San Juan. The general direction of flow of the North Branch, so far as it was traced, is about 30 degrees west of south; that of the South Branch for about 2 miles close to its head, nearly southwest, thence nearly west to its junction with the North Branch; and that of the main stream below the junction about 18 degrees south of west. A stadia line, carrying elevations, was run from the mouth of the river 15.4 miles to near the head of the South Branch to an elevation of 478.6 above mean sea level, and thence leaving the river, a few hundred feet farther and part way up the ridge, to an elevation of + 636.8. An observation taken during the Machuca survey indicates that the main ridge rises near here to an elevation of + 1,500 or over, although at the heads of the streams there may be places somewhat lower.

A stadia line was also run up the North Branch to a point 13 miles (by the line) from the San Juan to an elevation, on the stream, of +224.8. The region between the two branches is occupied by a high spur of the Chontales, which attains an elevation of +1,500 or more. It was deemed unnecessary to carry the line farther up this branch, because both the nature of the country and the distance involved would preclude its use for canal purposes. The valley of the Bartola is generally narrow, its bottom of rock, and the hills abrupt. The height of the main ridge renders a canal by this route impracticable.

MACHUCA-NEGRO SURVEY.

This survey was made by the writer.

The Machuca (called by the natives Sarnoso) rises in the Chontales southeast of the sources of the Bartola, and flows into the San Juan near the foot of Machuca Rapids. Like the Bartola, it consists of two main branches, which come together 5.7 miles (by the river) from the San Juan. The North Branch comes in from a little east of north. The general direction from the head of the East Branch to the mouth of the main stream is about 19° 22′ south of west, making, however, in the lower two-thirds of its course quite a detour to the south of this line. The distance from the mouth to the summit of the survey (by the line) is 15.2 miles.

The Rio Negro heads in the Chontales eight-tenths mile nearly south from the head of the East Branch of Machuca, and flows a little east of north until it approaches the latter within 400 feet, at the place where the survey line crosses the ridge. From this point to the foot of the Great Falls of Negro, where the survey ended, a distance of 13 miles (by the line), the bearing is about 17° 36′ north of east, the river, however, making a long detour to the north. It receives three large branches between its source and Great Falls. Only one of them is of interest in this connection, as the other two come in from the left. This branch enters from the southwest about 1.8 miles (by the line) above the foot of Great Falls. It is 60 to 70 feet wide at its mouth, and appears to carry about one-half as much water as the Negro immediately above their junction. A reconnaissance was made of it for about 2 miles from its mouth, to a point where it forks, one branch coming in from the southwest and the other from the south. Each of these branches is nearly as wide as the main stream. This river, for convenience of reference, I have called the Salvador. The branch from the southwest is apparently the same stream whose headwaters were examined by Mr. Tenny during the La Cruz del Norte survey, and will be noticed under that head.

The survey along these streams was made by stadia, and the elevations determined partly by stadia and partly by Y level.

The crest line south of the Machuca was developed to a point above the forks, and reconnoissances made between that point and the main ridge to determine the approximate course and relative elevation of the crest.

The valley of the Machuca is narrow and the slopes abrupt in most places. The bottom of the stream is largely of rock, which causes numerous rapids and occasional falls. The ridge to the south dividing it from La Cruzita del Norte and La Cruz del Norte is generally very narrow at its crest, especially in the Saddles, where it is not unusual to find the top not more than 15 or 20 feet wide, the ground dropping sharply, and with practically the same slope on each side. The elevations in the Saddles for 5 miles from the mouth of the river range from +235 to +345 above mean sea level, and then the ridge rises with more or less uniformity until it reaches +723, where it joins the main ridge at the point where the waters of the Machuca, Negro, and La Cruz del Norte have their common source. At the summit the line passes from the Machuca to the Negro through a gap in the ridge not over 100 feet wide, the ground rising rapidly on each side on a slope of perhaps 15 to 20 degrees. The distance from water to water in the two streams is about 400 feet, the relative elevations being as follows:

Surface of water in Machuca	+539.1
Surface of ground at summit	+544.2
Surface of water in Negro	+520.8

The valley of the Negro is narrow; the slopes of the hills are steep. Falls and rapids are numerous and the country more rugged than along the Machuca. From a point a short distance below the mouth of the Salvador to below the foot of Great Falls the river runs through a gorge, over rock bottom, forming a favorable place for damming the stream. The line having been run as much as possible along the streams, the survey shows nearly the minimum possible profile. A profile along a projected canal line would necessarily be much heavier, both streams being tortuous, with narrow valleys.

With the bottom at +69, a canal by this route would have a cutting about 24½ miles long, with a depth at the summit of 475 feet.

LA CRUZ DEL NORTE SURVEY.

This survey was made by Mr. M. W. Tenny, assistant engineer. A reconnoissance was first made, by means of pocket compass and aneroid barometer, of the main stream and all the larger branches, especially those putting into it from the east, with the result that the first one above the mouth was found to have the lowest summit and the desired general direction.

A stadia line, carrying elevations, was run up this branch, beginning at the mouth of the main stream at the San Juan, to a point eight-tenths mile beyond the summit, and 6.4 miles (by the line) from the San Juan. Beyond this point a reconnoissance was made with pocket compass for nearly 2½ miles.

The La Cruz del Norte flows into the San Juan about 7 miles below the mouth of the Machuca. It occupies a somewhat oval-shaped vallley, the major axis of which is a line from the head of Rio Negro (as determined by the Machuca-Negro survey) to the point where the stream flows into the San Juan, about 5.4 miles in length. The declivities are therefore necessarily steep, as the water has to descend nearly 700 feet in this distance.

The survey shows that the valley of the East Branch is comparatively straight and the rise to the top of the ridge rapid. Beyond the summit, where the line strikes the headwaters of the Salvador, the fall is very gradual for about 1½ miles, where the stream plunges over a 30-foot fall, and from this point to the end of the reconnoissance drops over a succession of falls and rapids, a portion of the way through a narrow gorge so rough as to be difficult of passage. Collating the information obtained by this and the Machuca-Negro survey, we have:

Surface of water in San Juan at mouth of La Cruz del Norte	+ 56
Elevation of summit, 5.6 miles from mouth of La Cruz	+ 468.7
Elevation at top of 30-foot falls of Salvador, 6.9 miles from mouth of the La Cruz, about	+ 394
Surface of water in Rio Negro at mouth of Salvador, about 14.3 miles from mouth of La Cruz	+ 68
Surface of water in Negro at foot of "Great Falls," 15.8 miles from mouth of La Cruz	+ 41

With bottom at +69, a canal by this route would involve a cutting about 15½ miles long, with a depth at the summit of 400 feet, but with a heavier profile than is shown by the survey, the latter having followed the stream very closely, whereas a projected canal line would, on account of the crookedness of the streams, cut into the hills more or less.

Bearing upon a supply of stone for use in the construction of a canal, these surveys show that along the streams falls occur at elevations at or near +200, +300, and +400 with great uniformity, indicating that at these elevations there is rock capable of withstanding the elements. In the valley of La Cruz del Norte these formations may prove to be useful, no part of the valley being more than 5½ miles in a straight line from the projected service railroad, and, owing to the abruptness with which the hills rise, available outcrops are likely to be found.

Profiles of the Machuca-Negro and the La Cruz del Norte lines are submitted herewith, marked plates 61 and 62.

Appendix U.

TRANSLATION OF THE CONTRACT ENTERED INTO BETWEEN THE GOVERNMENT OF NICARAGUA AND THE ATLAS STEAMSHIP COMPANY, LIMITED, DATED AT THE CITY OF MANAGUA, ON THE 30th DAY OF SEPTEMBER, 1897.

The National Legislative Assembly decrees:

Only article. The contract entered into between the minister of public instruction, provisionally in charge of the portfolio of public works, on behalf of the Government, and Louis Wichman, representative of the Atlas Steamship Company, Limited, is, with the modifications subsequently agreed upon by both parties and the modifications introduced by the House, approved in the following terms:

Manuel Coronel Matus, minister of public instruction, provisionally in charge of the portfolio of public works, representing the Government of the State, and Louis Wichman, representing the Atlas Steamship Company, Limited, in accordance with the power of attorney exhibited, have agreed on the following contracts, with the object of expediting steam navigation on Lake Nicaragua and the river San Juan del Norte, which each day offers greater difficulties; of facilitating communication with the Atlantic coast, on which great interests depend, and in the hope of commercial and agricultural development that shall improve the condition of the country.

I. In consideration of the great expenses that the Atlas Steamship Company, Limited, hereinafter called "the company," shall incur for the aforesaid object, the Government grants it the exclusive right during thirty years to navigate by steam the Silico Lagoon, counting from the final ratification of this agreement, and the exclusive right during the same period to construct tramways and railways at convenient places along the line of the river San Juan to avoid obstacles therein.

II. The company binds itself to construct on its own account a narrow-gauge railway that shall put the place known as Colorado Junction, or another suitable point, in communication with the Silico Lagoon, so as to avoid the navigation of the dry and most difficult part of the river San Juan and effect more rapid transit to the port of San Juan del Norte during the summer. The length of this line shall be 5 miles, more or less, and at its terminals the company shall erect houses and piers that shall combine the requisites for passenger traffic, the transportation of merchandise, and for other services.

III. The Government shall subsidize the company to the extent of \$5,000 for each mile of the said railway, payable in successive monthly installments of \$1,000 from the time the governor of San Juan del Norte advises that the construction works of the railway have commenced, and providing the works are not interrupted. In case the works are interrupted, payments shall be suspended until the works are recontinued.

IV. The Government declares this work to be of public utility, so that the company may expropriate lands of private property required for right of way in accordance with the laws in the matter. The company shall have for the same purpose the right to occupy, free of all charge, such national lands as the line may cross, together with a strip of land 100 yards wide along the entire length of the line.

V. The Government also grants the company the right to cut in the national forests adjacent to Lake Nicaragua and the river San Juan, free of all charge, all the wood it may require for the use of the steamers, tramways, railways, piers, houses, and workshops, and for other purposes of the traffic.

VI. The Government concedes the right of occupying, in the ports and places of transit, such lots of national land as may be necessary for the establishment of stores, tramways, offices, workshops, stations, etc. It is understood that such lots shall be selected by agreement with the Government, and that in case any of them should be private property, the Government shall authorize their expropriation, in accordance with which the company shall pay the just price as fixed by experts, unless the price shall have been agreed upon between the owners and the company.

VII. The company's employees and laborers shall be exempt from civil and military service, and to this effect the respective authorities shall issue such exemptions as may be necessary to insure the good service of the company.

VIII. The steamers, railways, tramways, stations, service houses, and other indispensable things for the purposes of the company shall, during the term of this contract, be exempt from national and municipal contributions.

IX. The company shall import, free of local and customs dues, the machinery, tools, materials, coal, provisions, and other articles necessary for its service, excepting strong liquors, but with strict observance of fiscal regulations and the requirements of the ministry of finance for due control and statistical purpose.

X. The company in the service of its enterprise shall have, subject to the laws of Nicaragua, the free use of the national telegraph lines, but this concession shall not prevent the Government from selling the said lines unconditionally.

XI. When the railway from the Silico Lagoon shall be finished, should the Government consider it convenient to its interests and those of the company, it shall remove the custom-house from Castillo to a point that will hinder as little as possible the rapid transportation of merchandise.

XII. The company is obliged to make at least three trips a month with its steamers from Granada to San Juan del Norte, and vice versa, and to call at least once a month at all the established ports of the lake which the steamer *Victoria*, or another of her size, can reach. The company shall carry the mails of the State on all trips free of charge. The aforesaid trips shall be subject to an itinerary of which the Government and public shall be notified and which can not be altered without three months previous notification to them. For each unjustified infraction of the itinerary the company shall pay a fine of from $25 to $100, which shall be collected by the Government.

XIII. Passengers and freight tariffs shall be in the money of the country and as moderate as the company can make them. The Government shall enjoy a rebate of 30 per cent on the transportation of its employees, other persons who travel for its account, its troops, and cargo.

XIV. In case of war, the company's steamers shall be placed at the order of the Government, which shall take them for its own account, acknowledging, upon returning them, the losses and damages their use may have occasioned. These losses and damages shall be appraised by an engineer, chosen by mutual agreement, or by two experts, one for each party, providing the parties hereto can not agree on the nomination of the former. Should the experts fail to agree on the estimate of losses and damages, the decision of an umpire appointed by the experts prior to their disagreement shall be final, and his decision can not be appealed from.

XV. The company binds itself to undertake as soon as possible such works along the river San Juan as may be necessary to facilitate the uninterrupted transportation of passengers and merchandise during the whole year by means of vessels and railways between San Juan del Norte and Lake Nicaragua.

Should the company, after careful study of the obstacles to navigation, wish to undertake works of greater magnitude, so as to secure a depth of water of 6 feet in the river San Juan at all seasons, and to deepen the bar of the port so that vessels of large tonnage can cross it, the Government shall give the company permission so to do.

XVI. This contract may be transferred to any foreign person or company, but in no case, neither in whole nor in part, neither directly nor indirectly, to any government. Should the contract be transferred to a company whose domicile is abroad, it shall constitute a representative in Nicaragua fully authorized and instructed for all affairs, judicial or otherwise. The said company shall be subject to the laws of Nicaragua.

XVII. For the purposes of the preceding article the company shall have an agent in Nicaragua.

Any difference that may occur in regard to the meaning and application of this contract shall be decided by one arbitrator chosen by mutual consent, or by two arbitrators, one for each party. In this case, should the arbitrators not agree as to the amount of losses and damage, the matter shall be decided by an umpire appointed before proceeding to the arbitration, and his decision shall be final. The tribunal of arbitrators shall be established at the latest within fifteen days from the time one party has notified the other of any difference that may occur, and it shall give its decision within six months, at the latest. Such decision can not be appealed.

XVIII. Should the railway from the Silico Lagoon to the river San Juan be not finished within three years from this date, this concession shall for that reason be forfeited.

The works of construction of the said railway shall commence at the latest within one year from the date upon which this agreement is signed, and should the company not do so it shall lose the deposit of $5,000 gold which it binds itself to make in the general treasury of the State within six months under penalty of the forfeiture of this contract.

The said deposit shall be returned to the company when the works of the railway referred to are finished.

XIX. This concession shall never be an obstacle to the carrying out of any contracts the Government may decide to make in regard to the opening of an interoceanic canal over the same route, nor shall it affect in the least those it may have already made.

XX. It is understood that during the term of this agreement the Government can not subsidize any other company of steamers on Lake Nicaragua.

XXI. In case of expropriation owing to the opening of the interoceanic canal, and considering the expenses the company may have incurred, it shall be indemnified by whom it may concern for the value of the materials of the enterprise, according to such title as the company may be able to show, it being understood that the Government of Nicaragua shall not pay in any case any indemnity whatever.

XXII. To determine the indemnity mentioned in the preceding article the procedure stipulated in Article XIV shall be followed in its entirety.

XXIII. Should either party not appoint its arbitrator within fifteen days after having been notified of any difference arising, or should the party appointed not accept, or should he be absent, the president of the supreme court of justice shall, within three days, and upon the petition of the other party, appoint an arbitrator.

XXIV. In no case and for no reason shall the company or whoever may represent it have the right of appealing to diplomatic intervention.

In proof of which are signed two of same tenor at Managua on the 5th day of June, 1897.

M. C. Matus,
Louis Wichman,
For the Atlas Steamship Company, Limited.

Given in the hall of sessions, Managua, September 28, 1897.

M. Morales, *D. P.*
Santiago Lopez.
Leandro Garcia.

Approved.

National palace, Managua, September 30, 1897.

J. S. Zelaya.
J. C. Munoz,
Acting Minister of Public Works.

This conforms to the contract published in the official daily.

Department of public works, Managua, October 31, 1898.

Munoz.

The undersigned, minister of interior relations of the State of Nicaragua, certifies that the signature of the minister of public works by the law which precedes this, reading "Munoz," is authentic.

Managua, November 2, 1898.

Erasmo Calderon.

I, the undersigned, consul of the United States, do hereby certify that the above signature of Erasmo Calderon is true and genuine.

Managua, November 2, 1898.

Chester Donaldson,
United States Consul.

APPENDIX C C 1.

TREATY OF AMITY, COMMERCE, AND NAVIGATION BETWEEN FRANCE AND NEW GRANADA. SIGNED AT BOGOTÁ, MAY 15, 1856. RATIFICATIONS EXCHANGED AT BOGOTÁ, JULY 24, 1857.

Numerous commercial relations having for a long time been established between the French Empire and the Republic of New Granada, it was deemed expedient to regulate their existence and to promote their extension by means of a treaty of amity, commerce, and navigation.

For that purpose, full powers have been conferred, to wit:

By His Majesty, the Emperor of the French, upon Baron Celean Goury du Roslan, commander of the Imperial Order of the Legion of Honor, Grand Cross of the Pontifical Order of St. Gregory the Great, etc.

By the Vice-President of New Granada, in charge of the executive power, upon Mr. Lino de Pombo, secretary of state for foreign relations.

Who, after exchanging the said full powers, and finding them in good form, have agreed upon the following articles:

ARTICLE I. There shall be constant peace and sincere and perpetual friendship between His Majesty the Emperor of the French, his heirs and successors, of the one part, and the Republic of New Granada, of the other part, and between the subjects and citizens of either State, without distinction of persons or places.

II. Frenchmen in New Granada and Granadians in France shall reciprocally enjoy the same liberty and security as the nationals in entering with their ships and cargoes, all places, harbors, and rivers that are or may hereafter be opened to foreign commerce. They shall, whether touching at several ports in succession or engaging in the coasting trade, be respectively treated in the same manner as the subjects or citizens of the most favored nation.

III. The subjects and citizens of either of the two contracting parties, shall be permitted, on the respective territories, freely to travel, sojourn, engage in trade, wholesale or retail, hire and occupy such dwellings, warehouses, and shops as they may need, effect shipments of merchandise and money, and receive consignments from the interior or from abroad and in all or any of these operations the said subjects or citizens shall not be subjected to any obligations other than those borne by the nationals.

In all their purchases and sales they shall be free to determine and establish the price of the effects, merchandise, or other articles, whether imported or domestic, whether sold in the interior or intended for export, provided they shall expressly comply with the laws and regulations of the country.

They shall enjoy like liberty for attending in person to their business, making their own entries in the custom-house, or having themselves represented by whomever they may see fit, attorneys, in fact, factors, agents, consignees, or interpreters, either for the sale or purchase of their property, effects, or merchandise, or for the lading, unlading, and clearing of their vessels. They shall likewise have the right to discharge all the duties with which they may be intrusted by their fellow-countrymen, by aliens, or by nationals in the capacity of attorneys in fact, factors, agents, consignees, or interpreters; and in no event shall they be subjected to charges, taxes, or imposts other than those to which are subjected the nationals or the citizens or subjects of the most favored nation.

IV. The subjects and citizens of either contracting party shall enjoy, in both States, the most complete and constant protection for their persons and property. They shall, in consequence, have free and easy access to the tribunals of justice for the prosecution and defense of their rights in every stage of proceedings and at every degree of jurisdiction established by law. They shall be free to employ, under all circumstances, such lawyers, attorneys, or agents of all classes as they may deem expedient to cause to act in their names. In fine, they shall, in this respect, enjoy the same rights and privileges as may be accorded to the nationals and shall be subject to the same conditions as are imposed on these latter.

V. Frenchmen in New Granada, and Granadians in France, shall be exempted from all personal services, in the land or sea forces, either in the national guard or militia, as well as from all war taxes, forced loans, military requisitions or services, of whatever nature. In all other cases they shall not be subjected, on account of their property, real or personal, to charges, demands, and imposts other than those to which the nationals themselves or the citizens or subjects of the most favored nation, without exception, may be subjected; it is well understood that whoever may claim the application of the latter part of this article will be at liberty to select that of the two treatments which will seem to him more advantageous.

VI. The subjects and citizens of either State shall not, respectively, be subjected to any embargo, nor be detained with their vessels, cargoes, and effects for any military expedition whatsoever nor for any public use of any kind, without an indemnity previously agreed to and determined by the parties interested and adequate to the use to be made and to the injuries, losses, delays, and damages occasioned by or likely to result from the use to which they may have been put.

VII. Frenchmen in New Granada, and Granadians in France, shall enjoy the most complete and unlimited freedom of conscience; they shall be permitted to practice their religion, publicly or privately, in temples or chapels, where religious functions are celebrated, or within their dwellings, in accordance with the system of toleration prevailing in both countries; they shall also be at liberty to bury their dead in the cemeteries of their religious communities, or in such others as they may designate and establish with the assent of the local authorities. The graves shall not be disturbed, nor the the ceremonies of interment and disinterment interrupted, in any way nor or any pretense.

VIII. The subjects and citizens of either contracting party shall have the right to own real estate within their respective territories and to dispose of said real estate and of all other property held by them by means of sale, donation, barter, testament, or any other method that may best suit them. In like manner, the subjects and citizens of either State who should fall heirs, under a will or ab intestato, to property situate in their respective territories shall succeed to the said property without hindrance, and dispose of the same at will, without paying inheritance taxes other than or different from those that should be paid by the nationals of the country in which the property may be.

IX. If, which God forbid, the peace between the two countries should, under circumstances that can not be foreseen, happen to be broken, there shall be granted on either side a term of not less than six months to traders on the coast and of one year to those in the interior of the country in which to wind up their affairs, dispose of their property and move it wherever they shall see fit; in addition, they shall be given a safe-conduct with which to embark at such port as they will designate of their own accord, unless such port be occupied or beleagured by the enemy, and their own safety or that of the State should stand in the way of their departing from that port, in which event they shall make their departure in such manner and by such route as may be practicable. All the other subjects or citizens having a fixed and permanent establishment in the respective States for the practice of some profession or industry of any kind, shall be permitted to hold said establishment and continue in the practice of their profession or industry without being in anyway molested, and they shall be left in full and complete possession of their liberty and property, so long as they shall commit no offense under the laws of the country.

X. In no case of war or conflict between the two nations shall the property or estates, of whatever nature, belonging to their respective subjects or citizens be subjected to any seizure, sequestration, or charges and imposts other than are demanded of the nationals. Furthermore, under the circumstances herein supposed, moneys due by private persons, as well as public funds, or bank or corporation stock, shall never be seized, sequestered, or confiscated to the detriment of the respective subjects and citizens.

XI. In no event shall the impost duties imposed in France on products of any kind whatever, of the growth or manufacture of New Granada, be other or higher than those to which are or will be subjected like products of the most favored nations. The same principle shall be observed in regard to exports. No prohibition of or restriction on the importation or exportation of any article whatsoever shall take place in the reciprocal trade of the two countries, unless it be equally applied to all other nations, and such formalities as may be required to prove that the merchandise respectively imported in either State was produced in or came from the other, shall also be common to all other nations. In brief, French commerce in New Granada and Granadian commerce in France shall be treated in all cases and in every respect like that of the most favored nation.

XII. All the products of the growth or manufacture of either country, the exportation of which is not expressly prohibited, shall pay in the port of the other the same import duties whether laden in French or Granadian vessels. In like manner, exported products shall pay the same duties and enjoy the same exemptions, allowances, and drawbacks as are now or may hereafter be reserved for exports shipped in national vessels.

XIII. French vessels entering ports in New Granada or clearing therefrom, and Granadian vessels entering or clearing from ports in France, shall not be subjected to tonnage, light-house, harbor, pilotage, quarantine, or other dues, dues charged to the vessel itself, different from or higher than those to which national vessels are or may be subjected.

XIV. French vessels in New Granada and Granadian vessels in France shall have power to discharge part of their cargoes in the port of their first arrival, and thence proceed with the remainder of their cargoes to other ports in the same State, either to finish discharging their cargoes or to complete their outward cargo at such ports, and shall not pay in each port dues other or higher than those paid by national vessels under similar circumstances.

XV. When vessels owned by subjects or citizens of either of the two contracting parties shall be wrecked or stranded on the coasts of the other, or when, in consequence of stress of weather or positive damage, they shall enter the ports or anchor on the coasts of the other, they shall not be subjected to any navigation dues, under whatever denomination such dues may be established, except pilotage and other dues representing compensation for services rendered by private concerns, provided that such vessels shall not discharge goods intended for consumption nor take a cargo for export. They shall, however, be permitted to land in storage and to warehouse a part or the whole of their cargoes, to prevent the perishing of merchandise, and no other dues shall be demanded of them than such as may pertain to the hire of warehouses and public yards that they may need for the storing of the goods or the repairing of the damage to the vessels.

XVI. All vessels shall be considered as French in New Granada and as Granadian in France that shall navigate under the respective flags and carry the license and other documents required by the legislation of the two States as evidence of the nationality of merchant vessels.

XVII. The vessels, merchandise, and effects belonging to the respective subjects and citizens that may have been captured by pirates within the jurisdiction of either contracting party or on the high seas and brought into or found in the harbors, rivers, roadsteads, and bays controlled by the other, shall be turned over to the owners upon payment, if any, of the cost of recapture as determined by the proper tribunals, after giving evidence of ownership to the said tribunals. It is well understood that the claim for restitution must be presented within a year by the party in interest, its attorneys, or by the agents of the respective Governments.

XVIII. The war vessels of either power shall be permitted to enter, sojourn in, and go into the gearing docks of the ports of the other which are opened to the most favored nation. They shall be subject to the same regulations and enjoy the same advantages.

XIX. If one of the contracting parties should happen to be at war with a third power, the other power shall not under any circumstance authorize its nationals to take or accept commissions or letters of marque for hostile operations against the former, or for the purpose of molesting the commerce and property of its subjects or citizens.

XX. Both contracting parties adopt, in their nautical relations, the principle that free ships make free goods. In consequence, should one of the parties remain neutral while the other is at war with another power, merchandise protected by the neutral flag shall also be deemed to be neutral, even though it should be the property of the enemy of the other contracting party. It is likewise agreed that a free flag also insures the freedom of persons, and that individuals belonging to a hostile power who might be found on board a neutral vessel shall not be taken as prisoners unless they be soldiers and for the time being in the service of the enemy. As a consequence of the same principle under which the flag and the cargo are assimilated neutral property found on board a vessel of the enemy shall be considered as enemy's property unless it should have been shipped on said vessel prior to the declaration of war or before it was known at the port whence the vessel may have sailed.

The two contracting powers shall apply this principle as regards other powers to those only which also recognize it.

XXI. Should one of the two contracting parties be at war with another power, and its vessels have occasion to exercise the right of visitation at sea, it is agreed that, if they come across a vessel belonging to the other party, the latter having remained neutral, they shall send in a boat two examiners charged with the duty of examining the papers relative to the nationality or the cargo. The commanders shall be responsible, personally and pecuniarily, for any vexation, insult, or act of violence that may be committed on the occasion. Visitation will be allowed on board such vessels only as may navigate without a convoy. In regard to convoyed vessels, it will be sufficient for the commanding officer of the convoy to declare, orally and upon his word of honor, that the vessels placed under his protection and escort belong to the State whose flag he flies, and to declare, when the vessels shall be bound for a port of the enemy, that they do not carry contraband of war.

XXII. In the event of war between either party and another power, nation, or State, the subjects or citizens of the other party will be permitted to continue trade and navigation with the said States, excepting the cities or ports that may be actually blockaded or beleaguered. It is, however, well understood that this freedom of trade and navigation shall not extend to articles deemed to be contraband of war, such as cannon and firearms, side arms, projectiles, powder, saltpeter, articles of military equipment, and all implements whatsoever made for warlike purposes.

In no event shall a merchant vessel owned by subjects or citizens of either country, bound for a port blockaded by the forces of the other, be seized, captured, or condemned, unless it shall have received previous notice or warning of the existence of the blockade from some vessel belonging to the blockading squadron or division. And in order that ignorance of the circumstances may not be alleged, and that such vessel as may have been duly warned shall be liable to capture if it should again repair to the same port during the blockade, the commanding officer of the war ship that shall have met it for the first time shall enter on the papers of the said vessel the day, place, and distance of his visit, and aforesaid notification made by him with the requisite formalities.

XXIII. Consuls of each one of the two countries may be established for the protection of commerce; but these officers shall not enter upon their duties or enjoy the rights, privileges, or immunities to which they may be entitled until they shall have obtained the authorization of the Government of the country. The latter will, moreover, retain the right of determining the residences at which it shall see fit to receive consuls. It is well understood that, in this respect, neither Government shall oppose to the other any restriction that does not apply in its country to all nations in common.

XXIV. The two contracting parties engage to negotiate, as soon as practicable, a consular convention which will determine in a clear, final, and reciprocal manner the rights, privileges, and immunities that the respective consuls, their chancellors and clerks, shall enjoy in the respective countries as well as the duties they shall have to discharge and the obligations to which they shall be held. In the meanwhile French consuls and vice-consuls in New Granada and Granadian consuls and vice-consuls in France shall, respectively, receive the same treatment and consideration as those of the most favored nation.

XXV. The Republic of New Granada shall enjoy, in all the French possessions and colonies, the same rights, privileges, and the same freedom of commerce and navigation as is now or shall hereafter be enjoyed by the most favored nation, and, reciprocally, the inhabitants of the French possessions and colonies shall enjoy, to this full extent, the same rights and privileges and the same freedom of commerce and navigation as are, under this treaty, granted in New Granada to the French, their commerce and their navigation.

XXVI. It is formally agreed between the two contracting parties that, independently of the foregoing stipulations, the diplomatic agents, the subjects of all classes, the vessels and merchandise of either State shall, as of right, enjoy in the other the exemptions, privileges, and immunities whatsoever conceded to the most favored nation, and this gratuitously, if the concessions be gratuitous, and for the same consideration if it should be conditional.

XXVII. The present treaty shall remain in force for a period of ten years counted from the day of the exchange of ratifications, but if, one year before the expiration of that term, neither contracting party should announce, by an official declaration, its intention to terminate or revise it, it shall continue binding on both parties for five years longer, and so on, from five to five years, so long as the official notice hereinabove mentioned shall not have been made at least twelve months in advance.

In the event of one of the contracting parties deeming that some of the stipulations of the present treaty may have been infringed to its detriment, it shall first lay before the other, together with its demand for redress, a statement of the facts, accompanied by such documents and evidence as may be necessary to show that its complaint is well founded, and it shall not, in any way, authorize reprisals or declare war unless the redress demanded by it shall have been denied or unfavorably received.

XXVIII. The present treaty of amity, commerce, and navigation, in twenty-eight articles, shall be ratified by His Majesty the Emperor of the French and by the President or the person in charge of the executive power in New Granada, with the approval of the Congress, and the ratifications shall be exchanged at Bogota within a term of eighteen months or sooner if possible. During that time and pending the exchange of ratifications the treaty of October 28, 1844, shall continue in force and effect.

In witness whereof the plenipotentiaries have signed the said treaty and hereunto affixed their private seals at Bogota, on the 15th day of May of the year of the Lord 1856.

[SEAL.] BARON GOURY DU ROSLAN.
[SEAL.] LINO DE POMBO.

ADDITIONAL ACT.

The undersigned, plenipotentiaries of His Majesty the Emperor of the French and of the Republic of New Granada, signers of the treaty of amity, commerce, and navigation concluded on May 15, 1856, recognizing the necessity and expediency of elucidating the sense and purport of some of the stipulations embodied in the said treaty, while the exchange of ratifications is still in abeyance, and with a view of removing for the future all grounds of doubt or controversy on the subject, by virtue of the full powers with which they are vested, have agreed upon the two following articles:

ARTICLE I. The reciprocity of rights, exemptions, and allowances regarding the importation and exportation of natural products, established, in favor of the flags of both countries, by Article XII of the treaty of May 15, 1856, does not include that which relates to special advantages or encouragements that may now or hereafter be conferred upon the national fisheries in either country.

II. It is stipulated that the freedom of commerce and navigation in all the French possessions and colonies, on the footing of the most favored nation, granted to New Granada by Article XXV of the said treaty, is and must be understood to be a compensation for the concessions, made by New Granada to France, in matters of commerce and navigation, and specially those in Article II relative to the coasting trade.

These two articles, additional to the above-mentioned treaty of May 15, 1856, shall be included in the instruments of ratification of the said treaty, and shall have the same force and validity as if they had been therein inserted word for word.

In witness whereof the two plenipotentiaries have signed and affixed their private seals unto the present article, done in duplicate, at Bogota, the 27th day of January of the year 1857.

[SEAL.] BARON GOURY DU ROSLAN.
[SEAL.] LINO DE POMBO.

Appendix C C 2.

CONVENTION OF ALIENAGE, COMMERCE, AND NAVIGATION BETWEEN THE REPUBLIC OF COLOMBIA AND THE FRENCH REPUBLIC.

[Translation.]

The President of the Republic of Colombia and the President of the French Republic, being equally animated by the desire of drawing closer the bonds of friendship which united the two States, and desiring to establish definite rules for the government of the commercial and maritime relations between Colombia and France, have determined to conclude an arrangement for that purpose, and have named as plenipotentiaries:

The President of the Republic of Colombia, Señor Marco Fidel Suárez, under secretary of state, acting minister for foreign affairs; and

The President of the French Republic, M. Alexander Napoleon Mancini, chargé d'affaires of the French Republic at Bogotá, Knight of the Legion of Honor;

Who, after having exchanged their respective full powers, found to be in due and proper form, have agreed upon the following articles:

Article I. The two high contracting parties reciprocally guarantee, each to the other, the treatment of the most favored nation in whatever relates to the settling of their respective citizens [in the territory of the other], and in whatever relates to commerce and navigation, as well as in respect to importation, exportation and transit, and generally all matters connected with custom-house duties and commercial operations, as also in respect to the carrying on of trade or manufactures, and in respect to the payment of the taxes pertaining thereto.

Article II. The present arrangement shall be ratified and the ratifications shall be exchanged in Paris as soon as possible, and shall go into effect eight days after the exchange of ratifications, and shall remain in force until the expiration of one year after the day on which one of the high contracting parties shall have denounced the same.

In faith whereof the respective plenipotentiaries have signed the present arrangement and affixed their seals thereto.

Done in Bogotá, in duplicate, the 30th day of May, 1892.

[seal] Marco F. Suárez.
[seal] A. Mancini.

Appendix D D.

TREATY OF PEACE AND FRIENDSHIP BETWEEN SPAIN AND COLOMBIA SIGNED AT PARIS, JANUARY 30, 1881.

[Ratifications exchanged at Paris, August 12, 1881.]

The Republic of the United States of Colombia, of the one part, and His Majesty Don Alfonso XII, Constitutional King of Spain, of the other, desiring to put an end to the disunion which has unhappily existed between the two States, have resolved to enter into a treaty of peace and friendship, which may perpetuate the alliance that ought naturally to unite the citizens of Colombia and the subjects of Spain, and to that end have named and appointed for their plenipotentiaries, to wit:

His Excellency the President of the United States of Colombia, Don Luis Carlos Rico, envoy extraordinary and minister plenipotentiary of that Republic to the French Republic; and His Majesty the King of Spain, Don Mariano Roca de Tagores, Marquis de Molins, Viscount de Rocamoza, Grandee of Spain of the first class, Knight of the famous Order of the Golden Fleece, Knight of the Order of Calatrava, Grand Cross of the Royal and Distinguished Order of Charles II, Grand Cordon of the Order of the Legion of Honor of France, of Pius IX, of the Rose of Brazil, etc., and his ambassador to the French Republic;

Who, after exchanging their full powers, and having found them in due order, have agreed on the following articles:

Article I. There shall be total oblivion of all that is past; and there shall be a solid and inviolable peace between the Republic of the United States of Colombia and His Majesty the King of Spain.

II. As soon as this compact comes into force each of the high contracting parties shall send a diplomatic representative to the other, as well as such consuls, vice-consuls, or consular agents as it may be judged convenient to establish in their respective ports, cities, or possessions; and both shall enjoy reciprocally all the privileges, exemptions, and immunities that are enjoyed by similar agents of the most favored nation.

III. The citizens of Colombia in Spain and the subjects of His Catholic Majesty in the Republic of Colombia shall be exempt from all compulsory service in the army, navy, and national guards, and from every contribution and impost not paid by the citizens or subjects of the country in which they may be residing. With regard to the distribution of taxes, imposts, and other general burdens, to liberty and protection in the exercise of their calling, and to the other rights relative to property and the security of person, and with regard to the administration of justice they shall be held to be on the same footing as the natives of the respective countries, subject in all cases to the laws and regulations of the one in which they may be residing.

IV. Until such time as the high contracting parties may have concluded a treaty of commerce and navigation, they agree that the citizens of the United States of Colombia, their ships and merchandise, shall enjoy within the territory of Spain, its canals and ports, all the advantages and exemptions accorded to the most favored American nation, gratuitously if the concession be gratuitous, and with one and the same compensation if it be conditional; and that the subjects of his Catholic Majesty, their ships and merchandise, shall enjoy in the United States of Colombia, its canals and ports, all the advantages and exemptions accorded to the most favored European nation, gratuitously if the concession be gratuitous, and with one and the same compensation if it be conditional.

V. The present treaty shall be ratified, and the ratifications shall be exchanged in Paris, as soon as may be possible.

In witness whereof the undersigned plenipotentiaries of the Republic of the United States of Colombia and of His Majesty the King of Spain, have hereunto set their names and seal in Paris, on the 30th January, 1881.

[SEAL.] LUIS CÁRLOS RICO.
[SEAL.] MARQUIS DE MOLINS.

Appendix F F.

CONTRACT BETWEEN THE UNITED STATES OF COLOMBIA AND THE PANAMA RAILROAD COMPANY, MADE IN 1867, AS MODIFIED BY THE CONTRACTS MADE IN 1876 AND 1880.

CONTRACT REFORMATIVE OF THAT OF APRIL 15, 1850, CONCERNING THE CONSTRUCTION OF A RAILROAD, FROM ONE OCEAN TO THE OTHER, ACROSS THE ISTHMUS OF PANAMA.

The secretary of finance and public improvements of the United States of Colombia, duly authorized by the executive power, on the one part, and on the other George M. Totten, engineer in chief and general agent of the Panama Railroad Company, with full power and authority from the directors of said company, having in consideration the stipulation in Article II of the contract made with said company and approved by the legislative decree of the 4th of June, 1850, and desiring to provide whatever may be needful for the perfection of the work of the said railroad, in order that it may better answer the necessities of the commerce of the world, and at the same time furnish a sure and permanent revenue to the treasury of the Republic, have agreed to modify and reform the said contract in the terms set forth in the following stipulations:

Article I. The Government of the United States of Colombia concedes to the Panama Railroad Company the use and possession, for ninety-nine years, of the railroad constructed by it, and which actually exists, between the cities of Colon and Panama. This concession comprises not only the road, but also the buildings, warehouses, wharves, dockyards, telegraph between Colon and Panama belonging to the road, and, in general, all the dependencies and other works of which the said company is now in possession necessary to the service and development of the enterprise, and those which in the future it may establish with the same purpose.

Article II. The Government of the Republic binds itself, during the time that the exclusive privilege which is conceded to the company for the working of the railroad remains in force, not to construct for itself nor to concede to any person or company, by any title whatever, the power to establish any other railroad on the Isthmus of Panama; and it also stipulates that while the said privilege continues in force the Government shall not have the power of undertaking for itself nor permitting any person to undertake, without the concurrence and consent of said company, the opening or working of any maritime canal which may unite the two oceans across the said Isthmus of Panama to the west of the line of Cape Tiburon on the Atlantic and Point Garachiné on the Pacific; but it remains stipulated that the right which is conceded to the company to give its consent does not extend to its opposing the construction of a canal across the Isthmus of Panama (except on the actual route of the railroad itself), but only to its exacting an equitable price for such privilege and as indemnification for the damages which the railroad company may suffer by the rivalry or competition of the canal.

If the sum which may be demanded by the company shall not appear equitable to the Government of the United States of Colombia, then it shall be fixed by arbitrators in New York or Panama, one to be named by the Government and the other by the company, and in case of their not agreeing the two shall name a third, whose decision shall be without appeal.

In pronouncing their decision the arbitrators shall take into consideration the grounds upon which the company rests and the information which the Government shall give upon the matter, and in view thereof they shall decide without appeal as they may deem most just and equitable.

The sum, whatever it may be, which shall be finally designated, shall belong one-half to the railroad company and one-half to the Government of Colombia.

ARTICLE III. In compensation of and as a price for these concessions the railroad company binds itself to pay to the Government of the United States of Colombia $1,000,000 in American gold, or in bills on New York payable in the same kind, as the Government may elect, on the day on which this contract shall be approved by Congress, and to pay from the present time, and until the expiration of the present privilege, an annual revenue of $250,000 [a] in American gold. The company will make the payments quarterly in New York to the agent designated by the Government of the United States of Colombia, or if the Government should desire, the company will place the money in London or Panama, the Government giving the necessary notice to the company in New York. These quarterly payments shall commence to count from the date of the approval of this contract by Congress.

From the revenue which the Government acquires by this contract there shall be set apart annually during twenty years $25,000, which the company shall deliver to the Government of the State of Panama.

ARTICLE IV. The company binds itself to extend the railroad on the Pacific side to the islands of Naos, Culebra, Perico, and Flamenco, or other place in the bay where there may exist a permanent depth of water for large vessels.

Whereas a certain contract was made between the Government of the United States of Colombia and the Panama Railroad Company, dated the fifth day of July, one thousand eight hundred and sixty-seven, in abrogation of and to take the place of another contract between the same parties of the fifteenth day of April, one thousand eight hundred and fifty, which first-mentioned contract was afterwards approved by the said Government, by legislative decree, on the sixteenth day of August, one thousand eight hundred and sixty-seven, with certain modifications, which modifications were accepted by the said railroad company; and whereas it was stipulated by the said new contract, by Article IV of the same, that the said railroad company should extend its railway to the islands of Naos, Culebra, Perico, and Flamenco, or any other place in the Bay of Panama where a permanent anchorage may be found for large vessels, as by reference to said contract will more fully and precisely appear;

And whereas the said railroad company has not yet completed the said work, and denies any present obligation to proceed with the same; and whereas the Congress

[a] $225,000 of this annual subsidy was advanced and paid by the company to the Colombian Government in November, 1880, for the full period intervening up to March 27, 1908.

of the United States of Colombia, on the twenty-sixth day of July, one thousand eight hundred and eighty, by an act passed on that day, authorized the executive power of the said United States of Colombia to enter into negotiations with the Panama Railroad Company, in order to declare it liberated from the obligations it assumed by the aforesaid Article IV of the contract made on the sixteenth day of August, one thousand eight hundred and sixty-seven, for the extension of the said railway in the harbor of Panama as aforesaid, by which act a sum of money was to be paid to the said Republic of the United States of Colombia sufficient, in the judgment of the executive power of the said Government, to compensate for the release from the said article as aforesaid;

And whereas the national executive power of the said Government has appointed Mr. Solomon Koppel as its agent and attorney for the purpose of negotiating with the said railroad company for the abrogation of the said Article IV, and has given to him full, complete, and absolute power to enter into, carry out, and conclude, in the name of the Government of the United States of Colombia, the negotiations for the purpose of abrogating the aforesaid Article IV of the said contract;

And whereas the chief executive of the said Republic of the United States of Colombia has exercised the discretion conferred upon him by the aforesaid act of Congress, by the issue to the said Solomon Koppel of instructions by which the said Solomon Koppel, as such agent and attorney of the Government of the United States of Colombia as aforesaid, is directed to negotiate only for an exemption or abrogation of the aforesaid Article IV for a period of not exceeding thirty consecutive years, and has further exercised the aforesaid discretion and authority conferred by the said act of Congress by fixing the amount to be paid by the said Panama Railroad Company for the abrogation of the said Article IV, and which, by the aforesaid written instructions, is limited to the sum of ten thousand dollars per annum for each of the years during which the said Article IV is suspended or abrogated;

And whereas the said Solomon Koppel is now in the city of New York, and has had a negotiation with the Panama Railroad Company touching the matters aforesaid, and has agreed with the said company to the suspension of the said Article IV for the full period of thirty years from the first day of November, one thousand eight hundred and eighty, upon condition that the said company should pay to the said Government of the United States of Colombia the full sum of ten thousand dollars per annum for each of the said thirty years, making an aggregate payment to the said Government for the suspension and abrogation aforesaid of three hundred thousand dollars in American gold; in all of which actings and doings the said Solomon Koppel has complied exactly with the written instructions of the said chief executive of the United States of Colombia as the same were communicated to him, and as the same have been handed by him to the Panama Railroad Company:

Now, therefore, this agreement witnesseth that, in consideration of the premises and for the aforesaid sum of three hundred thousand dollars in gold coin, payable at the rate of ten thousand dollars in each year from the execution hereof by the Panama Railroad Company to the United States of Colombia, the said Government has fully exonerated, released, and discharged, and does hereby fully exonerate, release, and discharge, the said Panama Railroad Company from all its obligations of every nature whatsoever arising upon or growing out of the aforesaid Article IV of the contract of the fifth day of July, one thousand eight hundred and sixty-seven, by which article the said company was bound to extend its railroad on the Pacific side, as is provided in and by the said contract, to which special reference is hereby made, and the said contract, in so far as concerns the extension of the said railroad into the bay of Panama aforesaid, is hereby, in accordance with the full power granted to the chief executive of the said Government by the Congress of the United States of Colombia, abrogated and annulled. But this abrogation, suspension, and annulment of the said Article IV shall continue only for the period of thirty years from and after the first day of November in the year one thousand eight hundred and eighty, and at the expiration of the said term of thirty years the said Article IV of the said original contract of the fifth day of July, one thousand eight hundred and sixty-seven, shall again be revived, and shall be and remain thereafter in force and effect as the same now exists. And the said Panama Railroad Company, in consideration of the aforesaid suspension, release, and abrogation of the said Article IV for the term and period as aforesaid, hereby agrees to pay to the said Government of the United States of Colombia the just and full sum of three hundred thousand dollars in gold coin, as follows, viz: The sum of ten thousand dollars on the first day of November in each and every year, payable in the city of New York, during the said term of thirty years, the first of said annual installments to be payable on the first day of November, which will be in the year one thousand eight hundred and eighty-one, and on each first day of November thereafter until the whole sum of three hundred thousand dollars shall have been paid. And it is further provided and agreed that in case the said Panama Railroad Company, or its successors, shall determine to extend its said line of railway to the islands in the bay of Panama, or to deep water in accordance with the terms of said Article IV as originally agreed, and shall actually construct the same, that then and from thenceforward the annual payment of ten thousand dollars for each of said thirty years shall cease for the remainder of said term then unexpired, anything herein contained to the contrary in anywise notwithstanding; but this termination of said annual payments shall not take effect until the expiration of six months after said Panama Railroad Company shall have given notice to the Government of the United States of Colombia of the actual completion of said extended line in the bay of Panama as aforesaid.—*Contract of 1880.*

ARTICLE V. During the whole term of this privilege the company shall have exclusive right to establish across the Isthmus of Panama, within the zone indicated in Article II, any class of carriage roads whatever, from one ocean to the other. The Colombian Government binds itself not to undertake for itself, nor to permit any other company or person to undertake within said zone, any other carriage road, either macadamized or of plank, or of any other class suitable for the use of wheeled vehicles, between the two oceans across the Isthmus of Panama. It being, nevertheless, well understood that the privilege of which this article treats can not and must not, in any manner, prevent the construction of any kind of roads in a direction distinct from that expressed, nor the completing, preserving, and improving of roads already existing, or which are actually being constructed on said isthmus.

ARTICLE VI. The company shall have the right for the whole term of this privilege:

First. To regulate and direct the use of the ports, embarking and disembarking places, wharves, anchorage grounds, etc., at the termini of the railroad, and to establish agents with powers to carry into effect the regulations that it may make in this particular in conformity with the laws of the Republic. These regulations shall be submitted to the approval of the executive power, without which they can not take effect. The executive power may refuse its approbation, alter and revoke them, as it may deem convenient.

Second. To use the embarking and disembarking places, wharves, etc., that it has constructed or may construct in the ports situated at the two extremes of the road.

Third. To use the landings necessary, and especially those designated for the storage and free deposit of all goods and merchandise admitted for transit over the isthmus on the railroad constructed by the company. By virtue of this privilege the company may collect as compensation for the use of the line of communication, means of transportation, landings, warehouses, and establishments of all kinds belonging to it such tolls for transporting, wharfage, storage, and labor as it may deem proper to establish.

The company continues in the exercise of all the rights conceded to it in the sixth article of the contract of 5th of July, 1867. Consequently it may regulate and direct the use of the ports, embarking and disembarking places, wharves, anchorage grounds, etc., at the termini of the railroad, and establish agents with powers to carry into effect the regulations that it may make in this particular in conformity with the laws of the Republic. These regulations shall be submitted to the approval of the executive power, without which they can not take effect; but the executive power, after having once approved them, can not change them nor revoke them without the consent of the company.—*Article 1 of contract of 1876.*

ARTICLE VII.—The executive power shall determine the forms to be observed in the landing of goods on either ocean, and the intervention therein of the officers of the Republic to prevent the effects destined for transit from one ocean to the other from being left on the way or fraudently introduced for internal consumption. Said precautions shall be such as may tend to prevent all frauds to the injury of the public revenue, without delaying or embarrassing the rapid dispatch and transit of passengers and packages of merchandise, luggage, and goods of all kinds which may be subjects of lawful commerce.

ARTICLE VIII.—The company may give to the actual railroad a different direction from that which it now has, and which it may deem most favorable to the enterprise, it being free to choose the points of departure and arrival which may appear to it most advantageous and most convenient for the entrance and anchorage of vessels, or for ports properly so called, and for embarking places, dry docks, places for lighterage, landings, warehouses, stations, hotels, and establishments of all kinds, and this without prejudice to what is stipulated in Article IV of this contract.

ARTICLE IX. The Government of the United States of Colombia ratifies the concession made to the Panama Railroad Company by the contract of the 15th of April, 1850:

First. Of the lands that it has required and that it may require for the establishment of the line of railway in its whole extent, provided such lands belong to the Government;

Second. Of the lands which were necessary for seaports, dry docks, river ports, landings, embarking places, places for lighterage, warehouses, stations, hotels, and generally for all the necessities of the service of the railroad, always provided that such lands shall be the property of the Republic;

Third. Of the concession made by gratuitous title and in perpetuity of 64,000 hectares of vacant lands in the territory of the State of Panama, with exception of the islands in both oceans and of the districts which formed on the 1st of January, 1849, the territories of Bocas del Toro and of Darien, limits of which were fixed by the law of the 9th of January, 1855. This concession may be extended to 96,000 hectares, if there shall be that number disposable within the limits of the ancient provinces of Panama and Veraguas in such manner that the Government can adjudicate them as vacant lands; and the company shall have the right to select them in the continental part of said provinces as they may deem most convenient. But it is stipulated that in the lands which the company may select on the line of road, and its vicinity, there shall positively be left regular intervals equivalent in extent to those (tracts) which shall be given to the company in order that the Government may be enabled to make grants or sales of land for other establishments which may desire to locate themselves on the line and in the neighborhood of the road.

Paragraph.—The lands granted to the company by sections first and second of this article shall be returned to the Republic at the expiration of the present privilege in the terms and with the formalties prescribed in this contract.

ARTICLE X. In the grant of vacant lands in perpetuity made to the company by the contract of 1850 and ratified in section third of Article IX of this contract, there is not included the number of hectares contained in the island of Manzanillo in the bay of Limon, but they are included in the grants treated of in the first and second sections of the article cited, with the exception of 4 hectares which the Government reserves as an area for the construction of buildings for public offices, schoolhouses, prison, and other objects of public use, which shall be delivered by the company properly graded and in condition for building upon them. But it is understood that in the designation by the Government of the place or places in which it desires to take the 4 hectares reserved to it by this article, it shall not choose those which may be necessary for the construction and service of the railway and its dependencies, nor those which may be already occupied by buildings now standing or which are to be reconstructed.

This selection may be made by the Government in anticipation, as it may see fit, in accordance with the plan of the city, in order that the lands may be delivered to it so soon as the nature of the ground permits of the grading being carried on.

Article XI. The lands conceded to the company by Article IX, section third, shall be delivered as may be requested on compliance with the legal formalities established for such cases, and it being incumbent on the company to prove their character as vacant lands, to measure them, and to make the respective plans. The adjudication of said lands shall be made by the executive power, and from the time the declaration is made in the premises they shall be considered definitely adjudicated to the company; but the provisional adjudication shall be made by the president of the State of Panama, submitted always to the examination and approval of the national executive power, and while not disapproved it will only produce the effect of preventing any ulterior grant of the same lands in favor of a third party. The Republic is not bound in any case to the vacating and guaranteeing the title of the vacant lands which may be adjudicated to the company.

The executive power will fix a time in agreement with the company within which the latter shall be bound to designate the vacant lands to which it has the right.

Article XII. When the lands which may be required for the extension of the line of the railroad, as referred to in Article IV of this contract, or for changes of direction of the line, or for the establishment of a second line of rails, shall be the property of private individuals, the company shall have the right to obtain them on an official appraisement and the just indemnification of the proprietor, in conformity with the dispositions of the law of the 22d of May, 1866, "concerning the mode of proceeding in those civil cases, the cognizance of which appertains to the tribunals of the Union."

Article XIII. The railroad enterprise is esteemed of public utility.

Article XIV. The company is authorized to propose to the executive power the regulations which it may judge proper for the police, security, and preservation of its ways of communication, ports, works, and establishments of all kinds; but such regulations shall not be put in force without the express approval of the executive power, which, even after having approved them, may amend or annul them as it may deem proper, proceeding always in conformity with the laws of the Republic.

The company continues authorized to propose to the executive power the regulations which it may judge proper for the police, security, and preservation of its ways of communication, ports, works, and establishments of all kinds.

Such regulations shall not be carried into effect without the express approval of the executive power; but the latter, after having approved them, can not change them nor annul them without the consent of the company.—*Article II of contract of 1876.*

ARTICLE XV. The tariff of charges and freights on money, carriage of merchandise, and transport of travelers over the railroad, board and storage in the depots and establishments of the company, shall be fixed by it, and modified as it may deem best for its interests, but it shall be bound to inform the local authorities of said tariffs and modifications with at least thirty days' previous notice.

ARTICLE XVI. The company binds itself to transport gratis over the railroad the national and state mails that may have to be carried from ocean to ocean or to any intermediate point; and it may make such pecuniary arrangements as it thinks proper for the transportation of foreign mails, the passage of which over the isthmus is declared free to all nations; but the Government of the Republic may prohibit the passage by the railroad of the mails of those nations that may be at war with it, in which case the company shall refuse to carry them over the railroad.

ARTICLE XVII. The company may freely introduce into the isthmus without payment of duties or imposts of any kind all the implements, machines, tools, materials, provisions, and manufactured articles intended for the construction, working, and preservation of the railroad, and the provisioning of the workmen employed on it.

ARTICLE XVIII. The company is exempt from paying taxes or contributions, national, municipal, of the State, or of any other kind, upon the railroad, its warehouses, wharves, machines or other works, things and effects of any kind belonging to it, and which in the judgment of the executive power are necessary for the service of the said railroad and its dependencies.

ARTICLE XIX. In compensation for these exemptions the company binds itself to transport gratuitously, and without the Government having to pay anything either for freight or for any other cause, the troops, chiefs, and officers, and their equipage, ammunition, armament, clothing, and all similar effects that may belong to, are or may be destined for the immediate service of the Government of the Republic, or of the State of Panama, as also their officials in service or in commission, and those individuals who, with their families and baggage, may come to the country in the character of emigrants, and of new settlers, with the permanent character of such, for account of the Government, up to the number of 2,000 annually. The executive power shall dictate the provisions as it may deem proper in such cases, in order to prevent those passengers whose entry into Colombian territory may be purely accidental from availing themselves of this concession.

The executive power of the Union shall dictate the provisions which may be necessary, at the request of the company, to prevent abuses in the gratuitous passage which Article XIX of the aforesaid contract concedes to national employees and those of the State of Panama.—*Article IV of contract of 1876.*

ARTICLE XX. Colombian productions shall be transported by the railroad during the first twenty years of this contract, paying only one-half the rates of freight or transportation previously fixed by the company for foreign products of the same class, but, this term being concluded, they shall pay a charge or freight not exceeding two-thirds of that previously fixed in the tariff of the company—tariff rates which the company can not increase in future in regard to Colombian productions.

In order that Colombian products may be transported by the railroad under the conditions of Article XX of the same contract, there must precede a declaration of the shipper, duly attested by the bill of lading of shipment, with a certificate of the administrator of the national treasury at the port of shipment, or other similar document, at the time of offering them, that such products are really Colombian; a necessary condition, without which there shall be no ground for any claim.—*Article V of contract of 1876.*

Article XXI.—Passengers, money, merchandise, objects, and effects of all kinds, destined for interoceanic transit over the railroad, while they remain in the warehouses and depots of the company, or in its possession, are exempt from dues and taxes, national, municipal, of the State, or of any other description. In like manner the vessels which may enter the ports at the termini of the railroad, as well as their officers, crews, and their agents, shall be exempt from the payment of tonnage dues, or of any other tax or contribution whatever on account of service applied directly to the interoceanic transit.

Article XXII.—Travelers passing from one sea to the other over the railroad shall not require any passports to pass over it, excepting in cases of foreign war or internal commotion, when the Government may deem the presentation of passports expedient for the security of the country or the preservation of public order. Nevertheless, persons who have been expelled from the territory of the Republic, or other individuals whom the laws forbid an entrance into the country, shall not pass over the railroad.

Article XXIII. In case the present privilege conceded to the company shall be declared forfeited by the competent tribunal, it shall return to the Republic such lands granted in ownership, and by gratuitous title, as may not be already transferred in fee to a third party, and it shall have no right to exact any indemnification for improvements nor for any other cause.

Article XXIV. It is obligatory upon the company to make a survey of the lands, with notice to the owners of adjoining lands, and to make a topographical plan of the road, with all its dependencies, such as bridges, aqueducts, viaducts, and other works which it may have constructed for the service of the railroad, in order that by means of such plan it may be clearly known what the company holds in ownership and to what purpose the exemptions provided for are destined.

Article XXV. The company binds itself to execute constantly, with all care, punctuality, and celerity, the transportation of the travelers, cattle, merchandise, goods, and materials of all kinds that may be confided to it, payment being made of the charges and prices of transportation that may be fixed in the respective tariff. The disposition of this article is, nevertheless, no obstacle to the company's entering into special contracts for the transportation of articles whose bulk, weight, or exceptional nature do not allow of their freights being fixed beforehand.

The provision of the final part of Article XXV of the aforesaid contract of 1867, by which the company was permitted to enter into special contracts for the transportation of articles whose bulk, weight, or exceptional nature would not allow of their freights being fixed beforehand, is made applicable to all kinds of articles of commerce.—*Article III of contract of 1876.*

Article XXVI. Vessels of nations which may be at war with the United States of Colombia shall not be admitted to the ports situated at either extremity of the railroad, nor shall the productions, effects, and property of such nations enjoy the free transit of the isthmus over the said road.

Article XXVII. It is obligatory upon the company to maintain constantly in Panama or Colon a representative with sufficient power and authority to treat, whenever it may be necessary, personally with the Government on matters having relation to the enterprise.

ARTICLE XXVIII. The present privilege can not be ceded or transferred to any foreign Government; that is to say, to any Government existing outside of Colombian territory, under pain of forfeiture of the said privilege by the mere act of attempting or verifying such cession or transfer, which act, from the present time, is declared absolutely null and of no value or effect. This privilege shall also be forfeited in case the railroad company shall not execute the transportation during a period exceeding four consecutive months (fortuitous cases excepted).

This privilege will also be forfeited by the failure of payment, after being one year overdue, of any of the quarterly payments. Delay in the payments for a less period subjects the company to the payment of interest at the rate of 7 per cent per annum.

None of the cases of forfeiture of the privilege fixed in Article XXVIII shall go into effect until the resolution of the Government in which the declaration of forfeiture is made is served in due form, and at least three months in advance, on the company and on the agents of the persons to whom the Government may transfer or hypothecate the revenue to which it is entitled by Article III, if said transfer or hypothecation shall have taken place; it being understood that if, after the notification has been given, and during the aforesaid three months, the company, or the interested persons of whom mention has been made, shall satisfy the Government, causing the reason for complaint or forfeiture to disappear, the said declaration shall not be carried into effect.—*Article VI of contract of 1876.*

The Government reserves to itself the right to hypothecate, in whole or in part, the revenue, of which mention has been made in Article VI of this contract (except the right of the State of Panama to the annual proportion of $25,000), before the time at which said revenue is to be paid, and whatever may be hypothecated shall be payable in such a manner as the Government may direct; and the railroad company binds itself, on being notified of any transfer or hypothecation, to accept it and to make payment at the maturity of the installments to the persons or parties in whose favor the transfer or hypothecation may have been made.—*Article VIII of contract of 1876.*

ARTICLE XXIX.—In case of the forfeiture of this privilege from any cause, the ownership and full possession of the railroad, with all its dependencies, appurtenances, and accessories, shall pass to the Republic without the company's having thereby any right to indemnification or remuneration of any kind.

ARTICLE XXX.—The Government of the Republic binds itself to protect and maintain in all their integrity the rights of the company resulting from the present contract; provided the company complies punctually on its part with the duties and obligations which it undertakes, and that the privilege continues in force.

ARTICLE XXXI. The rights which said Republic reserved to itself by the contract of the 15th of April, 1850, to redeem the privilege of the company, being especially hypothecated as an additional security for the loan contracted by the said Republic in London under date of the 1st of October, 1863, it is stipulated that the products from the railroad, which by this contract belong to the Government, remain subsidiarily applicable to the payment of the obligations of the Government of the Republic, in regard to that loan, whether it be to complete the annual installments which the Government is obliged to pay in London on account of the interest and amortization of the capital, or to redeem the bonds of the loan at par, if in 1874 their redemption shall not have been completed.

ARTICLE XXXII. In consequence of the stipulation in Article III, the Government renounces the benefit or participation of 3 per cent which by Article LV of the primitive contract it had in the net products of the enterprise, and the quota of 5 per cent which had also been reserved in its favor by Article XXX of said contract in the transportation of correspondence, and which quota it was stipulated should not be less than $10,000 annually. The account of these profits shall be liquidated immediately in the terms fixed by Article LV, up to the day on which the present contract begins to rule and have effect, and the payment of the balance which may result in favor of the Republic shall be made by the company in New York to the order of the Government.

ARTICLE XXXIII. Questions which may arise between the Government of the Republic and the railroad company concerning the understanding or the fulfillment of this contract, shall be decided by the courts and tribunals of the Colombian Union according to the constitution and laws of the Republic.

Questions that may arise between the Government of the Republic and the railroad company as to the understanding or the execution of this contract, and of those of 1850 and 1867, to which this one refers, shall be decided without appeal by the federal supreme court of the Colombian Union without the intervention of any other tribunal.—*Article VII of contract of 1876.*

ARTICLE XXXV. The ninety-nine years of the duration of the privilege conceded by this contract shall be counted from the date on which it may be approved by the Congress.[a]

ARTICLE XXXVI. At the expiration of the term of the privilege, and by the sole fact of its expiration, the Government of the Colombian Union shall be substituted in all the rights of the company, and shall enter immediately into the enjoyment of the line of communication, of all its fixtures, of all its dependencies, and of all its products. The company shall be bound to deliver to the Government, in good order, the roads, the works which compose them, and their dependencies, such as landing and discharging places, offices, machines, and in general whatever movable or immovable objects, whether destined for the especial service of transportation or applicable to any other object connected with the enterprise.

ARTICLE XXXVII. The present contract contains all the concessions and privileges which the existing Panama Railroad Company has acquired for the future. In virtue of which it is declared, and the parties hereby expressly agree, that at no time can the company claim rights or privileges which are clearly not contained in this contract, unless they may be granted by subsequent acts.

ARTICLE XXXVIII. The contract of the 15th of April, 1850, approved by the legislative decree of the 4th of June of the same year, is hereby re-formed by the terms of the present contract; and extended as it is in thirty-eight articles, it shall be submitted to the approval of the executive power of the Republic, and, when obtained, it shall be presented to Congress, the consent of which is required in order that, being enacted into a law, it may be carried into effect.[b]

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[a] Which was August 16, 1867.

[b] Congress approved August 16, 1867.

AMENDMENTS AGREED UPON BETWEEN THE PANAMA RAILROAD COMPANY AND THE REPUBLIC OF COLOMBIA, AUGUST 18, 1891.

ARTICLE I. Article XX of the contract of July 5, 1867, approved by law No. 46 of the same year, shall read as follows:

From and after July 1, 1892, Colombian products passing over the Panama Railroad shall pay only half of the rate of freight established by the company for foreign products of the same class.

ARTICLE II. Salt from the Colombian salt pits of the Atlantic coast intended for the national ports of the Pacific shall be transported by the same railroad company at the following rates:

A quantity not exceeding 6,000,000 of kilograms each year, and which shall in no case exceed 1,000 tons per month, at the rate of $2 gold per ton without any deduction. Shipments of the salt referred to that may exceed the quantity above stated shall pay the rate that is established for the other Colombian products in the previous article.

Appendix G G.

WYSE CONCESSION, MARCH 20, 1878.[a]

CONTRACT FOR THE CONSTRUCTION OF AN INTEROCEANIC CANAL ACROSS COLUMBIAN TERRITORY.

Eustorgio Salgar, secretary of the interior and of foreign relations of the United States of Colombia, duly authorized of the one part, and of the other part Lucien N. B. Wyse, chief of the Isthmus Scientific Surveying Expedition in 1876, 1877, and 1878, member and delegate of the board of directors of the International Interoceanic Canal Association, presided by General Etienne Türr, in conformity with powers bestowed at Paris, from the 27th to the 29th of October, 1877, have celebrated the following contract:

Article I. The Government of the United States of Colombia grants to Mr. Lucien N. B. Wyse, who accepts it in the name of the civil International Interoceanic Canal Association, represented by their board of directors, the exclusive privilege for the construction across its territory and for the operating of a canal between the Atlantic and Pacific oceans. Said canal may be constructed without restrictive stipulations of any kind.

This concession is made under the following conditions:

First. The duration of the privilege shall be for ninety-nine years from the day on which the canal shall be wholly or partially opened to public service, or when the grantees or their representatives commence to collect the dues on transit and navigation.

Second. From the date of approbation by the Colombia Congress for the opening of the interoceanic canal, the Government of the Republic can not construct, nor concede to any company or individual, under any consideration whatever, the right to construct another canal across Colombian territory which shall communicate the two oceans. Should the grantees wish to construct a railroad as an auxiliary to the canal, the Government (with the exception of existing rights) can not grant to any other company or individual the right to build another interoceanic railroad, nor do so itself, during the time allowed for the construction and use of the canal.

Third. The necessary studies of the ground and the route for the line of the canal shall be made at the expense of the grantees by an international commission of individuals and competent engineers in which two Colombian engineers shall take part. The commission shall determine the general route of the canal and report to the Colombian

[a] Translation from the Diario Official of Bogota, Wednesday, May 22, 1878.

Government directly, or to its diplomatic agents in the United States or Europe, upon the results obtained, at the latest in 1881, unless unavoidable circumstances, clearly proven, should prevent their so doing. The report shall comprise in duplicate the scientific labors performed and an estimate of the projected work.

Fourth. The grantees shall then have a period of two years to organize a universal joint stock company, which shall take charge of the enterprise and of the construction of the canal. This term shall commence from the date mentioned in the preceding paragraph.

Fifth. The canal shall be finished and placed at the public service within the subsequent twelve years after the formation of the company which will undertake its construction, but the executive power is authorized to grant a further maximum term of six years in the case of encountering superhuman obstacles beyond the power of the company, and, if after one-third of the canal is built, the company should acknowledge the impossibility of concluding the work in the said twelve years.

Sixth. The canal shall have the length, depth, and all other conditions requisite in order that sailing vessels and steamships measuring up to 140 meters long, 16 meters in width, and 8 meters in draft shall, with lowered topmast, be able to pass the canal.

Seventh. All public lands which may be required for the route of the canal, the ports, stations, wharves, moorings, warehouses, and in general for the construction and service of the canal as well as for the railway, should it be convenient to build it, shall be ceded gratis to the grantees.

Eighth. These unoccupied public lands shall revert to the Government of the Republic with the railroad and canal at the termination of this privilege; there is also granted for the use of the canal a belt of land, 200 meters wide, on each side of its banks throughout all the distance which it may run, but the owners of lands on its banks shall have free access to the canal and its ports as well as to the right of use of any roads which the grantees may open there; and this without paying any dues to the company.

Ninth. If the lands through which the canal shall pass or upon which the railroad may be built should in whole or in part be private property the grantee shall have the right to demand their expropriation by the Government according to all the legal formalities in such cases. The indemnity which shall be made to the landowners, and which shall be based on their actual value, shall be at the expense of the company. The grantees shall enjoy in this case, and in those of temporary occupation of private property, all the rights and privileges which the existing legislation confers.

Tenth. The grantees may establish and operate at their cost the telegraph lines which they may consider useful as auxiliaries in the building and management of the canal.

Eleventh. It is, however, stipulated and agreed that if, before the payment of the security determined upon in Article II, the Colombian Government should receive any formal proposal, sufficiently guaranteed in the opinion of the said Government, to construct the canal in less time and under more advantageous conditions for the United States of Colombia, said proposal shall be communicated to the grantees or their representatives that they may be substituted therein, in which case they shall be preferred; but if they do not accept such substitution the Colombian Government, in the new contract which they may celebrate, shall exact, besides the guarantee mentioned in Article II, the sum of $300,000 in coin, which shall be given as indemnity to the grantees.

ARTICLE II. Within the term of twelve months from the date at which the international commission shall have presented the definite results of their studies, the grantees shall deposit in the bank or banks of London, to be designated by the national executive power, the sum of 750,000 francs, to the exclusion of all paper money, as security for the execution of the work. The receipt of said banks shall be a voucher for the fulfillment of said deposit. It is understood that if the grantees should lose that deposit by virtue of the stipulations contained in clauses 2 and 3 of Article XXII of the present contract, the sum referred to, with interest accrued, shall become in toto the property of the Colombian Government. After the conclusion of the canal, said sum, without interest, which latter will in this case belong to grantees, shall remain for benefit of the treasury, for the outlays which it may have incurred or may incur in the construction of buildings for the service of the public officers.

ARTICLE III. If the line of the canal to be constructed from sea to sea should pass to the west and to the north of the imaginary straight line which joins Cape Tiburon with Garachiné Point, the grantees must enter into some amicable arrangement with the Panama Railroad Company, or pay an indemnity, which shall be established in accordance with the provisions of law 46, of August 16, 1867, "approving the contract celebrated on July 5, 1867, reformatory of the contract of April 15, 1850, for the construction of an iron railroad from one ocean to the other through the Isthmus of Panama."

In case the international commission should choose the Atrato, or some other stream already navigable, as one of the entrances to the canal, the ingress and egress by such stream, and the navigation of its waters, so long as it is not intended to cross the canal, shall be open to commerce and free from all imposts.

ARTICLE IV. Besides the lands granted in paragraphs 7 and 8 of Article I, there shall be awarded to the grantees, as an aid for the accomplishment of the work, and not otherwise, 500,000 hectares of public lands, with the mines they may comprise, in the localities which the company may select. This award shall be made directly by the national executive power. The public lands situated on the seacoast, on the borders of the canal or of the rivers, shall be divided in alternate lots between the Government and the company, forming areas of from one to two thousand hectares. The measurements for the allotment or locating shall be made at the expense of the grantees and with the intervention of Government commissioners. The public lands thus granted, with the mines they may hold, shall be awarded to the grantees as fast as the work of construction of the canal progresses, and in accordance with rules to be laid down by the executive power.

Within a belt of 2 myriameters on each side of the canal, and during five years after the termination of the work, the Government shall not have the right to grant other lands beyond the said lots until the company shall have called for the whole number of lots granted by this article.

ARTICLE V. The Government of the Republic hereby declares the ports at each end of the canal, and the waters of the latter from sea to sea, to be neutral for all time; and, consequently, in case of war among other nations, the transit through the canal shall not be interrupted by such event, and the merchant vessels and individuals of all nations of the world may enter into said ports and travel on the canal without being molested or detained. In general, any vessel may pass freely without any discrimination, exclusion, or preference of nationalities or persons, on payment of the dues and the observance of the rules established by the company for the use of the canal and its dependencies. Exception is to be made of foreign troops, which shall not have the right to pass without permission from Congress, and of the vessels of nations which, being at war with the United States of Colombia, may not have obtained the right to pass through the canal at all times, by public treaties wherein is guaranteed the sovereignty of Colombia over the Isthmus of Panama and over the territory whereon the canal is to be cut, besides immunity and neutrality of the said canal, its ports, bays, and dependencies and the adjacent seas.

ARTICLE VI. The United States of Colombia reserves to themselves the right to pass their vessels, troops, ammunitions of war at all times and without paying any dues whatever. The passage of the canal is strictly closed to war vessels of nations at war, and which may not have acquired, by public treaty with the Colombian Government, the right to pass by the canal at all times.

ARTICLE VII. The grantees will enjoy the right during the whole time of the privilege to use the ports at the termini of the canal, as well as at intermediate points, for the anchorage and repair of ships and the loading, depositing, transshipping, or landing of merchandise. The ports of the canal shall be open and free to the commerce of all nations, and no import duties shall be exacted except on merchandise destined to be introduced for the consumption of the rest of the Republic. The said ports shall therefore be open to importations from the commencement of the work, and the custom-houses and the revenue service which the Government may deem convenient for the collection of duties on merchandise destined for other portions of the Republic shall be established, in order to prevent introduction of smuggled goods.

ARTICLE VIII. The executive power shall dictate, for the protection of the financial interests of the Republic, the regulations conducive to the prevention of smuggling, and shall have the power to station, at the cost of the nation, the number of men which they may deem necessary for that service.

Out of the indispensable officials for that service, ten shall be paid by the company, and their salaries shall not exceed those enjoyed by employees of the same rank in the Baranquilla custom-house.

The company shall carry gratis through the canal, or on the auxiliary railway, the men destined for the service of the nation, for the service of the State through whose territory the canal may pass, or for the service of the police, with the object of guarding against foreign enemies, or for the preservation of public order, and shall also transport gratis the baggage of such men, their war materials, armament, and clothing which they may need for the service assigned to them.

The subsistence of the public force which may be deemed necessary for the safety of the interoceanic transit shall likewise be at the expense of the company.

ARTICLE IX. The grantee shall have the right to introduce, free of import or other duties of whatever class, all the instruments, machinery, tools, fixtures, provisions, clothing for laborers which they may need during all the time allowed to them for the construction and use of the canal. The ships carrying cargoes for the use of the enterprise shall enjoy free entry into whatever point shall afford them easy access to the line of the canal.

Article X. No taxes, either national, municipal, of the State, or of any other class, shall be levied upon the canal, the ships that navigate it, the tugs and vessels at the service of the grantees, their warehouses, workshops, and offices, factories of whatever class, storehouses, wharves, machinery, or other works or property of whatever character belonging to them, and which they may need for the service of the canal and its dependencies during the time conceded for its construction and operation. The grantees shall also have the right to take from unoccupied lands the materials of any kind which they may require without paying any compensation for the same.

Article XI. The passengers, money, precious metals, merchandise, and articles and effects of all kinds which may be transported over the canal, shall also be exempt from all duties, national, municipal, transit, and others. The same exemption is extended to all articles and merchandise for interior or exterior commerce which may remain in deposit, according to the conditions which may be stipulated, with the company in the storehouses and stations belonging to them.

Article XII. Ships desiring to cross the canal shall present at the port of the terminus of the canal at which they may arrive their respective registers and other sailing papers, prescribed by the laws and public treaties, so that the vessels may navigate without interruption. Vessels not having said papers, or which should refuse to present them, may be detained and proceeded against according to law.

Article XIII. The Government allows the immigration and free access to the lands and shops of the grantees of all the employees and workingmen of whatever nationality, who may be contracted for the work, or who may come to engage themselves to work on the canal, on condition that such employees or laborers shall submit to the existing laws, and to the regulations established by the company. The Government promises them support and protection, and the enjoyment of their rights and guaranties, in conformity with the national constitution and laws during the time they may sojourn on the Colombian territory.

The national peons and laborers employed on the work of the canal shall be exempt from all requisition of military service, national as well as of the State.

Article XIV. In order to indemnify the grantees of the construction, maintenance, and working expenses incurred by them, they shall have, during the whole period of the privilege, the exclusive right to establish and collect for the passage of the canal and its ports, the dues for light-houses, anchorage, transit, navigation, repairs, pilotage, towage, hauling, storage, and of station according to the tariff which they may issue, and which they may modify at any time under the following express conditions:

First. They shall collect these dues, without any exceptional favor, from all vessels in like circumstances.

Second. The tariffs shall be published four months before their enforcement in the Diario Oficial of the Government, as well as in the capitals and the principal commercial ports of the countries interested.

Third. The principal navigation dues to be collected shall not exceed the sum of 10 francs for each cubic meter resulting from the multiplication of the principal dimensions of the submerged part of the ship in transit (length, breadth, and draft).

Fourth. The principal dimensions of the ship in transit—that is to say, the maximum exterior length and breadth at the water line, as well as the greatest draft—shall be the metrical dimension inserted in the official clearance papers, excepting any modifications supervening during the voyage. The ship's captains and the company's agents may demand a new measurement, which operations shall be carried out at the expense of the petitioner; and,

Fifth. The same measurement—that is to say, the number of cubic meters contained in the parallelopipedon circumscribing the submerged part of the ship—shall serve as a basis for the determination of the other accessory dues.

Article XV. By way of compensation for the rights and exemptions which are allowed to the grantees in this contract, the Government of the Republic shall be entitled to a share amounting to 5 per cent on all collections made by the company, by virtue of the dues which may be imposed in conforming with Article XIV, during the first twenty-five years after the opening of the canal to the public service. From the twenty-sixth up to the fiftieth year, inclusive, it shall be entitled to a share of 6 per cent; from the fifty-first to the seventy-fifth to 7 per cent, and from the seventy-sixth to the termination of the privilege to 8 per cent. It is understood that these shares shall be reckoned, as has been said, on the gross income from all sources, without any deduction whatever for expenses, interest on shares or on loans or debts against the company. The Government of the Republic shall have the right to appoint a commissioner or agent, who shall intervene in the collections and examine the accounts, and the distribution or payment of the shares coming to the Govern ment shall be made in due half-yearly installments. The product of the 5, 6, 7, and 8 per cent shall be distributed as follows:

Four-fifths of it shall go to the Government of the Republic, and the remaining one-fifth to the government of the State through whose territory the canal may pass.

The company guarantees to the Government of Colombia that the share of the latter shall in no case be less than the sum of $250,000 a year, which is the same as that received as its share in the earnings of the Panama Railroad, so that if in any year the 5 per cent share should not reach said sum, it shall be completed out of the common funds of the company.

Article XVI. The grantees are authorized to require payment in advance of any charges which they may establish; nine-tenths of these charges shall be made payable in gold, and only the remaining one-tenth part shall be payable in silver of 25 grams, of a fineness of 900.

Article XVII. The ships which shall infringe upon the rules established by the company shall be subject to the payment of a fine which said company shall fix in its regulations, of which due notice shall be given to the public at the time of the issue of the tariff. Should they refuse to pay said fine, nor furnish sufficient security, they may be detained and prosecuted according to the laws. The same proceedings may be observed for the damages they may have caused.

Article XVIII. If the opening of the canal shall be deemed financially possible, the grantees are authorized to form, under the immediate protection of the Colombian Government, a universal joint-stock company, which shall undertake the execution of the work, taking charge of all financial transactions which may be needed. As this enterprise is essentially international and for public utility, it is understood that it shall always be kept free from political influences.

The company shall take the name of The Universal Interoceanic Canal Association; its residence shall be fixed in Bogota, New York, London, or Paris, as the grantees may choose; branch offices may be established wherever necessary. Its contracts, shares, bonds, and titles of its property shall never be subjected by the Government of Colombia to any charges for registry, emission, stamps, or any similar imposts upon the sale or transfer of these shares of bonds, as well as on the profits produced by these values.

Article XIX. The company is authorized to reserve as much as 10 per cent of the shares emitted, to form a fund of shares, to the benefit of the founders and promoters of the enterprise. Of the products of the concern, the company take, in the first place, what is necessary to cover all expenses of repairs, operations, and administration, and the share which belongs to the Government, as well as the sums necessary for the payment of the interest and the amortization of the bonds, and, if possible, the fixed interest or dividend of the shares; that which remains will be considered as net profit, out of which 80 per cent at least will be divided among the shareholders.

Article XX. The Colombian Government may appoint a special delegate in the board of directors of the company whenever it may consider it useful to do so. This delegate shall enjoy the same advantages as are granted to the other directors by the by-laws of the company.

The grantees pledge themselves to appoint in the capital of the Union, near the national Government, a duly authorized agent for the purpose of clearing up all doubts and presenting any claims to which this contract may give rise. Reciprocally and in the same sense, the Government shall appoint an agent who shall reside in the principal establishment of the company situated on the line of the canal; and, according to the national constitution, the difficalties which may arise between the contracting parties shall be submitted to the decision of the federal supreme court.

Article XXI. The grantees, or those who in the future may succeed them in their rights, may transfer these rights to other capitalists or financial companies, but it is absolutely prohibited to cede or mortgage them under any consideration whatever to any nation or foreign government.

Article XXII. The grantees, or their representatives, shall lose the right hereby acquired in the following cases:

First. If they do not deposit, on the terms agreed upon, the sum which by way of security must insure the execution of the work.

Second. If, in the first year of the twelve that are allowed for the construction of the canal, the works are not already commenced, in this case the company shall lose the sum deposited by way of security, together with the interest that may have accrued, all of which will remain for the benefit of the Republic.

Third. If, at the end of the second period fixed in paragraph 5 of Article I, the canal is not transitable, in this case also the company shall lose the sum deposited as security, which, with the interests accrued, shall remain for the benefit of the Republic.

Fourth. If they violate the prescriptions of Article XXI; and,

Fifth. If the service of the canal should be interrupted for a longer period than six months without its being occasioned by the acts of God, etc.

In cases 2, 3, 4, and 5, the federal supreme court shall have the right to decide whether the privilege has become annulled or not.

ARTICLE XXIII. In all cases of decisions of nullity, the public lands mentioned in clauses 7 and 8 of Article I, and such lands as are not settled or inhabited from among those granted by Article IV, shall revert to the possession of the Republic in the condition they may be found in, and without any indemnity whatever, as well as the buildings, materials, works, and improvements which the grantees may possess along the canal and its accessories. The grantees shall only retain their capital, vessels, provisions, and in general all movable property.

ARTICLE XXIV. Five years previous to the expiration of the ninety-nine years of the privilege, the executive power shall appoint a commissioner to examine the condition of the canal and annexes, and, with the knowledge of the company or its agents on the isthmus, to make an official report, describing in every detail the condition of the same and pointing out what repairs may be necessary. This report will serve to establish in what condition the canal and its dependencies shall be delivered to the National Government on the day of expiration of the privilege now granted.

ARTICLE XXV. The enterprise of the canal is reputed to be of public utility.

ARTICLE XXVI. This contract, which will serve as a substitute for the provisions of law 33, of May 26, 1876, and the clauses of the contract celebrated on the 28th of May of the same year, shall be submitted for the approval of the President of the Union and the definite acceptance by the Congress of the nation.

In witness whereof they sign the present in Bogota, on the 20th March, 1878.

EUSTORGIO SALGAR,
LUCIEN N. B. WYSE.

BOGOTA, *March 23, 1878.*

Approved:

AQUILEO PARRO,
President of the Union.
EUSTORGIO SALGAR,
Secretary of the Interior and of Foreign Relations.

(By decree of Congress, May 17, 1878, approved May 18, 1878, the foregoing contract, with certain modifications in the original draft, was duly approved. In the foregoing translation of the contract the modifications introduced by this decree have been incorporated for convenience with the contract as originally signed, so that the translation represents the actual form of the contract as modified and finally approved by Congress.)

Note from Lucien N. B. Wyse, wherein he declares he accepts all the modifications made by law 28 to the contract for the construction of the interoceanic canal.

To the honorable Secretary of the Interior and Foreign Relations:

I have the honor to inform you that I accept each and all of the modifications introduced by Congress to the contract which I celebrated with Señor Eustorgio Salgar, your worthy predecessor in the department of the interior and foreign relations, for the construction of the interoceanic canal, which contract was approved by the executive power under date of March 23 last.

The modifications to which I have alluded are those recorded in law No. 28 of the 18th instant.

I hasten to lay this declaration before the Government of Colombia, so that it may be taken in consideration, in order that said law may be effective in all its parts.

Bogota, May 18, 1878.

LUCIEN N. B. WYSE,
Chief of the International Scientific Commission for the Survey of the Isthmus,
Member and Delegate from the Board of Directors of the Interoceanic Canal Association.

Appendix H H.

ADDITIONAL CONTRACT MODIFYING THAT OF MARCH 23, 1878, APPROVED BY LAW 28 OF THE SAME YEAR—LAW 107 OF 1890. (DECEMBER 26.)

EXTENSION OF TEN YEARS FOR THE OPENING OF THE INTEROCEANIC CANAL ACROSS COLOMBIAN TERRITORY.

The Congress of Colombia decrees:

ONLY ARTICLE. The contract modifying that of March 23, 1878, for the opening of an interoceanic canal across Colombian territory, concluded between his excellency the minister of foreign affairs and Mr. Lucien N. B. Wyse, special representative of the receiver of the Compagnie Universelle du Canal de Panama, is approved in all its parts, which contract is literally as follows:

Antonio Roldan, minister of foreign affairs, duly authorized by His Excellency the President of the Republic, hereinafter called the "Government," of the one part, and Lucien N. B. Wyse, naval commander, engineer, original concessionary of the interoceanic canal, and special delegate of the receiver of the Compagnie Universelle du Canal de Panama, under powers of attorney executed at Paris May 16, 1890, hereinafter called the "concessionary," of the other part, have agreed to modify the contract of March 28, 1878, for the opening of an interoceanic canal across Colombian territory, approved by law 28 of the same year, in accordance with the following stipulations:

ARTICLE I. The Government grants to the receiver of the Compagnie Universelle du Canal de Panama an extension of ten years, within which the canal is to be finished and put in public operation. The said extension is consented to subject to the following conditions:

First. The concessionary agrees to transfer all the plant of the company in liquidation to a new company, which shall undertake the completion of the work of the interoceanic canal.

Second. The new company shall be formally organized with a capital sufficient for this purpose, and shall resume the work of excavation in a serious and permanent manner not later than February 28, 1893.

Third. The concessionary, or his successors, shall furnish monthly to the National Government at Panama the sum of 10,000 piasters, in Colombian coin of 0.835, for the maintenance of 250 men of the military garrison of the department of Panama, whom the Government undertakes to assign for the preservation of order and for the security of the line of the canal during the work of excavation, and upon its termination for the protection of interoceanic transit.

In case the company should have need of a greater number of men of the public forces, the Government will assign them to said service, taking them from the military garrison of the department, but the additional expense occasioned by this increase, reckoned upon the basis already established, shall also be borne by the company.

The company binds itself to furnish places set apart for the occupancy of the troops upon points on the line at which the Government has none of its own. The last part of article 8 of the original contract for the privilege is modified in these respects.

Fourth. The navigation of the lakes which may form part of the canal shall be free to small vessels, in accordance with the regulations which the company may prescribe for this purpose. The latter shall not be responsible for the inherent risks of this navigation. The internal regulation of the lakes shall be settled by the Government at the proper time, taking into account the general interests of the enterprise.

Fifth. The company binds itself to reestablish public transit at the mouth of the Rio Grande by means of bridges or boats, as it shall consider most practicable; and if, in consequence of the number of vessels, passage should become hereafter too difficult, the company shall reestablish it between Emperador and Arraijan to the satisfaction of the Government.

Article II. Besides the public lands granted gratis by the contract of 1878, the expropriation of lands, buildings, and plantations which shall prove necessary to the canal and its dependencies shall be made by the Government, on account of the company, in conformity with the ninth condition of Article I of the aforesaid contract, approved by law 28 of 1878.

Such expropriations shall be made with all speed which the legislation of the country upon the subject permits. The expropriated real estate shall be immediately delivered over to the concessionary, or his successors.

Article III. The Government also undertakes to take the necessary steps for restoring to the new company the complete enjoyment of the lands belonging to the company in liquidation unlawfully occupied by private persons, and to procure a judicial decree that all persons who, without previous consent, shall have built or planted upon the lands bought by the company in liquidation for the purpose of works of excavation, installation, and unloading shall have no right to any indemnity.

Article IV. As compensation for the services which the Government agrees to render, in accordance with the two preceding articles, the concessionary, or his successors, shall pay to the Government 10,000,000 francs in gold, and shall issue to it gratis in addition 5,000,000 francs in 10,000 dividend-bearing shares of the new company of 500 francs each, full paid, having the right to no other dividends than those which are declared on ordinary shares. The said 10,000 shares shall remain attached to their respective stubs until the other shares shall be full paid, but, upon notice to the company, the Government shall have the power, when it shall see fit, to assign or pledge them.

The 10,000,000 francs to which this article refers shall be paid by the concessionary, or by his successors, in five equal annual installments, the first being paid three months after the new company for the completion of the canal shall be fully organized, in conformity with the second condition of Article I. From this sum shall be deducted 2,500,000 francs, as well as the interest accrued up to the date of the present contract, which the Government owes to the company in liquidation for the loan of 1883, the deduction being made, in the first place, for the purpose of fixing the amount of the five installments just mentioned. By this payment the said loan shall be finally discharged.

ARTICLE V. A special member, whom the Government has the right to appoint in the company's board of directors, in conformity with article 20 of the contract in force, shall enjoy in the new company to be organized for the completion of the canal, the same advantages and compensation granted to the other directors by the charter of the company, but neither the said appointee nor the official agent of the Government residing in the isthmus, shall make any publication relative to the company without the express authorization of the Government.

ARTICLE VI. If the new company for the completion of the canal shall not be organized, and if the work of excavation on the canal shall not be resumed within the period fixed by the second condition of Article I, the contract in force shall lapse and the Republic shall enter into the possession and enjoyment, without the necessity of a previous judicial decree, and without indemnity, of the works of the canal and its annexes, which revert to it in accordance with article 3 of the contract of 1878.

SECTION 1. It is understood that the contract shall also lapse, and the provisions of this article shall become applicable if, the company for the completion of the canal not being organized before February 28, 1893, the legal representative of the Compagnie Universelle du Canal Interocéanique or its successors abandon the maintenance of the works, plant, and buildings now existing upon the isthmus, and belonging to the company.

SEC. 2. The maintenance of the property enumerated in the preceding paragraph shall be considered abandoned when the legal representative of the Compagnie Universelle du Canal Interocéanique in liquidation, or his successors, shall discharge the force of employees which he now has on the isthmus, or shall cease to make the necessary expenditure for preventing the loss or deterioration of the said property.

SEC. 3. It is, moreover, understood that the buildings, plants, works, and improvements which are to become the property of the Republic under the circumstances provided in this article, and in conformity with article 23 of the contract of 1878, shall be inalienable, and are to be in good condition, subject to deterioration arising from use, from unavoidable causes, or from accident.

ARTICLE VII. As soon as the company for the completion of the canal shall be legally organized, and shall have resumed the work, in conformity with the provisions of the second condition of Article I of this contract, the Government shall assign to it in the department of Panama the 250,000 hectares of public lands to which it has been already declared by decisions of the executive power to be entitled, and shall issue to it the respective patents, provided that the legal formalities in the premises be accomplished on the part of the company.

ARTICLE VIII. The security of 750,000 francs deposited by the canal company in accordance with article 2 of the contract in force shall be maintained as a guaranty for the fulfillment of the obligations arising from the said contract and of those assumed by the concessionary under the provisions of the present contract.

ARTICLE IX. All rights and obligations created by the contract of March 23, 1878, for the opening of an interoceanic canal across Colombian territory, approved by law 28 of the same year, shall continue in full force and vigor without other restrictions and modifications than those contained in the present contract.

ARTICLE X. In order that the present contract may have full force and effect, it shall be submitted to the approval of His Excellency the President of the Republic, and to that of Congress.

Done in duplicate, at Bogota, the 10th day of December, 1890.

ANTONIO ROLDAN.
LUCIEN N. B. WYSE.

Appendix I I.

CONTRACT OF EXTENSION.[a]

CONTRACT GRANTING EXTENSION TO THE PANAMA CANAL COMPANY, IN LIQUIDATION.

Between Marco F. Saurez, minister of foreign affairs, duly authorized by His Excellency the Vice-President of the Republic, and in accordance with the powers granted to the executive power by law 91 of 1892, hereinafter called "the Government," of the one part, and Francois Mange, engineer, director of the operations of the liquidation on the Isthmus, special representative of the receiver of the Compagnie Universelle du Canal de Panama, under powers of attorney granted him at Paris, January 24, 1893, hereinafter called "the concessionary," of the other part; it has been agreed to modify the contracts of March 23, 1878, and December 10, 1890, for the opening of an interoceanic canal across Colombian territory, in conformity with the following stipulations:

Article 1. The extension of ten years granted in article 1 of the contract of 1890 to the receiver of the Compagnie Universelle du Canal de Panama remains in force, subject to the conditions then provided, except the second, which is modified by the extension until October 31, 1894, of the period within which the new company is to be formed and work on the canal is to be resumed in a serious and permanent manner.

The term of ten years shall begin to run from the date of the formal organization of the new company.

Article 2. The concessionary or his successor acknowledges the validity of the former contracts and of the present contract, and binds himself to do, in France, all acts necessary to insure its validity. These proceedings are to be concluded not later than August 31 next.

Article 3. As compensation for the extension which the Government grants by article 1, and to indemnify it for the advantages which it relinquishes accordingly, the concessionary or his successor acknowledges an indebtedness in favor of the Republic amounting to the sum of 2,000,000 francs in gold, which added to the 10,000,000 provided in article 4 of the contract of 1890, constitutes a total indebtedness of 12,000,000 francs in favor of Colombia, exclusive of 5,000,000 francs in 10,000 shares, also mentioned in the article aforesaid.

Article 4. The contracting parties further agree that from the 12,000,000 which have just been mentioned in the preceding article shall be deducted the sum of 4,000,000 francs which the Colombian

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[a] Translation from Diario Oficial of Bogota, April 5, 1893, No. 9125.

Government and the treasury of the department of Panama owe to the company in liquidation for the loan of 1883 and its interest, and for services and material furnished to the administration of this department from 1881 to 1892. Accordingly, this debt becomes finally extinguished, leaving the Republic free from all obligation with regard to this matter, and reducing to 8,000,000 francs in gold, the sum which the new company is to pay to the Government.

Article 5. The 8,000,000 francs mentioned in the preceding article shall be paid by the concessionary or his successor in the following manner: 150,000 francs August 31, 1893; 150,000 francs October 31, 1893; 200,000 francs December 31, 1893. The remainder shall be paid in four installments, the first to be paid three months after the new company for the completion of the canal shall be formally organized. The first of these installments shall be 1,500,000 francs and the three others 2,000,000 francs each.

Article 6. The Republic shall enter into possession and ownership, without need of previous judicial decision and without any indemnity, of the canal itself and the annexes dependent thereon, in conformity with the contracts of 1878 and 1890, in each of the following cases:

If the new company shall not be organized within the period fixed by article 1.

If the work shall not be resumed within the period fixed by the same article.

If the receiver sells the property which is to belong to the Republic in case of lapse, or abandons its maintenance, all in conformity with the provisions of the previous contracts, saving and excepting deterioration arising from use, unavoidable causes, or from accident.

If the inventory mentioned in article 7 of the present contract shall not be made.

If the conditions of article 2 of the same contract shall not be fulfilled.

Article 7. A general inventory of the property of the company in liquidation, which shall comprise as well the property which is to belong to the Government in case of lapse as that which is to belong to the company in liquidation, shall be prepared upon the Isthmus. It is understood that rolling stock and floating plant shall be comprised in this inventory, which is to be made in conjunction with the agent of the Government at Panama, and is to be completed not later than August 31, 1893.

Article 8. The security of 750,000 francs deposited in conformity with the contract of 1878 by the canal company and confirmed by the contract of 1890 shall be maintained as a guaranty for the fulfillment of the obligations arising from the said contracts and those to which the concessionary agrees by the present contract.

Article 9. Disputes which may arise between the contracting parties with regard to the present contract or the former contract shall be submitted to the supreme court of justice of Colombia.

In conformity with the provisions of article 7 of law 145 of 1888, the concessionary waives the right to diplomatic intervention concerning the duties and rights arising from the three contracts, except in case of denial of justice.

Article 10. All rights and obligations arising from contract of March 23, 1878, and contract of December 10, 1890, for the excavation of an interoceanic canal across Colombian territory, approved by law 28 of 1878, and by law 107 of 1890, shall continue in full force and vigor, without other modifications than those provided in the present contract.

ARTICLE 11. The concessionary declares that he accepts all the provisions of the present contract which impose special obligations upon the receiver, as well as those which affect the company which may be formed.

ARTICLE 12. The present contract must, in order to be valid, be approved by His Excellency the Vice-President of the Republic.

Done in duplicate at Bogota the 4th day of April, 1893.

MARCO F. SUAREZ.
FRANCOIS MANGE.

EXECUTIVE GOVERNMENT, *Bogota, April 4, 1893.*

Approved.

[SEAL.] M. A. CARO.

The Minister of Foreign Affairs.
MARCO F. SUAREZ.

APPENDIX J J.

CONTRACT RELATIVE TO THE GRANTING OF AN EXTENSION OF TIME TO THE NEW COMPANY OF THE PANAMA CANAL.[a]

Whereas the national executive power has dictated the following decree No. 721 of 1900 (April 23), by which provision is made for the granting of an extension of time to the new company of the Panama Canal, the President of the Republic having seen the memorial by which the new company of the Panama Canal has solicited of the Government an extension of six years for the completion of the work and putting it into public service; and having seen the communications in which the special agent, Dr. Nicolas Esquerra, expounds to the Government the public expediency of granting the extension herein considered, decrees:

ARTICLE 1. The Government may grant to the new company of the Panama Canal an extension for the fixed term of six years to complete the work and put it into public use: *Provided*, That it shall deposit at the disposition of the national treasury, within one hundred and twenty days, computed from the date on which this instrument shall be notified to the said company, in such bank or establishment as may be designated by the Government, 5,000,000 francs in French gold.

ARTICLE 2. The said extension will begin to run on the 31st day of October, 1904; consequently the canal must be completed and put into public use on the 31st day of October, 1910, at the latest.

Let it be communicated and published.

Given at Peña, department of Cundinamarca, this 23d day of April, 1900.

MANUEL A. SANCLEMENTE.
RAFAEL M. PALACIO,
Minister of State.
CARLOS CUERVO MARQUEZ,
Minister of Foreign Affairs.
CARLOS CALDERON,
Minister of Finance.
JOSE SANTOS,
Minister of War.
MORCO F. SUAREZ,
Minister of Public Instruction.
MARCELIANO VARGAS,
Minister of the Treasury.

Now, therefore, we, to wit, Carlos Calderon, minister of finance of the Republic, duly authorized by the executive power, on the one part, and, on the other part, Alejandro N. Mancini, in his capacity of agent

[a] Translation from Diario Oficial, Bogota, May 7, 1900, No. 11278 (ministry of finance).

of the new company of the Panama Canal and as representative of the same, by virtue of the power of attorney which he has laid before the ministry of finance, have executed the following contract:

ARTICLE 1. The Government of the Republic grants to the new company of the Panama Canal a delay of six years, from the 31st of October, 1904, in which to complete the work on the canal and deliver it to the public service, under the terms of the existing contracts. In consequence the said work shall have to be completed and put into the public service on the 31st day of October, 1910.

ARTICLE 2. In consideration of the extension referred to in the foregoing article, the new company of the Panama Canal will pay to the Republic the sum of 5,000,000 francs in French coin, in the city of Paris, ninety days from the date on which this contract shall have been approved by the Most Excellent President of the Republic. Said payment shall be made by the company to the firm or bank in the city of Paris in whose favor the minister of the treasury of the Republic may draw.

ARTICLE 3. This contract requires the approval of the council of ministers and that of the Most Excellent President of the Republic.

In witness whereof we have signed three copies of even tenor, at Bogota, this 25th day of April, 1900.

CARLOS CALDERON.
ALEJANDRO N. MANCINI.

PRESIDENCY OF THE COUNCIL OF MINISTERS.
Bogota, April 25, 1900.

In the session of this day the foregoing contract was examined and unanimously approved.

CARLOS CUERVO MARQUEZ,
President.
ALEJANDRO M. OLIVARES,
Secretary ad hoc.

NATIONAL EXECUTIVE POWER,
Peña, Department of Cundinamarca, April 26, 1900.

Approved.

MANUEL A. SANCLEMENTE.
CARLOS CALDERON,
Minister of Finance.

Appendix K K.

Memorandum of legal status of the New Panama Canal Company, including translations of French laws and judicial decrees affecting its organization, and the charter of the company.

The general incorporation law of France of July 24, 1867, under which the old Panama Canal Company was organized, is found in the French Code of Commerce, by Leopold Garrand, London, 1880, page 703.

The amendatory act of August 1, 1893, which modified the law prior to the organization of the new company, is found in Bulletin Des Lois de la Republique Francaise, twelfth series, volume 47, page 491, published in Paris, 1894.

Extract from the judgment of the civil tribunal of the Seine, rendered February 4, 1889, pronouncing the dissolution of the Compagnie Universelle du Canal Interocéanique de Panama and appointing a receiver.

The court, in consideration that the civil or commercial character of a company is recognized, not by the particular form which it takes, but by the nature of the enterprise which constitutes its principal object; that it therefore matters little that the Compagnie du Canal Interocéanique de Panama is a société anonyme, this circumstance not being enough to impress upon it a commercial character;

In consideration, that as to its object, according to article 2 of its articles, it comprises the construction of a maritime canal for deep-water navigation between the Atlantic Ocean and the Pacific Ocean, across the part of the American isthmus which belongs to the United States of Colombia, as well as the operation of said canal and of the various enterprises which are connected therewith; that in reality the company is formed for the operation of the canal and in view of the profits which it may obtain and that the construction itself is not the principal aim of the enterprise, but only a necessary means for carrying it out;

That the operation can not be assimilated to a transportation business, the company limiting itself to the opening of a new way for navigation upon payment of fixed tolls;

In consideration, that therefore, the company has for its principal object the development of real estate under conditions under which the State of Colombia might have developed it itself if it had not granted the concession to third parties; that it is therefore purely civil, and that on this account, its duration being moreover limited, any one of the associates may apply for its dissolution in conformity with article 1871 of the civil code;

In consideration that the objection would be unavailing, that the present application has been made in violation of article 74 of the articles of incorporation, according to which no proceeding at law can be taken by one or more shareholders against the company, its board of directors, or one of the members of the board, until it has been submitted to the examination of the shareholders' meeting, whose opinion is to be submitted to the court at the same time with the action; that on the one hand this provision, which implies a simple opinion to be stated by the shareholders' meeting and not at all a preliminary consent to be given by it, is not of such a character as to be binding upon the court when it is not set up by the defendant; that it could not, moreover, prevail against the right which every member acquires by article 1871 of the civil code, the protection of which concerns considerations of public policy; that, on the other hand, it appears from the papers in the case that if the special shareholders' meeting of January 26 last could not be legally organized, in spite of the reiterated notices sent to the shareholders, there is no reason to hope that a new call would have a more efficacious result; that thus the plaintiffs would be deprived, by the mere force of circumstances and without possible recourse, of a right which article 1871 of the civil code intended to assure them; that, finally, the calling of a new meeting would involve, according to the articles, such delays that the corporate interests which are now at stake might suffer irreparable injury;

In consideration that the further objection can not prevail that, in accordance with article 68 of the articles of incorporation, the dissolution of the company before its expiration must be voted by a meeting of shareholders held under special conditions fixed in article 69; that none of the terms of these articles implies the idea that the right in question belongs exclusively to the shareholders' meeting and that the courts are deprived of it; that such a provision would be in contradiction with the principle laid down in article 1871 of the civil code, and would obviously nullify its object;

That, furthermore, what was said above relative to the shareholders' meeting of January 26 last, and the impossibility of calling to any useful purpose a new meeting within the period fixed by the articles, is pertinent here again, and that from every point of view the application should be received;

In consideration that on the merits article 1871 of the civil code confers upon the court the power of deciding finally whether the company, under the circumstances contemplated, can still continue its normal course or whether its dissolution is rendered necessary by the very situation in which it is placed; that it is now established that the Compagnie du Canal de Panama has ceased to act in a regular way; that it has suspended payment upon its securities and that the continuation of work on the canal is insured only for a very limited time; that since December 14 last it has been necessary to confide its management provisionally to appointees of the court, who have taken the necessary measures to protect temporarily the important interests connected with its existence, that these wholly provisional measures are now insufficient or will shortly become so, and that it is important to take action to ward off dangers, the consequences of which would be irreparable;

In consideration, therefore, that there is occasion for pronouncing the dissolution of the company and providing for its winding up; that there is occasion also for ordering a provisional execution of the present judgment, notwithstanding appeal, and without security, applying article 135 of the code of civil procedure;

For these reasons, pronounces the dissolution of the Compagnie Universelle du Canal Interocéanique de Panama and orders that it be wound up;

Appoints Mr. Joseph Brunet receiver of said company with the broadest powers, especially to grant or contribute to any new company all or a part of the corporate assets, to enter into or ratify with the contractors for the Panama Canal all agreements having for their purpose the insurance of the continuance of the works, and to this end to contract all loans and form all sinking funds;

Declares that in case the receiver appointed can not act, provision will be made for replacing him in the ordinary way;

Authorizes him henceforth to apply in the same way for all special powers which may be necessary for the performance of his duties, and, if he thinks fit, for the addition of one or more receivers;

Orders provisional execution of the present judgment, notwithstanding appeal and without security;

Condemns the defendant company to the expenses.

ACT OF JULY 1, 1893, RELATIVE TO THE LIQUIDATION OF THE UNIVERSAL COMPANY OF THE PANAMA INTEROCEANIC CANAL.

The Senate and the Chamber of Deputies have adopted and enacted, and the President of the Republic promulgates, the following law:

ARTICLE 1. From the date of the promulgation of the present law, all actions now in course of procedure that have been brought by holders of bonds or obligations emitted by the Universal Company of the Panama Interoceanic Canal, or that have been brought by any creditors of the said company, whether against the receiver in his official capacity or against the directors to enforce their responsibility, or against third parties for restitution, or arising in any other manner whatsoever, are hereby declared discontinued and suspended.

The plaintiff may follow up and prosecute said actions only by complying with the requirements of articles 2 and 3 hereof.

All proceedings concerning attachments and execution, even those now in course of enforcement and procedure, against the personal or real estate or property of the said company, are likewise discontinued and suspended.

1.—Bond or obligation holders' attorney.

ARTICLE 2. All rights of action, of any character whatever, accruing to owners of obligations emitted by the Universal Company of the Panama Interoceanic Canal whether against the receiver in his official capacity, or against the directors to enforce their responsibility, or for a right to restitution arising from any other cause, shall be enforced and sued on by an attorney or representative appointed for the purpose, on request of the commonwealth's attorney for the jurisdiction of the civil tribunal of the Seine, by a decree in chambers.

In case there should arise a divergence or opposition of interests between the different classes of bondholders, one or more special attorneys may be appointed in the manner and form just above provided for. The powers of the attorneys aforesaid may be revoked at the same request and in the same manner. There shall be no appeal from said orders or decrees.

However, any obligation holder shall have the right to enter an action for damages in connection with a criminal matter or to intervene in proceedings instituted by the attorney or representative aforesaid, doing so at his own expense and cost without in any way delaying the proceedings or judgment.

Moreover, every obligation holder shall have the power to bring any action, in his individual right and at his own risk and peril, which the attorney shall have refused or failed to enter within one month after he shall have been notified and requested to enter the same.

Suits brought by the attorneys or representatives shall not block the right of action on the part of the company belonging to the receiver. The attorneys shall have power to call on the receiver for communication of all documents tending to shed light on the truth; their legal residence shall be the jurisdiction within which shall be carried on the winding up or liquidation of the company's affairs; the tax costs arising from the exercise of their official duties shall be defrayed from the credits of the receivership, so far as this may be done without impairing the reimbursement to the latter of the sums which it shall have advanced.

Article 3. All actions emanating from the receiver or from the attorneys, or from interested parties individually, shall be brought before the civil tribunal of the Seine. Such proceedings as may arise from the distribution of the credits or balance remaining in favor of the company shall be brought likewise before this tribunal. Suits instituted by parties intervening in damages shall remain in the jurisdiction where already the prosecution has been inaugurated.

Article 4. The attorney shall have full and complete enjoyment of the "judicial assistance privilege" (consisting in the exemption from payment of the usual costs attending a judicial proceeding) in the carrying on of actions and in the executing of verdicts or decisions which he shall have obtained. Likewise he shall enjoy the same in all interventions sounding in damages, and in the case of all recording taxes which might be otherwise exacted. On his request presented to the commonwealth's attorney, pleaders, advocates, and sheriffs shall be appointed in the manner and form prescribed by article 13 of the law dated January 22, 1851.

However, the "judicial assistance privilege" shall not extend to costs of transportation for judges, for Government officials, or for experts, nor to the latter's fees, nor to witness taxes. As to stamp duties, costs of recording, and court costs in general, the treasury shall exact them from the debtor only, after the payment of such judgment as shall have been obtained by the plaintiff's attorney.

Article 5. The attorney shall have power to compromise or to desist from further action, though he may do so only after consulting with three jurists appointed by the commonwealth's attorney; and all compromises or withdrawals of actions shall have to be ratified and approved by judicial decree rendered in chambers.

He alone shall be empowered to levy execution on judgments pronounced by the court, or to receive the sums obtained on compromise, whether such compromise have been obtained on his own demand or on that of obligation holders acting in an individual capacity; all sums thus received shall be deposited by him at the deposit bureau, and the receiver shall give him due quittance therefor.

II.—*The receiver.*

ARTICLE 6. Before proceeding at all to distribute the credits of the company, the receiver shall publish in the Journal Officiel and in the Journal Officiel (Commune edition) a notice calling on all parties interested to produce their claims against the company and the proofs thereof within the space of six months, under pain of becoming barred from bringing any action on the said claims.

The production of the claims and the transmission of proofs in support thereof may be made by simple registered letter.

ARTICLE 7. The receiver shall proceed to verify and to admit said claims in the manner and form prescribed by articles 495 and 497, first paragraph, of the Code of Commerce.

ARTICLE 8. Should the claim be contested, notice of this fact shall be sent by registered mail to the claimant in question, and the latter shall have a term of three months within which he must institute proceedings before the civil tribunal of the Seine, in order to have his claim adjudicated.

Judgment must be pronounced hereon within the space of one month, as in the case of matters demanding immediate and summary adjudication. An appeal from such decision must be entered within ten days from the notification of said judgment either to the party in person or at his domicile.

ARTICLE 9. The distribution of all dividends arising from an action brought by the company or from actions brought by the attorney or representative of obligation holders, or from any other source whatever, shall be made by the receiver, who alone shall have competency to receive opposition or objections to the same.

ARTICLE 10. All acts tending to alienate any assets of the company, all contracts entailing a transfer or contribution of the whole or of a part of the assets of the concern, emanating from the receiver of the Universal Company of the Panama Interoceanic Canal, shall be subject to the approval or ratification of the civil tribunal of the Seine, who shall, on the report of one of the justices, pass on the question in open court.

ARTICLE 11. All decrees of approval or ratification rendered in accordance with the preceding article shall be published, within a term of ten days, in the Journal Officiel and in the Journal Officiel (Commune edition).

This decree may be attacked by a third party, by the shareholders, by the attorney of obligation holders, and by other creditors of the company within a delay not exceeding one month from the date of publication aforesaid. The civil tribunal shall adjudicate the question within the space of one month, as in the case of matters demanding an immediate and summary adjudication. The appeal from such decision must be entered within ten days from the time of notification of said judgment to the party in person or at his domicile.

ARTICLE 12. The Universal Company of the Panama Interoceanic Canal, the civil, i. e. non-trading, company formed for the purpose of redeeming the obligations or bonds of the Panama Canal (issue of March, 1888), and the civil or non-trading company for the redemption of the lottery bonds of the Panama Canal, are hereby exempted from the payment of all stamp duties, and of all transfer or transmission taxes now due or about to become due on any shares, obligations, or bonds of the said companies.

ARTICLE 13. Beginning with the date of the promulgation of the present law, no limitation in bar of actions in damages shall begin to run against the creditors of the Panama Canal Universal Company until the balance remaining to the credit of the company shall have been realized on and entirely distributed.

ARTICLE 14. Shareholders, subscribers, or buyers of stock having acquired title to the same before the company was placed into the hands of a receiver, provided they represent at least one-twentieth of the capital stock, may join a common interest and entrust one or more attorneys or representatives with maintaining any action and with representing them in court.

The present law, deliberated upon and adopted by the Senate and Chamber of Deputies, shall be enforced as a law of the State.

Done at Marly-le-Roi on the 1st day of July, 1893.

CARNOT.

By the President of the Republic:

E. GUERIN,
Keeper of the Seals, Minister of Justice.
P. PEYTRAL,
Minister of Finance.

The following is the charter of the New Panama Canal Company, organized under general corporation laws of France, October, 1894:

TITLE I.—*Formation and object of the company—Name—Principal office—Duration.*

ARTICLE 1. There is formed between the present founder and the subscribers to the shares hereinafter created a commercial joint-stock company under the name of the Compagnie Nouvelle du Canal de Panama, in conformity with the acts of July 24, 1867, and August 1, 1893.

ARTICLE 2. This company has for its objects:

1. The completion of the Maritime Ship Canal between the Atlantic and Pacific oceans.

2. The exploitation of the said canal and of the various enterprises connected therewith.

3. The construction and exploitation of all lines of railway within the vicinity of the canal and the management of all interests which the company may possess and acquire in lines already constructed.

4. The exploitation of lands granted and mines therein contained.

All under the clauses and conditions of the concession as fixed by the act of the Congress of the United States of Colombia, dated May 18, 1878 (law 28 of 1878), and of the extensions of the concession dated December 26, 1890 (law 107 of 1890), and April 4, 1893.

ARTICLE 3. The principal office of the company is at Paris, provisionally fixed at No. 63 bis Rue de la Victoire, and hereafter at such place as the board of directors shall designate.

ARTICLE 4. The company shall begin from the date of its formal organization. Its duration shall be the same as that of its concession; that is to say, ninety-nine years from the date when the canal shall be open in whole or in part for public service or when the company shall begin the collection of dues for transit and navigation.

TITLE II.—*Contributions—Capital—Shares—Payments.*

ARTICLE 5. A party to these presents is M. Jean Pierre Gautron, judicial administrator of the civil tribunal of the Seine, residing at No. 13 Rue Tronchet, Paris.

"Acting as and in the capacity of sole receiver of the Compagnie Universelle du Canal Interocéanique de Panama, by virtue of the powers conferred by judgment of the civil tribunal of the Seine, dated February 4, 1889," M. Gautron, appointed to said office of receiver by a judgment of the chambre du conseil of the civil tribunal of the Seine, dated July 21, 1893, in his said capacity contributes to the company:

First. All rights accruing to the company in liquidation from the laws of the government of the United States of Colombia, dated May 18, 1878, and December 26, 1890, as well as from any decrees, acts, or things whatever which have occurred in the execution of these laws, with all the advantages provided by these laws, together with all lands and real estate granted to the company in liquidation or acquired by it.

All subject to the fulfillment of the conditions of the laws and extensions of the concessions and to the payment of all sums remaining due from the receiver to the Colombian Government.

Second. The works executed and under execution, workshops, buildings, hospitals, plant, erected and not erected, materials and supplies, etc., belonging to the Compagnie Universelle du Canal Interocéanique in liquidation, as well as all deposits as security made by said company in liquidation.

Third. The plans, estimates, studies, documents of every nature collected by the Compagnie Universelle du Canal Interocéanique, relating in any manner to the study, execution, or exploitation of the canal or its dependencies, as well as the benefit of all agreements with all third persons.

Fourth. The rights of every nature, part interests, and generally any others whatsoever which may belong to the Compagnie Universelle du Canal Interocéanique, in liquidation, in the railroad from Panama to Colon, operated by an American company called the Panama Railroad Company, whose principal office is at New York, as said rights are enjoyed and exist; M. Gautron, as receiver, binding himself to transfer the same to the present company in the form required by the laws of the United States of America.

In such manner, moreover, as the said rights and properties are enjoyed and exist and in the condition in which they are.

The present company shall be the owner of the property and rights granted and contributed from the date of its formal organization, except as hereinafter provided with respect to the Panama Railroad.

This grant and contribution are made by M. Gautron with the reservations and subject to the conditions hereinafter expressed, to wit:

First. There shall be appropriated to the receiver 60 per cent of the net profits of the enterprise, as these profits shall be determined under articles 51 and 52 hereof.

Second. There shall be appropriated 50,000 shares, full paid, on account of those now issued to the Government of the United States of Colombia, in accordance with the extension law of December 26, 1890.

Third. The rights of every nature in the Panama Railroad belonging to the estate in liquidation and contributed by M. Gautron under section 4 of this article shall become the property of the present company from and after the stockholders' meeting provided for by article 75 hereof without any pecuniary compensation, but upon the express condition that the canal be constructed within the time fixed by the agreement of concession. Upon default in completion within such time said rights shall revert to the estate in liquidation.

If, contrary to all expectation, the meeting in question should not take the necessary action for the completion of the canal, or if the course of action adopted by the meeting can not be carried out, the said rights in the railroad shall remain the property of the present company, but it shall pay into the estate in liquidation the sum of 20,000,000 francs by way of indemnity, and the share of profits set apart for the estate in liquidation shall be half the profits of the present company without other deductions than those provided in sections 2 and 3 of article 51 hereof.

Accordingly said rights shall remain inalienable in the hands of the new company until either the payment of said sum of 20,000,000 francs or the entire completion of the canal.

Fourth. Until the entire completion of the canal, M. Gautron, in his official capacity, shall have the right to appoint a commission of control, composed of three members, taken as far as possible from among the engineers of the department of bridges and roads and the inspectors of finances, to inspect the progress of the works, the conditions and maintenance of the plant and buildings, as well as the accounts relating to these different objects.

The expense of this commission shall be borne by the new company.

Article 6. The capital of the company is fixed at 65,000,000 francs, divided into 650,000 shares of 100 francs each.

Of these 650,000 shares 50,000 full paid are set apart for the Government of the United States of Colombia, in accordance with the extension law of December 27, 1890, as provided in the preceding article.

As for the balance of 600,000 shares they are to be issued for cash subscriptions.

Capital may be increased once or several times by vote of the regular stockholders' meeting, and, upon the proposition of the board of directors, by the issue of new shares.

Article 7. The 50,000 shares set apart for the Government of the United States of Colombia, though full paid, shall not be entitled to interest or dividends on the same terms as the shares issued on subscription.

These 50,000 shares shall remain attached to their respective stubs, and shall be negotiable under the conditions provided by article 2 of the French law of August 1, 1893, and by the concession laws.

Article 8. A preference is reserved to the stockholders and bondholders of the Compagnie Universelle du Canal Interocéanique, in liquidation, in subscribing for stock of the present company, to the extent of one-half the present capital and the total amount of all future issues.

Article 9. The amount of each share is payable in cash into the company's treasury or to the representatives who shall be appointed for subscriptions by the new company.

It shall be payable as follows: Twenty-five francs immediately on subscription, 25 francs on October 15, 1894, and the balance as calls shall be made by the board of directors.

Payments shall become due, in accordance with calls made by the board, upon notice published one month in advance in one of the Paris newspapers designated for the publication of legal notices.

Any shareholder may, however, pay up his shares in advance and at any time.

ARTICLE 10. The first payment is represented by a receipt in the name of the subscriber which, within two months from the organization of the company, shall be exchanged for a provisional certificate, also in his name.

All further payments, except the last, shall be indorsed upon this provisional certificate.

Upon the last payment being made, a permanent certificate shall be issued to the shareholder, which shall be either to bearer or in his name, at his option.

ARTICLE 11. The board of directors shall fix the form and style of the certificates of stock.

Provisional and temporary certificates shall be taken from a book with stubs; they shall be numbered in order and stamped with the seal of the company; they shall be signed by two directors, or by one director and a person appointed by the board of directors.

ARTICLE 12. All payments in arrears upon calls shall bear interest at the rate of 6 per cent per annum from the day when they shall be payable, for the benefit of the company.

In default of payment within the month wherein the same shall become payable the board of directors may, at its option, bring action at law, or sell the certificates on which payment shall not have been made.

Such sale may take place fifteen days after notice published in the Journal Officiel or one of the other papers in the department of the Seine designated for the publication of legal notices. It shall take place at the risk of the person in default through an agent de change of the Paris Bourse or through a notary, at the option of the board of directors.

The certificates for the shares sold will become void and will be replaced by a new certificate, in the name of the purchaser, of the same number.

The price of the sale will be deducted from the sums due the company from the subscriber for the share and his assigns, who will all remain jointly and severally liable for the difference and entitled to any surplus.

ARTICLE 13. Shares shall stand in the names of subscribers until fully paid, in accordance with the law of August 1, 1893.

Moreover, no share can be sold, and the board of directors can not authorize its transfer, until it shall have been fully paid.

This prohibition, however, will not apply to shares belonging to future issues.

Every owner of shares to bearer shall always have the right to require the conversion of shares to bearer into shares registered in his name.

ARTICLE 14. The shares confer a right to a proportional part in the corporate assets, in profits to be distributed as interest or dividends, and in reserve funds.

Interest and dividends are paid to bearer either upon presentation of the certificate to be stamped for registered certificates, or upon presentation of the coupon for certificates to bearer, at the company's office at the times which shall be fixed by the board of directors.

ARTICLE 15. The transfer of shares to bearer is effected by simple delivery.

That of registered certificates shall take place by a declaration of transfer entered on the books of the company and signed by the transferer and transferee or their attorneys.

The expenses of transfers, changes, and conversions shall be borne by the new assignees.

ARTICLE 16. The board of directors may authorize the keeping and deposit of certificates to bearer in the company's treasury. In that case, it shall determine the form of the registered certificates of deposit, the conditions of their delivery, and the precautions with which the execution of this measure should be surrounded in the interest of the company and of the shareholders.

ARTICLE 17. Shareholders shall not be liable upon the contracts of the company beyond the amount of the shares which they own.

In no event can any call be made for funds beyond the amount of the shares.

ARTICLE 18. The shares are indivisible as regards the company, which recognizes only a single owner for each share.

All owners of undivided parts of a share must be represented in dealing with the company by one and the same person.

ARTICLE 19. The rights and obligations attached to the share follow the certificate into whatever hands it comes.

The possession of a share imports full consent to the statutes of the company as well as to all acts of a stockholders' meeting.

The heirs, creditors, or assigns of a shareholder can not, on any pretext, require a partition or sale of the corporate property, obtain an attachment, require the sealing of the company's books, registers, papers, and securities, nor interfere with its administration.

They must, for the exercise of their rights, rely exclusively upon the corporate statements, the action of the stockholders' meetings, and the decision of the board of directors.

TITLE III.—*Board of directors.*

ARTICLE 20. The company is administered by a board composed of not less than nine nor more than fifteen members, chosen from among the shareholders.

ARTICLE 21. The directors do not, in consequence of their duties, contract any personal or joint and several obligations. They are responsible only for the performance of their duties.

ARTICLE 22. Directors are appointed by the stockholders' meeting for not more than six years.

If the board is composed of nine, twelve, or fifteen members, one-third shall be elected every two years, the outgoing members to be determined during the first period of six years by lot, and thereafter by seniority.

If the number of directors be any other than those above specified, the stockholders' meeting shall determine the mode of choosing new members and the duration of their terms.

Outgoing directors may always be reelected.

The second meeting of stockholders for organization shall fix the number of members of the first board and shall proceed to choose them.

This first board may, if it think fit, add to itself new members within the limits hereinbefore fixed, and must cause appointments so made to be ratified by the first regular stockholders' meeting.

ARTICLE 23. In case of vacancy arising from resignation or death, the board of directors may fill the same until the next meeting of stockholders.

Directors thus appointed continue in office only until the expiration of the terms of their predecessors.

ARTICLE 24. Every director must be the owner of 250 shares, which are registered in his name and inalienable. They shall be stamped to indicate this inalienability, and remain deposited in the company's treasury during the whole term of office of the owner.

These shares constitute a guaranty for all acts of management.

ARTICLE 25. The board of directors shall appoint each year from among its members a president and, if there be occasion, one or more vice-presidents.

The president and vice-president may always be reelected. In case of the absence of the president and of the vice-president or vice-presidents, the board may appoint, at each session, one of its members to fulfill the duties of the office.

ARTICLE 26. The board of directors shall meet at least once a month. It shall meet, also, at the call of the president, as often as the interests of the company require.

Questions shall be decided by a majority of the members present.

In case of equal division, the vote of the president shall preponderate.

Five directors at least must be present to form a quorum.

When only five or six directors are present all action, to be valid, must be taken by a majority of 4 votes.

No member of the board can vote by proxy.

ARTICLE 27. The proceedings of the board of directors shall be recorded by minutes signed by the president and one of the members present at the meeting.

Copies or extracts from these minutes must, to be produced in evidence elsewhere, be certified by the president or by two directors.

ARTICLE 28. The board of directors is vested with the broadest powers for the management and administration of the affairs of the company, for the selection and exploitation of the public lands granted by paragraphs 7 and 8 of article 1 and by article 4 of the concession law.

The board of directors may ask any new concessions, consent to all agreements with third parties for the purchase of enterprises or of concessions connected with any of the objects of the company.

It shall appoint and dismiss employees, determine their functions and powers, fix their salaries and pay.

It shall order and regulate expenditures.

It shall sign correspondence as well as all notes, indorsements, drafts, checks, transfers, and conversions of public stocks and securities belonging to the company, and it shall contract and consent to all advances.

It shall take all financial measures necessary to the progress of the company, and make all loans other than those which must be authorized by the stockholders' meeting.

It shall lay before the stockholders' meeting all propositions concerning loans on mortgage and the issue of obligations.

It shall administer the rights in the Panama Railroad Company contributed to the company under the terms of article 5.

It shall arrange the order of business for stockholders' meetings and the accounts which are to be submitted to them. It shall make a report to each stockholders' meeting upon the accounts and the condition of the corporate affairs.

It shall fix provisionally the dividend and determine, if occasion arises, the installment to be paid on July 1 on the receipts and disbursements closed by the inventory June 30 preceding.

It shall decide upon the following subjects, to wit:

1. Calls for money upon the shares.
2. Temporary investment of funds in hand.
3. Studies and projects, plans and estimates for the execution of the works.
4. Agreements and bargains for works of various characters, bargains with penalty, and contracts not concerning the works.
5. Hiring, selling, letting, and exchanging real and personal property, purchasing and hiring vessels or machines necessary for the execution of the works and the exploitation of the enterprise.
6. Annual budgets.
7. Fixing and modifying dues of every nature to be collected by virtue of the concession, conditions and manner of collecting tolls.
8. Disposition of reserve funds.
9. Regulation of deposit of stock and obligation of the company.

It shall sue for the collection of dues, the recovery of all debts, give all acquittances and discharges, consent to all replevies of mortgaged property, distresses, attachments, and other impediments, with all releases of preference, mortgage, and suit for cancellation, all before or after payment. It may ratify all previous acts.

It shall authorize all judicial actions, whether as plaintiff or as defendant, treat, adjust, and compromise the said actions, as well as all affairs of the company.

In general, it shall do, in the corporate interest, all acts which it thinks necessary and useful, the powers above recited being purely declaratory and not in limitation of the rights of the board of directors.

ARTICLE 29. The board of directors may, for the general administration of the company, delegate all or a part of its powers either to one or more of its members, with the title of director-delegate, or to one or more managers or submanagers taken from outside the board.

It may, moreover, delegate either to one or more directors, or to one of the employees of the company, or to one or more third persons, all or a part of its powers, by special authorization, and for one or more definite affairs or objects.

ARTICLE 30. The directors shall be compensated, over and above the share of profits fixed in article 52, by tokens of attendance, the amount of which shall be determined by the stockholders' meeting, and which it shall be the duty of the board of directors to distribute to its members.

TITLE IV.—*Technical commission.*

ARTICLE 31. The board of directors is authorized to associate with itself a technical commission chosen from among persons competent in matters of public works and especially from the retired inspectors general of the departments of bridges and roads and finance.

This commission, upon communications made to it by the board of directors, shall give its opinion on questions relative to the execution of the works.

The number of members of the technical commission, as well as their remuneration, shall be fixed by the board of directors.

TITLE V.—*Commissioners.*

ARTICLE 32. The stockholders' meeting shall appoint one or more commissioners, members or not, invested with the functions committed to them by law.

If any of the commissioners can not act, the one or more who remain shall act without them.

A compensation is allowed them to be fixed by the stockholders' meeting.

TITLE VI.—*Stockholders' meeting.*

ARTICLE 33. A regularly constituted stockholders' meeting shall represent all the stockholders.

ARTICLE 34. The stockholders' meeting shall be composed of all holders of at least ten shares.

All holders of less than ten shares may unite to form the necessary number and cause themselves to be represented by one of their number, as provided by the law of August 1, 1893.

The meeting shall be regularly constituted when the shareholders who compose it represent a quarter of the capital of the company.

ARTICLE 35. When, upon first assembling, the stockholders present do not comply with the conditions above specified, in order to make the proceedings of the meeting valid it may be adjourned for not less than twenty days.

A second call shall be made in the form prescribed by article 37 hereof.

The deliberations of this second meeting can only relate to the order of business provided for the first meeting. Its acts shall be valid, whatever may be the amount of capital represented by the stockholders.

ARTICLE 36. A stockholders' meeting shall be held every year at a day and place fixed by the board of directors before December 31.

Extraordinary meetings also shall be held whenever the board of directors may consider it useful.

ARTICLE 37. Ordinary and extraordinary meetings may be called by means of a notice inserted at least twenty days previously in one of the Paris papers designated for the publication of legal notices.

ARTICLE 38. Shareholders in order to have the right to take part in or to have themselves represented at stockholders' meetings must prove, at the domicile of the company, at least five days before the meeting, by the deposit of their certificates in the company's treasury or in that of one of the establishments designated for this purpose by the board of directors.

Deposits made under these conditions give a right to the issue of cards of admission in the name of the depositor.

Registered holders of registered shares or of certificates of deposit have also the right to be represented at meetings by proxies furnished with regular powers, the form of which shall be determined by the board of directors.

Holders of powers must deposit their proxies at the domicile of the company within the time fixed by the board of directors for each meeting.

No one can represent a shareholder at the meeting unless he is himself a member of the meeting.

Married women, however, may be represented by their husbands if they have the management of their rights and shares, and in like manner minors or incompetents may be represented by their guardian.

Usufructuaries and naked owners must be represented by one of them, furnished with a power from the other, or by a common proxy who is a member of the meeting.

Companies which are stockholders, as well as the Government of Colombia, may each be represented by a delegate who is not himself a shareholder.

ARTICLE 39. The stockholders' meeting shall be presided over by the president or one of the vice-presidents, and, in default of these, by a director appointed by the board.

The two largest shareholders present at the opening of the meeting, who accept, shall be appointed tellers.

The board shall appoint the secretary.

ARTICLE 40. Action by the stockholders' meeting shall be determined by a majority of votes of the members present or regularly represented.

In case of equal division the vote of the president shall preponderate.

ARTICLE 41. Ten shares shall give the right to one vote. The same shareholder can not cast in all more than two hundred votes, whether as shareholder or as proxy.

ARTICLE 42. A secret vote may be required by ten members representing together at least two hundred votes.

ARTICLE 43. The action of the stockholders' meeting is recorded in minutes signed by the president, the tellers, and the secretary.

Copies or extracts from these minutes to be used in proceedings at law or otherwise must be certified by the president or by two directors.

ARTICLE 44. At each stockholders' meeting a list shall be kept of members present. It shall contain the names and residences of the shareholders and the number of shares held by each. This list shall be certified by the officers of the meeting and deposited with the company's records.

ARTICLE 45. The order of business for the stockholders' meeting shall be fixed by the board of directors.

No other questions than those contained in this order of business can be brought before the meeting.

ARTICLE 46. The stockholders' meeting shall hear the report of the board of directors on the corporate affairs.

It shall also hear the report of the commissioner or commissioners upon the condition of the company, on the balance sheet, and on the accounts presented by the board of directors.

It shall discuss and, if need be, approve the accounts.

It shall authorize, on proposal of the board, the creation of special supplemental reserve and sinking funds which may be found useful.

It shall fix the dividend to be paid.

It shall elect directors in place of those retiring and the commissioners.

It shall vote all loans by means of the issue of obligations or by mortgage.

It shall audit the first accounts after the execution of the works.

It shall pass upon the propositions of the board of directors.

It shall vote upon the increases of capital proposed by the board of directors.

It shall consider and finally decide upon all the interests of the company, and confer upon the board of directors all the supplementary powers which shall appear useful.

It shall have extraordinary power of decision upon the course to be taken in accordance with article 75 hereof.

ARTICLE 47. The action of the stockholders' meeting, taken in conformity with the statutes, shall bind all shareholders, even although absent or dissenting.

TITLE VII.—*Statements of condition—Inventories.*

ARTICLE 48. The corporate year shall begin July 1 and end June 30. The first period shall comprise the time between the formal organization of the company and June 30, 1895.

ARTICLE 49. The board of directors shall prepare every six months a summary statement of the condition of the company as to assets and liabilities.

This statement shall be submitted to the commissioner or commissioners.

ARTICLE 50. There also shall be made up at the end of each corporate year an inventory showing the real and personal property of the company and all indebtedness due to or by it.

This inventory shall be presented to the stockholders' meeting.

TITLE VIII.—*Annual accounts—Sinking funds—Interest—Reserve funds—Dividends.*

ARTICLE 51.—The annual income from the enterprise shall be first applied to the payment of—

1. The share for which the United States of Colombia has stipulated for its own benefit, according to the terms of the concession law.

2. The expenses of maintenance and exploitation, the cost of administration, and all corporate charges in general, interest and sinking funds on loans which may have been contracted.

3. The previous deduction of one-twentieth of the net profits, after payment of all the charges hereinbefore mentioned, for the formation of a legal reserve fund.

4. Five per cent upon the corporate capital, the income of which shall be applied by the stockholders' meeting, in accordance with the propositions of the board of directors, not only to form the sinking fund to be established in accordance with article 55 hereof, but also to provide dividend on the shares not extinguished.

ARTICLE 52. The excess of annual income after the various deductions provided in the preceding article constitutes the net income or profits of the enterprise.

From these profits shall be deducted 5 per cent for the benefit of the board of directors.

The surplus shall belong to the amount of 40 per cent to the shares issued and to the amount of 60 per cent to the Compagnie Universelle du Canal Interocéanique in liquidation.

ARTICLE 53. The payment of interest and dividends shall be made at the company's office or at the offices of the representatives designated by the board of directors.

The payment of interest shall be made at two periods, January 1 and July 1 in each year.

Dividends shall be payable on January 1 next after the vote of the annual stockholders' meeting.

The board may, nevertheless, if it thinks fit, authorize a payment on account of dividends on the preceding 1st of July.

ARTICLE 54. Interest and dividends remaining unclaimed at the expiration of five years from the time when payable shall become the property of the company.

ARTICLE 55. The extinguishment of the shares shall be accomplished in ninety-nine years from the putting of the canal in operation.

Provision shall be made for this extinguishment by means of the deduction hereinbefore provided for in article 51, the amount of which shall be fixed by the stockholders' meeting on recommendation of the board of directors.

The shares to be paid off shall be designated by drawing lots, which shall be publicly done at the times and in the manner fixed by the board of directors.

ARTICLE 56. The numbers of shares drawn for payment shall be posted in the company's principal office.

ARTICLE 57. Shares drawn for payment shall be paid at the places designated for the payment of dividends and interest.

Holders of extinguished shares have the same rights as holders of shares not extinguished, except as to the dividend which may be paid in accordance with article 51 hereof.

ARTICLE 58. The share of 60 per cent set apart for the Compagnie Universelle du Canal Interocéanique in liquidation, may, if the receiver so requests, be represented by certificates, to such number as he shall fix, leaving it to him to make a proper distribution thereof among the parties in interest.

This right to a share in the profits shall not give to any of those who enjoy it any right to take part in any way in the acts or administration of the company.

In all cases the provisions of articles 18 and 19 hereof concerning shares are equally applicable to the certificates of interest.

All expenses and formalities connected with these certificates must be borne by the holders.

Before distributing these certificates the receiver must make arrangements for their being represented in dealings with the new company; these arrangements must be satisfactory to the board of directors of the present company.

ARTICLE 59. The reserve fund is composed of the accumulation of the sums deducted from the annual profits in accordance with article 51 hereof.

When this reserve fund reaches one-tenth of the capital of the company, its creation may be suspended. It must be resumed when the amount of the reserve has sunk below one-tenth of the capital of the company.

TITLE IX. *Modification of the statutes—Dissolution.*

ARTICLE 60. If experience shows the desirability of making modifications in or additions to the present statutes, the stockholders' meeting shall provide for the same in the manner fixed in articles 61 and 62 hereof.

It may especially determine upon a reduction of the capital of the company, a reduction in the duration, the prolongation, the earlier dissolution of the company, or its consolidation with other companies. It may even introduce modifications in the objects of the company, without, however, changing their essential character.

ARTICLE 61. Meetings which are to consider the different subjects mentioned in the preceding article will not be regularly constituted, nor will their action be valid, unless they are composed of a number of shareholders representing at least one-half of the capital of the company; but in such case the board of directors shall have the right in its calls to reduce, as far as it shall think desirable, the number of shares which must be held in order to take part in the meeting, and in such case the holder of the minimum number of shares necessary to take part in the meeting shall have one vote, the holder of ten shares shall have two votes, the number of votes increasing at the rate of two votes for ten shares, provided that the total number of votes of any member shall not exceed two hundred.

Moreover, all owners of a number of shares less than that fixed for admission to the meeting may unite to form the requisite number of shares and may cause themselves to be represented by one of their number in accordance with the law of August 1, 1893.

ARTICLE 62. It is here explained that it is in order to conform to the French law now in force that the present statutes require the representation of one-half the capital of the company at the stockholders' meetings called to consider the subjects specified in article 61 hereof, and a representation of one-quarter of the capital in the other meetings; but it is expressly understood that the company may take the benefit of any new laws which may decrease the amount of capital necessarily represented in stockholders' meetings, and that new legislative provisions concerning this question will become applicable to the company hereby created upon a resolution to that effect of a meeting of stockholders called in accordance with the rules laid down in articles 34 and 35 hereof.

ARTICLE 63. In case of dissolution of the company, the meeting of stockholders on recommendation of the board of directors shall determine the method to be adopted either for the liquidation or reorganization of the company as a new company. It may appoint one or more liquidators, and may confer upon them the broadest powers.

ARTICLE 64. During liquidation the powers of the meetings of stockholders shall continue as during the existence of the company.

It shall have, especially, the right to approve the accounts of the liquidation and to give acquittance therefor.

The appointment of liquidators shall terminate the powers of the directors and of all mandatories.

TITLE X.—*Conferring of jurisdiction—Suits.*

ARTICLE 65. In accordance with article 20 of the concession law of May 18, 1878, differences which may arise between the Government of the United States of Colombia and the company shall be submitted to the Federal supreme court (Colombia).

But for all other litigation the company shall have its domicile at Paris.

ARTICLE 66. The company shall be considered commercial in its essence as in its form, and shall accordingly be within the jurisdiction of the tribunal of commerce of the Seine.

ARTICLE 67. Suits concerning the general and collective interests of the company can not be brought either against the board of directors or against one of its members, except in the names of shareholders representing one-twentieth of the capital of the company. Actions concerning the rights of members can not be brought by a shareholder, or group of shareholders, representing less than a twentieth of the company's capital.

And no action at law brought by one or more shareholders against the company, its board of directors, or one of its members can be brought into court until after having been submitted to the examination of a meeting of shareholders, whose opinion shall be submitted to the magistrates at the same time with the complaint itself.

ARTICLE 68. Every shareholder in case of litigation must make election of a domicile at Paris, and all notices and summonses to him may be lawfully served at the domicile by him elected, without regard to the distance of the real domicile.

In default of election of a domicile, he shall be deemed to have elected for notices, judicial and extra judicial, the office of the attorney of the Republic at the civil tribunal of first instance of the Seine.

The domicile elected, actually or impliedly, as has just been stated, shall carry with it the conferring of jurisdiction on the competent tribunals of the Seine.

ARTICLE 69. In all litigations which may arise between the company and third persons, notice of all judicial or extra judicial documents must necessarily be given by service of a copy personally upon the president of the board of directors at the principal office of the company.

TITLE XI.—*Temporary provisions.*

ARTICLE 70. The subscription of the entire capital of the company, and the payment of at least one-fourth the capital in cash, shall be evidenced by a declaration of the founder acknowledged before a notary.

To this declaration shall be annexed a list of the subscribers and the state of the payments made.

ARTICLE 71. This declaration, with vouchers, shall be submitted to the first stockholders' meeting, which shall verify its accuracy.

The same meeting shall cause the value of the contribution hereinbefore mentioned, and the consideration for the advantages agreed to be given, to be appraised.

ARTICLE 72. A second meeting shall be called to approve, if proper, the contribution and advantages in question.

The same meeting shall elect the directors and the commissioners created by article 32.

The minutes of the meeting shall show the acceptance of the directors and of the commissioners.

The company shall be organized upon their acceptance.

ARTICLE 73. Stockholders' meetings called for the organization of the company shall be composed of all the shareholders, who have each a vote, provided that the holders of several shares shall have one vote for every ten shares; but no person shall have more than ten votes.

The meetings for organization must be composed of a number of shareholders representing half the capital of the company. The capital, one-half of which must be represented for verification of the contribution, shall be composed only of the payments not subject to verification.

If the meeting does not include a number of shareholders representing half the capital, it can act only provisionally; in such case a new meeting shall be called.

Two notices, published eight days apart, at least one month in advance, in one of the papers in which legal notices are published in Paris shall give notice to the shareholders of the provisional action taken by the first meeting, and this action shall become final if approved by a new meeting composed of a number of shareholders representing at least one-fifth of the capital of the company.

Article 74. All general provisions of Title VI, relative to stockholders' meetings, not inconsistent with those contained in this title, shall be applicable to meetings of stockholders for organization; except that meetings for organization may be called by a notice inserted in a newspaper in which legal notices are published in Paris, as follows: For the first meeting, two days beforehand, and for the second meeting at least ten days beforehand.

Article 75. When the amounts expended as well for the work done upon the canal as for the discharge of the burdens resulting from the contribution of Mr. Gautron shall reach about one-half of the cash capital of the company at the minimum, a special technical commission, theretofore appointed at a proper time, shall pronounce upon the results obtained from the work already done and upon the conclusions to be drawn therefrom as to the remainder of the enterprise.

This commission shall be composed of two members appointed by the board of directors of the present company and of two persons appointed by the liquidation of the old Compagnie Universelle du Canal Interocéanique. These four members shall appoint a fifth, who shall be president of the commission, and if they can not agree this president shall be appointed by the president of the tribunal of commerce of the department of the Seine.

The board of directors shall be required to make public the opinion of this commission and to call a special meeting of stockholders in the manner provided in articles 61 and 62 hereof.

This meeting shall consider the ways and means tending to insure the completion of the work and the stipulations contained in article 5, section 4, No. 3, hereof.

Title XII.—*Publications.*

Article 76. Within the month of the organization of the company the directors shall file in the registry of the tribunal of commerce of the Seine and of the justice of the peace of the ninth arrondissement of Paris—

1. A copy of the articles of association.
2. A copy of the document showing the subscription of the capital and the payment of one-fourth.

3. A copy or a certified copy of the action of the stockholders' meeting in accordance with articles 71 and 72 hereof.

4. A copy or a certified copy of the list of the names of the subscribers.

ARTICLE 77. Within the same time an extract from the documents and proceedings specified in the preceding article shall be inserted in one of the newspapers publishing legal notices in Paris in pursuance of law.

ARTICLE 78. Full powers are granted the holders of the documents for the filing and publication in question.

ARTICLE 79. Finally, it is noted that all the provisions contained in the two last preceding titles relative to the organization and publications of the present company have been dictated only by the requirements of the French law as to joint-stock companies now in force.

Express reservation is made of the benefit of all new provisions which the legislature may introduce into the law.

EXTRACT FROM THE MINUTES OF THE CIVIL TRIBUNAL, LOWER COURT, FOR THE DEPARTMENT OF THE SEINE, SITTING IN THE PALACE OF JUSTICE, PARIS, JUNE 29, 1894, APPROVING AND RATIFYING THE CHARTER OF THE NEW PANAMA CANAL COMPANY.

The civil tribunal, lower court, for the department of the Seine, sitting in the palace of justice, Paris, has rendered, in open and public sessions of its first division, the following judgment:

Done at the sitting of the 29th day of June, 1894.

The tribunal having examined and considered the petition presented by Gautron as receiver of the court for the Universal Company of the Panama Interoceanic Canal, which petition is signed by De Biéville, his counselor, and the tribunal having also examined and considered the documents produced, and the petition aforesaid being conceived as follows:

To the honorable the president and justices of the first division of the civil tribunal of the Seine, the petitioner, Mr. Jean Pierre Gautron, receiver of the court, residing in Paris, No. 13 Tronchet street, represents as follows:

That he is acting in his capacity as receiver for the Universal Company of the Panama Interoceanic Canal, whose legal residence is in Paris, No. 63 Rue de la Victoire; that he was named receiver as aforesaid by a decree rendered in chambers by the civil tribunal of the Seine on the 21st day of July, 1893.

That he, through his attorney and counselor, Mr. de Biéville, respectfully states that on the 4th day of February, 1889, Mr. Joseph Brunet was named, by recorded decree of the first division of this tribunal, receiver for the Universal Company of the Panama Interoceanic Canal, and was given most extensive powers, notably that of granting or making a contribution of either the whole or a part of the assets of the company to a new company or association.

That by a recorded decree of this tribunal rendered in chambers on the 13th day of February, 1890, Mr. Achille Monchicourt was named coreceiver for the said company with Mr. Joseph Brunet, and was given the same powers, to use individually or in conjunction with the latter.

That owing to the resignation of Mr. Brunet, Mr. Achille Monchicourt has been confirmed by a chamber's decree dated the 8th day of March, 1890, as sole receiver for the said company, with the broadest powers, notably that of giving or making a contribution to a new company or association of either the whole or a part of the assets of the company aforesaid, of entering into and rectifying with contractors all contracts and agreements aiming to the continuation or preserving of the work, and of prolonging and renewing all agreements, of giving all guarantees necessary for this purpose.

Finally, that by a decree rendered in chambers on the 21st day of July, 1893, Mr. Jean Pierre Gautron was appointed coreceiver with Mr. Achille Monchicourt, with the same and equal powers, to use individually or jointly with the said Mr. Monchicourt.

That owing to the decease of Mr. Achille Monchicourt, which occurred on the 14th day of March, 1894, Mr. Gautron remains sole receiver of the Panama Interoceanic Canal Company.

That a new company is in process of formation at the present time for the purpose of resuming the work and completing the canal.

That the constitution and by-laws of this company, called the New Panama Canal Company, have been drawn up and deposited for record by Mr. Gustave Ramet, formerly president of the tribunal of commerce at Rennes, and have been filed also in the records and minutes of Mr. Lefebvre, notary, in Paris.

That your petitioner, by virtue of the powers conferred by the orders and decrees aforesaid on the receiver for the Panama Interoceanic Canal Company, is preparing to make contribution to the new company now being constituted:

First. Of all rights whatsoever accruing to the old company from the laws of the Government of the United States of Colombia, dated May 18, 1878, and December 26, 1890, as well as from all decrees, acts, or facts whatever having followed upon these laws in the course of their execution, and all advantages and benefits accruing therefrom and stipulated by these laws and decrees, together with all territory and real estate having been granted and ceded to the interoceanic company now in process of liquidation, or acquired by the same; all this provided the new company fulfill the conditions prescribed and imposed by the laws and acts passed in granting or extending the concession, and provided it pay and discharge all sums and indebtedness remaining due to the Colombian Government by the old company.

Second. Of the work already done and accomplished, of the yards, workshops, buildings, hospitals, plant mounted and unmounted, and of the stores, etc., belonging to the receivership, as well as of all deposits.

Third. Of the plans, estimates, surveys, and specifications, and of all documents whatsoever gathered and collected by the Universal Company of the Interoceanic Canal bearing in any manner on the study, construction, or improvement, and operation of the canal or of its appurtenants, as well as the privileges attached to the same and all contracts or agreements with third parties.

Fourth. Of all rights of any nature and description, part ownership or any other rights whatsoever which may belong or accrue to the Interoceanic Canal Universal Company now being liquidated, in the Panama Railroad at Colon, now worked and operated by an American company known as the Panama Railroad Company, whose legal residence is in New York. The said rights shall be transferred such as they are, carrying with them all privileges entailed by them; and Mr. Gautron binds himself in his official capacity to invest with them the present company in the form and in compliance with all formalities required for such transfer by the laws of the United States of America.

The said rights shall be transferred, as well as the said property, in full, such as they exist and with all that they entail.

Your petitioner further respectfully shows as follows:

That the said grant and contribution are made, or are to be made, by him with the following reservations and under the following conditions, to wit:

First. The receivership shall have and receive a part in the net profits and gains of the enterprise, amounting to 60 per cent of the said profits and gains, such as the same shall be determined and computed under articles 51 and 52 of the by-laws.

Second. Fifty thousand shares of entirely paid-up stock shall be given to the Government of the United States of Colombia, as prescribed by the extension act of December 26, 1890.

Third. The rights of every nature and description accruing to the receivership from the Panama Railroad, and ceded by Mr. Gautron, as set forth in paragraph 4 above, shall become the property of the new company from the date of the meeting provided for by article 75 of the constitution and by-laws. No pecuniary compensation is required of the new company for the cession of said rights, but they are transferred on the condition and with the full understanding that said transfer shall be void if the canal be not completed within the time appointed by the grant. Should the work not be completed within the said period of time, the said rights shall revert to the receivership.

If, contrary to all expectations, the meeting in question should fail to take the necessary measures to complete the canal, or if the measures thus taken by said meeting should fail of execution by reason of impossibility to carry them out, the present company would still retain the said rights accruing from the railroad aforesaid; but it would have to pay to the receivership a sum of 20,000,000 francs as an indemnity, while the receivership's share in the gains and profits of the new company would then be equal to one-half of said gains and profits without further previous deduction than such as is provided for by paragraphs 2 and 3 of article 51.

Fourth. Until the full completion of the canal Mr. Gautron shall have power, in his capacity as receiver, to appoint a controlling or supervising committee, composed of three members selected as much as possible from among civil engineers and finance inspectors, in order to inspect the progress of the work, the condition and maintenance of the plant and of the real property, as well as the accounts kept in relation to these various objects.

The compensating of this committee shall be at the expense of the new company.

Your petitioner further shows that it is proper for him to submit to the civil tribunal of the Seine, for ratification and approval, the conditions of the said grants and contributions and the constitution and by-laws of the company formed for the completion of the canal.

Wherefore your said petitioner, acting in his official capacity, respectfully requests and prays the honorable president and associate justices of this court purely and simply to ratify and approve the purport and conditions of the grants or contributions intended to be made by the receiver for the Universal Company of the Panama Interoceanic Canal to the New Panama Canal Company now in process of formation, as well as the constitution and by-laws of the last-mentioned company.

All proper reservations being made, justice will be done.

A. DE BIÉVILLE.

Having considered the order issued by the president of the court, dated the 27th day of June, 1894, appended to the said petition and directing:

That this be communicated to the commonwealth attorney, and that Mr. de Boislisle, vice-president, is hereby appointed to make a report. Done at the palace of justice, Paris, on the 27th day of June, 1894, and signed "Baudouin."

Having considered the written opinion of the commonwealth attorney, likewise appended to the said petition, which opinion is thus conceived:

The attorney for the commonwealth refers the matter to the tribunal of justice.

CABAT.

Having considered articles 10 and 11 of the act of July 1, 1893, which articles are thus framed:

ARTICLE 10. All acts tending to alienate any assets of the company, all contracts entailing a transfer or contribution of the whole or of part of the assets of the concern, emanating from the receiver of the Universal Company of the Panama Interoceanic Canal, shall be subject to the approval or ratification of the civil tribunal of the Seine, who shall, on the report of one of the justices, pass on the question in open court.

ARTICLE 11. All decrees of approval and ratification rendered in accordance with the preceding article shall be published, within a term of ten days, in the Journal Officiel and in the Journal Officiel (Commune edition).

This decree may be attacked by a third party, by the shareholders, by the attorney of obligation holders, and by other creditors of the company, within a delay not exceeding one month from the date of the publication aforesaid. The civil tribunal shall adjudicate the question within the space of one month, as in the case of matters demanding immediate and summary adjudication. The appeal from such decision must be entered, within ten days from the time of notification of said judgment, to the party in person or at his domicile.

Having heard at the sitting of the court Mr. de Boislisle, vice-president, in his report, and Mr. Cabat, assistant attorney for the commonwealth, in his opinion, and having deliberated upon the same in accordance with law.

Whereas it appears from the terms of article 5 of the constitution and by-laws of the New Panama Canal Company, which constitution and by-laws have been duly acknowledged before Lefebvre and his colleague, notaries in Paris, under an act of June 26, 1894, that Gautron, acting in his official capacity as receiver for the Universal Company of the Panama Interoceanic Canal, has declared himself as ceding or contributing to the said company newly formed:

First. All rights whatsoever accruing to the old company by virtue of the laws of the Government of the United States of Colombia, dated May 18, 1878, and December 26, 1890, as well as those accruing from all decrees, acts, or facts having followed upon these laws in the course of their execution, and all advantages accruing therefrom and stipulated by these laws and decrees, together with all territory and real estate granted and ceded unto the interoceanic company now in process of liquidation or acquired by the same—all this provided the new company fulfill the conditions prescribed and imposed by the laws and acts passed in prolongation or extension of the grant, and provided it discharge and pay all sums and indebtedness remaining due to the Colombian Government by the old company.

Second. The work already done and accomplished, the yards, workshops, buildings, hospitals, plant, mounted and unmounted, and the stores, etc., belonging to the receivership of the Universal Company of the Panama Interoceanic Canal, as well as all deposits which may have been made by the said company now in process of liquidation.

Third. The plans, estimates, surveys, and specifications, and all documents whatsoever gathered and collected by the Universal Company of the Panama Interoceanic Canal bearing in any manner on the study, construction, or improvement and operation of the canal and its appurtenants, as well as the privileges attached to the same, and all contracts or agreements with third parties.

Fourth. All rights of any nature and description, part ownership, or any other rights whatsoever which may belong or accrue to the Interoceanic Canal Universal Company, now being liquidated, in the Panama Railroad at Colon, now worked and operated by an American company, known as the Panama Railroad Company, whose legal residence is in New York, the said rights being transferred such as they are and exist, carrying with them all the privileges which they entail; and Mr. Gautron binding himself, in his official capacity, to invest with them the present company in the form, and in compliance with all the formalities, required for such due and valid transfer by the laws of the United States of America.

Whereas, moreover, the said rights are to be transferred, as well as the said property, such as they exist and with all that they entail, and whereas these cessions or grant and contribution have been made by Gautron, in his official capacity, with the following reservations and under the following conditions, to wit:

First. The receivership shall have and receive a share in the net profits and gains of the enterprise amounting to 60 per cent of the said profits and gains, such as the same shall be determined and computed under articles 51 and 52 of the constitution and by-laws.

Second. Fifty thousand shares of entirely paid-up stock shall be given to the Government of the United States of Colombia, as prescribed by the extension act of December 26, 1890.

Third. The rights of every nature and description accruing to the receivership from the Panama Railroad, and ceded by Mr. Gautron, as set forth in paragraph 4 above, shall become the property of the new company from the date of the meeting provided for by article 75 of the constitution and by-laws. No pecuniary compensation is required of the new company for the cession of these rights, but they are transferred on the condition and with the full understanding that said transfer shall be void if the canal be not completed within the time appointed by the grant. Should the work not be completed within the said period of time, the said rights shall revert to the receivership. If, contrary to all expectations, the meeting in question should fail to take the necessary measures to complete the canal, or if the measures thus taken by the said meeting should prove impossible of execution, the present company would still retain the said rights accruing from the railroad aforesaid; but it would be bound to pay to the receivership a sum of 20,000,000 francs as indemnity, while the receivership's share in the gains and profits of the new company would then be equal to one-half of the said gains and profits without further previous reduction than such as is provided for by paragraphs 2 and 3 of article 51. Consequently, the said rights shall remain inalienable in the hands of the new company aforesaid, either until the payment of the said 20,000,000 francs or until the full completion of the canal.

Fourth. Until the full completion of the canal Mr. Gautron shall have power, in his official capacity, to appoint a controlling or supervising committee composed of three members, to be selected, as far as possible, from among civil engineers and finance inspectors, in order to inspect the progress of the work, the condition and maintenance of the plant and real property, as well as the accounts kept in relation to these various subjects. The compensation of this committee shall be at the expense of the new company.

Whereas, according to the terms of article 51 of the constitution and by-laws of the said new company, the annual proceeds of the enterprise shall be used to pay and discharge:

First. The share in the gains and profits stipulated and reserved to itself by the Government of the United States of Colombia according to the terms of the grant.

Second. The costs of maintenance and the operating expenses, the expenditures entailed in the management of the concern, and, generally speaking, all charges incurred by the company, as well as the payment of interest and the redemption of all loans which may have been contracted.

Third. The deduction of one-twentieth, levied on the net profits after the settlement and cancellation of all items of indebtedness above enumerated, the said deduction to be applied to the formation of the legal reserve fund.

Fourth. Five per cent of the capital stock, the same to be applied by the general meeting, as the board of directors may advise, both to the formation of the redemption fund which is to be established under article 55 and to the payment of interest on unredeemed shares.

Whereas, according to the terms of article 52, the net gains and profits of the enterprise will consist in whatever will be left of the annual proceeds after deduction of the various items enumerated in the preceding article hereof, while 5 per cent of these net profits will be set apart for the benefit of the board of directors, and the surplus shall go 40 per cent to the shares created and 60 per cent to the Interoceanic Canal Universal Company now in process of liquidation.

Whereas, finally, by the terms of article 75, when the expenses incurred for the work done on the canal and for the settlement of obligations resulting from the contribution made by Gautron in his official capacity as receiver shall have reached a sum equal to at least one-half of the capital stock (excluding nonspecies portion of the same), the results then achieved from the work already done and the consequent decisions to be taken for the future of the enterprise shall be passed upon by a special technical commission brought together at some previous and opportune time, the said commission to consist of two members designated by the board of directors of the present company and of two persons named by the receivership of the former universal company for an interoceanic canal, together with a fifth member whom the other four shall designate and who shall be president of the said commission, but who in case the other four members should fail to agree, shall be appointed by the president of the tribunal of commerce for the department of the Seine.

Whereas the board of directors shall be bound to make public the report made by this commission and to summon an extraordinary or special general meeting.

Whereas this meeting shall have to deliberate on ways and means to insure the completion of the work and on the stipulation herein above set forth, article 5, paragraph 4, No. 3; whereas the constitution and by-laws in question must be submitted, by the terms of article 10 above mentioned, of the law dated July 1, 1893, to the tribunal for ratification touching the contributions intended to be made to the New Panama Canal Company by Gautron in his official capacity, and whereas this ratification is prayed for by Gautron.

Whereas the said contributions are within the competency of the receiver, according to decrees which appointed him with the broadest powers, notably with that of ceding or contributing to a new company all or a part of the company's assets; whereas the conditions stipulated for the benefit of the Universal Company of the Panama Interoceanic Canal seem to be in accord with its own interests, and therefore it is proper to ratify and approve the agreement declaring these contributions and conditions:

For these reasons the court, leaving unimpaired the right of shareholders, of the attorney or representative of obligation holders, and of other creditors of the company to intervene and make objection under article 11 of the law dated July 1, 1893, does hereby approve and ratify, purely and simply, the constitution and by-laws of the New Panama Canal Company as received by Lefebvre and his colleague, notaries, in Paris, on the 26th day of June, 1894, touching the contributions made by Gautron in his capacity as receiver of the Universal Company of the Panama Interoceanic Canal, and the court hereby orders that the present decree be published within the space of ten days, in the Journal Officiel and in the Journal Officiel (Commune edition), according to article 11 of the law of July 1, 1893.

BAUDOUIN.
DE BOISLISLE.
LASNIER.

Done and adjudged by Messrs. Baudouin, president; De Boislisle, vice-president; Laporte, judge; Tassart, supernumerary judge; Le Berquier, supernumerary judge, in the presence of M. Cabat, assistant attorney for the commonwealth, attended by Lasnier, clerk, June 29, 1894.

The order was signed by the honorable president of the court, by the reporting judge, and by the clerk.

Recorded in Paris, July 11, 1894, folio 50, thir subdivision.

Received 9 francs and 38 centimes, decimes included.

[Translation.—Paris, June 8, 1888.]

LAW AUTHORIZING THE COMPAGNIE UNIVERSELLE DU CANAL INTEROCÉANIQUE DE PANAMA TO ISSUE IN FRANCE SECURITIES REPAYABLE WITH PRIZES.

The Senate and the Chamber of Deputies have adopted, the President of the Republic promulgates the law of the following tenor:

ARTICLE 1. The Compagnie Universelle du Canal Interocéanique de

Panama is authorized to create, up to 600,000,000 francs, an issue of securities, payable with prizes by lot, upon the following conditions:

First. The securities issued shall bear annual interest, the rate of which can not be less than 3 per cent on their par value.

Second. The total annual sum distributed in the form of prizes can not, in any case, exceed 1 per cent of the par value.

Third. The par value of the securities issued can not be less than 300 francs; subsequent division of the securities issued is forbidden.

Fourth. The payment of this loan in a period of ninety-nine years, at furthest, shall be secured by a sufficient deposit, for this especial purpose, of French Government bonds, or of securities guaranteed by the French Government. The Compagnie Universelle du Canal Interocéanique de Panama, to meet the obligation imposed upon it, is authorized to increase, under the same conditions, the said loan of six hundred millions, by the sum necessary for the formation of this guaranty fund, this increase of loan not to exceed 20 per cent of the par of the issue.

ARTICLE 2. If the Compagnie Universelle du Canal Interocéanique de Panama should hereafter convert all or any of its former obligations, the provisions of article 1 shall be applicable to the new securities created by means of this conversion.

ARTICLE 3. All material necessary for the completion of the works shall be manufactured in France. The raw material must be of French origin.

ARTICLE 4. All prospectuses, posters, publications, and other documents intended for advertising must bear, in type of the same size as that used for announcing the loan, and below the amount of the loan, the notice:

Loan authorized in conformity with the provisions of the law of May 21, 1836, by the law of June 8, 1888, but without any guaranty or responsibility of the State.

The same notice shall be put at the top of the temporary or permanent certificates issued to subscribers.

Any violation of the above provision will entail the withdrawal of authorization by simple order of the minister of finance.

The present law, considered and adopted by the Senate and by the Chamber of Deputies, shall be executed as a law of the State.

Done at Paris June 8, 1888.

CARNOT.

By the President of the Republic:

P. PEYTRAL,
Minister of Finance.

LAW OF JULY 15, 1889, AUTHORIZING SALE OF LOTTERY BONDS AT REDUCED RATES.

ARTICLE 1. The receiver of the Universal Company of the Interoceanic Canal of Panama is authorized to negotiate, at any price and without interest, such of the lottery bonds authorized by the law of June 8, 1888, as had not been placed or sold up to the 4th day of February, 1889, when the said company was dissolved and was turned over into the hands of a receiver.

The sums resulting from the negotiation or sale of the said bonds shall be free from attachment or execution up to the amount of 34,000,000 francs.

In case the receiver should contribute or give to a company formed for the purpose of completing the canal all or a part of the assets of the receivership, the new company shall only have power to emit and issue bonds as yet unplaced or unsold by complying with the terms of the law of June 8, 1888, touching the minimum price of sale and the distribution of interest.

ARTICLE 2. As the sale shall proceed of those bonds on which full payment has not been made of the sum required to constitute the guaranty fund or capital prescribed and provided for by the first article of the law of June 8, 1888, the receiver must turn over the complement of this sum to the civil, *i. e.*, nontrading, company created with a view to the formation of the said fund or capital.

The deposits made by the civil or nontrading company by virtue of the law of June 8, 1888, and also of the present law, shall not be withdrawn, but shall preserve their special character and shall remain specially pledged until complete discharge of the lot guaranty and of the capital reimbursement.

APPENDIX M M.

CONTRACT BETWEEN NICARAGUA AND THE AMERICAN ATLANTIC AND PACIFIC SHIP-CANAL COMPANY, SIGNED AT LEON AUGUST 27, 1849.

The supreme director of the State of Nicaragua and The American Atlantic and Pacific Ship-Canal Company, composed of Cornelius Vanderbilt, Joseph L. White, Nathaniel H. Wolfe, and their associates, being always citizens of the United States, desiring to settle the terms of a contract for facilitating the transit across the Isthmus of Nicaragua from the Atlantic to the Pacific oceans, by means of a ship canal or railroad, have appointed as commissioners on the part of the supreme director of the State of Nicaragua, Messrs. Hermenegilda Zepeda and Gregorio Juares, and on the part of the said company Mr. David L. White, with full powers to arrange and conclude a contract for the above-named purposes, which commissioners, having exchanged their respective powers, have agreed upon and concluded the following artic'es:

ARTICLE I. The State of Nicaragua grants to the said company the exclusive right and privilege of constructing a ship canal across its territory, by a single route and at its own expense, from the port of St. Johns, of Nicaragua, or any other more feasible point on the Atlantic, to the port of Realejo, Gulf of Amapala, or Fonseca, Tamorinda, St. Johns of the South, or any other point on the Pacific Ocean which the engineers of the company may decide upon, by means of the St. Johns River, Lake Nicaragua, River Tipitapa, Lake of Leon, or any other rivers, lakes, waters, and lands situated within its territory, with the object of connecting the two oceans, and to make use of, for its construction and navigation, said rivers, lakes, waters, and lands, both public and private. And the State also grants to the company the exclusive right to the administration, management, and control of the said canal, according to the following articles:

II. The dimensions of the canal shall be such as may be necessary for the passage of vessels of all sizes, and the point at which it shall terminate on the Pacific, in the event that the engineers of the company shall decide upon two or more points as equally practicable, shall be that one most consistent with the mutual interests both of the State and the company.

III. The company binds itself to construct, at its own expense, in the harbors at the extremities of the route of said canal, custom-house buildings of the necessary capacity for the use of the State and company.

IV. The exclusive rights and privileges herein granted to the said company by the said State shall be enjoyed by the same for the fixed period of eighty-five years, counted from the day in which the canal shall be completed and put in use.

V. The company hereby agrees to pay to the said State for the said grant the following sums of money, namely:

First. Ten thousand dollars by draft on the said company in the city of New York as soon as this contract shall be ratified by the Legislature of the State.

Second. Ten thousand dollars at the expiration of one year from this same date, and $10,000 each year thereafter until the completion of the said canal, the above sums to be paid to the State in the city of Leon, or in the city of New York, as the State may elect. Also the said company makes a free donation to the said State of $200,000 of stock in the enterprise, which shall be delivered to the State as soon as the certificates of stock shall be distributed by the company.

VI. Said State shall receive for its proportion of the income of said canal, after the same shall be put in use, the following interests, namely: For the first twenty years, 20 per cent annually out of the net profits after deducting therefrom the interest of the capital employed in its construction at the rate of 7 per cent per annum, and 25 per cent each year thereafter out of said net profits, after deducting the said 7 per cent, until the expiration of the full period of the term hereinabove granted. And the State shall also receive 10 per cent out of the net profits, without any deduction of interest, of any route which the company may establish between the two oceans, whether it be by railroad or carriage road or by any other means of communication, during the twelve years herein granted for the construction of said canal.

VII. The said company shall be bound to make and present an annual report and account to the Government of Nicaragua, setting forth the receipts and expenditures, as well as a statement of the condition of the works of the canal, which report shall be certified by the proper officers of the company. The State, however, shall have the right, through any commissioners which it may appoint for that purpose, to inspect and examine at any time the books of the company to satisfy itself of the correctness of the said receipts and expenditures.

VIII. It is hereby stipulated that the State of Nicaragua shall have the privilege of taking stock in the said canal, to the amount of $500,000, within one year from the date of the ratification of this contract, which it may distribute, as it may deem proper, among any of its native citizens or the citizens of the adjoining States, upon giving notice to the company of such intention through the United States consul in the city of Leon.

IX. It is further stipulated that a majority of the stock of said canal shall always be owned by citizens of the United States; in evidence of which the stock books of said company shall always be open to inspection at the principal office of the company, wherever the same may be located.

X. The company binds itself to commence the preliminary surveys for said works within the period of twelve months from the date of the ratification of this contract, and also to complete the said canal within twelve years from the same date. But if any fortuitous or unforeseen events, beyond the control of the company—as, for example, earthquakes, epidemics, wars, or any other events of this nature—should appear during the progress of the work to suspend its execution, the time thus lost shall not be reckoned as a part of the stipulated time above given for its completion. In case such event should occur, the company shall give immediate notice to the Government of the same, for the purpose of deciding, in connection with the company, upon the nature of such event.

XI. If none of the events which are expressed in the preceding article should occur, and the work shall not be completed within the said period of twelve years, then whatever may have been done by the company to that time in the prosecution of the work shall be forfeited to and become the property of the State without any indemnity.

XII. The State gives to the said company the right to take, free of any charge or indemnity, any of the public lands or forests within the State, all the wood, stone, lime, timber, or any other materials which it may require for the construction and use of said canal and its dependencies. And the said State hereby further gives to the company the right to take and make use of such portions of the public lands as it may require for the establishment or erection of houses, stores, docks, wharves, stations, and all other useful objects connected with the works of said canal.

XIII. In case the company shall require any materials, such as wood, lime, stone, etc., which may be found in or upon the lands of particular individuals, it shall be obligated to pay for the same at such price as may be agreed upon between the company and such individuals; but all the lands which may be required for the passage of the canal in its entire route shall be at the expense of the State, and the company shall not be liable to pay any indemnity for the same.

XIV. All the articles that the company may require, both for the surveys and explorations, and for the construction and use of the works of the canal, such as machines, instruments, tools, etc., and all other necessary materials, shall be admitted into the State free of duties of all kinds, and may be discharged in any of its harbors or at any other point within its territory that the company may select, in this last case, however, giving notice of such intention to the proper Government officer. But the company shall have no right to introduce within the territory of the State any goods, merchandise, or any other articles of commerce for sale or exchange without paying the duties established by law. And they are also prohibited from importing any articles or materials which may be monopolized or prohibited by the State for any purpose, except for the use of the works of the canal.

XV. The State binds itself to facilitate and aid in every possible way the engineers, contractors, employees, and laborers who may be employed in the explorations and surveys of the route, and in the construction of the works of the canal, and to this end stipulates that all citizens of the country who may be so employed by the company shall be free and exempt from all civil or military service of the State whatsoever; but to entitle them, however, to the right of exemption from such military service they shall have been previously in the employ of the company for at least the period of one month. The State also guarantees to all foreigners who may be employed on the works of the canal the same rights, liberties, and privileges as are enjoyed by inhabitants of the country, and also that they shall not be molested or disturbed in their labors while thus employed by any internal commotions or disorders of the country, and at the same time that they shall be free and exempt from all taxes, duties, or direct contributions whatsoever during the time they may be in the company's employ.

XVI. The said company agrees to receive from the State as laborers upon the works of the canal any convicts who may be capable of labor upon such terms as may be agreed upon between the company and the State.

XVII. The said company agrees to transport across the said canal all passengers, goods, merchandise, and materials of every description which may be intrusted to it; and also stipulates that the canal shall be open to the transit of vessels of all nations, subject to fixed and uniform rates of tolls that may be established by the company.

XVIII. The company shall establish a tariff of fees or tolls for the transportation of all passengers, goods, wares, merchandise, and property of every description, and for vessels of all kinds passing through or along the said canal, which shall have the force of law from the moment in which it shall be communicated to the Government of Nicaragua, which shall be obliged to sanction the same within eight days after its reception; and at the same time, with a view to induce the largest and most extended business by this route, the said company agree to fix the said tariff of fees or tolls for the same at the lowest possible rate consistent with the mutual interests both of the State and the company; and in case that the company should determine at any time to alter such tariff, it shall be incumbent upon it to give six months' previous notice of such determination in the State paper of Nicaragua and in the principal seaport towns of the United States.

XIX. The rate of tolls and charges for the transit of the products and manufactures of the State of Nicaragua and the adjoining States shall be regulated by a particular and more favorable tariff, which shall be agreed upon between the State and the company.

XX. The State grants to all steamers and vessels of the company during the continuance of this contract the right of ingress and egress to, from, and through all its harbors, rivers, and waters, both on the Pacific and Atlantic oceans and the interior, and the use of the same free of all duties or charges of any kind whatsoever, as, for example, anchorage, tonnage, etc.

XXI. The State hereby stipulates that all vessels and steamers of the company, and also all goods, merchandise, manufactured articles, or any other property which may be conveyed therein passing through the said canal from one sea to the other in either direction to any foreign country, shall be free and exempt from all kinds of Government duties or taxes whatsoever, and shall also be secure and protected from all interruption or detention in their course on the part of the State.

XXII. The company shall furnish to the State annually a list of al its vessels employed in the navigation of the route, containing the names and descriptions of each of such vessels, which shall be registered in the archives of the State, and thereupon the State shall give to the company a separate certificate of the register of each one of the said vessels, signed by the proper officer of the Government, which certificate shall serve always as a passport for said vessels through all the harbors of the State upon presenting the same to the custom-house or harbor officer.

XXIII. The exclusive right which the company has acquired by this contract of navigating the said lakes, rivers, and waters of the said State by means of steam vessels, from one sea to the other, is understood as not to exclude the natives of the country from free interior navigation by means of sailing or any other vessels, excepting steam vessels.

XXIV. The company binds itself to transport by the said canal, on board of any of its vessels, all the principal officers of the Government and its subalterns, in case of Government necessity, from one point of said route to any other one at which said vessels may stop, without any charge to the State therefor.

XXV. The company is to convey by any of its steamers or vessels, free of cost or charge, over the route of the said canal all the official correspondence of the State, in consideration of which the State agrees not to collect or recover any postage or duties of any kind upon any of the correspondence of the said company.

XXVI. The company binds itself to construct, at its own expense, bridges upon that part of the canal that may be made between the lakes and the Pacific, upon such principal highways as may be agreed upon between the State and the company. The said State, with the consent of the company, shall establish rates of toll or charges upon such persons or things as may pass over said bridges, the profits from which shall be appropriated to redeem the capital invested in their construction, and the interest thereon at the rate of 7 per cent per annum; and when such capital and interest shall have been reimbursed to the company then the profits shall be divided equally between the State and the company for the remaining period of this contract, but such bridges shall continue under the control and management of said company.

XXVII. The State of Nicaragua, with the object of facilitating the colonization of the lands contiguous to the river St. John and the adjacent rivers, and of the canal which in or along it may be constructed, makes a free donation to the company of eight stations or sections of land to be located at such points upon either one or both of the banks of the said river or canal as the company may elect, each one of which stations shall be of 6 English miles in length, fronting upon the river or canal, and 6 miles in width, measured from the bank of the canal or river toward the interior. And the State further grants to the company the right of alienating the lands which compose said sections to settlers, or any other person or persons who may wish to locate themselves upon the same. Said sections of land are granted upon the following conditions:

(1) They shall be located by the company in such a manner that they shall be at least 3 English miles distant from each other.

(2) That no one of them shall be located within the distance of 4½ English miles from the mouth of the St. Johns River.

(3) The State reserves to itself the right to such points as shall be necessary for its military fortifications and public buildings.

(4) That the lands granted shall not be alienated to settlers until six months after the commencement of the survey of the route of the said canal.

(5) The State reserves to itself the supreme dominion and sovereignty over said lands and their inhabitants.

(6) That said lands shall not be alienated by the company to any government whatsoever.

XXVIII. The colonies which the company may establish upon said lands shall be colonies of Nicaragua, and thereupon the settlers shall be subject to the laws of the State the same as the natives of the country, being, however, exempt for the term of ten years from all taxes and direct contributions, and from all public service, as soon as each colony shall contain at least fifty settlers.

XXIX. The State further agrees that in case any event may hereafter occur, as named in the preceding Article X, to suspend or prevent the construction of the canal, or if the said contract shall become forfeited or annulled by either or both of the parties, and also in case the said contract shall continue in force for the full period of eighty-five years, mentioned in the preceding Article IV, the said State shall always acknowledge as private property the lands which may have been alienated or ceded by the company to settlers or other persons in virtue of the legal title which the company has acquired by this contract to the said lands.

XXX. The company shall have the exclusive right to construct rail or carriage roads and bridges, and to establish steamboats and steam vessels on the said rivers and lakes as necessary accessories to and in furtherance of the execution of the canal; but the company hereby stipulates and agrees that, in case the construction and completion of the said canal, or any part of it, becomes impossible by any unforeseen event or insurmountable obstacle of nature, to construct a railroad or rail and carriage road and water communication between the two oceans, provided the same may be practicable, within the same period as is stipulated for the building of the said canal, and subject to the same terms, conditions, regulations, and restrictions as far as they can be made applicable to the same.

XXXI. The State hereby binds itself not to sell or dispose of any of its public lands located upon or near the river St. Johns, or upon or near any of the routes or points designated in Article I of this contract, until after the surveys shall have been made and the route determined of the said canal.

XXXII. The State also binds itself to protect and defend the company in the full enjoyment of the rights and privileges granted in this contract, and also binds itself not to contract with or cede to any government, individual, or companies whatsoever the right of constructing a ship canal, railroad, or any other communication across its territory between the two oceans, or the right of navigating by means of steam vessels any of its rivers or lakes which may be occupied by this company while this contract continues in force. But should this contract become forfeited or annulled, then the State shall be privileged and free to contract with any other individuals or companies as it may deem proper.

XXXIII. In case any dispute or controversy shall arise during the existence of this contract between the State and the company, the same shall be determined by a reference to five commissioners, to be chosen in the following manner, viz, two to be named on the part of the State, two named by the company, and the fifth to be selected by the four thus appointed, who shall hear and determine the matters in controversy, and decide upon the same; which decision of the said commissioners shall be final and without appeal, and binding upon both the State and the company.

XXXIV. It is further provided that in the event of the four commissioners thus chosen not being able to agree upon the selection of the fifth, the State and the company shall then choose three individuals, out of which number they shall select one to act as such fifth commissioner; but should they disagree in such selection, then the choice shall be made out of said number by lot.

XXXV. After the period of the eighty-five years herein granted to the company shall have expired, the company shall surrender to the State the canal or roads, and its dependencies, revenues, and privileges, free from all indemnity, for the capital which may have been invested in the said work. But it is nevertheless stipulated that the company shall receive 15 per cent annually out of the net profits of the canal for the period of ten years after such surrender, provided the cost of the same shall be less than $20,000,000; but should the cost be $20,000,000 or more, then the company shall receive said 15 per cent for the period of twenty years after such surrender.

XXXVI. It is expressly stipulated on the part of the State of Nicaragua that the vessels, products, manufactures, and citizens of all nations shall be permitted to pass upon the proposed canal through the territory of the State, subject to no other or higher duties, charges, or taxes than shall be imposed upon those of the United States: *Provided always*, That such nations shall first enter into such treaty stipulations and guarantees respecting said canal as may hereafter be entered into between the State of Nicaragua and the United States.

XXXVII. It is finally stipulated that this contract and the rights and privileges which it confers shall be held inalienable by the individuals composing the company herein named and their associates, and that it shall never, in whole or part, be transferred or assigned to any other company, nor in any way become dependent upon or connected with any other company, whatever may be the objects of the same.

XXXVIII. The present contract shall be ratified by the legislature of the State in the shortest possible period; and, on the part of David L. White, shall be ratified immediately after, as agent of the company which he represents, in virtue of the powers conferred on him to this effect.

In testimony of which we, the respective commissioners, have signed and sealed the present contract in triplicate, in the city of Leon, in the State of Nicaragua, the 27th day of August, in the year of our Lord 1849.

[SEAL.] HERMEND ZEPEDA.
[SEAL.] GREGORIO JUARES.
[SEAL.] DAVID L. WHITE.

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REPORT ON INDUSTRIAL AND COMMERCIAL VALUE OF CANAL.

By Emory R. Johnson, Ph. D.

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CHAPTER I.—*Scope and method of the investigation.*

This study of the isthmian canal from the standpoint of its use, or its industrial and commercial value, has been made for the accomplishment of two purposes. One object was the presentation of an analytical discussion of the more important relations of the proposed waterway to the commerce of foreign nations and to the industries, transportation interests, and domestic and foreign trade of the United States. The other purpose was to compare the commercial advantages of the Nicaragua route with those of one across Panama, all other routes having been eliminated from consideration.

There are two sides to an investigation of the value of an isthmian canal, one industrial and the other commercial. A careful study of the leading industries of the different sections of the United States is requisite to an analysis of the effects which the canal will accomplish or to a fruitful discussion of the commerce that will use the waterway. Commerce is but the auxiliary of industry; and a complete discussion of the economic value of an isthmian canal first requires an examination of the leading industries of the United States and other important countries, and then a consideration of the volume of business which those industries would bring to the canal.

While this report does not discuss the entire field as thus defined, it covers those parts of the subject that are of direct importance to the American people. The relation of the canal to the industries and domestic and foreign commerce of the United States has been studied with care and is presented with considerable detail, nearly half of this discussion being devoted to the subject. A separate chapter is given to each of the four sections of the United States—the southern, eastern, central, and western—for the purpose of considering the manner in which the proposed canal will affect their industries and commercial progress, and these chapters are followed by more detailed studies of the coal and iron and steel industries and the shipbuilding and maritime interests, with special reference to the effects which the new interoceanic route will have upon each. The facts bearing upon the use of the canal by sailing vessels are analyzed and the influence which the new waterway will have upon the future place of the sailing vessel as an ocean carrier is considered. The effect of the canal upon the traffic of American railways is also made the subject of a special chapter.

The foreign countries whose resources and trade have been examined are those of the Pacific, and they were chosen for investigation partly because it was believed that in general the effect of the interoceanic canal upon them would be greater than upon other foreign countries; that their commercial relations and economic conditions would be most benefited. The present and prospective importance to the United States commercially, and politically also, of the Pacific nations was another reason for studying carefully the relation of the canal to the progress of those countries. The industries and trade of the countries of western South America and the manner in which the isthmian canal will affect their progress and our commercial relations with them have been examined with special care, because of the importance of this extensive section to the world's commerce. The information concerning this region is comparatively meager and the significance of the section for the traffic of an interoceanic canal and the commercial progress of the United States is frequently underestimated. The industries and trade of Japan, China, Australia, the Philippines, Hawaii, western Mexico, and Central America, and the effects of the isthmian canal upon them are also discussed.

The latter part of this discussion relates to the traffic that will use the waterway. The effects which the isthmian canal will have upon the length of the ocean routes connecting the United States and Europe with the various countries of the Pacific are shown by eight tables, the distances in which were calculated by the United States Hydrographic Office.

The investigations made to ascertain the present and prospective available tonnage of canal traffic are described in Chapters XVIII to XXI, inclusive. Three statistical studies are discussed in the report, and after describing and presenting the results of the three investigations the tonnage figures obtained by the three different methods of inquiry are compared.

After having determined the amount of canal traffic available in 1899, and having ascertained the rate of increase in that traffic during the previous decade, estimates are made concerning the probable tonnage that will be available for the canal in 1909 and 1914. The growth in the traffic passing the Suez is analyzed and an estimate is made regarding the increase in the tonnage of the isthmian canal during the first decade of its use.

In the discussion of available canal tonnage the effect of tolls upon the use of the waterway by the traffic between the different sections has been considered. The detailed analysis of the relation of tolls to the volume of traffic using the canal was, however, reserved for a special chapter in which the question is treated at some length.

Printed material, books, pamphlets, and official statistical reports published by the United States and foreign countries have been examined, and an extensive correspondence has been carried on with men engaged in different lines of business so as to secure data concerning industrial and commercial facts in descriptive rather than statistical form. Special and different inquiries were addressed to manufacturers, importers, and exporters, the owners, operators, and builders of ships, and the higher officials of a number of the larger railway companies. The information received from individual sources is frequently referred to, but for obvious reasons the personal or corporate name of the correspondent is not given. The information regarding the industries and trade of foreign countries was in part supplied by special reports prepared for the commission by consuls and ministers of the United States in accordance with instructions sent them by the State Department.

In order to supplement the information obtained from the sources just enumerated, visits were made by one member of the commission, and in some instances by two, to twenty-nine large commercial and industrial cities. The places visited included the larger seaports from Portland, Me., to Galveston Tex., and the interior industrial cities of Pittsburg, Cleveland, Cincinnati, Detroit, Indianapolis, Milwaukee, Chicago, St. Louis, Memphis, Louisville, Chattanooga, Birmingham, and Atlanta. In each of these cities the commercial organizations, manufacturers, and others interested in the development of their industries assisted the visiting commissioners by giving them information. Special reports were prepared for the commission by the commercial organizations in these and other cities.

From the nature of the subject investigated, some of the conclusions regarding the industrial effects of the canal must be based on premises concerning which differences of opinion may exist. Moreover, the presentation of the industrial data and a discussion of them can not be made as brief and concise as a mathematical demonstration. These limitations apply in less degree to the statistical material used in measuring the volume of traffic available for the use of the canal. The conclusions to which this inquiry has led are here given without claiming that they are absolutely correct in every particular, but they are close approximations to the truth attained by careful research.

Much time and labor have been given to the preparation of maps locating the resources and industries of the foreign Pacific countries discussed in Chapters XI to XVI of the report. Chapter XVII, on distances, is accompanied by commercial maps showing the location and length of the ocean routes by present lines of trade and by those that would pass through a Nicaragua canal and a Panama canal.

The information used in the preparation of the maps accompanying the report was derived from numerous sources. American and foreign government publications have been consulted, and geographical literature and maps, both published and unpublished, have been examined. The United States consular reports, and particularly certain special reports prepared for the canal commission by the consular representatives of the United States in the various foreign countries, were a valuable aid, especially in the preparation of the maps of Australia, China, South America, and Japan. In a number of cases the text of these special reports was accompanied by maps prepared in accordance with suggestions made by the commission. The publications of the Bureau of the American Republics have been used to some extent in preparing all of the American maps. With the exception of two countries, this is also true of Bianconi's commercial charts. The commission has secured many facts by an extensive correspondence; and in the following specific references to the authorities for the information contained in the maps no attempt is made to give all the sources drawn upon.

The map of Chile contains much information furnished by the representatives of the Chilean Government, and among the other sources of the data used special mention should be made of the work of the United States Weather Bureau and of the book on South America by F. G. Carpenter. The chart of northwestern South America contains many data contributed by the Bolivian Government. The Geographic Society of Lima sent, in manuscript, a carefully prepared agricultural map of Peru. Some facts were taken from Carpenter's "South America" and from "Between the Andes and the Ocean," by W. E. Curtis. The reports of the Intercontinental Railroad surveys were of value in the preparation of this map and also of that of Central America.

The map of Mexico is based in part upon the economic map recently published by the Bureau of the American Republics. This information has been largely supplemented and verified by extensive correspondence with Americans engaged in business in Mexico. The following authorities, in addition to those more generally referred to above, were consulted: French and Belgian consular reports, and "Geographical Notes on Mexico," by M. Romero.

The map of New Zealand was constructed almost entirely from information derived from the yearbook and the other excellent reports published by the government of that colony.

For the Australian map the information came chiefly from the maps accompanying the special consular reports and from the detailed industrial descriptions contained in the official publications of the various States.

The map of China draws largely upon the economic maps published by Beresford in "The Breakup of China," and Chisholm's "The Resources and Means of Communication of China." The data used were, in almost every case, verified by the excellent economic map prepared for this commission at the United States legation in Pekin or by reference to some of the following works on China: Reports of Imperial Maritime Customs; "A Journey in Western Szechuen," by Bishop; "China in Transformation," by Colquhoun; "China in Decay," by Krauss; "Through Yangtse Gorges," by Little; "The Earth and Its Inhabitants," by Reclus.

For the data used in the map of Japan large use was made of the facts in Ransom's "Japan in Transition," which were verified and supplemented by reference to a special United States consular report and to Japanese Government reports, public and special.

CHAPTER II.—*The isthmian canal and the industries and trade of the Southern States.*

The products of the South find their present foreign market mainly in Europe, but they are desired in greater or less degree by nearly all countries, those of the Pacific Ocean as well as those of the Atlantic. Because of the geographical position of the South its exports can not readily reach the markets of the Pacific. The position of the South as regards Pacific trade is very similar to that of the west coast of the United States as regards its commerce with Atlantic countries.

As compared with the States adjacent to the North Atlantic, those of the Gulf are considerably nearer the eastern terminus of an isthmian canal. In the following table the distances of Greytown and Colon from New York are compared with their distances from the most important Gulf ports:

From—	To Greytown.	Less than distance from New York to Greytown.	To Colon.	Less than distance from New York to Colon.
Boston	2,220	[a] 160	2,165	[a] 184
New York	2,060	....	1,981	....
Philadelphia	2,000	60	1,960	21
Norfolk	1,849	211	1,779	202
Savannah	1,646	414	1,586	395
Tampa	1,117	943	1,215	766
Pensacola	1,223	837	1,344	637
Mobile	1,250	810	1,371	610
New Orleans	1,257	803	1,380	601
Sabine City	1,344	716	1,465	516
Galveston	1,360	700	1,481	500

[a] More.

It will be seen that of the Gulf ports included in the table Tampa is nearest to Greytown and Colon and that the ports to the west of Tampa are successively farther from the two isthmian ports, Tampa being approximately 250 miles closer than Galveston is to the Caribbean termini of the two canal routes. This would give Tampa some advantage over the other Gulf ports in the canal trade were not the benefits derivable from the shorter ocean route in part, if not quite, overcome by the longer railway haul to that city as compared with Pensacola and other Gulf ports from many of the sources of the heaviest volumes of traffic originating in the Southern States.

The proximity to the canal of the Gulf States and cities as compared with the North Atlantic section of the country will help the South in developing a direct trade through the canal and in drawing a larger amount of the export and import trade of the Mississippi Valley to the Gulf ports, but the more northerly ports, especially New York, will possess the advantage of having more facilities for shipping at all times to different parts of the world. However, as the commerce of the South with Pacific countries develops because of the opportunities afforded by the isthmian canal for dispatching freight more promptly to different ports of the world, the Southern gateways will enjoy in increasing measure the benefit of their relative nearness to the canal.

THE CANAL AND THE COTTON INDUSTRIES.

The raising of cotton has been the dominant industry of the South for nearly a hundred years, and, although the development of other resources is giving that section of the country an increasingly diversified economic life, cotton and the manufactures based upon it now hold and will probably retain the first rank. The rapid multiplication of cotton mills and the extensive manufacture of cotton-seed products have latterly strengthened very greatly the industrial position of the cotton crop.

The chief Pacific market for our raw cotton is Japan, which took 312,269 bales, valued at $12,712,619, during the year ending June 30, 1900, the gain over the previous years having been large. The sales for 1898 and 1899 averaged about 200,000 bales a year. The consumption of raw cotton in the mills of Japan has increased with extraordinary rapidity. In 1887 the Japanese imports of raw cotton were only 28,400 bales, by 1895 the amount had increased to 380,000 bales, and in 1898 the imports were 660,000 bales. In 1895 57.3 per cent of these cotton imports into Japan were obtained in China. British India supplied 32.5 per cent, the United States 8.4 per cent, and other countries 1.8 per cent. Three years later the imports from China dropped to 11.1 per cent. Those from British India rose to 56.3 per cent, while the purchases in the United States comprised 30.8 per cent, the amount obtained from other countries remaining at 1.8 per cent. It is fair to conclude from these percentages that the United States is certain to find a large and growing market for raw cotton in Japan.

The cotton cloth shipped from the United States finds its way to numerous Pacific countries. China, the largest buyer, took $8,783,134 worth in 1900, her purchases for the two previous years having averaged $7,500,000 annually. Among the other buyers of cotton manufactures are the British East Indies, which took $524,419 worth in 1900, and Australia, whose purchases amounted to $622,228. Besides this, the Hawaiian Islands took $572,541 worth. The demand of these and other Pacific countries is increasing, and our sales to them are growing, even under the present adverse conditions to be overcome in reaching their markets.

About 300,000 bales of the cotton exports to Japan for the fiscal year 1900 were shipped during the first eight months of the season. The distribution of these 300,000 bales among the three shipping routes gave the Atlantic ports, New York and Savannah, 44,000 bales; the Gulf ports, New Orleans, Galveston, and Pensacola, 87,000, and the Pacific coast ports, which were reached by rail, 169,000 bales. Nearly three-fifths of the cotton exported to Japan that year took the overland route, involving a railway haul of 2,000 miles to the seaboard.

The cost of transporting such a bulky commodity as cotton from the southern section of the United States to North Pacific countries by rail to our west coast, and thence by steamer, or from our Atlantic or Gulf seaboard through the Suez Canal (sometimes direct, and sometimes via England or Germany), are so high as greatly to restrict the trade. This fact is clearly shown in letters received from firms that are exporting cotton from Texas, New Orleans, Charleston, and elsewhere. The difficulties under which cotton is exported to oriental markets by the existing routes can be illustrated by quoting a few sentences from a communication received from a representative New Orleans firm:

> Two direct steamers went last year from this port to Japanese and one to Chinese ports (Shanghai) around the Cape, and more steamers went from Galveston, but these steamers are too long on the way. First of all, they have to stop in port here a long time to collect all the lots which are bound for Japan; then they travel two or three months, whereas payment is made by Japanese and Chinese buyers against ninety days draft, thereby causing loss of interest. To avoid this loss Japan bought last year (1898) a lot of cotton in Texas, the nearest State for shipment via San Francisco, but the Southern Pacific and other roads, owing to the inclement weather, etc., could not handle the big quantity, and cotton that should have gone out in January was in San Francisco by June. The rate to Yokohama and Kobe (Hiogo) is 80 cents per hundred pounds gross, to Shanghai 90 cents per hundred pounds gross; insurance 2 per cent, equal to one-eighth cent per pound. We believe China and Japan will consume over 2,000,000 American cotton (bales) a year within the next five years. A good deal of cotton to China yet comes from Hamburg, Germany, and London, England. Any shorter and safer route would materially increase consumption and net more to the producer here, as big freight and high insurance stand in the way of trade.

The cotton manufacturing industry of the South, as well as the exporters of raw cotton, will be served by the canal. With 5,000,000 spindles already in operation and the erection of new mills constantly going on, the growth in the cotton manufacturing business of the South will in the future be limited only by the extent of the market that can profitably be reached. The secretary of the New Orleans Cotton Exchange, a recognized authority on the cotton industry, makes the following statement in regard to the growth of the business of cotton manufacturing in the United States:

> The American mills, north and south, took, in the year 1890, 2,346,000 bales, and of this the census of that year tells us 2,259,000 bales were consumed. In 1899 American mills consumed 3,589,000, or 1,330,000 bales more. Our mills now turn out more goods than necessary for this country alone, and it is essential to their prosperity that export facilities be had that will enable them to compete successfully with other countries in the great markets of the world, especially those of the Far East. To the Southern States particularly, which have increased their consumption from 547,000 bales in 1890 to 1,400,000 in 1899, and give promise of still greater progress in the near future, an outlet through an isthmian canal is of the first importance.

In a special report received by the commission from a committee of business men in Charleston, S. C., the opinion is expressed that "within a period of five years South and North Carolina will spin more cotton than they grow." The report also states that "the cloth they manufacture is almost entirely of the coarser grades, such as is used in South America and the Orient. The average growth of the two States is 1,450,000 bales. They spun into cloth last year (1899) 970,000 bales."

Although, as the foregoing quotation states, the chief market in the Orient is for the coarser grades of cottons, there seems to be a growing demand for the finer qualities. Several manufacturers report an increasing sale of the finer qualities of cloth, and these statements would indicate that the eastern market is in the future to be one where a variety of cotton manufactures can be sold.

At present the cotton goods exported from this country to the East go out largely by way of New York and through the Suez Canal, although a portion of the trade is done by way of transcontinental railways.

THE CANAL AND THE IRON AND STEEL INDUSTRIES OF THE SOUTH.

The most notable phase of the recent industrial progress of the South has been the growth of the iron industry, whose chief center is in the district about Birmingham, in the north central part of Alabama. Two members of the commission visited this section, and Chattanooga, where a large variety of iron and steel wares are manufactured, and were strongly impressed by the extent and range of the present activities, and by the possibility of future development.

A special report prepared for the commission by a committee appointed by the Birmingham Commercial Club contains the following statement:

We have the three essential materials for iron making—coal, ore, and limestone within exceptional proximity, within rifle range of the furnaces; and in consequence of these geological conditions and the low cost of individual materials, iron can be produced in this district cheaper than at any other point in the known world.

The use that is being made of these resources of coal and iron is concisely stated in this report:

Less than twenty-five years ago the first coal mine was opened. In 1878 fires were lighted in its first furnace. There are now in this district about 125 coal mines, with a capacity of about 20,000 tons output per day; about 5,000 coke ovens, with a capacity of about 4,500 tons per day; two steel mills, with a capacity of about 1,160 tons per day; one wire, rod, and nail mill, with a capacity of 500 tons per day.

In addition to these there are about 200 more small manufacturing concerns, all established within the last twenty-five years.

The Southern States, including the Virginias, at the present time produce nearly one-fifth of all the iron ore mined in the United States, and the Alabama and Tennessee mines yield nearly one-seventh of the total. The pig-iron manufacture in Alabama in the year ending June 30, 1900, equaled about 1,200,000 tons.

The iron industries of the Birmingham district are devoted most largely to the manufacture of pig iron. This pig iron is in part manufactured into cast-iron pipe, wire, and nails, and the other simpler iron and steel products.

The iron of the Alabama district is mostly shipped outside of the State. During the last ten years about 20 per cent of the iron has been used in local establishments; about 5 per cent was taken by Southern States other than Alabama, 1 per cent went to the Pacific coast and to Mexico, 19 per cent was exported to foreign countries other than Mexico, and 55 per cent of the entire output was marketed north of the Ohio and Potomac rivers.

For the last three years about one-fifth of the iron produced in the Birmingham district has been exported. This export of iron began as late as 1896, and during the years 1897 and 1898 was larger than it has since been. These foreign sales of iron from the Southern furnaces have been facilitated by the cheap rates obtainable on iron, which makes desirable freight for a part of the cargo of steamers that load with cotton.

In the Southern States, outside of the Birmingham district, notably in Chattanooga, machinery, engines, implements, and a variety of iron and steel articles are being manufactured both for the domestic and foreign trade. Twenty-one Chattanooga firms are already shipping to or beyond the Pacific coast of the United States, and most of these are engaged in some form of iron and steel manufacture. The disadvantageous conditions under which they are conducting this trade at the present time are illustrated by a letter received from the head of one of the large establishments of that city engaged in the manufacture of steel plows. He says:

> We have made several shipments to Australia and some to China this year (1900). Some of these we had to ship by rail to San Francisco and pay a freight of $1.50 per hundredweight (to San Francisco), when we could have reached New Orleans and put them on a vessel for 24 cents.

In the foregoing discussion of the iron manufactures of the South and the effect which the opening of a canal would have upon them the statements made are intended to be illustrative rather than comprehensive. Alabama and Tennessee contain the largest iron producing and manufacturing regions in the Southern States, but Virginia and West Virginia have come to be important centers for those industries. Their industrial and commercial interests, however, are more closely associated with the North Atlantic than with the South Atlantic and the Gulf, and they have consequently not been considered in this discussion.

THE CANAL AND THE EXPORTATION OF SOUTHERN LUMBER AND FOREST PRODUCTS.

In a special study of the lumber trade of the United States made by the United States Bureau of Statistics and published in the Monthly Summary of Commerce and Finance, November, 1900, the importance and general location of the timber resources of the Southern States are described in the following concise manner:

> The timbered region of the South Atlantic and the Gulf slope is, commercially, the most important district in the United States. A circle whose center is Chicago and whose circumference begins with Norfolk, Va., and sweeps southwestward to the lower left-hand corner of Arkansas passes through the heart of the Southern pine region from beginning to end. The hard-wood region of the South lies inside of the great pine belt and south of the Ohio River, embracing the mountainous section of every Southern State east of the Mississippi, together with the whole of West Virginia, Kentucky, and Tennessee. The Piedmont and mountain sections and the river valleys of the slopes of the Southern Alleghenies are the home of the best remaining hard woods east of the Mississippi, if not the best in the entire country.

The standing supply of timber in the Southern States is estimated to be about 700,000,000,000 feet B. M., about 30 per cent of the present total amount within the United States.

The exports of forest products from the United States have reached large proportions and are increasing. Our total foreign sales in the year ending June 30, 1900, of wood and manufactures of wood, not including other forest products, were $50,598,416, and were double the amount sold ten years ago. This increase has been due to several causes, prominent among which are the restrictions which European nations are placing upon the cutting of their timber. Most of the lumber shipped abroad is cut on the Pacific coast and in the Southern States. The latter furnish more than half of the lumber exported from the United States, and somewhat more than seven-tenths of the lumber sent abroad from the South goes to Europe. One-fourth of the Southern exports are now marketed in the West Indies, Mexico, Central America, and eastern South America.

Although the lumber exports from the United States are large, they are estimated to be not more than 8 per cent of the total amount manufactured in the country. The lumber coasting trade of the Atlantic States is much in excess of the foreign shipments from that region, but the opposite is true of the Gulf cities. The chief lumber-shipping ports on the Gulf are Pensacola, Mobile, Pearl River, Mississippi, and New Orleans, but there are now others doing a large business, the trade being well distributed. The stave trade, one of the important branches of the lumber business, is centered at New Orleans, which handles more than half of all the staves exported from the country.

The large and rapidly growing exportation of lumber from the Southern States, not only to Mexico and the West Indies, but also to Brazil, Uruguay, and Argentina, indicates that large shipments would be made to the west coast of South and Central America if an isthmian canal were in existence. Those sections are obliged to import a large part of their lumber, and by way of a canal they will be nearer the Gulf cities of the United States than the mouth of the Rio de la Plata now is. There is a demand on the west coast of all three Americas for hard wood, and from Southern California south soft woods are needed.

The hard-wood lumber is now being shipped from the Southern States to the Atlantic South American States and to the Pacific coast of the United States. The cost of transportation by all water from Memphis through a canal to Pacific markets would be so low as to make possible the development of a more important trade. The industrial progress of the west coast of all the three Americas will greatly enlarge the demand for lumber. This larger business will be shared both by the regions of present supply and by other and new ones now debarred from trade because of their inaccessibility to the markets.

Naval stores—turpentine, resin, tar, etc.—constitute an important class of forest products. These commodities have always been produced in the South, because that is the home of the long-leaf pine, from which they are obtained. Besides supplying the large home demand for naval stores, the Southern States exported about $12,500,000 worth in the year ending June 30, 1900. The previous year the exports were valued at about $10,000,000, and in the year before that at about $9,000,000. The chief foreign markets are in Great Britain, Germany, and other European countries, but there is a growing demand for the commodities in all Pacific countries.

Although the United States uses a vast amount of paper, its annual exports of that commodity now amount to about $6,250,000 in value, the paper being made mainly from wood pulp, which is also extensively used for pails and other utensils. The manufacture of pulp and paper are industries naturally associated with the use of the forests for lumbering purposes. To some extent pulp is a by-product of the lumber industry, because much of the material used in its manufacture would otherwise be wasted in cutting off the forests. At the present time the pulp mills are mostly located in the northeastern part of the United States, partly because the poplar and spruce timber that has thus far been used mainly in pulp manufacture exists most abundantly in that section. As far as the supply of available timber is a determining factor, the pulp manufacturing industry can be developed in the South as well as in the North. Pulp is now manufactured from hemlock as well as spruce, and such timbers as basswood, cucumber, buckeye, maple, birch, and beech are successfully used in connection with poplar. Cottonwood is well adapted to paper making and is largely used for that purpose, being nearly as good as poplar.

Australia is a very large buyer of American paper and woodenware, being the third heaviest purchaser, and ranking second among our foreign markets for printing paper, of which she takes 35 per cent of all our exports. In the Australian, South American, and other Pacific markets, our trade in paper, woodenware, and other products made from wood could be increased by facilities for cheaper shipments.

THE CANAL AND THE FERTILIZER INDUSTRIES OF THE SOUTHERN STATES.

The South already uses large amounts of fertilizers on its cotton and tobacco plantations, its grain fields, and its truck farms, and the future demands will be larger than the present. Much of the soil of the South, while it possesses excellent physical characteristics, is not strong in those chemical properties required by the various plants that are grown. Unless carefully cultivated and kept up by fertilizing, the soil is soon exhausted; but when care is taken in tilling the ground and restoring to it the chemical constituents that are taken by the various crops, the farms are highly and continuously productive. Such being the case, the South must inevitably require a constantly increasing amount of fertilizers as the population becomes more dense and the change from extensive to intensive methods of agriculture becomes necessary.

The South has great stores of phosphate rock, the most important mineral constituent of commercial fertilizers. The supply of this mineral is the source of a large foreign trade and the basis of important fertilizer manufacturing industries. The exports of crude phosphate amounted to 776,220 tons, valued at $6,376,367, in the year ending June 30, 1900. The States in which most of the rock is mined are Florida, South Carolina, and Tennessee. The amounts obtained from each State and the amount of increase in the production is shown by the following table. One noticeable fact is the recent prominence which Tennessee has acquired in the phosphate production. The figures are from the latest published report of the United States Geological Survey:

Production of phosphate rock, 1894 and 1899, and value where mined.

State.	1894.		1899.	
	Tons.	Value.	Tons.	Value.
Florida	527,653	$1,666,813	726,420	$2,804,061
South Carolina	450,108	1,745,576	[a]357,090	1,078,099
Tennessee	19,188	67,158	130,192	1,192,916
Pennsylvania			2,000	9,000
Total	996,949	3,479,547	1,515,702	5,084,076

[a] Including 440 tons from North Carolina.

The opening of an isthmian canal will affect the fertilizer industries of the Southern States in two ways: (1) In the manufacture of commercial fertilizers nitrate of soda is used, and this at present has to come from Chile around Cape Horn or through the Straits of Magellan. (2) There would be a large market for the manufactured product in California, Hawaii, and other Pacific countries if the costs of reaching those markets were lower. Cheaper transportation will enable the manufacturers of fertilizers in South Carolina, Virginia, and probably in Tennessee to supply the growing demand of the Australian and California agriculturists. With the growth of population and the increasing value of land in those countries, present methods of agriculture are becoming unprofitable, and a change must be made. Farming is carried on in Japan in a very intensive manner, and large quantities of fertilizers are required. In the Hawaiian Islands there is already a considerable demand for the article, and portions of western South America will in time import large quantities of the commodity.

Although Florida is the State from which the largest quantity of crude phosphate rock is obtained, the region about Charleston, S. C., is where the largest amounts of commercial fertilizers are manufactured. A special report prepared for the Commission by the Cotton Exchange and Chamber of Commerce of Charleston contains the following information in regard to the phosphate industry of that vicinity and the benefit which would be conferred by the opening of a canal across the Isthmus:

> Inquiries have come for the manufactured fertilizers from the Sandwich Islands, and efforts are now being made to sell the manufactured fertilizers there and in Japan. In connection with this commodity, it may be stated that Charleston manufactures more commercial fertilizers than any place in the world, the output of the factories here being 400,000 tons per annum. With cheap rates of freight that the isthmian canal would give large quantities of this fertilizer would undoubtedly move to different countries bordering on the Pacific Ocean. The only commodity moving from Charleston to any of the countries touching the Pacific Ocean is phosphate rock, to the Sandwich Islands and Japan. About 5,000 tons, approximately three steamer loads, of this commodity go from here annually to these countries. The value of this commodity here is $4 per ton; the steamer freight has averaged about $7.50 per ton to Japan. The high freight rate is a barrier to a large movement of this commodity to the islands named.

The chemical company which controls a larger fertilizer manufacturing business than any other concern in Virginia and North Carolina stated in letters received from them in May and July, 1900, that they had imported about 10,000 tons of nitrate of soda during the preceding twelve months. They also say that they could use a great deal more if the cost of the nitrate were reduced. In regard to the effect which the present rates of freight have upon their west coast business, they state as follows:

> There is now a demand for goods we produce, viz, superphosphates, on the west coast of this country. Our recent efforts to secure freights on large bulk cargoes which would make such business possible from Atlantic coast ports have proved unavailing. Overland freights on our products from this coast to the Pacific coast are entirely prohibitory.

THE CANAL AND COMMERCE OF THE GULF PORTS.

Several forces are now operating to increase the future commercial importance of the Gulf ports, and in order to appreciate the probable scope of the influence of the proposed canal upon the commerce handled through the Gulf gateways a brief analysis of those forces is essential.

The Gulf ports have capacity for handling a large commerce. Large wharves and piers have been, and are being, erected by the railway companies, which, together with other corporations, are making large investments for the purpose of increasing the trade of these ports. The Plant System at Port Tampa, the Louisville and Nashville at Pensacola, the Illinois Central and Southern Pacific at New Orleans, the Southern Pacific and the Atchison, Topeka and Santa Fe at Galveston, these and other roads are expending large sums for the development of terminal facilities. The Mobile and Ohio, the Louisville and Nashville and other companies are developing the port ot Mobile.

The Gulf ports have the commercial advantage of being nearer than the Atlantic seaboard is to the larger portion of the Central West, the upper part of the great Mississippi Valley. These cities are convenient gateways for a greater or less share of the import and export traffic of the entire Mississippi Valley. The relative distances by rail from representative Mississippi Valley points to New York and to New Orleans are shown by the following table:

From—	To New York.	To New Orleans.	Saving to New Orleans.
	Miles.	*Miles.*	*Miles.*
Chicago, Ill	912	912	0
Duluth, Minn	1,390	1,337	53
Minneapolis, Minn	1,332	1,297	35
St. Paul, Minn	1,321	1,279	42
Sioux City, Iowa	1,422	1,258	164
Omaha, Nebr	1,402	1,070	332
Dubuque, Iowa	1,079	968	111
St. Louis, Mo	1,058	695	363
Peoria, Ill	1,006	860	146
Cairo, Ill	1,089	554	535
Evansville, Ind	989	708	281
Louisville, Ky	867	746	121
Nashville, Tenn	939	557	382
Denver, Colo	1,932	1,336	596
Kansas City, Mo	1,335	878	457

All points south and west of Lake Superior, northern Michigan, Lake Michigan, and a line drawn from Chicago through Indianapolis, Frankfort, Ky., and on to Charleston, are nearer New Orleans and to several other Gulf ports than to New York. While distance is not the only factor in determining the direction in which traffic will move, it is one of the factors, and the proximity of the industrial centers of the Central States to the Gulf cities will greatly assist those ports in securing a large share of the South American and Pacific trade. The Gulf ports have the advantage of being able to bring the railway car and the steamer side by side at terminals where freight can be very economically handled, and this is a factor that will materially assist their commercial progress.

The following tables show to what extent the ports of the Atlantic and of the Gulf, respectively, have increased the tonnage of the vessels entering and clearing in foreign trade during the past ten years. The first table compares all the ports of the Atlantic with all the ports of the Gulf. The second table compares the increase made in the tonnage of entrances and clearances by each of seven of the North Atlantic ports with the growth accomplished by each of the five leading Gulf ports:

Tonnage of vessels entered and cleared at Atlantic and Gulf ports, years ended June 30, 1890, 1895, 1900.

Ports.	1890.	1895.	Gain in five years.	1900.	Gain in ten years.	Gain in ten years.
						Per cent.
Atlantic	22,649,610	24,186,387	1,536,777	32,777,196	10,127,586	44.72
Gulf	4,035,256	4,679,247	643,991	8,414,432	4,380,176	108.55

Tonnage of vessels entered and cleared at the seven leading North Atlantic ports and at the five leading Gulf ports, years ended June 30, 1890, 1895, and 1900.

Port.	1890.	1895.	Gain in 5 years.	1900.	Gain in 10 years.	Gain in 10 years.
North Atlantic ports:						Per cent.
Portland	260,796	250,312	0	716,001	455,205	174.54
Boston	2,613,335	3,115,478	502,143	4,145,187	1,531,852	58.62
New York	12,283,740	13,188,085	904,345	16,020,290	3,736,550	30.42
Philadelphia	2,530,094	2,711,434	181,340	3,736,615	1,206,521	47.69
Baltimore	1,969,501	1,608,257	0	3,452,654	1,483,153	75.31
Newport News	266,138	440,046	173,908	1,095,727	829,589	311.71
Norfolk	183,533	208,992	25,459	592,887	409,354	223.04
Total	20,107,137	21,522,604	1,415,467	29,759,361	9,652,224	48.00
Gulf ports:						
Port Tampa	9,080	174,466	165,376	208,595	199,515	2,197.30
Pensacola	815,778	703,380	([a])	1,115,382	299,604	36.73
Mobile	254,012	532,399	278,386	1,054,471	800,459	315.13
New Orleans	2,035,072	1,997,769	([a])	3,395,442	1,360,370	66.85
Galveston	343,575	767,629	424,054	1,538,300	1,194,725	347.73
Total	3,457,517	4,175,643	718,126	7,312,190	3,854,673	111.49

[a] Decrease.

In order to show the gains, above referred to, in the grain export traffic of the Gulf cities, a table, taken from evidence prepared for the Interstate Commerce Commission in 1899, is submitted.

Percentage of the total wheat, corn, and flour exports handled at the Atlantic, Gulf, and Pacific ports, respectively, during the years 1880, 1885, 1890, 1895, and 1899.

	Wheat.	Corn.	Flour.
Atlantic ports:	Per cent.	Per cent.	Per cent.
1880	78.3	83.7	83.7
1885	56.1	79.7	77.8
1890	40.9	75.3	79.1
1895	53	78.6	80
1899 [a]	48.8	76.2	79.4
Gulf ports:			
1880	2.5	3.2	0.9
1885	1.9	12.8	0.2
1890	4.5	14.7	0.4
1895	2.5	9.8	1.7
1899 [a]	29.4	15.1	3.9
Pacific ports:			
1880	13.9	0.1	10.8
1885	37.9	0.1	14.4
1890	50 5	0.1	13.1
1895	38.3	0.5	10.4
1899 [a]	17.3	....	11.4
Miscellaneous ports:			
1880	5.3	8	4.6
1885	4.1	7.4	7.6
1890	4.1	9.9	7.4
1895	6.2	11.1	7.9
1899 [a]	4.5	8.7	5.3

[a] Four months, January 1 to April 30, inclusive.

The Gulf ports are making substantial commercial progress. Their trade is growing with the industrial progress of the South, and they are handling an increasing volume of business originating in the central section of the United States. This latter source of the commerce of the Gulf cities is usually spoken of as due to a diversion of traffic away from the Atlantic ports. This statement, however, does not exactly describe what has occurred. During the past score of years there has been an enormous expansion of the industrial activities of the central West, and at the same time the railway systems leading to the Gulf have increased in number and efficiency. The result has been that both the Atlantic and Gulf lines have handled an ever-increasing volume of business. The business of the Gulf cities shows a greater percentage increase, but the absolute growth in the traffic to and from the Atlantic has been much larger than the increase in the business handled through the Gulf gateways.

Many commodities are now moved a third of the distance across the continent to the Eastern seaports of the United States for shipment to the Orient. At the present time, with the exception of some occasional full cargoes, mainly of cotton, the trade between the southern sections of the United States and the Orient is carried on either by way of the Pacific ports or through the Atlantic gateways. New York City handles by far the larger share of the oriental and west coast South American commerce of the southern and central sections of the United States. If an isthmian canal were in existence, the South American and trans-Pacific trade of the Southern States would be largely handled by the Gulf ports, and the Central States would have the advantage of a new route, which they would doubtless adopt from time to time in accordance with the conditions of competition prevailing among rail and ocean carriers.

The effect of the canal upon the traffic of the Gulf cities will consist less of diverting existing traffic to new routes than of bringing about trade not now in existence. It will lead to a larger commerce between the southern section of the United States and the west coast of South America. This trade will consist largely of the importation of nitrate of soda for use in the manufacture of fertilizers and explosives and of the exportation of lumber, coal, manufactures of iron, steel, wood, and cotton goods. The southern section of the United States has practically no direct trade at the present time with the west coast of South America.

The opening of the canal would lead to a direct trade between the Gulf ports and the Orient—a trade consisting of the exchange of cotton, cotton goods, lumber, and manufactures of iron and steel, for the tea, silk, mattings, curios, and other manufactures characteristic of the Orient.

An important effect of the canal upon the trade of the southern section will result from giving that region a more direct and economical connection by water with the Pacific States. The coal, steel, cotton goods, cotton-seed products, and fertilizers of the Southern States will find a growing market west of the Rocky Mountains, whence the South will secure wool, wines, fruits, and barley.

In their efforts to increase their trade, the Gulf cities now suffer because their exports are so much greater than their imports. But few goods are brought into the country by way of the Gulf cities. One effect of the opening of a canal will be to remove this handicap partially, although not entirely. The Gulf cities will be ports from which a larger portion of our imports from tropical and oriental countries will be distributed. The present one-way trade of the South, with its consequent relatively high costs for transportation, will, to a considerable extent, give way to a reciprocal and more economically transported commerce.

Chapter III.—*The canal and the industries and trade of the northeastern section of the United States.*

The northeastern section of the United States does more manufacturing and has more foreign trade than any other part of the country; and, although the central, southern, and western divisions of the United States are rapidly expanding and diversifying their industries, there is no probability that the States and seaports of the Northeast will cease to rank first in manufacture and foreign commerce. Inasmuch as the chief commercial reason prompting the United States to construct an isthmian canal is to connect our two seaboards and to promote the foreign trade of the country, the effects of the proposed waterway upon the industrial and commercial activities of the section of the country having the densest population, the most-highly diversified industries, and the largest trade with other nations constitute an inquiry meriting careful consideration.

GEOGRAPHICAL LIMITS OF THE NORTHEASTERN SECTION.

The geographical limits of the northeastern section are clearly defined on the south by the mouth of the James River and by the railway systems from the West having their termini at Norfolk and Newport News. South of those cities and the territory served by the Chesapeake and Ohio and the Norfolk and Western railways the industrial and commercial affiliations are mainly with the South Atlantic and Gulf States. The western margin of the northeastern section of the United States can not be so easily and distinctly marked, because the industries of the East shade off into those of the Central West by close gradations. The latitude being the same, the two regions are not much differentiated by diversities of climate, and their common stores of coal and iron give them the basis for several identical industries. The industrial and commercial similarities of the East and Central West, however, have very marked limitations. East of Pittsburg the economic activities are dominantly manufacturing and commercial, while westward from that city agriculture grows increasingly important, and before the State of Ohio is passed it becomes characteristic of most parts of the region.

The region about Pittsburg—that is, the western part of Pennsylvania and eastern Ohio—lies on the borderland between the Northeast and the Central West, with both of which it has close business relations. The iron ore used in this region comes mainly from the west; its coal supply is local. Its markets are both east and west, although the larger volume of trade is with the American States and foreign countries adjacent to the Atlantic. Its business connections are such as to prevent its being with strict propriety included with either the Central West or the East; but, if placed with either, it will best be grouped with the northeastern section, which, for the purpose of this discussion, will be held to include eastern Ohio, West Virginia, and that part of the United States east of that region and north of the mouth of the James River.

INDUSTRIAL CHARACTERISTICS.

The northeastern section of the United States has become much like western Europe industrially and commercially. It has a large foreign trade in manufactured products, made in part from materials obtained domestically and to some extent from raw and partially manufactured materials imported from other countries. The southern, central, and far western sections of the United States are drawn upon alike by Europe and the eastern part of the United States for the raw materials of industry; indeed, those sections of our country contain the granaries, mines, and forests that supply a large share of the needs of the manufacturing nations grouped about the North Atlantic.

Both Europe and the northeastern section of the United States are obliged to secure a part of their supply of the crude materials required by their manufactures from the tropical and south-temperate latitudes of the Atlantic, Pacific, and Indian oceans. The nitrate of soda from Chile, the lumber and grain from the Pacific slope of the United States, the Australian wool, meats. and hides; the teas, silks, and mattings from the Orient; the sugar and spices, rice, jute, hemp, vegetable oils, and gums from the British and Dutch East Indies and Oceania are examples of the large class of imports derived by the North Atlantic nations from the lands of the Pacific and Indian oceans. These raw materials and oriental wares are for the most part paid for by European and American manufactures, which are finding a large and growing market in the countries of the western part of the American continent and in the islands and continental countries of the South Pacific and Far East.

The Suez Canal has given Europe convenient access to the raw materials and markets of the Indies and the Orient, but her ships are still obliged to make the long detour around Cape Horn in order to reach the western ports of the Americas. The eastern half of the United States is less favorably situated than Europe is for trading with Pacific countries. The distances to Australasia. Malaysia, China, and Japan are shorter from Europe than from our Atlantic coast. For the trade with the west coast of South and North America, also, the advantages are with Europe, partly because sailing vessels, which have been used extensively in this commerce, can make the trip from Europe more quickly than from the United States. and also because of the cheaper freight rates from Europe to Pacific America than from the eastern United States to that section, the lower freight charges being secured by the European shippers on account of the large tonnage of vessels sailing from Europe in ballast or partly loaded.

In studying the relation of the canal to the southern and western sections of the United States, the most typical industrial resources and activities have been separately considered and the changes that the proposed waterway will produce have been pointed out, and that plan of investigation could readily be followed for the Southern and Western States, because of the relatively small number of large industries typical of each of the sections. In the Northeastern States, however, where manufacturing has reached a high degree of development, the number of large industries is much greater than in the South and

West, and, in order to avoid making the discussion prolix, it is necessary to group the varied economic activities in a small number of large classes.

Most of the economic activities of the Northeastern States are directly or indirectly associated with four groups of industries, a study of which with reference to the effects of the isthmian canal will present the more important, though by no means all, of the relations of the waterway to the future industrial and commercial progress of that section of the United States. These four groups are (1) the mining, transportation, and exportation of coal; (2) the manufacture of iron and steel and of the machines and tools made of steel; (3) the shipbuilding and maritime interests; (4) the various classes of textile manufactures. If, in addition to considering these four groups of industries, an analysis be made of the effects which an isthmian canal would have upon (5) the commerce, or the import and export business, of the North Atlantic seaports, the chief relations of the proposed waterway to the economic interests of the Northeastern States can be presented. In this chapter only the textile industries and the commerce of the North Atlantic cities will be discussed. The effect of an isthmian canal upon the coal-mining industry of the country, and the relation of our coal trade to the commercial use of that waterway, are subjects of such importance that a special chapter, No. VI, has been given to their discussion. The relation of the canal to the iron and steel industries of the United States is discussed in Chapter VII. The effects which the isthmian canal will have upon American shipbuilding and maritime interests are considered in Chapters VIII and IX, Chapter VIII dealing with the subject directly and exclusively and Chapter IX indirectly, in connection with an analysis of the factors affecting the use of the canal route by sailing vessels.

THE CANAL AND THE TEXTILE INDUSTRIES OF THE NORTHEASTERN STATES.

The importance which the textile industries of the United States are assuming is shown by comparing the number of machines used in the industries in 1900 with those employed in 1890. The following table is taken from the July, 1900, issue of the Textile World:

Comparison of textile machinery in 1900 with 1890.

	1900.	1890.	Per cent of increase.
Cotton spindles	21,057,983	14,188,103	48.4
Cotton looms	490,398	324,866	50.9
Woolen sets of cards	7,806	7,245	7.9
Worsted combs	1,510	855	76.6
Woolen and worsted looms	80,759	67,817	19.0
Knitting machines	75,721	36,462	107.6
Silk spinning and twisting spindles	1,426,245	718,360	98.5
Silk looms	48,246	20,822	131.7

The silk industry in the United States is confined almost entirely to the New England and Middle Atlantic States, only two Southern States having yet established the industry, and much the same statement may be made regarding the woolen industries, although the mills are somewhat more widely distributed. There are now in the United

States nearly half as many cotton spindles as there are in the United Kingdom, the country is far ahead of all others in the textile industries, and the number of our mills is rapidly increasing. The cotton manufacturing industry is increasing in both the northeastern section of the country and in the Southern States, the growth being more rapid in the latter region. In 1900, according to the Textile World, the Southern States were operating 5,845,429 spindles and the Northern mills 15,242,554. Ten years earlier the South possessed only 1,828,972, and the Northern States had 12,722,341. During the decade the number of spindles in the South increased 4,016,457, or 219.6 per cent. The gain in the number of spindles in the Northern States was 2,520,213, or 19.8 per cent. Massachusetts is far ahead of all other States in the number of spindles, it having 8,012,331 in the year 1900. Rhode Island ranked second, with 2,090,138; South Carolina came third, with 1,794,657; North Carolina fourth, with 1,499,540, and then came New Hampshire, Georgia, and Kentucky.

We are now supplying ourselves with nearly all of the various grades of cotton used in this country, with the exception of certain foreign-made articles of a higher grade, the demand for which is kept up by custom, and have developed a foreign trade which has amounted to about $24,000,000 annually for the past two years. Our silk and woolen mills are still unable to meet the home demand, and we are obliged to import large quantities both of manufactured goods and raw materials. We have no silk exports, and the sales of woolen goods amount to only $1,250,000 a year. Three-fourths of the raw silk comes from Pacific countries, and we are obliged to purchase wool in China, Oceania, the west coast of South America, and the west coast of Mexico and the United States.

The exports of cotton manufacture from the United States are sent mainly to the countries of the Pacific Ocean. China takes about half of our exported cotton cloth, and the sales to Australia, the Hawaiian Islands, other parts of Oceania, and numerous Pacific countries are slowly increasing. One significant fact concerning our foreign trade in cotton goods is the small market which we now have in South America. The cotton goods purchased by those countries now amounts to between $70,000,000 and $80,000,000 a year. Barely 6 per cent of those goods come from the United States. It seems probable that the United States will be able in the future to supply a large share of the demand of these countries for cotton goods. The opening of the canal will give our mills ready access to the west coast of the continent, and make much more favorable the conditions of competition for the trade of the western third of South America, a region from which we are practically debarred.

In the manufacture of the higher grades of woolen goods it is necessary to import considerable quantities of Australian wool. At the present time most, although not all, of this wool comes to North Atlantic ports of the United States by way of London, which is the great wool market of the world. The advantage of importing wool from London is that the American buyer is able to select his purchases from a large and varied stock. The disadvantage is that the American exporter has to pay freight charges for a route that is somewhat roundabout as compared with the future route via an isthmian canal, and has to bear the expenses incurred in handling, storing, and selling the wool in London. With the growth of our wool manufacturing industries we shall be obliged to import increasing quantities of Australian, South American, Chinese, and South African wools, and it is reasonable to expect that New York or Boston will become the wool market of this country. Should this change take place, it will be brought about largely by the effect which the canal will have upon ocean routes.

The textile industries of the United States have developed later and more slowly than many other manufacturing activities, because they have their natural home in thickly populated countries, where an abundant supply of skilled and inexpensive labor is available. The populous States of our country now possess the requisites of textile manufacture, and the cotton, woolen, carpet, silk, and weaving industries generally are expanding rapidly. Foreign markets will in the future be needed for the products of our spindles and looms, as well as for the output of our furnaces, foundries, and other manufacturing establishments.

THE CANAL AND THE COMMERCE OF THE NORTH ATLANTIC PORTS.

Our European commerce at present includes a part of both the import and export trade of the United States with Pacific countries. The outbound rates from Great Britain, Germany, and Belgium being very low, because the heavier volume of their commerce is inbound, and the facilities for shipping directly from the eastern part of the United States to the west shore of the American continents and to other sections of the Pacific being limited, our trade with those regions is frequently sent to Europe and the goods there transshipped. This roundabout route is still used, although the reduction in the rates on our transcontinental railways, the establishment of the American-Hawaiian Steamship Company's line between New York and San Francisco, the increased facilities and connections for handling freight via the Panama Railroad, and the placing of more vessels on the route between New York and Australia have made the American exporters and importers less dependent than they formerly were on securing transportation by way of some European ports of transshipment.

After the American canal route has become available it is probable that little, if any, of our South American and Pacific foreign commerce will be handled by way of Europe. Possibly some shipments to the east coast of South America, south of Cape St. Roque, will be sent to Europe and taken thence by the lightly laden outbound vessels. This will depend upon the rapidity with which we develop our facilities, during the next ten or fifteen years, for shipping directly from the United States to that region. Probably none of the trade between our eastern seaboards and the west coast of North, Central, and South America will take the indirect route after the Isthmus can be traversed by ocean vessels.

The reciprocal nature of the trade that will be carried on through the canal between the eastern half of the United States and the western part of South America is discussed in Chapter XI. That chapter and the others dealing with the relation of the proposed canal to the trade and industries of the countries of the Pacific should be read both with reference to our own trade and with regard to the effect which the canal will have on the foreign countries discussed.

The trade of the United States with Japan and continental Asia, the Indies, and Oceania is now carried in part through the Pacific ports of the United States and British Columbia by means of the railways and steamship lines having termini there; but the larger share of the business is shipped by way of the Atlantic seaboard Several firms run steamers via the Suez Canal between New York and eastern ports, and three regular lines of steamers and sailing vessels connect New York with Australia by way of the Good Hope route. There is also a large amount of traffic between our eastern seaboard and oriental countries in tramp steamers chartered for limited periods. The steamers going out from New York to the Indies, China, or Japan pass through the Suez Canal and usually return by the same route. Chartered steamers going out from New York to an oriental port frequently cross the Pacific to Chile to obtain nitrate cargoes for Europe. Steamers returning to our eastern seaboard from Australia more frequently come via Suez and call at Europe, while the sailing vessels cross the Pacific Ocean to secure a west-coast cargo for New York or some other Atlantic port. There is an important round-the-world movement of vessels at the present time, the extent of which will probably be increased by the American canal.

After the isthmian canal is completed, the shipments between our Atlantic or Gulf ports and Japan, the Philippine Islands, Australia, and the continent of Asia north of Hongkong will usually make use of the American canal route; although some ships will doubtless go and come by the Suez route, for the purpose of doing business at intermediate ports. A large part of the world's commerce will be done by tramp steamers whose characters will take them in whatever direction and along whatever route the movement of tonnage is strongest. The outbound traffic of the United States to most sections is heavier than the inbound; the opposite is true of European commerce. The tramp steamer will, whenever possible, move with, rather than counter to, the flow of traffic.

One certain effect of the isthmian canal upon the Atlantic ports of the United States will be to cause the major portion of their commerce to and from places east of Singapore to use the American canal instead of the present easterly routes. Between Singapore and Shanghai, and in the region of the Philippines and the Dutch East Indies, there will be a region whose trade with our Atlantic and Gulf seaboard will be divided between the American and Suez Canal routes. It is believed, however, for reasons stated in Chapters XIX and XX, that the conditions of competion will be more favorable for the American than for the Suez route.

Our exports to Australia and New Zealand will consist mainly of general manufactures, and to some extent of heavy iron and steel products. The major portion of the general manufactures will be sent out from the North Atlantic ports; the iron and steel products will probably be shipped very largely from the Southern States. Most of the wool, hides, gums, etc., imported from Australia and New Zealand will enter by the North Atlantic cities, which are the most convenient gateways to the section of the country where manufacturing is most fully developed.

After the canal has come into use probably but a small part of the trade carried on between the Southern States and Pacific markets will be handled through North Atlantic ports; soon after the opening of the isthmian waterway facilities for importing and exporting directly through Southern ports may be expected to develop.

The general effect of the canal upon the commerce handled by the North Atlantic ports will be to enlarge its volume and variety. The Pacific countries, both American and transoceanic, will be markets for increasing amounts of American manufactures and the source of growing quantities of the raw materials required by the industries in the Northeastern part of the United States. The subsequent chapters dealing with the industries and trade of foreign Pacific countries indicate in detail the character of the commerce that will be promoted by the construction of the canal. The establishment of a new highway for a large share of the world's commerce will necessarily change the present routes of some trade. It will cause the ports of our North Atlantic seaboard to cease to handle some of the traffic now passing their gateways, and will likewise bring to them some commerce now tributary to other cities. The chief effect of the canal upon the commerce of the ports of the Northeastern States will come from the industrial changes that will follow upon the opening of the interoceanic waterway. The commerce of that section must progress pari passu with its industrial advance, and the manufacturing development of the Northeastern States during the coming decades promises to be large and many-sided.

Reports prepared with especial care were received by the commission from the commercial organizations in Boston and Philadelphia. A brief statement of some of the facts presented in those reports will indicate some of the relations which will exist between the isthmian canal and the trade of the North Atlantic ports.

Appended to the report from Philadelphia, which was prepared under the joint auspices of the Board of Trade and the Maritime Exchange, were two tabular statements, one of which gave the quantity and value of the principal items of commerce between Philadelphia and Pacific markets. The other table compared the distances for sailing vessels and full-power steamers by way of existing routes to the Pacific markets with the distances by way of a Panama canal route and by way of a waterway across Nicaragua. Concerning the saving in freight rates that an isthmian canal would accomplish for the commerce of Philadelphia the report states:

> The canal would provide a shorter water route than any now followed between Philadelphia and certain important ports of the Pacific, notably those of the west coast of North and South America and the Hawaiian Islands; * * * it would appear that its existence should constitute a factor of significance in regulating freight rates, at least with those ports.

The report does not attempt to state in precise terms the saving in freight rates that would be accomplished by the canal, because of the complexity of the factors entering into the fixing of rates, and because of the difficulty of predicting what readjustments may take place in ocean transportation as the result of the opening of a new highway for such a large part of the world's commerce, but it illustrates the saving which the new route would effect in cost of ocean transportation by presenting an estimate based upon the daily costs of operating a modern freight steamer of 6,000 tons cargo capacity. The calculation led to the conclusion that a saving of about 75 cents per cargo ton would be accomplished by using the canal route instead of existing water routes between Philadelphia and San Francisco, Vancouver, or Acapulco. In this calculation a toll of $1 per net register vessel ton was assumed. The report closed with the following statements regarding the relation of the canal to Philadelphia:

The prospect of the inevitable increase of our country's transoceanic commerce in the near future enhances the importance of an isthmian canal as contributing to the facilities of ocean transportation, but we would, however, point out that whether the canal exists or not, supply and demand must, in the last resolution, determine the volume of our port's trade.

The canal project, while opening a new route, would in reality open up no markets that are not already accessible, but it would seem that the canal would be a favorable factor by shortening the routes to some important points, and thus assist our merchants to enter into more effective competition with nations of Europe which are now enabled to underbid us in the Far East, by reason of the more economical and expeditious transportation which their merchants enjoy by way of the Suez Canal route.

In the statement that the volume of Philadelphia's trade must, in the last analysis, be determined by supply and demand, the underlying thought evidently is that the opening of a new ocean route must be considered as only one of the factors determining the volume of any community's foreign trade. Supply and demand, however, it must be remembered, is but a general statement of the manner in which production and consumption are kept in equilibrium. There is no absolute law or principle explaining the final adjustment of production and consumption embodied in the general term "supply and demand." The intensity of demand and the volume of supply are both subject to modification by any factor capable of altering costs or prices, or both. The effect of the isthmian canal will be to lower the cost of producing many things at Philadelphia and elsewhere, and to reduce the prices at which those products can be sold to the consumers in Pacific markets. Stated concretely, the manifold manufacturing industries of Philadelphia will be able, after the canal is in existence, to produce more cheaply and will be able to put their commodities on Pacific markets at lower freight costs. The persons who buy these articles in those markets will be able to secure commodities more cheaply, and the amount they consume will correspondingly expand.

The city of Boston has developed a large commerce with Europe, but has a comparatively small direct maritime trade with Pacific countries. A small share of its Pacific business, import and export, is carried by the transcontinental railways, but a much larger part is handled through New York or via Liverpool. The report of the special committee of the Boston Chamber of Commerce states:

We have from Boston practically no water-borne commerce with the west coast of Central and South America, the west coast of the United States and Canada, Japan and China, Australia and Oceania. * * * While we send to the Orient a considerable quantity of our manufactured wares, and receive from Asia and Australasia a large quantity of merchandise there produced, the trade is not systematized. Transportation is carried through a variety of channels, but only a small portion of it comes to or goes from Boston directly.

Boston's tea imports, according to the report, come by three routes, by way of the transcontinental railroads, or through New York, or via London. The Australian wool comes chiefly by sailing vessels direct from Melbourne, but a part is received by way of the London market. The chinaware from Japan and China "comes chiefly across the Pacific and by rail via Vancouver and San Francisco."

The readier access to the raw materials and markets of the Pacific countries afforded by the isthmian canal will promote the manufacturing and commercial progress of New England and of the territory tributary to Boston. This will give Boston a larger trade and increase the incentives for the operation of tramp and line vessels between Boston and Pacific ports of the United States and foreign countries. A large increase in American shipping during the coming fifteen years seems to be indicated by the trend of our economic development; and this, together with the larger trade tributary to Boston, will naturally tend to cause Boston to depend less upon other ports. What is true of Boston in this regard will obtain with other Atlantic cities; and the general effect of the canal upon the commerce of the North Atlantic cities will be to increase its total volume and promote its distribution among the several ports.

The manner in which the isthmian canal will affect the industries and commerce of the northeastern section of the United States is illustrated in a concrete way by a letter received from a firm located in New York and engaged in the manufacture of pumping engines and hydraulic machinery for the home and foreign trade. The firm has a large trade with several important Pacific countries.

> We have a large trade on the western coast of the United States, and this would undoubtedly be increased if we had a short water route, so that we might ship machinery at a reasonable freight rate. This is probably of more importance in the case of first-class freight, as the risk of railroad transportation to intricate machinery is greater than water transportation, and therefore the freight rates are unusually high, as we are obliged to pay from \$1 25 to \$4 per 100 pounds. You can readily see the advantage of a canal to the fruit and other agricultural industries in California if they are able to purchase machinery for irrigation at a lower price than they are now obliged to pay for it.
>
> Our business in the Sandwich Islands has been very large in the past few years—at the rate of over one-half million dollars per year. This could undoubtedly be increased, and at the same time the sugar and other industries there fostered if we were not handicapped by the long railroad haul across the country.
>
> Our business in Japan and China has not been large, owing to the fact that we are obliged to ship by all-water route in order to keep the prices down to meet European competition. Such a large proportion of our machinery is sold on contract where time is so much an object that we are badly handicapped, and that which is sent out for stock requires the tying up of considerable capital and loss of interest, owing to the long time the material is on the water in transit.
>
> Our trade on the western coast of South America is growing but very slowly. We believe that a canal would be of great benefit to the western coast of South America in building up their industries by enabling people to purchase machinery, etc., to so much better advantage, and that this country would receive the benefit of this, as a good line of steamers from here direct down to the western coast would undoubtedly tend to throw most of the business to this market.

As the manufacturing activities of the northeastern section of the United States multiply, the volume of imported raw materials brought in by way of an isthmian canal will increase, and the stream of manufactured articles flowing out through the canal to the market of our west coast and of foreign Pacific countries will grow steadily larger with every lowering of the costs of production and transportation. The proposed waterway will readjust the routes of shipment and open avenues for a larger and more varied commerce.

Chapter IV.—*The canal and the Central West.*

The term Central West is generally applied to the five States north of the Ohio River and the seven trans-Mississippi States of Minnesota, Iowa, Missouri, Kansas, Nebraska, and the two Dakotas. These twelve States have a combined area of 753,550 square miles, and a total population of 26,335,243. That is to say, they comprise one-fourth of the area, and nearly one-third of the population of the United States, exclusive of Alaska and our insular possessions.

The eastern, southern, and western sections of the United States are situated adjacent to or comparatively near the seaboard, and the imports and exports received or dispatched by them through an isthmian canal will need to be hauled a relatively short distance by rail. The Central West, on the contrary, is situated from 500 to 1,500 miles from the ocean, and the trade which it may have by way of a canal will, on an average, be moved nearly 1,000 miles by railroad. Will the canal affect the industries and Pacific trade of this interior section of the United States?

INDUSTRIAL RESOURCES OF THE CENTRAL WEST.

Taking this region as a whole, its most important industrial resources are those connected with agriculture. The States in the western part of this section of our country are entirely agricultural, but Ohio and Indiana are extensively engaged in manufacturing, and Michigan, Wisconsin, and Illinois have numerous cities in which large manufacturing activities are carried on. In most of these States there are abundant supplies of the raw materials of industry. Ohio and Illinois have large fields of coal in which 30,000,000 tons of bituminous coal are annually mined, and Indiana, Iowa, Missouri, and Kansas have deposits from which 10,000,000 tons are taken yearly. The natural-gas wells of Ohio and Indiana are a valuable source of fuel for parts of those States. In the northern section of the Central West there are large forests of excellent white pine, while in the central and southern portions of the region a good quantity of hard-wood timber is available. Throughout all these States foods are cheap, and in the more thickly populated sections there is a large supply of intelligent labor.

In northern Michigan, Wisconsin, and Minnesota over seven-tenths of all the iron ore mined in the United States is obtained, the rich deposits of those States being made available by the cheap transportation on the Great Lakes to the coal fields of Pennsylvania, Ohio, and Illinois. The low costs of pig iron and steel in Ohio, Indiana, Illinois, and other States of the Central West unite with the abundant stores of cheap fuel and good lumber to establish a sure foundation for diversified manufacturing activities. This foundation is being rapidly built upon, and several of the States of this part of our country are manufacturing on a large scale both for the extensive and expanding home markets and for our trade with foreign countries in all parts of the earth.

Ohio is the leading State of the central Western group in the variety and amount of its manufactures. Cleveland and Cincinnati, the largest cities of the State, are typical industrial centers, and in order to illustrate the relation of the proposed isthmian canal to the Ohio as a whole a special discussion is given below of the industries and foreign trade of those cities and the manner in which they will be affected by the new water route to and from the Pacific. Indianapolis is the metropolis and most important industrial center of Indiana, and the same is true of Chicago as regards Illinois, and St. Louis with reference to Missouri.

By studying the relation of the canal to these cities and a few others of minor rank, as is done in the following pages, it is believed that the effects of the interoceanic waterway upon the Central West generally can be adequately portrayed.

In the tier of four States situated farthest west in the section being considered in this chapter the export business consists almost entirely of grain and provisions, but from all the other eight Commonwealths there are sent out to foreign markets, in addition to those articles, large quantities of agricultural machinery, wooden ware, vehicles, tools and implements of all kinds, stoves, engines, and other iron and steel products in great variety, boots and shoes, and many other articles enumerated in detail in the reports received from commercial organizations, the volume and variety of the export trade increasing from west to east, from the Missouri River to the State of Ohio.

There is also an important volume of imports from Pacific foreign countries and the west coast of the United States required in the Central West. These imports consist in part of wool, nitrate of soda, canned fruits, vegetables and salmon, Japanese and Chinese goods in large variety, and hemp, jute, gums, and waxes. Those from foreign Pacific countries come in part by way of our Pacific ports, but most largely through New York.

PRESENT ROUTES OF SHIPMENT FROM CENTRAL WEST.

The exports from the central West to foreign Parific countries are now sent by various routes, most of which can be indicated by referring to the shipments from Chicago, the largest and most centrally located city of the region. The manufactures of that city, particularly mining and other heavy machinery, are sent to many parts of the world. Heavy freight destined for Mexico is frequently sent directly by rail, but shipments are often made via New York, and sometimes by way of San Francisco. Assignments for the east coast of Central America may go either by New Orleans or New York. Most of those for the west coast of Central America and all those for western South America go via New York and thence either by the Isthmus of Panama or around South America. Until four years ago most shipments of machinery from Chicago to Australasia, Malaysia, and the Orient are reported to have been sent to some European port and there transshipped, but latterly vessels direct from New York have handled the business. The shipments to Hawaii go via San Francisco or some other Pacific port, as also do those that must reach trans-Pacific countries with a minimum of delay, but when time permits heavy freight is sent through New York. Further information regarding the routes by which commodities from the Central West are shipped to Pacific markets is given below, where a communication received from the chamber of commerce of Cleveland is referred to.

THE CANAL AND THE INDUSTRIES OF CLEVELAND.

The State of Ohio is situated in that indeterminate border land lying between the northeastern section of the United States, where manufacturing and commerce are the dominant activities, and the Central West, where agriculture still heads the list of industries. The State consequently now ranks well up in the list of manufacturing Commonwealths, and its future development must inevitably increase the magnitude and variety of its industries. Something concerning the effects which the isthmian canal will have on the economic progress of Ohio may be found in the subsequent chapters devoted to "The canal and the iron and steel industries." By referring with some detail in this connection to the interest of Cleveland and Cincinnati in the canal, the relation of the new water route to the foreign trade not only of those cities, but also of Ohio and much of the eastern part of the Central West, will be indicated.

Cleveland, which is now the metropolis of Ohio, has become, by virtue of its location on Lake Erie and at a point where the coal from Pennsylvania and Ohio and the iron ore from Lake Superior can be readily and economically brought together, a great center for the manufacture of iron and steel products and the home of a large variety of activities. It has the advantages of cheap fuel and low transportation costs to domestic markets.

The Chamber of Commerce of Cleveland was requested to address a circular letter to the merchants and manufacturers of the city, asking them to state what commodities they were sending or receiving from various Pacific countries, by what routes these shipments to and from Cleveland were made, and to indicate how they would be affected by the proposed canal. Letters were sent by the chamber of commerce to 153 establishments and replies were received from 58, of which 38 manifested a direct interest in the canal and 9 others favored the opening of the waterway because it would inevitably benefit their business. Thirty of the 38 having a direct interest in the opening of the canal were manufacturers and 8 were importers and wholesalers. Of the 30 manufacturers who replied that they were shipping to Pacific countries, 6 thought their business was such that the canal would not be of much help to them, and 1 person thought the canal would give his rivals in New England a greater advantage than they now possess.

The foregoing analysis of the replies indicates, first of all, the well-known fact that the manufacturers of Cleveland—and the same is true of the Central West and most of the United States at the present time—are producing mainly for the home market. It is also evident, from the letters, that several Cleveland firms doing a foreign business have not yet developed a trade with Pacific countries. Some report that they are debarred from this trade by the present cost of transportation. A few Cleveland firms whose goods reach Pacific markets are unable to report the amount of trade in those markets because their goods are sold to New York or London exporters. Other firms having no foreign Pacific trade report that they are doing business in our west coast States, and they especially complain of the present high costs of transportation by rail.

The variety of commodities shipped from Cleveland to the various countries of the Pacific Ocean is surprisingly large. In the report submitted by the Cleveland Chamber of Commerce the articles sent to each section of the Pacific are enumerated, the routes by which the commodities are shipped are stated, and the principal imports into Cleveland from these several sections are named. This part of the report is so informative that it merits quotation, although the multitude of details in the statement deprives it of the usual fascination of literature.

1. Commodities shipped from Cleveland to the following parts of the world during 1899:

A. West coast of Central and South America: Carbons, iron roofing, iron houses, wire, barb wire, wire nails, galvanized smooth wire, annealed wire, wire fencing, telegraph wires, oil stoves, gas stoves, twist drills, machinists' tools, tackle blocks, sewing machines, ironwork.

B. West coast of the United States and Canada: Sugar machinery, carbons, iron roofing, iron houses, iron magazines, pneumatic cranes, machine tools, bolts and nuts, steel springs, barb wire, wire nails, galvanized smooth wire, annealed wire, wire fencing, telegraph wires, malleable iron castings, oil stoves, gas stoves, cloaks and suits, manufactured wool stock, oil and grease, paint and varnish, wire brushes and brooms, foundry supplies, bristle brushes and brooms, twist drills and machinists' tools, steel plate and castings, hot-air registers, imported and domestic whiskies, brandies, gins, imported cordials, wines, tackle blocks, forgings, turn-buckles and railroad iron, sewing machines, ironwork.

C. Japan and China: Nail machinery, carbons, pneumatic cranes, jacks, and pulleys, machines, barb wire, wire nails, galvanized smooth wire, annealed wire, wire fencing, telegraph wires, oil stoves, gas stoves, twist drills and machinists' tools, automatic or self-filling buckets, rolling-mill machinery, sewing machines, ironwork.

D. Australia and Oceania: Nail machinery, carbons, bolts and nuts, barb wire, wire nails, galvanized smooth wire, annealed wire, wire fencing, telegraph wires, malleable iron castings, oil stoves, gas stoves, wire brushes, twist drills. machinists' tools, tackle blocks, sewing machines.

E. The Indian Ocean: Barb wire, wire nails, galvanized smooth wire, annealed wire, wire fencing, telegraph wires, oil stoves, gas stoves, sewing machines, ironwork.

2. Routes over which these commodities were shipped to each of the destinations named.

A. West coast of Central and South America: Via New York, through New York exporters; via Cape Horn; via Isthmus of Panama (railroad).

B. West coast of the United States and Canada: Southern Pacific Railway via San Francisco; over various railways and lakes; via Isthmus of Panama (railroad).

C. Japan and China: Via New York; via Pacific coast; Suez Canal; from Cleveland to San Francisco by rail, to Vladivostok via Nagasaki, Japan.

D. Australia and Oceania: New York exporters; via steamers from New York and around Cape of Good Hope; by rail to San Francisco, thence by steamer.

E. The Indian Ocean: Via New York, Suez Canal.

3. Commodities received from the countries and sections named.

A. West coast of Central and South America: Wool, nitrate of soda.

B. West coast of the United States and Canada: Canned goods, dried fruits, wine, brandy, beans, raisins, canned fruits, salmon, nuts, wool.

C. Japan and China: Straw mattings, mattings and rugs, tea, notions, rattan cane, china reeds, split bamboos.

D. Australia and Oceania: Wool.

E. The Indian Ocean: Burlaps and jute bags.

The results of the inquiry concerning Cleveland's trade in Pacific countries may be summarized by saying that this great manufacturing center has begun to trade with practically all sections of the Pacific, and that some firms are now doing a business of considerable importance. The chamber of commerce and numerous individuals conferred with believe that Cleveland's interests will be largely promoted by an increase in the city's trade with Pacific countries. The present Pacific trade of the city is widely distributed and comprises a wide range of commodities.

CINCINNATI AND THE CANAL.

The industries of Cincinnati differ largely from those of Cleveland, but are quite as typical of the manufacturing activities of Ohio, because they are even more diversified. The articles produced include a large number of commodities created by the application of skilled labor to the cruder manufactures of steel, lumber, and leather. Besides being able to secure those materials advantageously, Cincinnati has the advantage of possessing in its population a homogeneous body of skilled labor well trained in a variety of arts. The Ohio River has assured the city cheap transportation for much of the crude and raw material required, and has aided in the economical distribution of its manufactures; and although the railroads now carry the greater volume of freight, a part of their business is now subject to a water competition.

From information obtained from the chamber of commerce, it appears that the industries which would derive most benefit from the canal are those engaged in the manufacture of machinery in large variety, vehicles, electric-railway equipment, saddlery and harness, pianos, office appliances, pork products, liquors, shoes, and furniture made from native and tropical woods.

There is at present a trade of some importance between Cincinnati and foreign Pacific countries; but the business with the west coast of the United States is of greater consequence. This Pacific coast trade is now much restricted by the cost of rail transportation. Cincinnati manufactures, moreover, find difficulty in competing in all Pacific markets with domestic and foreign producers so situated that shipments can be made by water. The home market east of the Rocky Mountains can be reached cheaply from Cincinnati, but in order to give her ready access to the Pacific trade, the cheaper transportation is reported to be necessary.

THE CANAL AND INDIANA.

The inquiries sent out by the Indianapolis Board of Trade to the manufacturers in Indianapolis and other parts of Indiana concerning their business in the Pacific markets of the United States and foreign countries and the effects of the canal were replied to by 150 firms. An analysis of the letters received shows that 63 of the 150 firms making answer are now doing business either on the west coast of the United States or in foreign Pacific countries; 87 of the 150 firms have as yet developed no trade in those markets; 77 of the respondents say that the canal would either directly or indirectly assist them in the development of the Pacific trade; 73 of the firms make no suggestion as to the effects of the canal. It is probable that these 150 firms may be taken as fairly representative of the larger manufacturing concerns of Indiana, and, if so, somewhat more than two-fifths of the Indiana manufactories now have trade in American and foreign Pacific markets. Somewhat over half of these representative Indiana firms foresee that the canal would be of direct or indirect assistance to them.

When one considers the present costs of reaching trans-Pacific markets from such a section as that of the State of Indiana, the significance of the foregoing showing in regard to the present Pacific trade of Indiana firms becomes manifest. A manufacturer in Indiana stated in a letter to the Commission that a shipment to Australia in 1899 was sent by way of New York at a total freight cost of $105. The freight on the same shipment would have been about $150 to San Francisco or Portland. The firm stated that it could usually reach Australia more cheaply than our Pacific coast.

THE CANAL AND ILLINOIS AND WISCONSIN.

The National Business League, whose offices are in Chicago, forwarded to the Commission 45 replies to the circular letter of inquiry sent to the members of the league. Twenty-one of these letters were from Chicago firms, 10 from concerns in other cities of Illinois, 8 were from Wisconsin, and 6 from other States; 34 of the respondents reported a Pacific trade, and 11 no present business in that section of the world; 35 believed that the canal would assist them, 7 said they would receive no aid, 2 gave no opinion, and 1 believed the waterway would be an injury to his business.

In the city of Chicago a great variety of manufacturing industries is carried on, and shipments are made to all the countries of the Pacific. Railway materials and mining and agricultural machinery, however, are especially important, mining machinery being sent to all parts of the world, wherever mining operations are carried on. The foreign trade of one Chicago firm engaged in the manufacture of mining machinery amounts to 15,000 tons annually. The agricultural machinery manufactured in and about Chicago is now shipped to the west coast of South America, to eastern Siberia, and to various parts of Australasia. The Australasian trade of one firm last year amounted to 11,000 tons. The shipments of this firm and presumably of others of that part of the country are made by way of New York, except on rare occasions, when, for the purpose of economizing time, the goods are routed by way of San Francisco or Vancouver. The rates from New York are usually much lower than those by way of the Pacific coast. The time taken to get goods from Chicago to Australia varies from sixty-five to eighty-five days, ten days of that time being required for getting the goods to New York City. The average time from Chicago to the Pacific coast is eighteen days, and steamers from our Pacific coast to Australasia take from twenty-two to twenty-eight days for the passage. The canal will shorten the distance by water from our Atlantic seaboard to Australasia by approximate distance to South America more than twice that number of miles.

The southern and central parts of Wisconsin are developing important manufacturing industries and a Pacific trade, although the cost of reaching Pacific markets is a heavy burden. A carriage company, for instance, situated near Racine, Wis., reports that it has for some time past exported vehicles to the western coast of South America, Australia, and the Orient, the shipments in the majority of cases being made via Atlantic seaports, "on account of the high cost of transportation by the transcontinental lines from here to the Pacific coast." The firm states that on business to Pacific coast points "we have to pay on a car of goods valued at $1,500 $320 for transportation." An Oshkosh, Wis., firm engaged in the manufacture of sash, doors, and blinds ships some of its products to jobbers in England who export commodities to various Pacific markets. A Milwaukee company which manufactures engines, pumping, mining, and other heavy machinery, and has branch offices in many parts of the United States and in several foreign countries, reports a large export trade with the Pacific coast of the United States and foreign Pacific countries. This firm states that "the rates from the European ports we generally find to be somewhat lower than from various United States ports, and this feature makes European competition more difficult to overcome."

There is a direct Pacific export business from all of the States of the Middle West except those forming the second tier of States west of the Mississippi River. In these four States—the two Dakotas, Nebraska, and Kansas—agricultural and food products comprise nearly all the commodities sent beyond their borders. Should the canal create larger home and foreign markets for those products it would work to the indirect, if not direct, benefit of these strictly agricultural commonwealths.

THE CANAL AND ST. LOUIS.

It remains only to speak of the State of Missouri. Most of the activities of the people of this large State are devoted to agriculture. Its hard-wood forests, however, yield an export product of much importance. The city of St. Louis is a prominent manufacturing center, and is one of the largest jobbing and distributing cities of the United States. Situated almost at the center of the United States, on the largest river of our country, and being the center of railway systems radiating in all directions, it has peculiar advantages both for manufacturing and for distributing articles required by the people living in that great stretch of country west of the Mississippi and south of the Missouri River. Our rapidly growing trade with Mexico is also largely controlled by St. Louis.

The circular letter of inquiry sent out by the Merchants' Exchange of St. Louis was generally responded to, and the exchange forwarded to the Commission 65 letters. Of these 65 firms making reply 32 stated that they were carrying on a trade in the western part of the United States or in foreign Pacific countries, and 33 answered that they have no present business in those sections; 48 of the 65 firms expressed the opinion that the canal would assist them either in developing their present business or in securing a trade that they were not able to engage in under present transportation conditions. Six companies reported that the canal would not be of any assistance to their business. Ten gave no opinion as to the effect of the canal, and 1 person expressed the belief that the canal would enable the New York exporters to injure his business. The most characteristic business of the city is its jobbing trade, which is now somewhat facilitated by the cheap river transportation. The St. Louis jobbers of heavy commodities will in the future have the advantage of economical water transportation, not only to and from the Gulf ports, but also between their city and all points reached by the canal route.

THE EFFECT OF THE CANAL UPON THE TRANSPORTATION FACILITIES OF THE CENTRAL WEST.

The large and varied industrial development which the Central West has enjoyed, in spite of its situation near the center of a great continent, has been due to its excellent transportation facilities. Throughout the past fifty years the Great Lakes have given the Central West the opportunity to trade with the eastern part of the United States under peculiarly favorable conditions. The commerce on the Great Lakes is growing with marvelous rapidity, and at the present time these lakes afford the cheapest inland transportation to be found in any part of the world. The Ohio, the Mississippi, and other rivers of the Central West have in the past been important auxiliaries to the commercial development of that section, and at the present time the Ohio River is of much assistance to southern Ohio and the other regions adjacent to the stream. With the decreasing costs of railway transportation, the importance of river navigation grows less; but Ohio, Indiana, Missouri, Iowa, Minnesota, and Wisconsin will in the future derive no small benefit from the opportunites which they will possess of shipping their commodities by river to Gulf ports. The opening of the isthmian canal will unquestionably emphasize the commercial importance of the Gulf cities, and will strengthen the reasons for improving the great river systems of the Central West.

The existence of the canal, the larger commerce at Gulf ports, the more favorable conditions for river navigation, and the continued growth in mileage and efficiency of the railway systems leading from the Central West to the Gulf will tend to strengthen the power of the Gulf seaports to share with the cities situated on the Atlantic the traffic from and to the Middle West. While it is not probable, for reasons that are elaborated in a subsequent chapter, that so large a share of the traffic of the Central West will be handled by the Gulf routes as by those connecting with the Atlantic, nearly all parts of the Central West will have the advantage of being able to choose between the Gulf and Atlantic routes, and this power of choice will insure to them that competition in transportation which always quickens industrial activity. The transportation facilities of the Central West will be made better by the canal, and the increased traffic to which the canal will give rise will lead to the extension and improvement of the agencies for rail and inland water transportation. Whatever affects the transportation facilities of the Central West touches its economic life at the very center.

CHAPTER V.—*The canal and the Pacific coast States.*

With the exception of that part of the United States comprised within the great Cordilleran Plateau or Rocky Mountain section of the United States, the Pacific coast States have been and still are the portion of our country most burdened by transportation costs, because the most highly developed manufacturing sections of the United States and of the world are adjacent to the North Atlantic and its tributary waters. The economies that have been effected in the cost of transportation by rail have so reduced freight charges as to make possible the movement of considerable quantities of valuable commodities across the great mountain divide, and to a limited extent bulky freight, such as cedar shingles and finishing lumber toward the East, and raw cotton and heavy machinery toward the West, will now bear the cost of transportation by rail. The amount of rail freight, however, now being carried between the Pacific and the States east of the Cordilleras, as is shown in another part of this report, is comparatively small, so small, indeed, that it is well within the facts to say that the Pacific section of our country is able to market its products by rail east of the Rocky Mountains only to a limited extent. The railroads have not yet satisfactorily connected the Pacific coast States with their largest and most natural markets.

Although the Pacific coast States of our country are developing an oriental trade of very satisfactory proportions, and there is every reason to believe that this commerce will grow in the future, nevertheless the trans-Pacific trade of our west coast will probably be small in comparison with the commerce of that section with the markets adjacent to the North Atlantic. The western part of the United States is now, and will be for a long time to come, devoted very largely to the production of food products, lumber, and the basic materials of industry. The natural markets for products of this kind are in the eastern part of our country and Europe.

THE CANAL AND CALIFORNIA.

It would be impossible, even if it were desirable, to consider every industry of California and discuss the manner in which it would be affected by the canal. This survey being intended to be suggestive rather than exhaustive, the purpose of the discussion can be accomplished better by considering only the grain, lumber, and horticultural and mining interests of the State. These are the industries that will make the largest use of the canal, and the industrial effects which that waterway will accomplish will be fully illustrated by a consideration of these characteristic economic activities of the State.

The two cereals that California produces for export are wheat and barley, both of which are now produced in large quantity. The average annual wheat crop of California for the past fifteen years has been about 30,000,000 bushels. The annual barley crop of the State during recent years has been about 20,000.000 bushels.

It is a noticeable fact that the wheat crop of California has not increased since 1893; indeed the recent annual productions have been less than they were in former years. The reasons for this are to be found partly in the low prices of wheat that have prevailed much of the time during the past decade, and in the fact that the transportation charges from the Pacific coast to the principal grain markets are relatively higher than from most of the other wheat-growing regions of the world. While the wheat production has declined, the amount of California wheat consumed at home and in the neighboring States has increased with the growth of population, and the consequence has been lighter foreign shipments than were formerly made. Twenty years ago wheat raising was the most attractive industry of the State, but since then the crops of the State have become diversified, the great wheat farms are being divided up, and single crop agriculture on an extensive scale has to some extent given way to more intensive cultivation of smaller farms devoted to the production of several crops.

The wheat crop of California is, however, a large and valuable one at the present time, and will probably continue to be. It is quite possible that better methods of culture, the use of fertilizers, and the ability to reach Atlantic markets more cheaply will largely increase the future wheat production of the State.

California barley is of excellent quality and is being exported in increasing quantity to England, where it is in demand for brewing purposes. The barley of California can meet the competition of other regions of production more easily than the wheat can, and cheaper transportation charges would enable the State to increase largely the sales of this cereal in foreign countries and the brewing centers in the central and eastern parts of the United States.

Corn and oats are not grown to much extent in California, barley being used instead of them for feeding stock. Corn and oats will not be exported from California after the canal has been opened, but a small quantity of them may be imported from the eastern half of the United States.

California has both an import and export trade in lumber. The exports by sea are comparatively light, being only 23,041,058 feet in 1899, and are sent mainly to Europe, Australia, Mexico, and Central America, less than one-third of the shipments being to Europe and the eastern United States. Although the annual output of the California sawmills is about 600,000,000 feet, the State is a large buyer of lumber for use at home and for sale in the mountain States east of her. About 200,000,000 feet of lumber—two-thirds of Washington's maritime shipments—are sent annually from Puget Sound to California.

The Sierras of California are well wooded with pines, spruce, and cedar, and the redwood forests extend along the coast from Oregon south half the length of the State. The redwood lumber is much in demand in Atlantic countries, and in the future will probably be exported more largely than at present. The costs of shipping lumber by the sailing vessels which now carry the traffic have averaged about 65s. ($15.85) per ton from the Pacific coast to Europe during the past ten years. During the past two years, 1899–1900, the charges have been even higher on account of the scarcity of ships. By way of an isthmian canal the rates for large cargoes would not need to be more than half the average charges of the past to the eastern United States and to European ports.

In the production of fruits, nuts, and wine California has reached a position of eminence, and the extensive horticultural interests of this and the other Pacific coast States are rapidly increasing in value with the betterment of the facilities for quick transportation in refrigerator cars to the Eastern markets. Formerly nearly all the excellent fruit of the West was dried or canned before shipment, but now a large part of it is marketed as green fruit. The following figures will indicate the increasing magnitude of the business of selling our west coast fruit in the central and eastern parts of the United States and in Europe. In 1895, 4,568 cars of green deciduous fruit were shipped from California to the Eastern cities, and in 1899, 9,694 carloads were sent. Efforts are being made to ship the Western green fruits to Europe, 42 carloads having been shipped from California in 1896, 58 in 1897, 42 in 1898, and 123 in 1899. The citrus-fruit shipments average 15,000 cars a year from California to our Eastern markets. Western dried and canned fruits find a ready and increasing market in Europe. There were 8,692 carloads of dried fruit shipped out of California in 1899, about 20 per cent of which went to Europe. The growth in the sales of California canned fruit in Europe has been especially rapid. In 1894 there were 85,817 cases sent to England, whereas in 1899 over half a million cases were shipped.

The production of nuts, raisins, and olives has reached large proportions. California raised 14,000,000 pounds of almonds in 1899—one-third the total large consumption in the United States. The California raisin crop is from 70,000,000 to 100,000,000 pounds a year, the shipments out of the State being 3,600 carloads in 1899. California olive oil is now being sold in many parts of the United States.

The foregoing figures refer particularly to California, but the development they indicate is typical of all the Pacific States. California preceded Oregon and Washington in the development of her horticultural industries, but these two States have latterly, with the increase in their population and the formation of better railway connections with the East, been making the valley of the Columbia River and its tributaries a section of large production and exportation of fruit. Although fruit is a commodity with a relatively high value for its bulk, it is also an article the consumption of which is most readily stimulated by a reduction in price. The production of fruits and other horticultural products is capable of being largely increased in California and the other Pacific coast States. If cheaper transportation can be secured for horticultural products from the Pacific coast to the Eastern United States and Europe, the production and consumption of fruits will expand. The figures of present shipments indicate that fair progress is being made in reaching our Eastern markets, but what has thus far been accomplished is reported to be but a good beginning.

The shipment of fruit long distances will always be made to a large extent by rail. There is, however, no doubt about the ability of the isthmian canal route to reduce the costs of shipping canned and dried fruits from the Pacific coast to our Eastern States and Europe. It is perhaps uncertain whether green fruits will be largely shipped by the canal route instead of by rail. Most varieties of green fruit, however, can be successfully shipped by water, provided proper arrangements for refrigeration are made, and provided the market permits of regular cargo or large berth shipments. Whether the water route will be used for the shipment of green fruits or not will depend upon the size of the market and the arrangements for prompt distribution among retail buyers. If the market is large enough and well organized, shipments will probably be made in vessels especially equipped for the service.

The production and shipment of California wine is such an important industry that it calls for special discussion in considering the industrial effects which the isthmian canal will produce. In 1897 no less than 34,000,000 gallons of wine were manufactured in California, the production having doubled in a decade. Since 1897 the amount made has fallen off, because of the ravages of the phylloxera, but the decline will probably be only temporary. Varieties of resistant stocks are being planted that are not subject to the attack of the insect, and there is every reason to suppose that the amount of wine produced in the future will more than equal the figures of the past.

Wine is mainly shipped in casks, and is a kind of freight adapted equally well to shipment by rail or by vessel, and at the present time shippers are making use of both means of transportation. In 1899 California shipped by sea to the Eastern States, most of it being consigned to the port of New York, 13,373 tons of wine. To Europe 570 tons were sent direct. Doubtless a part of that consignment to New York was exported to Europe. Shipments to Europe and the eastern part of the United States are partly direct by way of the Panama Railroad and in part around South America. Some of the 585 tons sent to Mexico crossed the Isthmus. During this same year the shipments of wine by rail from the State were 64,520 tons, the amounts sent by rail being between four and five times the total cargoes sent by water to Atlantic ports. In addition to the wine, there were shipped by rail 3,599 tons of brandy and 1,475 tons of "wine and brandy not segregated." The brandy shipments by water amounted to 346 tons. Under the present conditions of expensive transportation a fair beginning has been made in the exportation of California wine to Atlantic countries, but it is certain that the wine production of the State can be largely increased with the more favorable conditions of competition that would result from lowering the expenses of reaching markets.

Among the other industries of California are those of fishing, mining, and grazing. These industries being common to all the Pacific coast States, they will be considered later in connection with the discussion of the relation of the canal to the industries of Oregon and Washington.

THE CANAL AND THE LUMBER AND GRAIN INDUSTRIES OF OREGON AND WASHINGTON.

The manufacture of lumber, the raising of grain, and the catching and packing of fish are industries of prime importance in both Oregon and Washington. The growth of fruit, particularly in Oregon, and the mining of coal in Washington are industries of secondary but increasing rank. The commerce of this section of the United States centers at Portland and in the cities on Puget Sound.

The supply of timber in Oregon and Washington is so abundant and of such excellent quality that the amount of lumber marketed is fixed entirely by the costs of transportation to the distant markets of the Orient, and particularly of the north Atlantic. It is estimated by the United States Geological Survey that the forests of Washington now contain about 115,000,000,000 feet of merchantable lumber. In the four northwestern counties of Oregon there are said to be 1,800,000 acres of standing timber, containing between fifty and sixty billion feet of lumber. These estimates may not be accurate, but they serve to show the magnitude of the forest resources from which Washington and Oregon will draw traffic for an isthmian canal.

Exports of lumber from the Pacific coast of the United States and British Columbia are now made to the countries of the Pacific, and a limited amount takes the long voyage around the Horn. In 1899 our three Pacific coast States shipped 13,354,000 feet to Europe, 5,149,000 feet to Argentina, and 15,944,000 feet to South Africa.

Although western Europe and the eastern coast of the United States would be the largest markets for Pacific coast lumber if the costs of transportation were not so heavy, the present difficulty of shipping lumber from the Pacific to the Atlantic is such that California usually sends to Europe, where the demand for redwood would be large if the price were lower, but one-fourth to one-third of her foreign exports of lumber. There were 422,211,000 feet of lumber shipped by sea from Washington in 1899. California usually takes 60 per cent of the whole amount and Hawaii one-sixth. After these countries comes Australia, then South Africa, Asia, Africa, Europe, and the east coast of the United States. The shipments to Europe and our east coast are chiefly spars for ships, while South Africa buys bridge material and other choice lumber. The opening of an isthmian canal would reduce by about 50 per cent the freight costs of marketing our west-coast lumber in Atlantic countries, and this reduction in freight expenses would add a corresponding amount to the value of all that part of the Pacific coast lumber for which there is a demand in these countries.

All three of our Pacific coast States are heavy exporters of wheat. The total amount produced in the three States in 1899 was 77,404,000 bushels, about one-seventh of the total production of the United States for that year. The exports to Europe were 17,396,712 bushels of wheat and 378,763 barrels of flour. Counting 5½ bushels of wheat for 1 barrel of flour, the total exports equaled 19,479,908 bushels of wheat. To South Africa 1,508,100 bushels were sent, making the total shipments to the Atlantic nearly 21,000,000 bushels, or about 562,000 gross tons. In addition to this, 638,094 bushels, or about 17,100 gross tons, of barley were shipped from California and Oregon to Europe.

The wheat exports from our west coast during the fiscal year ending June 30, 1899, were unusually light on account of the shortage in the crop. During the previous fiscal year the total exports of wheat from the three Pacific States to Europe, including flour expressed in bushels of wheat, were 34,869,921 bushels. The exports of wheat and flour to South Africa and Brazil equaled 5,344,145 bushels. Thus in 1898 the total exports of wheat from our Pacific coast to the Atlantic were 40,214,066 bushels, or 1,077,207 gross tons. The barley exports of 1898 were 5,628,747 bushels from San Francisco and 250,792 bushels from San Diego, a total of 5,879,539 bushels, or 125,918 gross tons. The total gross tonnage of these wheat and barley shipments to the Atlantic during the year ending June 30, 1898, were 1,203,125 gross tons, more than double the tonnage of the succeeding year. The 580,000 gross tons exported in 1899 could have been carried in 65 steamers of 4,000 tons net register. To have carried the 1,203,125 gross cargo tons of grain shipped around the Horn in 1898 would have required 135 steamers of 4,000 tons net, and that vessel tonnage, 540,000 tons net register, more nearly represents the average annual requirements of the Pacific coast grain shippers than does the tonnage of 1899.

At the present time this grain goes around the Horn in sailing vessels averaging about 1,800 tons register. After the isthmian canal has been opened the ship used will doubtless be a steamer of not less than double, and probably three or four times, the size of the sailing vessels now employed. The freight rates now vary from $5.50 to over $10 per long ton—from 15 to 26 cents a bushel—depending upon the available supply of ships. A steamer of large dimensions could doubtless carry the grain by way of a canal from our west coast to Europe for 10 cents a bushel—$3.73 a gross cargo ton—and pay from that freight receipt $1 per register ton—less than 50 cents per cargo ton—for canal tolls.

THE WEST-COAST FISHERIES.

The fisheries of the Pacific coast constitute an important industry that gives rise to the exportation of a large volume of valuable freight. The salmon pack of Alaska, British Columbia, and our west coast in 1899 amounted to 3,138,040 cases, each containing 48 1-pound cans. Three-fifths of this was packed in Alaska and British Columbia and two-fifths in Washington and Oregon. A package of 48 pounds of salmon weighs 70 pounds, and 3,138,040 cases would occupy 80,000 measurement tons of 40 cubic feet each. It would require about twenty fully loaded vessels of 2,000 net register tons each to carry the freight.

The shipments of salmon to the Eastern part of the United States and to Europe are heavy, both from British Columbia and from San Francisco. From San Francisco the shipments by sea in 1899 to our Eastern States were 261,683 cases, valued at $1,157,608. The total ocean shipments from our Pacific ports (mainly from San Francisco) to foreign countries east of the Horn in 1899 were 21,014,989 pounds, or 437,801 cases, which would amount to 11,608 measurement tons of 40 cubic feet. At the present time these salmon exports by sea are shipped in English sailing vessels around the Horn, and the business is handled mostly by English houses.

In addition to the ocean shipments of salmon, there are fresh salmon, halibut, and other kinds of fish shipped east by rail. The American consul at Vancouver reports that one company "takes in the open sea to the north of Vancouver from a million to a million and a half pounds of halibut each year. The halibut steamers bring the fish to Vancouver, where they are packed in ice and shipped to Boston."

THE HOPS, WOOL, AND MINERAL INDUSTRIES OF THE PACIFIC COAST.

The three States under consideration produce three-fourths of all the hops grown in the United States, and a large share of the Western hops are shipped to our own and European consumers. The production of hops in the Western States can be much increased whenever the market conditions warrant a larger output. At the present time but a small share of the hops is shipped east to our own or foreign countries by water, and our west coast is compelled to compete with European growers and under the limitations imposed by expensive transportation.

The Pacific coast States and the neighboring commonwealths of the Cordilleran Plateau supply the woolen mills of the Eastern States with a large part of the fiber they require. Only a part of the wool would be shipped through the canal, but the freight on the large part of that shipped by rail from points west of the one hundred and fifth meridian would be affected by the isthmian waterway.

The principal mining industry of the Pacific States at the present time is that of gold. Some copper is mined and a variety of other minerals in small quantities. The effect of a canal upon them could hardly be important. Mining machinery would be obtained somewhat cheaper, and the canal, by promoting immigration and more rapid settlement in the West, might provide the mining companies with a large and a cheaper supply of labor.

EFFECT OF THE CANAL UPON THE TRADE OF WEST-COAST PORTS.

The general effect of the canal upon the people of the Pacific coast will be that of enabling them to buy cheaper and sell dearer and to carry on a larger trade with the people of their own and foreign countries. The manner in which the seaports of the west coast will share in this larger trade constitutes an inquiry of local and general interest. San Francisco is the centrally located port and has a harbor of great natural excellence. Formerly that city controlled nearly all our Pacific coast trade, and in the fiscal year 1899–1900 about 67 per cent of the foreign commerce of the Pacific ports was handled through San Francisco. The trade of San Francisco, however, has averaged but little more during the past five years than it averaged during the preceding quinquennial period. The value of the imports of the five years ending in June, 1900, show a gain of 24 per cent over the total for the preceding five years, while the exports show a decline of 11 per cent. The other important ports of the Pacific coast, with one exception, have had an increase in both imports and exports, and in the case of the Puget Sound section the growth of foreign trade has been especially rapid.

The resources of the country about Puget Sound have been much developed during the past decade, and the transcontinental railways reaching the Sound have both increased the facilities for land transportation and have placed in service trans Pacific steamship lines by means of which they are able to make through shipments between interior points in the United States and the Orient. There is one line from San Francisco to the Orient operated in connection with a railway company—the Pacific Mail Steamship Company; but from Puget Sound there are three steamship lines operated by the transcontinental railway companies. The consequence has been an increase in the foreign trade of the United States customs district of Puget Sound from $6,206,456 in 1890–91 to $25,051,670 in 1899–1900. During the past five years the total exports from the Puget Sound customs district were 146 per cent greater than the exports for the preceding period of equal length. The total imports show a gain of about 500 per cent.

In the case of Portland, or the customs district of Willamette, the growth has been less rapid, a comparison of the totals of the two quinquennial periods showing a gain of 60 per cent in exports and 38.6 per cent in imports. In the foreign trade of San Diego the exports of the last five years are nearly treble those of the preceding, but the imports have fallen off 17 per cent.

The foregoing figures indicate that with the exception of Puget Sound, where there has been very rapid increase, and Portland, where the growth has been moderately large, the maritime foreign trade of our west coast has not developed greatly during the past decade. The opening of the isthmian canal may be expected to increase the ocean commerce of the Pacific-coast section as a whole and enable the southern seaports to make a better showing, as compared with the northern, than they have been making in the past decade.

San Diego, Los Angeles, and also San Francisco will not only have a better route to the Atlantic than they now possess, but will have the advantage of being convenient ports of call for vessels engaged in the coasting trade between our two seaboards and, to some extent, for the vessels plying between Atlantic and Oriental ports through the canal. The short-distance or great-circle route between the American isthmus and Japan and China runs close to the coast of the United States, and, with the exception of those vessels that desire to call at the Hawaiian Islands, this route will be the one naturally taken by vessels to and from the Orient. This great-circle route will also have the advantage of enabling steamers to coal on the west coast of the United States, or at Vancouver, where satisfactory steaming coal can be secured comparatively cheaply. Vessels bound for the East will be obliged to run against opposing winds and currents, but this disadvantage will probably be more than offset by the shortness of the route and by the coaling facilities.

How will the canal affect the maritime commerce of ports as far north as Portland and Puget Sound? If the industrial analysis made in the preceding pages is accurate there will be a large increase in the exportation of agricultural and forest products. These northern ports will also be the natural gateways for a large share of the export trade of Idaho, Montana, and Wyoming, and for a portion of the commerce of British Columbia. It would seem certain that the canal will enlarge the export business of the northern Pacific ports.

The canal doubtless will secure some import business that would otherwise be turned over to the transcontinental railways at Puget Sound points and at other more southerly Pacific ports, but a study of the through business now being done by the transcontinental railroads shows it to be of small amount, so small that the canal would not have to create a large tonnage of new traffic for the railways to cover what it could divert from the roads. A discussion of the transcontinental railway traffic may be found in Chapter X of this report.

There are two forces that will favor Puget Sound as a gateway for imports from Japan and the Continent of Asia. Vessels on their eastward voyage across the northern Pacific along the great-circle route for the southern Pacific ports of the United States, or for the American isthmus, will add only about 500 to 600 nautical miles to their voyage by calling at Puget Sound. Under those conditions it would seem that Puget Sound points would naturally become important centers for the distribution of Japanese and Asiatic goods. But in addition to being near to the ocean highway, along which a large quantity of imports will travel, the Puget Sound ports will be able to supply steamers with coal. The coal obtainable in these ports will be required by the vessels engaged in the commerce of the north Pacific, and this fuel supply will give to Washington and British Columbia the possession of a magnet that will attract commerce with great force. That region is now deriving from its coal much assistance in the development of its commerce; the opening of a canal will inaugurate commercial conditions on the Pacific that will enhance rather than lessen the efficiency of Puget Sound coal as an agency for the promotion of commerce.

In this discussion of the relation of an isthmian canal to the industries and commerce of the Pacific coast States only the larger industries of the section have been considered. The business activities here dealt with are concerned mainly with the production of food and the raw materials of manufacture. The fisheries and horticultural business of our Western States require a considerable amount of auxiliary manufacturing for local purposes; but with the exception of lumber and flour and a small amount of leather the Pacific coast manufactures but little for export. This will be characteristic of the section for some time to come, although the use of the Puget Sound coal, and the petroleum oil of southern California, and the application, by means of electricity, of the abundant water power of California to industrial purposes will make possible a greater diversification of industry than has yet been accomplished.

The most general statement that can be made of the effect which an isthmian canal will have on the Pacific coast is that the waterway will enable that section to meet more easily and successfully the growing competition of those countries whose similar productions make them commercial rivals of our Western States. Argentina is a large and growing exporter of grain, wool, and hides; but it possesses all the requisites of successful horticulture, and just as our Western States have done, so will Argentina become a large producer of fruits and wine, both for domestic and foreign markets. Much the same development may safely be predicated of South Africa and Chile. Without an isthmian canal our West coast will have increasing difficulty in meeting the competition of these rival sections.

CHAPTER VI.—*The coal supply for the commerce and countries of the Pacific—The canal and the coal trade of the United States.*

Abundant and cheap coal and iron are resources fundamental to highly diversified industries and an extensive domestic and foreign commerce, and their importance increases rather than diminishes with the development of the economic organization of society. Whatever affects these resources and the activities directly connected with them strengthens or weakens the foundation upon which the industrial and commercial superstructure of society is based. Coal has become the almost universal fuel force of manufacturing and commerce; and except in that limited field where electricity generated by water power can be utilized it is the motive power of business activity. It more than any other factor determines where most industries shall be located, and the price of coal is at the present time not only determining which sections within each country shall succeed most largely but it is also deciding which of the industrially resourceful and well-equipped nations of the world is to achieve the highest measure of economic success.

If the abundant supply of coal in the eastern half of our country is available for export at a moderate cost, it will tend to increase the use of the isthmian canal by the merchant marine of our own and foreign countries, to facilitate the development of the commerce of the Pacific, and to enhance the industrial changes that may be wrought by the waterway on the west coast of South America and North America as far north as southern California. With the exception of the coal beds of the section of country adjacent to Puget Sound in Washington and British Columbia, there are as yet no large and valuable coal supplies on the entire west coast of the Americas available for the vessels engaged in the commerce of the Pacific or for the fuel which future industrial development will require. There are coal deposits in northern Mexico, northern Peru, and southern Chile, and there are petroleum fields in Peru. These several sources of fuel may possibly become valuable for the commerce and industry of the Pacific coast generally, but what has thus far been accomplished in connection with these fields would hardly warrant one in expecting them to become of much more than local importance. Probably during the early years of the use of the canal, and possibly for many years, the west coast of America from California south, and the coaling stations of the Pacific generally, will draw their supply from other than Mexican and South American sources.

The routes followed by steamers is determined, when a choice is possible, almost as much by coal costs as by distances. The larger share of the world's ocean commerce originates or ends in the countries about the North Atlantic, and a large share of the North Atlantic trade with the nations of the Pacific will have the choice of the Suez and American canal routes. For a part of this Atlantic-Pacific trade the Suez route will be shorter, and for another portion the American route will have an advantage in distance. The route chosen will, to some extent, depend upon the relative cost of coal at the stations along the respective routes. This is equivalent to saying that, in the competition of the two canals for the traffic free to choose between the two waterways, the route will be more successful that can furnish vessels with the cheaper coal, unless a disparity in toll charges and the chances for securing and delivering cargo at intermediate ports should be sufficient to offset the advantage of cheaper fuel.

An abundant supply of good coal, obtainable at moderate prices in the coaling stations of the Pacific, in addition to the commercial and industrial benefits conferred, will be of advantage to our Navy, because of the necessity of our maintaining a number of naval vessels on that ocean. The efficiency of a naval squadron is even more dependent than that of a merchant fleet upon an adequate and sure supply of good coal, and whatever will increase and cheapen the coal supply of the Pacific will enable the United States to protect its commercial and colonial interests with fewer risks and less expenditure.

SOURCES FROM WHICH THE COAL CONSUMED ON THE PACIFIC IS NOW OBTAINED.

The Pacific States of the United States are not only unable to export much coal, but are, with the exception of the State of Washington, obliged to import large quantities. The fuel required by the steamers on the Pacific Ocean and for industrial purposes by the countries in and adjacent to the Pacific Ocean is practically all supplied by other countries than our own. In 1899 we sent a small amount of coal for the first time, 34,000 tons, to the British East Indies, and less than 2,000 tons to the Dutch East Indies. This, however, was due to unusual conditions, and does not indicate the probable beginning of coal exports to the East Indies. For several years we have sent a little coal to the Hawaiian Islands, probably as ballast, and in 1898 our shipments to the Hawaiian and Philippine Islands reached 16,580 tons, and in 1899, 80,209 tons. Nearly all of this tonnage, however, can probably be accounted for by the military operations which we carried on in the East after the spring of 1898.

Washington, our only Pacific State having a surplus of coal, produced 2,000,000 tons in 1899, the output having doubled since 1893. The larger part of this coal is consumed locally, some of it used by the steamers calling at Puget Sound ports, and California imports about 400,000 tons annually.

The State of Oregon has coal mines of minor importance, but which may possibly be so developed as to enable that State to supply a part of its own fuel needs. In 1898 the output of the Oregon mines was but 52,000 tons, and the statistics for the last ten years do not reveal any tendency toward the increased output. However, there are said to be veins in Oregon which are expected to yield considerable quantities of low-grade bituminous coal in the future.

British Columbia has well-developed coal mines on Vancouver Island, and veins that are probably extensive are being opened up on the mainland. The total coal production of Canada in 1898 was 4,172,655 tons; ten years earlier it was 2,658,000 tons. The greater part of the present output is obtained in British Columbia, although Nova Scotia, Quebec, and Ontario all produce limited quantities.

Regarding the coal mines of Vancouver, the United States consul at Victoria reports that the total output of the island in 1898 was 1,117,915 tons, and for 1899, 1,666,251. The shipments to foreign countries in 1898 were 765,961 tons, and in 1899, 769,091 tons. San Francisco and the southern ports of California, the Hawaiian Islands, and the steamships engaged in the trade between America and China and Australia are consumers of this British Columbia fuel. The imports of British Columbian coal into California in 1899 amounted to 652,926 tons, which figures represent an increase of 50 per cent during the last ten years, although the amount of British Columbian coal imported into the United States at the present time is considerably less than it would be had not the coal from the State of Washington become available for the California trade. The constantly increasing use of petroleum and electricity in California has probably made the demand for coal in that State less than it would otherwise have been.

At the present time neither the State of Washington nor British Columbia is furnishing any considerable amount of coal to the coaling stations of the Pacific nor sending very much coal to Pacific countries generally. It would seem, nevertheless, that the supply of coal in this section of the United States and Canada was large enough to make possible the development of an important coal export business. Although a large part of the coal thus far discovered and worked is either lignite or low-grade bituminous, and but little, if any, bituminous coal equal to the best bituminous of the eastern part of the United States has yet been found, the best coal of Vancouver and the State of Washington is satisfactory for steaming purposes and is now employed for both industrial and commercial uses. There is no genuine anthracite coal mined in this district.

For many years Japan has been developing her coal mines, with the result that the total production rose from 1,402,000 tons in 1886 to 5,080,000 tons in 1896. During this decade the domestic consumption rose from 726,000 tons to 2,936,000 tons. Thus, while the consumption grew rapidly, it had not increased so fast as the total production, and Japan was able to increase her exports during the decade from 776,000 tons to 2,144,000 tons. Since 1896 the coal exports from Japan have increased largely. The tonnage figures for the recent production and exportation are not available; but the value of the coal exported rose from 11,545,801 yen ($5,772,900) in 1897 to 15,168,799 yen ($7,584,400) in 1898. Japan supplies a large quantity of coal to steamers engaged in the oriental trade, and also sends coal to Pacific ports.

Australia is a country producing a moderate but increasing amount of coal of good quality, the total production growing from 4,179,000 tons in 1888 to 6,313,000 tons in 1898. The only colony of Australia that has a surplus for export is New South Wales, whose foreign shipments in 1898 amounted to 2,791,796 tons. The shipments out of New South Wales are larger than the total exportation of Australia, which fact indicates that some of the New South Wales exports were to other Australian colonies. The total coal imports of the Australian colonies were 1,000,000 tons, and two-fifths of this amount was drawn from sources outside of Australia. Australian coal is at the present time distributed quite generally throughout the Pacific, the shipments being facilitated by the cheap transportation available. A large number of vessels leave Australia for America with coal as ballast, and this has enabled Australia to market her coal readily in Hawaii and in both North and South America. For the last decade California has annually procured from 200,000 to 400,000 tons of Australian coal, and Australia and Japan are at the present time supplying the larger part of the coal to be found in the tropical and southern sections of the Pacific.

Another important source of the coal used in the Pacific is Great Britain. The vessels which carry the grain, lumber, and nitrates of the west coast of America are frequently obliged to make the outbound voyage from Europe in ballast. This enables Wales to compete even with British Columbia and Washington in the California coal trade. A part of the coal thus imported, a portion of which is Welsh anthracite, is used for domestic purposes. The continued use of British coal on the Pacific is due, in part, to its superior quality and in part to the exceedingly cheap transportation which the coal is able to obtain.

In addition to the coal supply mentioned above, California annually purchases in the eastern part of the United States a limited amount of anthracite. There is also brought from the Eastern States a limited quantity of high-grade bituminous coal for smithing purposes. This anthracite and smithing coal are obtained from Pennsylvania and Maryland, and have not amounted to 50,000 tons in any year during the past decade.

The foregoing survey of the principal sources from which the coal used on the Pacific is now secured will serve to show that the coal fields are widely scattered and are by no means so productive as those in the eastern part of the United States or in Europe. The Australian, Washington, British Columbia, and Japanese coal fields are all capable of development, but the increase in their output will be only moderately rapid. Much is said but comparatively little is known in regard to the coal fields of China. It is possible that within the next decade and a half railroads will have been constructed from the Chinese fields to the seaboard and that foreign capital will have opened up the Chinese mines. Should that take place, the largest future coal supply for the Pacific will be China. Unless that does take place, however, the Pacific coal supply, until the isthmian canal has been constructed, will be drawn from the four countries mentioned above, unless that which is highly improbable should occur and there should be found in Mexico and western South America richer fields of available coal than are now known to exist.

PUGET SOUND COAL.

The proximity of the coal resources of Puget Sound to Oregon and California and their availability for the use of the steamers engaged in the American-Asiatic trade of the North Pacific make desirable a further inquiry into the quantity, quality, and marketability of the coal of this section.

Although the Canadian coal production, most of which is to be accredited to British Columbia, was only 4,172,655 in 1898 and had increased only a little over 1,000,000 tons since 1890, the reports of our consuls and other sources of information indicate the existence of extensive deposits. These coal beds, however, are not especially thick, and the costs of mining have not been so low as in the great coal-mining regions of the world. The best mines yet developed are those of Vancouver Island and Crows Nest Pass, both of which produce a fair grade of bituminous coal from which coke can be made. The Crows Nest Pass field, at the eastern edge of the Cordillera Mountains, near the Canadian Pacific Railway, is a valuable source of supply for the metal-mining industries of the mountain district and for the section of the country just east of that region, but is too far from the coast to be marketed profitably at tide water. The Vancouver coal is favorably located for transportation, and it has been the source of most of Canada's exports of the mineral. Most of the foreign sales of this coal have been in the United States, where it has competed successfully with the product of other countries, without being able, however, to monopolize the market.

The coal mines of the State of Washington, although the product is somewhat inferior to the better grades of the British Columbia output, have been developed more rapidly than have the rival Canadian fields. The figures of production remained nearly constant at about 1,000,000 tons from 1886 to 1893, but for the five years ending in 1899 there was a rapid growth, the amounts being, in short tons, for 1895, 1,191,410; 1896, 1,195,504; 1897, 1,434,112; 1898, 1,884,571; 1899, 2,020,260. The latest report of the United States Geological Survey, that for 1899, says:

Washington is the only one of the Pacific coast States whose coal product amounts to as much as 1 per cent of the total bituminous output of the United States. It is also the only State on the Pacific coast producing true bituminous coal, the entire product of California and Oregon being lignite or brown coals. Some of the Washington coals are true coking coals, over 50,000 tons in 1899 being made into coke. Some of the coals produced in Washington approach anthracite in character, and some "natural coke" has been observed.

These fields have an area about three times that of the Pennsylvania anthracite beds, but are not especially rich deposits except in limited and scattered areas. Like those of the Cordilleran Mountains generally, they have suffered badly by the irregular fracturing of the earth's crust.

As regards the quality of the Puget Sound coal three sources of information may be drawn upon in this discussion—the studies of the United States Geological Survey, to which reference has just been made, the experience of those using the coal on vessels and in industries, and the tests made by the United States Navy.

Several large consumers of coal, including the ocean steamship companies, report that the Puget Sound coal can be used to advantage for steaming purposes, although it is inferior to the product of the best bituminous fields. The president of one of the steamship companies states:

The British Columbia coals that are now being mined are considered fair average steam coals. The Washington coals are lignites, semibituminous, and bituminous. The lignites are used principally as house coals, the screenings from such lignites being used at points close to the mines for steam purposes, as they are sold at a very low figure. The semibituminous and bituminous coals range from fair to good steam-producing coals.

The firm using as much coal as any industrial concern on the Pacific ordinarily secures its coal from the Washington mines, and an authority regarding the sources of the coal used in California wrote in reply to the question, "Is the coal from Washington and British Columbia good for steaming purposes?"—

The lignite coals are not. Those of a more bituminous character are so used, but they have not the evaporative power of the better grades of bituminous used on the Atlantic seaboard, nor are they so good as the bituminous grade from Australia or the semianthracite coals from Cardiff and Wales.

The numerous analyses and tests made by the United States Navy of coals mined in different parts of the world indicates that the bituminous coals of West Virginia and Wales rank highest, that the Alabama coal is somewhat better than the Australian, and that the Australian product is superior to that exported from Washington or British Columbia.

On account of their different qualities these several coals will sell in the same market for different prices; and the decision of the question whether the Puget Sound mines will in the future control the market in which the ships and industries of the Pacific coast will secure their coal will depend both on the relative qualities and on the costs of mining and delivering the competing products. The foregoing review of the present sources of the coal used in Pacific markets shows that there are, and will be, several regions competing for this coal trade. The nature of this competition can be shown to advantage by a brief reference to the coal trade of California at the present time.

THE FUEL SUPPLY OF CALIFORNIA.

The sources of California's coal supply constitute one of the interesting facts of the world's commerce. Every continent, except Africa and South America, is drawn upon. Europe, Asia, Australia, and both sides of North America export coal to California. The annual production of the State being only 160,000 tons of low-grade coal, nearly all the supply has to be imported. At the present time about half the amount consumed is received from foreign countries and half from the United States. The following table shows the origin of the foreign and domestic imports, and indicates that the American product is gaining on the foreign:

Coal imports of California.[a]

	1889.		1894.		1899.	
	Tons.	Per cent.	Tons.	Per cent.	Tons.	Per cent.
Foreign:						
British Columbia	417,904	31.0	647,110	42.4	623,133	36.2
Australia	408,032	30.0	211,733	13.9	139,333	8.1
Great Britain	45,617	3.5	176,198	11.5	93,263	5.4
Japan	1,340	....	15,637	1.0	9,390	.6
Total	872,893	64.5	1,050,678	68.8	865,059	50.3
Domestic:						
Washington	372,514	27.5	395,173	25.9	627,450	36.4
California and Oregon	87,600	6.5	65,263	4.2	189,507	11.0
Pennsylvania and Maryland	18,950	1.5	16,640	1.1	38,951	2.3
Total	479,064	35.5	477,076	31.2	855,908	49.7
Grand total	1,351,957	100.0	1,527,754	100.0	1,720,967	100.0

[a] In addition to the amounts given in this table there has been a small quantity of anthracite annually obtained from Utah and Wyoming since 1893. The figures for alternate years are, for 1893, 21,562 tons; 1895, 37,530 tons, 1897, 44,343 tons, and 1899, 19,000 tons. The anthracite imported from Wales is included in the figures for Great Britain given in the table,

The prominence of the United Kingdom as an ocean carrier and the possibilities of her foreign trade in coal are well illustrated by her large shipments of that bulky commodity halfway around the world. In past years California has received a part of her coal from Australia and Great Britain in ships that carry her wheat to Europe. The coal from Great Britain has varied from 3½ to 15 per cent of the total imports during the last dozen years, while the supply obtained from Australia has ranged from 11½ per cent to 30 per cent of the total. In the past from 25 to 35 per cent of the California supply has been drawn from these two foreign sources. For several reasons, however, coal shipments from these countries are falling off. The price at which British and Australia coal can be sold in California fluctuates sharply, and rises and falls according to the prospect of the cereal crops and the expectation on the part of shipowners of remunerative homeward business. Under extremely favorable conditions freights on coal from

Great Britain have been as low as 8s. per ton, while during the succeeding year they have reached 19s. from the same ports.

When California was largely dependent upon Great Britain and Australia for her coal supply, the practice was common of importing the coal from those countries on a speculative basis, the coal shippers sending out the cargo with the intention of selling the coal on or before its arrival at the port of destination. During recent years California buyers have adopted the practice of making contracts for the delivery of coal at fixed prices for periods of time, and the speculative shipments have nearly ceased. This change in business methods has given an advantage to the coal miners of the Puget Sound section.

The decline of the Australian and British coal in the California trade, and the concurrent development of the Puget Sound coal, is well illustrated by the statistics of the coal imports of that State. In 1889 Australia furnished 30 per cent of California's coal needs; in 1899 the Australian shipments formed only 8 per cent. In 1899 but a small amount of coal was shipped from Great Britain, whereas, in 1892, 15 per cent of the coal imports of California came from the United Kingdom. In 1899 the supply obtained from Great Britain amounted to only $5\frac{1}{2}$ per cent. The State of Washington, on the contrary, supplied California with $27\frac{1}{2}$ per cent of her coal in 1889, and with 36.4 per cent in 1899. In 1899 the Puget Sound section, including British Columbia, Vancouver, and the State of Washington, furnished California with nearly three-fourths of her coal supply. Ten years earlier the amount from this section was $58\frac{1}{2}$ per cent of the total.

The importations of coal into California have increased very slowly, the present amount being only $1\frac{3}{4}$ million tons, whereas twelve years ago $1\frac{1}{3}$ million tons were brought into the State. These figures show clearly enough that California has not yet become a State with diversified manufacturing industries, her principal business activities being concerned with the production of grain, fruit, and wine, the sawing of lumber, and the mining of metals. Most of the manufacturing is auxiliary to these industries.

As has been stated in another chapter of this report, the auxiliary manufacturing industries of California are making an increasing use of electrically transmitted water power. Electricity thus generated is also extensively used for power and lighting purposes in the towns. Furthermore, California would be obliged to use more coal than she does at the present time were there not petroleum oil fields in the southern part of the State, from which increasing supplies of oil are being annually taken for industrial and domestic fuel purposes and for use in railroad locomotives.

Concerning the value of oil for fuel the secretary of the Los Angeles Chamber of Commerce makes the following statement:

> At the present time it is estimated that 4 barrels of oil are equal to 1 ton of coal, and the expense of handling the same is so much less that 3 barrels of oil are nearly equivalent to a ton of coal. As the development of the oil fields continues the price of oil will be reduced, and unless the present price of coal can be greatly reduced coal will cease to be a factor in our manufacturing industries.

This statement probably overestimates the industrial importance of the development of the oil fields of southern California, nevertheless the opening of them has resulted in an extensive substitution of oil for coal. The oil is not adapted to lighting purposes, but makes a good fuel.

The foregoing facts indicate that under the existing conditions of transportation and competition the coal needs of the west coast of the United States and Canada will be drawn mainly, and within a few years almost entirely, from the fields near Puget Sound. The steamers of the north Pacific, excepting such as make the trip to Australia, will draw their chief supply from the same section. Will the opening of an isthmian canal enable the coal of the eastern and southern portion of the United States to enter the west coast markets of our country? Will this coal from east of the canal be able to compete with the Puget Sound product in the markets of the tropical and southern sections of the Pacific? In order to answer these questions it will be necessary first to inquire into the prices at which Puget Sound coal can be sold in Pacific markets, and then to examine the present and probable future costs of delivering our eastern and southern coal at tide water, and to take account of the methods that will probably prevail in the transportation of coal from the eastern and southern mines to the vicinity of the canal and beyond, when that waterway shall have become available.

PRICES AND COSTS OF COAL IN DIFFERENT SECTIONS OF THE UNITED STATES.

The prices of coal on the Pacific coast range higher than the prices of similar grades in the Atlantic ports. In the Puget Sound cities near the mines "good steam coals" range in price from $2.25 per gross ton for the lower grades to $3.25 per gross ton for the better qualities, free on board vessels. Vancouver coal sells for $2.50 to $3.50 per ton, according to quality, in the British Columbia coaling stations. Portland and Astoria secure their coal from the Washington mines at a cost, delivered, of $4.50 to $5.25 per ton. The authority for these figures is the general manager of a steamship company doing a large coasting business, and he also states:

> San Francisco uses, for household purposes, a large quantity of Washington lignite coals and British Columbia bituminous house coal. For steam purposes the British Columbia and Washington bituminous coals are used. rates ranging from $4.80 to $5.50 per gross ton at the wharf.[a]

Another authority says:

> The San Francisco prices are variable. Steam coals from Washington will vary from $5 to $6 per ton; from Vancouver Island from $5.50 to $7, and from Australia from $5.50 to $7.50 (gross tons in each case).

The same gentleman reports that the price paid by a San Francisco firm, whose business requires a large amount of coal, ranges from $4.75 to $5.25, delivered from the ship. This coal ordinarily comes from the Puget Sound mines in Washington.

The superior quality of the Comox and other British Columbia coal enables them to command a somewhat higher price than the Washington product, but the Washington mines, probably on account of our tariff of 67 cents a ton on bituminous coal, have been annually securing a larger percentage of the coal business of California and Oregon. The imports of the British Columbia coal into California have remained about constant during the last six years.

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[a] The unavoidable use of both long and short tons in this discussion may be confusing. Bituminous coal from Pennsylvania and West Virginia and Virginia is sold in the Atlantic ports by the ton of 2,240 pounds; in the Gulf ports by the ton of 2,000 pounds. On the west coast coal prices are quoted on the ton of 2,240 pounds.

The prices just cited are probably not the lowest ones possible in the future. When the market shall have become larger, when new mines shall have been developed, and those now in operation shall be worked on a larger scale, and, what is most important, when the means of land and ocean transportation shall have been improved, enlarged, and cheapened, the Puget Sound mine operators can doubtless deliver coal in California and elsewhere considerably cheaper than at present. It is the belief of one competent to speak that—

> The foreign sources of supply are becoming less important to us (California) with the development of northern mines, and the day is not far distant when the northern capacity will be equal to the entire demand. At the moment it would seem to be a question of miners and water transportation, for certainly the northern coals can be laid down here at a cost so far below that of coals from Great Britain and Australia as to overcome any possible difference in quality.

The coal exported from the eastern half of the United States will be taken mainly from two sections, the Pennsylvania and West Virginia fields in the Upper Ohio Valley and the mines in north central Alabama. The coal from the Upper Ohio Valley section is shipped by rail to the several North Atlantic ports, where it is sold in large amounts to industrial plants and ocean vessels, and whence a limited quantity is now exported to foreign countries for naval and industrial purposes. In the handling of coal, both for domestic coast-wise distribution and for foreign export, Norfolk and Newport News have some advantages over the Atlantic ports north of them, because of the exceptionally high grade of the coals handled and the spacious and inexpensive terminal facilities possible in their harbors, which are also, because of their nearness to the ocean, convenient stations for vessels desiring to coal.

The railway haul from the mines to Baltimore and Philadelphia is somewhat shorter and more economical than to Norfolk and Newport News, but the disadvantage of the longer railway distance to the ports at the mouth of the James is counterbalanced by the closer proximity of those cities to the sea and their central situation on the Atlantic coast.

The Ohio River is another route used for the shipments of large quantities of coal from Pennsylvania and West Virginia. The coal sent down the Ohio is mainly destined for Cincinnati and other Ohio River points, but a considerable share of the total is distributed along the Mississippi, about 3,000,000 short tons reaching New Orleans each year. The distance from Pittsburg to New Orleans by river is about 2,200 miles, and, as will be shown presently, it is the extraordinarily cheap transportation which this river navigation makes possible that will in the future give importance to the Upper Ohio Valley as a coal-exporting section of the United States.

The city of Birmingham, in the Alabama coal and iron district, is about 260 miles by rail from Mobile and Pensacola and 350 miles from New Orleans. The deposits are rich, the costs of mining are comparatively low, and the distance to good tide-water harbors is short.

The prices of coal have recently been high on account of the almost unprecedented industrial demands of the past two years. In September, 1900, two members of the Isthmian Canal Commission had a conference in Pittsburg with persons shipping large quantities of coal down the Ohio and Mississippi rivers, and the price at which bituminous coal was then selling in New Orleans was found to be 39 cents a bushel, or $4.32 a ton of 2,000 pounds. It was also stated by a prominent coal merchant that $3.50 a short ton in New Orleans would be as low a price as would be accepted at that time even on a contract calling for the delivery of a large quantity. In reply to an inquiry addressed to the secretary of the New Orleans Board of Trade in July, 1900, the response received was:

A large dealer here advises that $3.50 per short ton would about cover cost of Pittsburg coal, and Alabama would be about the same.

The same inquiry was made of the general freight agent of one of the Gulf railroads, and his reply, under date of July 10, 1900, was:

I have addressed dealers in coal asking for their prices free on board vessels Pensacola and Mobile for export. I am quoted on coal free on board vessels at Pensacola $2.60 per ton of 2,240 pounds, and at Mobile $2.35 per ton of 2,000 pounds ($2.64 per long ton).

There is no export business moving through New Orleans, nor has it moved that way for some time, but the cost of coal free on board vessels at New Orleans would probably be at least 75 cents per ton higher than to Mobile and Pensacola.

The price of coal for local use was considerably higher at that time, because the railway companies regularly make a large rebate in their rate when the coal handled is exported or sold to vessels other than tugs or local harbor crafts. The export price for the best Pocahontas coal in October, 1900, was $2.50 per 2,240 pounds. The bunker price of that coal was then $3.10 per long ton trimmed in bunkers. At the same time the price of bituminous coal in vessel cargo lots at Philadelphia was $2.30 per gross ton. The price paid by local manufacturers was $3.75 per long ton.

The prices just quoted are so much above ordinary charges that it was necessary for the accomplishment of the purposes of this investigation to inquire what price conservative business men considered would, under existing conditions of transportation, cover the costs of mining and delivering the coal at the seaboard, including adequate business profits.

Pittsburg firms mining and shipping coal by rail and by river state that the price of the coal at that section need not average over $1 per short ton on the barges in the Monongahela River, and that under the present conditions of Ohio River navigation a rate of $1 per short ton would yield a good profit to the vessel men for transporting the coal from Pittsburg to New Orleans.

One of the Pittsburg firms doing a large business in mining coal and shipping it down the Ohio and Mississippi rivers prepared the following detailed statement of the cost of mining coal and getting it to New Orleans. The items are not estimates, but are the costs actually incurred. The word "ton" means 2,000 pounds:

One ton, mine-run coal, f. o. b. works	per ton..	$0.75
Expense of transporting same to Pittsburg	do....	.10
Transporting from Pittsburg to Louisville	do....	.20
Transporting from Louisville to New Orleans	do....	.37
Cost of boat containing coal	do....	.70
Total cost of coal and boat at New Orleans	do....	2.12

Only about 30 per cent of the coal barges or flats sent to New Orleans are brought back; the remaining seven-tenths are sold as rough lumber mainly to the planters. According to the above statement the purchaser of the coal is charged 70 cents per ton of coal for the boat containing the coal. The firm that submitted the statement accompanied the list of costs with the following explanation:

In the event that we want the boat back after having been unloaded, we buy it back from the customer at a very low price, thus enabling us to get the boat back home with a profit to us.

The cost of coal in New Orleans is the same, whether the barge be towed back to the coal mines or not.

This statement as to the cost of coal on the barges seems to be corroborated by the fact that the price of Pennsylvania bituminous at the mine has, according to the reports of the United States Geological Survey, averaged 76.4 cents during the past decade. The testimony of the above-mentioned firm and of other Pittsburg coal merchants is that Pittsburg coal could be delivered with profit in large quantities on board vessels in New Orleans at a total charge of $2 to $2.25 per short ton, or $2.50 per ton of 2,240 pounds.

In Birmingham, Ala., the committee of the Commission was informed in September, 1900, by the vice-president of one of the large mining and transportation companies that Alabama coal could be profitably sold at that time, free on board vessels at Gulf ports, at $2.50 per short ton. That this estimate was a liberal one is proven by the fact that for the last ten years the average price of Alabama coal at the mines has been 96 cents, and that at the time the committee visited Birmingham the railroad freight rate on coal for export from the Birmingham district to Mobile, including "the cost of placing the coal into the ship's hold at the coal chute," was $1.10 per ton of 2,000 pounds.

In 1898 the average mine cost of Alabama coal, as a whole, was only 75 cents, according to the report of the United States Geological Survey, and in Jefferson County, where 57 per cent of the total production of the State originated, the average mine cost was but 69 cents per ton of 2,000 pounds. The railway charges in 1900 were generally higher than they were in previous years, and more than they need to be in the future for the conduct of a larger volume of traffic according to the most improved methods. Indeed, the export rate on pig iron from Birmingham has been $1 per ton. In view of these figures and of the testimony of several Alabama men engaged in the transportation and mining business, it would seem certain that coal from the Birmingham district can now be sold free on board vessels at Mobile and Pensacola for $1.75 to $2 per short ton ($1.96 to $2.24 per long ton).

Under the present conditions of mining and transportation the North Atlantic seaboard price of bituminous coal free on board can be placed at $2.25 to $2.50 a long ton, or $2 to $2.25 a short ton, depending upon the quality of the coal and the ports through which it is handled.

Briefly stated, it appears that the price of bituminous coal, under existing conditions of transportation, may be expected to be somewhat higher on the North Atlantic seaboard than in the Gulf ports of Pensacola and Mobile; and that in the New Orleans market the Upper Ohio Valley coal will normally range about 25 cents above the price of Alabama coal in Pensacola and Mobile. In respect to the quality, however, the coal from the Pittsburg section is somewhat superior to that from Alabama, the difference probably being sufficient to offset the greater price of the more northern product. Speaking generally, the mine operators of the eastern and southern parts of the United States could now offer bituminous coal for export for $1.75 to $2.25, or at an average price of about $2 a short ton.

RIVER TRANSPORTATION OF COAL FROM PENNSYLVANIA, WEST VIRGINIA, AND ALABAMA.

The Ohio River traffic is a matter of such importance in connection with this discussion of the exportation of American coal to and beyond the isthmian canal that a brief description ought perhaps to be given of the manner in which the coal transportation is now conducted on the river. The following statement of the methods of handling the coal traffic originating in the Monongahela River Valley is taken from a special report of the Chamber of Commerce of Pittsburg. After stating that the Monongahela River has been made navigable 102 miles above Pittsburg by means of nine locks and dams constructed and operated by the United States Government, and that the river flows through the center of rich coal fields, the secretary says:

> Three species of boats loaded on the Monongahela River for the Ohio River trade are used by the shippers, viz: Coal boats, drawing 8 to 8½ feet and carrying 1,000 to 1,100 tons; coal barges, drawing 6 to 7 feet, carrying 500 tons, and coal floats carrying from 200 to 300 tons.
>
> The tow boats usually bring from the mines about 3,000 tons of coal in small fleets, arranged for passing the locks conveniently. * * * At Pittsburg * * * the small coal fleets are moored while awaiting rises sufficient for navigation on the Ohio River. * * * When rises of 10 feet occur, or sufficient for 8-foot coal barges, fleets from 10,000 to 15,000 tons are made up for shipment to Cincinnati or Louisville.
>
> At Louisville, two, and sometimes three of the Pittsburg fleets are made up into monster fleets of from 35,000 to 40,000 tons and towed to New Orleans by powerful tow boats. A fleet conveying 40,000 tons covers about 10 acres.

The coal fields of Alabama lie along streams capable of providing navigation to Mobile for barges drawing about 6 feet of water; and these rivers, particularly the Warrior, which flows through the most productive coal deposits, are being improved by means of locks and dams. Coal can now be barged from a few miles above Tuscaloosa, Ala., through the Warrior and Tombigbee rivers to Mobile, and when the Warrior River improvements shall have been extended 45 miles farther to Jefferson County it will be possible to ship coal in barges carrying from 400 to 500 tons and drawing 6 feet of water directly from the mines to the Gulf. The barges can be constructed of the low-priced steel obtainable in the Birmingham district, and by means of them coal can be profitably transported to tide water for 50 cents a ton.

The coal barges now so extensively used on the Ohio and Mississippi rivers are made of wood. Some of them are strongly built, and after discharging their cargoes are towed back to the mines for reloading. A large share of the coal barges (70 per cent of those used for shipping coal to New Orleans) are constructed as cheaply and fragilely as possible, and, as was stated above, are sold for rough lumber in or near New Orleans. That these types of barges will be used a decade or fifteen years hence seems improbable in view of the increasing costs of lumber and the present and declining costs of steel. The pressed steel car is rapidly displacing the wooden one for railway coal traffic, and it is rational to expect that wood will give place to steel in barge construction.

Steel river barges with a draft of 6 to 10 feet and a capacity of 500 to 1,000 tons will have the added advantage of being strong enough to be towed on the Gulf and Caribbean. By means of them coal can be shipped directly from the Pennsylvania, West Virginia, and Alabama mines, not only to the Gulf ports, but also to the coaling stations of the West Indies, Mexico, and Central America, including the important stations that will certainly be established at the termini or along the line of the canal.

It is possible the opening of an isthmian canal will lead to the use of a special type of river barge for handling coal for export. A barge capable of drawing 15 to 20 feet of water might be loaded to a draft of 9 feet at the mines, to a draft of 12 feet at Louisville, and for six months of the year to 15 or 20 feet at Vicksburg. Barges of this size and type, could, of course, be towed through to any desired seaport, American or foreign. The suggestion that such barges might be used was made by a gentleman who has had large experience in shipping coal down the Ohio. Under these conditions of transportation coal costing $1 per short ton free on board at the mine could be sold in Panama, Greytown, and other Caribbean or Gulf ports for $3 or less per ton. American coal at $3 a ton of 2,000 pounds in these ports will not only hold the market against all foreign competition, but will be so much less expensive than the price at which coal can be obtained along the Suez Canal route as to give the American route a strong commercial advantage resulting from the possession of cheap coal for steamers.

In 1900, when the prices were abnormally high, coal was selling from $5.83 to $8.63 a gross ton under yearly contracts along the Suez Canal route, the price increasing with the distance from the British mines. The following average contract prices of coal have prevailed during each of the past five years at the more important stations along the Suez route, the figures having been obtained from a large coal merchant of London by the London representative of an American firm of shipbrokers.

Contract prices in shillings and pence for the past five years.

[London, e c., October 31, 1900.]

Coal port.	1896.		1897.		1898.		1899.		1900.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
Colombo	22	6	29	0	26	6	29	0	35	6
Aden	25	6	([a])		([a])		34	0	36	6
Port Said	16	6	18	0	19	6	23	0	26	0
Malta	15	6–16	15	6–16	18	0	22	0	24	0
Algiers	15	6	15	6	18	0	22	6	25	0
Gibraltar	15	6	15	6	17	0	21	6	24	0

[a] No contracts.

NOTE.—The above are prices at which contracts were made with the principal shipowners for the years named, and do not show variations in "current" prices that occurred from time to time. All large shipowners contract; therefore the variations in the respective "current" prices do not affect them. The contract prices in the autumn of 1900 at Port Said were 26s., but current prices there were 40s. The contract prices for 1901 were higher than those for 1900.

"During the years 1896 and 1897," according to the London informant, "the Welsh coal market was quiet and freights were much lower than for the past two years;" but even during those years the coal costs along the Suez route were higher than the probable future cost of coal in the stations of the West Indies and the Caribbean. Moreover, every indication points to increasing rather than diminishing costs of coal in Europe, and the future prices of European coal in the Mediterranean, Red, and Arabian seas can hardly be expected to be so low as they have prevailed in normal times in the past.

CONCERNING THE MARKETING OF APPALACHIAN COAL WEST OF THE CANAL.

Well-informed men engaged in mining and shipping coal testified in September, 1900, that the freight rate would then be about $3 per ton for shipping coal 5,000 knots in chartered vessels. Assuming a tide-water price of $2.50 per gross ton, a canal toll of 45 cents per cargo ton (this would be about equal to $1 per vessel net register), and a freight rate of $3 a ton, coal from the mines east of the Mississippi River would have sold for about $5.95 a long ton in 1900 in California, Hawaii, and the east coast of South America. This price of $5.95 is not suggested as the probable price of Eastern coal in Pacific markets after the opening of the canal, but it has some value, inasmuch as it represents a maximum, and shows what would be quoted were the present conditions as regards costs of coal and transportation to prevail.

After the canal has become available coal can be shipped through it to Pacific ports either as ballast, as berth, or part cargo freight, as full cargo shipments in chartered vessels, or in towed barges. The rates for part cargoes or berth lots will in all probability be so high as usually to preclude shipments of that character, but there will be a large amount of steam vessel tonnage going in ballast or with light cargoes westward through the canal for the Chilean nitrate, the Hawaiian sugar, and the grain and lumber of the west coast of the United States and Canada. Such being the case, there will naturally be more or less coal carried as ballast to those ports of the Pacific and at a very low freight rate. Moreover, vessels may be owned or chartered by coal companies for the purposes of taking westward full cargoes of coal and bringing eastward nitrates, sugar, grain, or lumber.

It is furthermore probable that the steel barges described above, if they are adopted for river traffic, will be towed with their cargo through the canal to Central American and west South American ports within a thousand miles of the canal. The smooth water of this part of the Pacific coast will be favorable for towing, and there will be economy in shipping direct from the mine to the Pacific port without transfer of cargo.

In view of these favorable facilities for the transportation of coal westward it would seem conservative to expect the freight costs of sending coal from the Gulf ports and the Atlantic ports of Norfolk and Newport News to points 5,000 knots distant—that is, in general terms, to northern Chile, Hawaii, and our west coast—will be as low as $2 per ton of 2,240 pounds, and possibly less in exceptional cases. The foregoing estimates regarding the cost of coal were that, with the existing transportation agencies, coal can be sold at tide water on the Atlantic and Gulf for an average price of $2 per gross ton, and that the costs of shipping coal to the Gulf will probably be less in the future than they now are. Assuming that the cost of coal at Gulf and Atlantic ports will at the time of the opening of the canal range from $1.50 to $2.25 per gross ton (depending upon the quality of the coal, the port of shipment, and the conditions of the market), that the ocean freight will be $2 per ton, and the canal tolls 45 cents per cargo ton, the cost of delivering Pennsylvania, West Virginia, and Alabama coal in the ports of the west coast of the United States, Mexico, Central America, South America as far south as northern Chile, and the ports of Hawaii will be from $3.95 to $4.70 per ton of 2,240 pounds. Having made this detailed inquiry concerning the present and probable future costs of delivering Appalachian coal at the Atlantic and Gulf seaboards and the cost of shipping this coal to Caribbean ports, it is now possible to consider whether and to what extent the Puget Sound coal and that from the eastern third of the

United States will compete in Pacific markets, particularly in California.

In the earlier part of this chapter the present prices at which Puget Sound coal was selling in California and Oregon were given. Those prices can doubtless be reduced during the coming ten or fifteen years. According to the annual report of the United States Geological Survey, the average cost of Washington coal at the mines was $1.78 in 1899, and for the ten years ending in 1899 the average was $2.16 per short ton. As the supply of labor becomes greater, and when the mining operations are conducted on a larger scale, the wages of labor will be somewhat lower and the total cost of mining will be less per ton; how much it is impossible to say. Possibly $1.50 per short ton would be a fair estimate. An average railway rate from the Washington mines to the seaboard of $1 a ton is as low as may be expected.

These estimates would make the average cost of Washington coal at the seaboard $2.50 a short ton or $2.80 a ton of 2,240 pounds, except for the coal from those mines close to the seaboard, which could sell their product at a lower price because of the cheap railway haul. As was stated above, the prices of coal in the year 1900 in Puget Sound cities ranged from $2.25 to $3.25 per gross ton. The Vancouver coal cost $3.50 per ton on an average in the British Columbia coaling stations. The ocean freight rates in 1900 were high, and this accounts for differences of $2.50 to $3 per ton then prevailing between the Puget Sound and San Francisco prices. It would seem that $1.50 per ton would ordinarily be a remunerative ocean rate to San Francisco and also to Hawaii. On the basis of these estimates a possible future price of $4 a gross ton for Washington coal in California and Hawaii may probably be predicted. British Columbia coal will be obliged to pay the tariff of 67 cents unless the existing law is changed. These estimates are based on too meager data to make it safe to accept them as being closely accurate, but they are probably approximately correct; and, if they are, they indicate that Puget Sound coal will be sold in California and Hawaii at from $4 to $5 per long ton by the time the isthmian canal shall have been opened. To Central and South American ports the freight rates would doubtless be 50 cents a ton more than the California and Hawaiian points and a selling price of from $4.50 to $5.50 per ton of 2,240 pounds would need to be predicted.

The conclusions to be drawn from these estimates regarding the prices at which Appalachian and Puget Sound coal can be sold in the Pacific markets are that the Appalachian coal will doubtless have an advantage over that from Puget Sound in Central and South American ports and that in California and Hawaii the two coal-producing sections will be active competitors; the Puget Sound mine owners will apparently be able to sell at a somewhat lower price than their Eastern rivals can afford to accept, but the producers of the Eastern and Southern States will have an article of slightly better quality to offer. The two chief reasons why the Appalachian coal can compete in the markets so near Puget Sound are the lower mining costs in the East and the exceptionally cheap transportation that will be available from the Appalachian mines to the seaboard and from the seaboard west, both in steel barges and in vessels seeking the Pacific coast for the eastbound cargoes of lumber, grain, sugar, and nitrates.

The general conclusions to this investigation of the probable sources of the future coal supply for the commerce and countries of the Pacific, and of this inquiry into the effects which the isthmian canal will have upon the coal trade of the United States are:

1. That the coal consumed for commercial and industrial uses on the west coast of the American continents, in Hawaii, and in the coaling stations of the eastern half of the Pacific Ocean will be supplied in the future mainly from the mines of the United States and Canada, unless the opening of the Chinese mines should revolutionize the coal trade of the Pacific. It is not probable that coal from the Orient or Australia will in the future be sold on this side of the Pacific. In this case, however, China is, as usual, the uncertain and indeterminable factor.

2. The isthmian canal will enlarge the export markets for American coal both by creating a demand for coal in Gulf, West Indian, and Central American stations to supply the steamers that will be engaged in our own and Europe's commerce through the canal, and also by opening in the Pacific ports of the American continents a coal market that is now important and which is certain to grow. We shall secure the larger share and probably nearly all of a coal trade that is now possessed by Great Britain and Australia, and the industrial progress that will result from the use of the canal will add to the volume of that trade.

At the present time the United States occupies an unimportant place as an exporter of coal to foreign countries other than Canada and Mexico, and while this promises to become less true in the future as the cost of our coal declines and that of the British product rises, and as the purchases of our high-grade steaming coal by foreign governments for their navies occur more frequently, nevertheless British coal producers will continue to have the great advantage which they now possess of abundant facilities for shipping their coal to all parts of the globe. The volume of Great Britain's total imports is so much larger than the volume of her exports that a large number of vessels are regularly obliged to start in ballast from the United Kingdom on their outbound voyages.

This enables the coal exporters of that country to secure very low rates to distant and widely scattered foreign markets and accounts for the fact that the foreign coal shipments from Great Britain have averaged 35,000,000 gross tons annually for the past five years.

While the total exports from the United States will continue to be more bulky than our imports, there will be a large tonnage movement westward through the isthmian canal of vessels with part cargoes or in ballast, and the canal promises to develop an important foreign and domestic market for American coal. The ability to distribute the excellent coal of the United States extensively among the countries of the Caribbean Sea and the Pacific Ocean will be of great benefit to the industries and commerce of those countries, and will redound to the advantage of our naval, maritime, and industrial interests.

Chapter VII.—*The isthmian canal and the iron and steel industries of the United States.*

The United States holds first place among the countries of the world in the amount of coal and iron ore mined. In 1899 three-tenths of the world's total output of iron ore and 32 per cent of the total coal supply were produced in the United States, and the production of both of these minerals is being increased rapidly, not with the prospect of exhausting a limited supply of raw materials, but by drawing upon abundant resources that have but recently been put under requisition.

In no other country has the increase in the amount of iron ore mined been so rapid as in the United States. Great Britain is now mining no more iron ore than she did thirty years ago. Germany, including Luxemberg, ranks next to our country in the amount of iron ore produced, and the production has developed rapidly during recent years; but although the German output was 18,000,000 tons in 1899, a large quantity of ore had to be imported, and the amount of pig iron turned out by German furnaces was barely two-thirds the pig-iron product of the United States, whose productions of iron equaled 13,620,703 tons of pig and 25,000,000 tons of ore.

THE UNITED STATES AS AN EXPORTER OF IRON AND STEEL PRODUCTS.

Iron and steel and their manufactures now constitute the fourth largest class of exports from the United States, breadstuffs, raw cotton, and provisions being the only categories having a greater value. For the year ending June 30, 1900, the values of these commodities were—

Breadstuffs	$262,734,026
Raw cotton	241,832,737
Provisions, meat, and dairy products	184,431,716
Iron and steel, and manufactures of	121,858,344

The growth in the exportation of iron and steel in crude and manufactured form has been very rapid during the past four years. In 1896 the total value was but slightly more than one-third of that of 1900. This rapidly growing trade is widely distributed, the most promising markets being in North and South America and the Orient. Of steel bars and rails British North America, Japan, and Asiatic countries were large buyers. Builders' hardware, saws, and tools found 45 per cent of their market in Europe, but Australia was also a large purchaser. Wire is very widely distributed. Electrical machinery, printing presses, and pumping machinery have been sold mainly in Europe, and also in the colonies of European nations. Our best foreign markets for locomotives are Japan, Canada, Mexico, Brazil, and Russia. American producers are finding their way into the markets of all parts of the world.

Among the letters received from the manufacturers of iron and steel was one from a firm whose plant is on the Atlantic seaboard. This firm reported, among other things:

> At present 25 to 30 per cent of our products are exported. We expect, however, by reason of our location at tide water, to constantly increase this proportion and ultimately export from 50 to 75 per cent.

In the year 1899 the capacity of this firm was about $10,000,000 worth of products per annum. At the time this letter was written the firm was filling a foreign order for 70,000 tons of rails for the trans-Siberian railway, and also an order for 30,000 tons of rails received from the government of Victoria, Australia. A Philadelphia firm shipped two full vessel cargoes of locomotives to China and Siberia in 1898, one full cargo in 1899, and another shipload in 1900, 156 in all, sent out in two years.

A firm in the eastern part of Pennsylvania reported:

> We shipped 3,000 tons of plates to Australia early this year, and similar quantities to various points, especially to China and Japan. * * * We shipped many thousands of tons to the Pacific coast, a part of which goes to New Orleans and thence overland. Some goes by way of Panama and some around Cape Horn.

A firm manufacturing $750,000 worth of files and rasps, one-third of which is sold outside of the United States, reported:

> We have lately developed a constantly growing business in all the Eastern countries, Japan, China, and the Straits Settlements. We are also selling to some extent on the west coast of South America.

One of the largest manufacturers of bridge material in the United States reports:

> Business is developing throughout the world, having sold bridges for many years to South American countries, and lately to China, Japan, and Russia. Probably 10 per cent of our present business is for export, with every evidence of large increase in the future.

Examples of this nature might be given in large number. The foregoing, however, are sufficient to illustrate the truth of the general proposition that the present exportation of iron and steel products from the United States, although large, is but the beginning of a rapidly increasing business that is certain to assume great proportions. The great iron and steel manufacturers of Pittsburg, Cleveland, and Birmingham expect this, and a visit to their great establishments and an inspection of their methods of manufacturing and distributing their products will convince any observer that the feelings of these manufacturers are well founded.

THE CONDITIONS OF PRESENT COMPETITION OF THE UNITED STATES WITH EUROPE.

The chief competitors that the United States must meet in exporting iron and steel manufactures are Great Britain, Germany, and Belgium. In selling for delivery in Europe we are at a disadvantage as regards costs of transportation, and must expect to overcome the handicap, if at all, by being more inventive and by introducing more economical processes of production than are employed by our rivals; that is, by making a better article at a lower cost of manufacture.

That we are now able to sell many manufactures of iron and steel and even pig iron in Europe shows that great progress has been made in the United States in reducing the expenses of production; indeed, we are able to enter all markets where the competitor does not have a decided advantage in lower costs of transportation. The cost of manufacturing iron and steel is lower in most of the centers of production in this country than in Europe, and the expenses are certain to decrease during the coming ten or fifteen years. The continuation of the present rapid growth in our foreign sales of iron and steel products is essentially a question of securing cheaper transportation, and especially to South American and trans-Pacific countries.

Most foreign countries, however, can be reached more economically under existing conditions by European producers than by American. Not only the west coast of South America, but also the east side of that continent south of the equator can at present be reached more cheaply from western Europe than from the iron-producing sections of the United States. The Suez Canal has brought Europe nearer than the United States is to the East Indies, Australia, China, Japan, and oriental countries generally; and until the American canal route becomes available American manufacturers and exporters of iron and steel and other articles will find their lower costs of production largely offset by the greater expenses of transporting their commodities to these promising foreign markets.

AMERICAN IRON AND STEEL TRADE WITH PACIFIC COUNTRIES.

The isthmian canal will affect the iron and steel industries of the United States chiefly by lessening the time and expense of reaching the Pacific markets of our own and foreign countries. These are the markets in which Europe and America will strive for supremacy, and the prize is worthy of zealous effort. Though now at a disadvantage in the competitive struggle for this trade, the American producers have already secured a desirable trade. The direct exports of our iron and steel products to foreign Pacific countries in 1900 were as follows:

Chinese Empire	$822,074
Japan	5,460,205
British Australia	7,386,358
Chile	655,935
Bolivia	23,006
Ecuador	292,314
Peru	495,411
Total	15,135,303

The principal exports from the United States to Pacific countries are and will be breadstuffs, lumber, raw and manufactured cotton, petroleum, and iron and steel products. The exportation of the last three of these five classes of commodities will be facilitated by the canal; and in the case of iron and steel products, which have to meet a specially strong competition from Europe, the isthmian waterway will be of great assistance to American exporters. The table indicates that the canal's influence will be exerted where important results are possible. The total exports of iron and steel products from the United States in the year ending June 30, 1900, amounted to $121,858,344, and the exports of those commodities to Pacific countries comprised one-eighth of the total.

THE MANNER IN WHICH THE ISTHMIAN CANAL WILL AFFECT THE AMERICAN IRON AND STEEL INDUSTRIES AS A WHOLE AND THOSE OF THE SOUTHERN STATES IN PARTICULAR.

Iron and steel and the manufactures of them being heavy commodities, with a relatively low value per unit of weight, they constitute a class of traffic for which water transportation is especially well adapted. They will naturally seek the canal route to Pacific markets. The future exports of iron and steel will be sent out both from the Southern States and from those north of the Ohio and Potomac rivers. Of the iron ore mined in 1899, 19 per cent, or 4,800,000 tons, were taken from the mines of the Southern States; 72.6 per cent came from the Lake Superior region, and 8.4 per cent from other States.

The Southern States have special advantages for the manufacture and exportation of pig iron because of the juxtaposition of the coal, iron ore, and limestone, and the comparatively short distance of the furnaces from the seaboard. In shipping pig and other forms of iron to our Western States, the Hawaiian Islands, and the Pacific coast of Central and South America, by way of an isthmian canal, the Southern producers and the Gulf seaports will have the advantage of being nearer the canal than the producers in other sections of the United States will be, and this will probably give the Southern mines, furnaces, and mills a large share of the iron and steel export trade to Pacific markets. The Northern producer will, however, by no means be debarred from successful competition, because the North Atlantic ports will have a greater volume of shipping and trade with the East than the Southern ports will have, and consequently more abundant facilities for dispatching their exports.

The iron and steel manufacturers of this country anticipate a large foreign trade with Pacific countries. An ironmaster of Birmingham, Ala., states:

> The canal would open to this district a demand for pig iron from the Pacific coast, including South America, now filled from England because of the absence of freight communications from Birmingham, which could otherwise supply it more cheaply. It would open up a demand for pig iron in Honolulu, Japan, China, and Australia, which would then be supplied to them more cheaply than from European markets. It would open up a demand in the last-named countries for cast-iron pipe, which at present is largely supplied from Belgium, which could then be more cheaply supplied from this district.

In Pittsburg the iron and steel manufacturers, who already ship extensively to Pacific markets, believe that the present business could be much increased by the use of an isthmian canal, and a special report prepared for the canal commission by the chamber of commerce of that city lays stress upon the possibility of exporting from the section of which Pittsburg is the industrial center large quantities not only of iron and steel products but also of coal, glass, petroleum, and pottery. In Cleveland, Ohio, one firm engaged in the manufacture of relatively high-priced iron and steel products in that city and elsewhere reported in 1900 that it was shipping annually to foreign Pacific markets 77,000 net tons, and was doing a large business with the west coast of the United States, the amount of which was withheld for special reasons. Another firm having headquarters in Cleveland and doing an annual business of over $21,000,000 in mining iron and coal and manufacturing pig iron informed the committee of the canal commission that—

> The opening of a canal across the American isthmus would prove of very great benefit to the iron and steel industries to whom we sell our raw materials—hence of great benefit to us. The development of trade in the Orient promises a large volume of business to the iron and steel industries of the world. With a canal the United States should, and in our judgment would, control this trade.

From the reports prepared for the commission by the commercial organizations of Pittsburg, Cleveland, and Birmingham it is believed that these statements of large iron and steel manufacturers in these cities represent the views held by practically all of those interested in the iron and steel industries of the United States.

CHAPTER VIII.—*The canal and the shipbuilding and maritime interests of the United States.*

The shipbuilding industry and the merchant marine are of great importance to the industrial, commercial, and naval welfare of our country. There are few industries of equal magnitude that require a larger number of auxiliary business activities, that employ so large a force of skilled labor, and that do more to call forth inventive genius. The permanent strength and efficiency of our merchant marine and our Navy are dependent upon our having well-equipped yards, owned by trained builders with inventive capacity. However much men may differ as to the policy to be adopted for building up our merchant marine, they are agreed as to the necessity for having a well-developed shipbuilding industry.

The desirability of having a large merchant marine under the American flag is also generally acknowledged. "The more facilities the more business." The existence of a greater number of vessels connecting our leading seaports with various parts of the world would be of assistance to us in developing our foreign trade. It is possible to secure a moderate amount of trade with a distant section of the world by depending entirely upon chartered vessels, but much more can be accomplished with the aid of regular lines of ships. The regular liners are needed not only for the passenger and mail services between our own and foreign countries, but also for carrying on trade at scattered points where the business is not large enough to warrant the use of chartered steamers. In building up our trade with the Far East, and with South America, we need lines of vessels as well as chartered ships. Neither agency is sufficient by itself.

The value of a large merchant marine as a training school for the Navy, and as a source from which to draw both men and vessels when a sudden expansion of the naval fleet becomes necessary, is a fact recognized in the naval and maritime policy of many countries.

THE CANAL AND SHIPBUILDING.

The isthmian canal will operate as has the Suez Canal, and hasten the change from sail to steam power in ocean commerce. By doing this the isthmian waterway will modify both the shipbuilding and the ship-operating industries. Inasmuch as few, if any, steamers will be constructed with wooden hulls, the canal will necessitate a larger and earlier reorganization than would otherwise occur in many of the shipbuilding plants now employed in constructing wooden vessels. This change from wooden to steel vessels may be a burden to some builders, but the country as a whole will be benefited.

One sure result of the opening of an isthmian waterway will be a larger coasting trade between our two seaboards. A larger coasting fleet will be required, and the vessels for this fleet must be built in American yards. The coasting fleet engaged in traffic through a canal will consist mainly, if not entirely, of steamers.[a] A part of our present coasting vessels will doubtless use the canal, but it is probable that a large number of ships will be built especially for the long-distance traffic that will be carried on through the canal. Most of them will be comparatively large ships, and will be freight vessels of the most modern design. The use of steel barges on the Ohio, Mississippi, Warrior, and other rivers promises to enlarge the demand for those vessels, and they must be constructed in American yards. Likewise an increase in the exports of iron and steel products will necessitate the

[a] Consult following chapter on "The use of the canal by sailing vessels."

handling of more ore on the Great Lakes, and thus add to the tonnage of vessels constructed.

In securing data for the discussion of the effect which the canal would have on the shipbuilding and maritime interests of the United States a circular letter containing six inquiries was sent to the American firms building and operating ships. Replies were received from forty of the persons addressed, and in most of the communications received each question was carefully answered. One of the interrogatories was, Will the opening of an isthmian canal and the development of its traffic stimulate American shipbuilding? Will the larger demand for coasting vessels so increase the output of American yards as to enable shipbuilders to construct all ships more economically, and thus to compete successfully with foreign builders in the construction of vessels for the foreign trade?

Nearly all the responses to this query were in the affirmative. The general character of the answers may be illustrated by quoting from two of the letters; one received from an Eastern shipbuilder and the other from a west coast shipowner. The statement of the shipbuilder was:

> In my judgment the opening of the isthmian canal and the development of its traffic would stimulate American shipbuilding to the extent of an increased demand for vessels to be used in trade affected by said canal. As a rule increased demand develops increased sources of supply, and the cost of product is invariably reduced in proportion of increased business to fixed expenses of any manufacturing establishment, and therefore the canal would in this case tend to enable shipbuilders to construct ships more economically and more surely to compete with foreign builders.

The response of the shipowner was:

> The increased facility afforded for the transfer of American vessels from ocean to ocean in trading between American ports will call for an increased number of vessels, which undoubtedly will result in new shipyards being established (both for the building and repairing of our vessels), which could be called upon when needed for the construction of vessels to carry on our foreign import and export trade. We already know that structural steel has been produced in the United States cheaper than in any other part of the world, owing to the almost inexhaustible beds of iron ore in the region of the Great Lakes, as well as in other sections, and the skill and economy with which it is mined and worked. When we combine this advantage with the facility which will be developed by a large increase in our capacity for building coasting vessels, we see no reason why in the future ocean carrying vessels of the best class may not be built as cheaply here, if not already done, as in any other country.

The cost of building ships in American yards has declined largely during recent years with the fall in the prices of iron and steel and coal, and with the introduction of more economical processes of handling material and doing work. Most of the large American shipyards are new and are equipped with the most approved labor-saving machinery. The labor costs are said to be higher in American than in foreign yards, but whether the cost of labor per unit of work done is greater in the United States is hard to determine. In most lines of iron and steel manufactures the labor costs of production in the United States can hardly be higher than in Europe. For many commodities the labor outlay is undoubtedly less, and it is not probable that the labor costs of building ships in the United States will continue permanently higher than in Europe. It is, however, hardly to be expected that American builders can construct the small merchant tonnage now being built by them at as low a cost per ton of shipping as can the foreign builders. Ships are built by retail in this country and by the wholesale abroad. "The British shipbuilders build many vessels from the same plans, buying or making not only duplicate or triplicate parts, shapes, machines, etc., but like parts by the dozen or score."[a]

The tonnage now being constructed by the American builders is nearly all for the coastwise and inland commerce, from which foreign-built vessels are excluded—that is, for the home market. It is, however, probable that the American shipbuilding industry will repeat the history which other iron and steel manufactures have had during the past ten years. From importers of large quantities of iron and steel products we have become large exporters of them, and are now rapidly finding our way into new markets. The present vigorous growth of the shipyards in the United States is doubtless but an earnest of a much larger future output, that will supply not only the home market, but will find its way largely into the competitive field. The increase which will occur in our domestic water commerce during the coming decade, and particularly after the isthmian canal shall have been opened, will enlarge the tonnage built in our yards, tend to lower the costs of construction and to induce American builders to seek foreign markets for their ships. The increase in the number of vessels built will be accumulatively beneficial to American builders. A larger American fleet means more repairing in the United States, and this will be a valuable aid to our shipyards.

THE OWNERSHIP OF OCEAN VESSELS BY EXPORTERS.

During the investigation of the relation of the canal to the maritime interests of the United States some gentleman well versed in maritime matters expressed the opinion that a considerable tonnage was to be added to our merchant marine engaged in foreign commerce by the purchase and operation of vessels by the large American manufacturing concerns which are now rapidly developing a heavy foreign trade. Manufacturing for export is already largely concentrated in the hands of large combinations of producers, and some of these combinations now find their foreign trade so important that they are considering the desirability of providing themselves with ocean vessels. One of the largest firms of the United States stated in a letter to the Commission that—

> The export business of our company has grown to such a remarkable extent that we have found it impossible to rely upon the customary means of transportation for delivery of our goods. For some time past we have been chartering ocean steamers for varying periods of time, and have found it quite difficult to cover our requirements even by this method. The ships we have so far built for the lake trade are too large to pass through the present canals to the Atlantic, but we have used some boats, owned by other companies, by the Welland Canal route, and find this practicable. The matter of providing proper means of transportation for the future is a very important one; and while we have not as yet decided the question, we are seriously considering the building of our own ships.

A report has come to hand that this question was decided in the affirmative.

The Northwestern Steamship Company in April and May, 1901, inaugurated a service between Chicago and Hamburg and Liverpool. Four steamers were put into operation, each having a capacity of 3,566

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[a] Report of Commissioner of Navigation, 1900, page 33.

tons dead weight. Nineteen days will be taken for the voyage from Chicago through the Great Lakes, the St. Lawrence River, the Gulf of St. Lawrence, and across the Atlantic. The vessels are built in Chicago, and their cargo will consist of grain and the manufactures of that city and the country commercially tributary to it.

For reasons stated in another part of this report, it is believed that the exportation of coal from the United States is going to increase and that it will assume large proportions after the canal is opened. The exportation of iron and steel products from the United States is growing and is certain to increase. The large corporations engaged in mining and in the manufacture of iron and steel, as well as those in the lumbering business, will doubtless find that provision must be made by themselves for handling their water-borne foreign trade. To a considerable extent the vessels which carry the exported oil are owned by the manufacturers of the oil. A part of this exported lumber is handled by the men who manufacture the commodity. The heavy purchases of European vessels by American capitalists during the spring of 1901 was doubtless in part for the purpose of securing better facilities for handling the export trade. The purchasers are also largely engaged in manufacturing for export.

THE CANAL AND THE AMERICAN MERCHANT MARINE.

The ownership and operation of ocean vessels by the large industrial firms as a part of their business, which has now in many cases come to include the entire process of obtaining the raw materials, converting them into usable commodities, and placing them in the hands of the consumer, whether foreign or domestic, will, to some extent, solve the question of our securing a larger merchant marine owned by Americans. Whether these vessels owned by American producers will be sailed under our flag, or under that of some foreign nation, will be determined by forces over which the isthmian canal will have but slight influence.

Some of the vessels employed in the commerce between our Eastern seaboard and the trans-Pacific countries will doubtless desire to participate in the interoceanic coasting trade of the United States, and in order to do so they will need to have the American registry. The action of Congress in restricting the commerce of Porto Rico and Hawaii with the United States to American ships suggests that our trade with the Philippines may also be limited to the vessels flying our flag. Should Congress take such action regarding the Philippines, a considerable share of the commerce of our Atlantic and Gulf ports with Japan and China will be carried in American vessels, because such ships would be able to participate in both our Philippine and foreign trade.

Any benefit conferred upon our shipbuilding industry will indirectly aid in the enlargement of the tonnage of American vessels engaged in the foreign trade of the United States. If the American purchaser could secure vessels at home as cheaply as in foreign yards, one of the present reasons for registering his ships under the flag of some other nation would be removed. The future growth of the merchant marine under the flag of the United States will depend on numerous factors, some economic and some political. The construction of the isthmian canal will apparently affect that growth favorably.

CHAPTER IX.—*Concerning the use of an isthmian canal by sailing vessels.*

In order to reach intelligent conclusions regarding the use which sailing vessels will make of a canal, there are at least three questions that must receive consideration. The first general question is concerning the place which those vessels now hold in the commerce of the world and of the United States; the rate at which steam has been displacing sail tonnage in our own and foreign shipping during the past twenty-five years, and the commercial position which the sailing vessel will occupy fifteen years hence should the present tendency to substitute the engine for the sail continue to prevail. Another subject meriting careful inquiry is whether there are special classes of traffic, such as lumber, grain, nitrates, and unrefined sugar, which have found the steamer the more economical carrier. If there are commodities that can be freighted more cheaply by sail than by steam, are they articles that would naturally be carried through the canal? The third general question is whether an isthmian canal, either in Nicaragua or at Panama, is a waterway adapted to navigation by sailing vessels. Are the conditions of winds and currents that prevail at the approaches to the canal such as to enable the sailor to use the waterway; and if the route is possible for the sailing vessel, will the economies resulting from its use be sufficient to induce the owners of such ships to adopt the trans-isthmian route? In the discussion that follows these three general questions will be considered in the above order of statement.

THE PLACE OF THE SAILING VESSEL IN THE COMMERCE OF THE WORLD AND OF THE UNTIED STATES.

That the sailing vessel is giving place to the steamer, both on the high seas and in domestic waters, is a well-known fact, to the significance of which attention has been drawn on many occasions. The United States, however, having certain obvious advantages over other nations for the construction of wooden ships, has given up the use of sails more slowly than any other important maritime nation, with the possible exception of Norway. In the enormous traffic of our Great Lakes we have come to use steam almost exclusively, but this is not the case with our seagoing marine.

The report of the United States Commissioner of Navigation for 1899 contains tables showing the extent to which the world's seagoing sail tonnage has declined during the last quarter of a century, and the increase which has taken place during the same period in the world's seagoing tonnage. The tables are taken from the records of the Bureau Veritas. The table regarding the sail tonnage is as follows:

Seagoing sail tonnage.

Country.	1873–74.	1878–79.	1888–89.	1898–99.	Decrease from 1874 to 1899.
					Per cent.
Great Britain	5,320,089	5,596,018	4,215,634	2,910,555	45
United States	2,132,838	2,075,832	1,913,090	1,285,859	40
Norway	1,137,177	1,374,824	1,328,296	1,144,482	....
Italy	1,126,032	963,625	718,889	463,767	59
Germany	893,952	914,671	737,028	535,937	40
France	768,059	595,933	352,418	279,412	64
All others	2,807,689	2,796,521	2,370,934	2,073,757	26
Total	14,185,836	14,317,430	11,636,289	8,693,769	40

The world's seagoing tonnage declined 40 per cent during the twenty-five years from 1874 to 1899, and the decline in the tonnage of the sailing vessels in our merchant marine has proceeded pari passu with the change occurring in the world's marine. This table, however, presents only one side of the change that has been taking place. When we come to study the figures of the growth of steam tonnage, we find that the United States has fallen far behind her rivals. The following table presents the gross tonnage of the seagoing steamships of over 100 gross tons operated under the flags of the various maritime nations of the world. For purposes of comparison there are appended to the table the statistics of the tonnage of the steamships engaged in foreign trade under the American flag:

Seagoing tonnage of the world.

Country.	1873–74.		1878–79.		1888–89.		1898–99.		Increase 1873–74 to 1898–99.
	Tonnage.	Per cent.	Tonnage.	Per cent.	Tonnage.	Per cent.	Tonnage.	Per cent.	Per cent.
Great Britain	2,624,431	60.4	3,465,187	62.4	6,873,552	62.3	10,993,111	58.5	311
United States	483,040	11.2	609,101	10.8	535,345	4.8	810,800	4.2	68
France	316,765	7.4	335,219	5.9	752,028	6.8	952,682	5.1	200
Germany	204,894	4.8	253,667	4.5	662,331	5.9	1,625,521	8.3	693
Spain	138,675	3.3	152,708	2.7	395,685	3.5	520,847	2.7	275
Italy	85,045	1.9	84,421	1.5	276,326	2.5	420,880	2.2	395
Holland	72,753	1.7	116,149	2.0	197,748	1.8	363,200	1.9	399
Russia	67,522	1.6	104,702	1.8	163,556	1.5	358,415	1.8	430
Norway	41,602	.9	53,331	.9	160,558	1.4	628,493	3.3	1,410
Japan					115,088	1.0	439,509	2.3	
All others	293,466	6.8	420,690	7.5	913,720	8.3	1,773,674	9.5	504
Total	4,328,193	100.00	5,595,175	100.0	11,045,937	100.0	18,887,132	100.00	336
Atlantic coast	165,280		141,145		129,961		227,731		38
Pacific coast	20,451		20,010		57,144		131,953		545

The world's seagoing steam tonnage has grown from 4,328,193 gross tons to 18,887,132 gross tons, an increase of 336 per cent, during the twenty-five years. Our seagoing steam tonnage, however, has risen only 68 per cent, the percentage of increase being only one-third that of France, the nation next above us who are the lowest on the list. While we have been raising our maritime steam tonnage from 483,040 gross tons in 1874 to 810,800 in 1899, Great Britain has lifted her figures from 2,624,431 gross tons to 10,993,111, an increase of 311 per cent over a tonnage that had already reached large proportions at the beginning of the period.

With the causes of our decline in the ocean-carrying trade we are not here concerned. It is evident that the decline in our seagoing sail tonnage presents no exception to the tendency of all countries to substitute steam for sails. Should our maritime sail tonnage decline only 40 per cent during the coming twenty-five years, it will be reduced to 771,515 gross tons; but there are strong reasons for thinking that the substitution of the engine for the sail will proceed more rapidly in the future than it has in the past. As the sailing vessels wear out they will be replaced by steamers. The American merchant marine engaged in the foreign trade has declined to small proportions, but there is no doubt that economic and political conditions favorable to the restoration of our carrying trade are rapidly developing, and that our new marine must almost certainly consist of steamships. The statistics of the tonnage of sailing vessels and steamers constructed in the United

States during the five years from 1894 to 1899 tend to confirm this view. During these five years 296,933 gross tons of sailing vessels were built in American yards and 570,831 tons of steamers. The figures, moreover, include the vessels built for the fleet on the Great Lakes, and this fleet consists partly of schooner-rigged barges that are classified as sailing vessels, although they are practically always towed.

In the future construction of ocean-going vessels it is probable that we shall do as we have done in constructing our lake fleet, and substitute steamers for sailing vessels. The gross tonnage of the vessels on the Great Lakes in 1875, 1880, 1890, and 1899 (not including canal boats and small barges), is shown by the following table, which also indicates the division of the tonnage between sailing vessels and steamers:

Number and gross tonnage of sailing vessels and steamers on the Great Lakes, 1875, 1880, 1890, and 1899.

Year.	Sailing.		Steam.	
	Number.	Tons.	Number.	Tons.
1875	1,710	339,787	891	202,307
1880	1,459	304,933	931	212,045
1890	1,272	328,656	1,527	652,923
1899	874	318,175	1,732	1,014,561

The steam tonnage of the lakes grew from 203,298 tons in 1879 to 1,014,561 tons in 1899, a forefold increase in twenty years. The sailing vessels, although they have decreased in number, have apparently not declined in tonnage. This is more apparent than real because, as was stated above, a part of the tonnage, classified as sailing, consists of schooner-rigged barges. The sailing vessel has ceased to be an important factor on the Great Lakes.

It may probably be assumed that the canal across the Isthmus will have been completed and put in operation by 1914; according to the foregoing facts, what will then be the position of the sailing vessel in our maritime fleet? If the rate of change from sail to steam that has taken place during the ten years from 1889 to 1899 should simply be continued, our seagoing sail tonnage will have declined to about 650,000 gross tons by 1914, and our seagoing steam tonnage will have grown to about 1,500,000 gross tons. But the increase in our seagoing steam tonnage will undoubtedly be much more rapid during the coming fifteen years than it has been during the past decade and a half. During the fifteen years from 1884 to 1899 the steam tonnage on the Great Lakes increased 214 per cent. If the seagoing steam tonnage of the United States in 1899, 810,800 gross tons, should increase by a like percentage during fifteen years, it would amount to 2,546,000 gross tons in 1914. The assumption of such a growth as this in our seagoing steam tonnage during the first decade and a half of the twentieth century does not seem unwarranted. An estimate would seem to be conservative that placed our sail tonnage at about one-sixth of our total tonnage in 1914. Should the sailing vessel after 1914 continue to give way to the steamer, the Isthmian canal will be used by sailing vessels only to a limited extent.

THE FUTURE USE OF SAILING VESSELS BY SPECIAL CLASSES OF TRAFFIC.

There are some kinds of freight, such as coal, lumber, grain, nitrate of soda, and sugar, especially adapted to movement by sail because they are shipped as full vessel cargoes and do not need to be transported rapidly or delivered promptly. Will this traffic continue to find the sailing vessel the more economical carrier?

If the sailing vessel is to be used for the carriage of commodities that can be shipped as full cargoes, the prevalent type of vessel will probably be large five and six masted schooners capable of carrying 5,000 or more tons of cargo. Two six-masted schooners have been built on the Maine coast during 1899 and several other large four and five masted sailing vessels have been built during the past two years. One of the two six-masted schooners is 302 feet 11 inches long on the keel and 345 feet long on deck. She has 48 feet 3 inches beam and is 22 feet 6 inches deep; her gross tonnage is 2,974, the net tonnage 2,743, and she will carry a little over 5,000 tons of coal. According to the owner, this vessel "was built expressly for the coal trade, yet she is built so as to go to any part of the world with any kind of cargo."

During 1899 and 1900 there was a revival in the business of building sailing vessels, both wooden and steel, caused by the great scarcity of ships, the high ocean freight rates, the high price of steel, and the unusual price of coal in Europe; but this was probably a temporary increase in the construction of sail tonnage. If the sailing vessel is in the future to occupy a prominent place in the ocean marines of the world, it will be because of its special adaptability to the transportation of such commodities as sugar, coal, nitrates, grain, and lumber. The best basis for deductions as to the future is the present practice of the large shippers and carriers of these special commodities.

The transportation of nitrates from Chile to Europe and the Atlantic seaboard of the United States is well adapted to the sailing vessel, and it was formerly supposed that the steamer could not compete with the sailing vessel in this traffic; but during the past few years a large part of the nitrate shipments have been made by steamers. It is obvious that the isthmian canal will make it much more difficult for the sailing vessel to compete with the steamer for this traffic.

As regards the transportation of grain and lumber, much the same change seems probable, although the lumber of our west coast is at present all shipped in sailing vessels. If sailing vessels can not advantageously use the canal in competition with the steamer—a question that is considered at length in the latter part of this section—the grain and lumber cargoes will certainly be taken by the steamers. The action recently taken by a company of New York business men who have acquired a large tract of timber in the Carolinas is significant in this connection. The lumber gotten out by this company will be shipped from Georgetown, S. C., by two large steamers built especially for his business.

Not long since a New York firm operating a large fleet of sailing vessels between the two American seaboards sold out the entire fleet and in 1900 and 1901 put in its place seven steamers which are to ply between New York and Pacific Ocean ports and Hawaiian Islands via the Straits of Magellan.

The trade between the North Atlantic countries and Australia has long been considered one that would be held by the sailing vessels against steam competition. This was the opinion of Lieutenant Maury. Three or four years ago, however, this business was invaded by steamers, which now carry the larger percentage of the traffic.

The facts regarding the present division of the trade between the Suez route and the route followed by sailing vessels are especially important in connection with this inquiry. In order to determine the extent and nature of the present competition of sailing vessels with steamers in the trade between Europe and the East, the following table has been compiled from British reports. It gives the tonnage of steam and sailing vessels cleared from British ports for the foreign ports of the East in the years 1893 and 1898. While it does not include the clearances from other North Atlantic countries, it undoubtedly represents the facts for the entire trade, because the major share of the commerce between the North Atlantic and the East is in the hands of Great Britain. Moreover, this table is to some extent supplemented by figures regarding the sail and steam tonnage employed in the trade from Germany to the East.

Tonnage of steam and sailing vessels cleared from British ports for the East in 1893 and 1898.

Destination of vessel.	Steam and sail combined.			Steam.		
	1893.	1898.	Increase in five years.	1893.	1898.	Increase in five years.
Java	194,873	182,582	[a] 12,291	164,080	170,500	6,420
Borneo and other Dutch possessions in the Indian Sea	10,858	2,144	[a] 8,714	2,034	10,921	8,887
French possessions in East Africa and Asia and Pacific islands	3,357	12,580	9,223	14,490	11,623	[a] 2,867
Portuguese East Africa and India	8,118	346,706	338,588	7,657	337,645	329,988
Philippine and Ladrone Islands	32,811	33,876	1,065	31,346	30,680	[a] 666
Abyssinia	2,743	6,948	4,205	2,743	6,948	4,205
Madagascar	706	7,054	6,348	....	2,186	2,186
Prussia	4,047	4,108	61	2,481	4,108	1,627
Siam	902	966	64	....	476	476
China, exclusive of Hongkong	34,027	71,283	37,256	30,590	66,441	35,851
Japan	83,401	413,906	330,505	74,644	389,900	315,256
Pacific islands	6,351	10,573	4,222	....	....	....
Zanzibar	6,416	3,683	[a] 2,733	4,861	3,683	[a] 1,178
Mauritius	34,920	71,977	37,057	12,633	55,706	43,073
Aden	85,183	96,654	11,471	85,183	96,654	11,471
British possessions in India:						
Bombay and Scinde	601,895	485,711	[a] 116,184	593,953	485,711	[a] 108,242
Madras	128,050	19,273	[a] 108,777	125,598	17,874	[a] 107,724
Bengal and Burmah	523,569	595,962 116,875	189,268	426,201	507,761 106,916	188,476
Ceylon	211,603	128,546	[a] 83,057	185,100	128,546	[a] 56,554
Straits Settlements	297,574	55,828	[a] 241,746	267,845	46,815	[a] 221,030
Hongkong	10,943	46,216	35,273	5,327	26,148	20,821
Australia and New Zealand:						
West Australia	43,692	50,353	6,661	22,559	26,041	3,482
South Australia	135,955	51,416	[a] 84,539	82,439	9,721	[a] 72,718
Victoria	143,309	73,247	[a] 70,062	97,329	9,328	[a] 88,001
New South Wales	199,200	393,843	194,643	122,658	293,952	171,294
Queensland	50,496	96,366	45,870	33,146	67,017	33,871
Tasmania	31,419	6,422	[a] 24,997	29,088	....	[a] 29,088
New Zealand	140,068	209,175	69,107	103,744	176,500	72,756
Total	3,026,486	3,594,273	567,787	2,527,729	3,089,801	562,072

[a] Decrease.

From the foregoing table it appears that the total clearances, steam and sail, from British ports for the East increased 567,784 tons during the five years from 1893 to 1898, and that nearly all of this increase was in steam tonnage, the growth in the tonnage of steam vessels being 562,072 tons, or all but 5,716 tons of the total increase. By making the proper subtractions, the sail tonnage for 1893 is found to be 498,757 tons; and for 1898, 504,472 tons. The facts, then, are that the sailing tonnage has remained practically stationary, while the steam tonnage has considerably increased. The sail tonnage has not fallen off absolutely, but has relatively declined. In 1893 the sail tonnage constituted 16.4 per cent of the total steam and sail, whereas in 1898 the sail tonnage constituted only 14 per cent of the total, the decline having been nearly 2½ per cent in five years.

The clearances from Great Britain to certain special ports in the East present figures quite as significant as the totals referred to above. The commerce entering Eastern Africa by way of the Portuguese possessions represents a comparatively new trade. In 1893 the trade was very small, but in 1898 it had grown to large proportions. It is interesting to note that practically all of this new tonnage consisted of steamers. Japan presents a similar showing. The recent rapid growth of the trade of Great Britain with Japan has brought into service a large amount of steam tonnage and but a very small number of sailing vessels. The figures for Bengal and Burmah also show that nearly all of the large increase in the clearances from Great Britain to those countries has consisted of steam tonnage. The same statement applies to New South Wales. In the case of New Zealand the increase in the steam tonnage during the five years under consideration has been larger than the total increase in steam and sail tonnage combined. This indicates a falling off in the use of sailing vessels.

In the trade from Germany to the Far East the change from sail to steam tonnage is taking place very rapidly. German trade directly with the East has largely increased during the past decade, and this new traffic has brought steamers, and not sailing vessels, into use. The following figures taken from the German report indicates this, and also show that sail tonnage has fallen off. In 1890 there cleared from German ports for British India and the islands of the Indian Ocean sail tonnage, 76,000 net tons; steam tonnage, 219,000 tons. In 1897 the figures were: For sail 55,000, and for steam 319,000. That is to say, during those seven years the tonnage of sailing vessels cleared from Germany for British India and the islands of the Indian Ocean decreased 21,000 tons, while steam tonnage increased 100,000 tons. In 1890 there cleared from Germany for China sailing vessels with a net tonnage of 9,000, and steamers with a tonnage of 70,000. In 1897 no sailing vessels cleared for China, but the tonnage of steamers had grown to 110,000 net tons.

MERITS OF THE STEAMER AND SAILING VESSEL COMPARED.

The special advantages of the sailing vessel are that its motor power costs nothing and that it requires a smaller crew of men than is necessary for a steamer of the same size. The British reports show that a typical sailing vessel of 2,381 net tons is manned by a crew of 34 men, 22 of whom are seamen. A steam vessel of nearly the same tonnage, 2,315 tons net, has a crew of 38 men, of whom 11 are seamen and 17 are engineers, firemen, and coal passers. Taking the total British merchant marine, the number of men was 15.8 in 1898 per 1,000 net tons on British sailing vessels, while on the steam vessel the number of men was 22 per 1,000 tons.

In the foreign trade of Great Britain the number of persons employed on sailing vessels for each ton net register was, in 1880, 2.32; 1890, 1.96; 1898, 1.65. On steam vessels the number employed for 100 tons net register was, in 1880, 2.95; 1890, 2.73; 1898, 2.32. These figures are sufficient to show that steamers require more men than sailing vessels for an equal amount of tonnage. In large, slow-going steam vessels the number of men required is relatively small and may, indeed, not exceed 1 man per 100 tons net register, but it is equally true that a large schooner requires a very small crew of men—even smaller than is needed by the large, modern, slow freight steamer.

There seems, moreover, to be but a small difference in the size of crews required by the more recently constructed steamers and sailing vessels of equal capacity. A steamer of 3,000 tons dead-weight cargo capacity (which would be a small steamer) and a sailing vessel of equal capacity (which would be a relatively large sailing ship) would each have a crew of 23 or 24 men. The sailing vessel's crew, however, would include a larger number of unskilled laborers—seamen—than would the steamer, and the sailing vessel's expenses for labor would be somewhat lower than the steamer's.

The disadvantages of the sailing vessel are its slow speed, its dependence upon the winds and currents, and the consequent uncertainty as to the time of delivering the cargo assigned to it. The superiority of the steamer consists in its speed and its ability to assure the delivery of its freight at a stipulated time unless violent storms are encountered. The disadvantages of the steamer are the cost of coal, the large amount of space taken up by the coal bunkers and machinery—one-fourth to one-third of the hull capacity—and the somewhat larger crew ordinarily required.

As regards the cost of coal, mechanical improvements have done a great deal to lessen the steamer's handicap. Some of these new steamers for the trade between our two seaboards will carry 10,000 dead-weight tons, besides 2,500 tons of coal. They have quadruple expansion engines, with boiler pressure of 210 pounds to the square inch. These vessels will consume 40 tons of coal per day, running at 9 knots per hour. It is planned now that in making the trip via the Straits of Magellan they will coal only at Coronel, Chile. The consumption of coal between New York and San Francisco via the canal will be about 1,000 tons each way. This will make the consumption 224 pounds per ton of freight each one-way trip. Assuming the price of coal free on board vessels in Atlantic ports to be $2.50 per ton of 2,240 pounds, it would take one-tenth of a ton of coal, costing 25 cents, to transport one ton of cargo between New York and San Francisco.

The data presented in the foregoing paragraphs do not fully demonstrate the inability of the sailing vessel to compete with the steamer in the future for the transportation of special classes of commodities, but the evidence strongly indicates that result. That the sailing vessel will continue to be used for some time to come, especially by the people of the United States, seems probable, but our use of the sailing vessel, however, will be restricted mainly to two classes of service. One of these two fields of usefulness will be that part of our coasting trade that can not readily be so organized as to be performed by regular lines of steamers. The other use to which we shall continue to put the sailing vessel will be that of performing the irregular or skirmish work of international trade. There is at the present time an irregular trade developing between the United States and several parts of South America—such, for instance, as that being carried on between the Gulf ports and the River Plata. In the earlier stages of the development of such a traffic the sailing vessel is a convenient agent; but when the trade becomes larger and the exchange of commodities between the two sections becomes regular and continuous, a line of steamers will be established, and most of the sailing vessels will be obliged to withdraw from the business. The withdrawal of sailing vessels from the trade between the United States and the Orient and the substitution of steamers for the greater part of the traffic between our two seaboards are instances of the substitution of the steamer for the sailing vessel when the amount of business to be done had become regular and large in volume.

WOULD SAILING VESSELS USE A CANAL AT PANAMA OR ACROSS NICARAGUA?

It does not seem probable that coal, lumber, grain, nitrates, and sugar—commodities that will make up a large share of the canal's traffic—will in the future be carried to a large extent in sailing vessels. Nevertheless, the sailing vessel will be a carrier of some importance when the canal is opened, and possibly for a score of years thereafter. Such being the case, the relative advantages of the Panama and Nicaragua routes for sailing vessels should be compared. The extent to which sailing vessels will use an isthmian waterway will depend upon the actual saving in time which a sailing vessel could make by using the canal instead of the Cape route, and upon whether sailing vessels can compete with steamers, both using the canal route.

In the year 1866 Lieut. M. F. Maury, in a letter written to a friend, made the following statement:

> The result of my investigations into the winds and currents of the sea and their influence upon the routes of commerce authorize the opinion which I have expressed before and which I repeat, namely, if nature, by one of her convulsions, should rend the continent of America in twain and make a channel across the Isthmus of Panama or Darien as deep, as wide, and as free as the Straits of Dover it would never become a commercial thoroughfare for sailing vessels, saving the outward bound and those that could reach it with leading winds. * * * You will observe at a glance that the Isthmus of Panama or Darien is, on account of these winds and calms, in a purely commercial point of view, the most out-of-the-way place of any part of the Pacific coast of intertropical America.

Those persons who have endeavored to prove that the Panama route could not be used by sailing vessels have quoted the foregoing statements of Lieutenant Maury and have interpreted his statements to mean that no sailing vessel would or could make use of a canal across the Isthmus of Panama. It is well, however, to note the exception which Lieutenant Maury makes at the close of his general statement. He says the Panama route "would never become a commercial thoroughfare for sailing vessels, saving the outward bound and those that could reach it with leading winds" In view of this limiting clause, it would seem that Lieutenant Maury thought sailing vessels outward bound from Europe or from any North Atlantic port to the Pacific might pass through a Panama canal. His statement would also indicate him to think that vessels bound from the west coast of the United States for the Atlantic might pass through a Panama canal during the winter months, when the winds and currents are favorable for vessels sailing southward toward Panama. When we consider that the larger part of the Pacific coast grain would be exported during the later autumn and winter months and that a large part of the lumber from the Pacific coast of North America might be shipped during the winter half of the year, we must conclude that Lieutenant Maury's apparently strong statement does not preclude the possibility of a considerable traffic in sailing vessels through that waterway.

Hydrographers, ship brokers, and sailing masters generally disbelieve in the practicability of the use of a Panama canal by sailing vessels. There is no doubt that sailing vessels can enter and clear the Bay of Panama—they now do so to a limited extent—nor would it be impossible for a sailing vessel to make use of a Panama canal; but there is little reason to think that the sailing ship would, under the conditions of competition that will prevail after the waterway has been opened, pass from one ocean to the other in any considerable numbers.

It perhaps ought to be stated in this connection that sailing vessels bound from Panama either to the north, south, or west are obliged to work their way southward and westward to the Galapagos Islands, and usually some distance west of that group, before getting the winds and currents that will take them to their destination. Vessels bound from Panama to San Francisco are advised by Maury's sailing directions to work their way down the Colombia coast, and during the months from June to January, inclusive, to change their course about latitude 2° north, standing off the coast to the westward, passing north of the Galapagos Islands. From February to June, inclusive, it is better for the vessel to work southward across the equator before turning to the west. The course toward the west is maintained until the one hundredth meridian is passed, and then the vessel may "edge away for Cipperton Rock (10° 18′ N. and 109° 10′ W.), after passing which they may push to the northward for the northern trades."

Before Maury worked out these sailing directions, as the result of his study of winds and currents, sailing vessels consumed 90 days, on an average, in sailing from Panama to San Francisco by the direct route. According to the geographer Berghaus, the average time taken to make the voyage by Maury's route is 37 days. The distance by the circuitous route is somewhat more than 5,000 nautical miles. The direct route, the one followed by steamers, is nearly 2,000 knots shorter than the one taken by sailing vessels.

A most careful study of the conditions affecting the use of the Panama and Nicaragua routes by sailing vessels was made by Lieut. Frederick Collins, U. S. Navy, in 1872. He studied the winds and currents prevailing at different seasons of the year in each part of that section of the ocean that would be traversed by sailing vessels plying between Panama, Nicaragua, and other Pacific ports, and then estimated the number of days that it would, on an average, take a sailing vessel to make the voyage between the two isthmian ports and other Pacific harbors. The general conclusion to which he came in regard to the navigation of the Bay of Panama was that "no great difficulty need be experienced in getting from the vicinity of the Bay of Panama to where good winds might be fonnd. * * * A careful computation gave only 10 days as the average time that would be consumed in getting a sufficient offing to secure good winds, provided the correct route was pursued." The route considered correct by Lieutenant Collins was the one adopted by Lieutenant Maury, to which reference was made above.

The distances which Lieutenant Collins calculated sailing vessels would have to travel in proceeding from Panama and from Brito to reach San Francisco, and the number of days which each of these trips would require, are indicated by the following table:

	Miles.	Days.
Panama to San Francisco	5,350	37
Nicaragua to San Francisco	3,240	23
Difference in favor of Nicaragua	2,110	14

The table makes the time required for a sailing vessel to reach San Francisco to be 14 days less when the trip begins at Brito than when it begins at Panama. The distances and time required for the return trip from San Francisco to Panama and Brito are indicated by the following table:

	Miles.	Days.
October to April:		
San Francisco to Panama	3,600	26
San Francisco to Nicaragua	3,000	22
Difference in favor of Nicaragua	600	4
April to October:		
San Francisco to Panama	4,000	31
San Francisco to Nicaragua	3,400	26
Difference in favor of Nicaragua	600	5

According to the calculations of Lieutenant Collins, the time required for a sailing vessel to make a round trip from Nicaragua to San Francisco would be nineteen days less than for a round-trip voyage between Panama and San Francisco. These figures would seem to indicate that if either route is available for sailing vessels, the Nicaragua route would possess decided advantages over the one at Panama. However, other authorities differ from Lieutenant Collins as to some of these conclusions. The figures given for the length of the average voyage from Nicaragua to San Francisco is 3,240 nautical miles. This seems too short; indeed, the United States Hydrographic Office estimates the distance to be 4,500 miles. The great-circle distance, or the length of the route followed by full-powered steamers, is 2,700 miles. Furthermore, experienced navigators assert that a vessel bound for Brito must beat up and down the coast or go far to the westward; and that, although the Nicaragua route is more advantageous than the one from Panama for sailing vessels, it is nevertheless necessary for vessels to make a long detour from a direct course.

The distance for steamers from Panama to San Francisco being 3,277 nautical miles, a 9-knot steam freighter would make the run in 15 days, a 10-knot ship in 13.6 days, and a vessel of 12 knots in 11.3 days. These figures are to be contrasted with 37 days, the average time required by the sailing vessel. From Brito to San Francisco the distance for steamers is 2,700 nautical miles. To make this run a 9-knot freighter would require 12½ days, a 10-knot ship 11¼ days, and a 12-knot vessel 9⅗ days. Lieutenant Collins made the time by sail between Nicaragua and San Francisco vary from 22 to 26 days, but, for reasons just stated, his calculations underestimate (possibly by about 5 days) the time that would actually be required.

SAVING TO SAILING VESSELS BY USE OF ISTHMIAN CANAL INSTEAD OF CAPE ROUTE.

Concerning the time required to make the voyage by sailing vessel from New York to San Francisco, abundant information is obtainable from the logs of the many sailing vessels that are now navigated between those two ports. A New York firm operating sailing vessels from New York to San Francisco has reported the time taken by eleven different sailing vessels that made the trip during the year 1898. The average time for these vessels was 138 days, the range being from 113 to 151 days. Another New York firm doing a large business with the Pacific coast has given the time required by seven sailing vessels whose voyages were made at different seasons of the year. The time taken ranges from 118 to 169 days, the average for the seven being 139 days. Both of these firms report that they consider 140 days to be a fair average for the west-bound passage. For the return trip from San Francisco to New York the time taken is somewhat less, and is said to average from 110 to 115 days.

In order to arrive at the time a sailing vessel would require to make the trip from New York to San Francisco by way of an isthmian canal, it is necessary to add the time that would be taken for the voyage from New York to the Isthmus, the time that would be required for making the transit through the canal, and the number of days necessary for reaching San Francisco after leaving the Isthmus. When Commander, now Rear-Admiral, Selfridge gave Lieutenant Collins instructions to investigate and report upon the time it would take sailing vessels to make a voyage between the Isthmus of Panama and various Pacific ports, he said:

> In composing the table you will allow an average of twenty days to and from the United States and the mouth of the Atrato; thirty days from the English Channel to the same point, and forty days homeward to Europe.

It would take a sailing vessel practically the same time to reach Panama or Greytown that it would to reach the mouth of the Atrato. On the basis of the averages accepted by Admiral Selfridge for the Atlantic part of the voyage, and by Lieutenant Collins for the Pacific portion of the trip, a vessel would be twenty days from New York to the Isthmus, thirty-eight days from Panama to San Francisco, a total of fifty-eight days, to which should be added one day for the passage of a Panama canal. Lieutenant Collins estimated twenty-three days as the time required by a sailing vessel to reach San Francisco from Brito. For reasons that have already been stated, this estimate seems to be too small. If twenty-eight days be accepted as a fair estimate of the sailing time required between Brito and San Francisco, the time required for a sailing vessel from New York to San Francisco would be twenty days for the Atlantic part of the trip from New York to Greytown, two days for the passage through the canal, and twenty-eight days from Brito to San Francisco, a total of fifty days. The probable time required by sailing vessels to make the trip from New York to San Francisco by way of the Cape and through the two canals would then be as follows:

For the Cape route one hundred and forty days; for the Panama route fifty-nine days, and for the Nicaragua route fifty days. According to these figures, a sailing vessel could save on an average eighty-one days by using a Panama canal instead of making the trip around the Cape, and ninety days by using the Nicaragua canal instead of the present route.

The east-bound trip from San Francisco to New York can, on account of the more favorable winds in the Southern Hemisphere, be made in a shorter time than is required for the west-bound trip. One hundred and fifteen days can probably be assumed as a fair average for the trip from San Francisco to New York around the Horn. Lieutenant Collins estimated that a vessel would on an average require twenty-six days from San Francisco to Panama during the winter months, and thirty-one days during the summer months. On the basis of these estimates the time required for a sailing vessel to make a voyage from New York to San Francisco by way of a Panama canal would be forty-seven days during the winter months and fifty-two days during the summer season. That is to say, a general average of about fifty days for the year as a whole. The time estimated by Lieutenant Collins for a sailing vessel starting from San Francisco to reach Nicaragua was twenty-two days in the winter months and twenty-six days in the summer season. This would make the time from San Francisco to New York forty-four days for half of the year and forty-eight days for the other half, or an average for the year of forty-six days.

In view of the uncertainties attending the navigation of the Pacific Ocean near the American coast, where sailing vessels are obliged to beat for a considerable part of the distance, it would seem conservative to add five days to each of the foregoing averages and assume fifty-five days for the trip by way of Panama and fifty-one days for the voyage by the Nicaragua route. Assuming that one hundred and fifteen days is the average time required for a vessel to make the east-bound trip around Cape Horn, the Panama route would enable the vessel to save sixty days and the Nicaragua Canal sixty-four days.

Vessel owners report that $75 per day will cover all the expenses of operating a sailing vessel of 2,000 tons net (including wages, interest, repairs, insurance, and all other items of expense). The foregoing reduction in length of voyage would effect the following net saving in the cost of moving a cargo of freight by such a sailing vessel between New York and San Francisco, which may be taken as typical Atlantic and Pacific ports. A sailing vessel bound from New York to San Francisco could save eighty-one days by way of the Panama route, which would be equivalent, at the rate of $75 per day, to a saving of $6,075. If we assume a toll of $1 per net ton and a towage cost of $450 for a Panama canal, the saving effected by the vessel would be as follows:

Eighty-one days, at $75 per day		$6,075
Toll at $1 per ton	$2,000	
Towage	450	
		2,450
Net saving		3,625

For the Nicaragua canal the account would stand as follows:

Ninety days, at $75 per day		$6,750
Toll	$2,000	
Towage	600	
		2,600
Net saving		4,150

The towage costs adopted in the foregoing estimates are on the basis of a charge of 30 cents per net register ton for towage through a Nicaragua canal and 22½ cents per net register ton for a Panama canal. In order to secure a reliable estimate of the probable cost of securing towage through each of the proposed canals, a score of large towboat companies were requested to submit an estimate of the charges that would need to be made for the service of towing. The letter requesting the information stated that—

> The total length of a canal at Nicaragua would be about 190 miles. Of this distance about 70 miles will consist of excavated channel, about 50 miles of improved river navigation, and about 70 miles of lake.

And—

> The distance from anchorage at Colon to anchorage at Panama is about 47 miles, only a short distance being open for navigation. It is also probable that sailing vessels would usually desire to be towed about 100 miles from Panama out to sea, and in making your estimate of the cost of towage for the Panama Canal we should be pleased to have you give both the cost of towage between Colon and Panama and the cost of towing 100 miles on the Bay of Panama.

The replies received in response to this request varied so largely that they did not furnish the basis for so close an estimate as it was hoped might be made. The estimate adopted was one of those midway between the higher and lower extremes, and one submitted by a well-informed gentleman who was known to have given the question careful consideration. His estimate of the cost of towing loaded sailing vessels through a Nicaragua canal was 30 cents per net ton register, and for towing loaded ships through a Panama canal and 100 miles to sea—147 miles altogether—was 22½ cents per net ton register.

Provision was made in the Panama estimate for towing vessels 100 miles out to sea, because it was believed that a sailing ship would ordinarily save more than enough in the time of getting to sea to pay the additional charges. Indeed, it is probable that a tow of several hundred miles would at times be found profitable.

The foregoing estimates of the savings possible for a sailing vessel to effect by using a Panama or a Nicaragua canal instead of the Horn route do not take into consideration the saving in insurance that would be effected by the reduction in insurance charges that would result from the use of an isthmian instead of a Cape route. This reduction would be about 50 per cent of the existing insurance charges, and would be the same for each of the two routes.

The foregoing calculations, it may be well to repeat, are based upon the estimated saving which a sailing vessel could ordinarily make by the use of each of the proposed waterways. It is well known that sailing vessels require very different times for making the run between the same ports. The foregoing estimates are intended only to represent the average savings possible.

Among the general deductions that seem warranted by the facts set forth in the preceding pages are the following:

1. A canal across Nicaragua would enable a sailing vessel to accomplish a greater net saving over the expenses of the present route around the Horn than could be effected by using a Panama canal. The difference in the advantages of the two routes for sailing vessels, while not large, is sufficient to be made a factor of some importance in deciding which route should be adopted were it probable that either route would be largely used by sailing ships.

2. Neither the Nicaragua Canal nor the one across the Isthmus of Panama would be much used by sailing vessels. The unmistakable tendency of commerce is to use steamers instead of sailing vessels for all classes of traffic. The sailing vessel would compete with the steamer for the traffic through either of the canals under conditions so unfavorable as to make practically certain the general substitution of the steamer for the sailing vessel for all lines of trade through the isthmian waterway.

The consideration of the Nicaragua and Panama Canal routes from the standpoint of their relative usefulness as commercial highways becomes mainly a question of determining which is the more advantageous route for the steamers engaged in the maritime commerce of the United States in particular and of the world in general.

CHAPTER X.—*The canal and the traffic of American railways.*

There are several ways in which the isthmian canal may affect the traffic of the railways serving the different sections of the United States. The canal will introduce a new and competing route for traffic between our two seaboards and between the eastern half of the United States and Pacific foreign countries. There may result from this one or all of four consequences:

1. The railway lines competing with the new water route may reduce their rates, and thus be able to hold their traffic against the new competitor. Should this be the result, the effect of the canal upon the freight of the railroads might be small; their rates would be reduced, but the traffic secured by the water route would consist of new business developed because of the water route, instead of traffic diverted from the other transportation lines.

2. The waterway may divert from the railway lines a greater or less share of their through business. Should this be the result of the waterway, the railways will be obliged to secure a compensating amount of new business or suffer a shrinkage in their traffic as the result of the competition of the waterway.

3. The canal may bring new business to the railways by making them collectors and distributors of the commodities carried between our eastern and western seaboards by the way of the Isthmus. In our country of great distances and of diversified industrial activities, generally distributed throughout our wide territory, the origin and destination of but a small portion of the water-borne commerce of the United States can be at seaboard points. The collection and distribution of commodities for traffic by water is and must remain mainly the work of the railway line. The major part of the traffic of the canal must be rail traffic previous to or subsequent to being handled by the ocean vessels.

4. The canal may make possible the establishment of new industries along the railway lines or cause an expansion of activity in the business of existing plants, and thus add to the local traffic of the railways. In general, whatever facilitates commerce establishes the most important prerequisite to industrial development.

The traffic whose routes may be modified by the opening of the interoceanic waterway is:

1. That originating and terminating at or near the seaboard points of our eastern and western coasts. The traffic between the territory

east of Buffalo and Pittsburg and that west of the Sierra Nevada and Cascade Mountain ranges will be most directly subject to the influence of the new waterway.

2. The trade of the central section of the United States with our Pacific slope and with foreign Pacific countries will, after the canal has been opened, be able to leave or enter the United States either by an Atlantic, a Gulf, or a Pacific port. If it passes in and out by an Atlantic or Gulf gateway, it will be canal traffic; if by a Pacific port, it will not.

CONCERNING THE STATISTICS OF TRANSCONTINENTAL RAILWAY TRAFFIC.

Statistics are not kept of the traffic which the railways now carry between the Atlantic and Pacific sections of the United States and between the Pacific and central parts of the country—the rail traffic that would be subject to canal competition were the waterway now in use. Some years ago the transcontinental freight bureau, whose offices are in San Francisco, compiled figures of the through business of the transcontinental lines, but the chief of that bureau reports:

> This office has compiled no statistics whatever for several years past, neither have they been furnished with any reports of the movements of business.

The managing editor of Poor's Manual of Railways says:

> This matter [the statistics of transcontinental railway traffic] has been the subject of inquiry for some time, and without any result.

The officials of the Pacific railways who were conferred with in regard to the volume of business that would be affected by the canal were unable to supply the information. The traffic manager of one of the lines reported :

> So far as our line is concerned, would say that we have virtually discontinued compiling statistics of this nature, finding after many years' experience that the expense incurred in compiling these figures was unwarranted.

One of the Pacific railway companies furnished the Canal Commission with a statement of the tonnage east and west bound for each of the important commodities comprising its total through traffic. By through traffic was meant that originating anywhere on the lines of the company and turned over by the company to some connecting railroad; also the freight received from some connecting road and carried to some point along its own system of lines. This classified statement comprises a total of nearly 2,000,000 tons of freight and gives an interesting exposé of the nature and volume of business being done by this important Pacific railway system. The figures, however, reveal but little information concerning what portion of this total traffic would be subject to canal competition were the isthmian waterway now in existence.

While information concerning the present volume of traffic of the Pacific railroads that would be subject to the competition of an isthmian canal were the waterway now open would be interesting and possess some value, it would not throw very much light upon the manner in which the business of the transcontinental railways will be affected some ten or fifteen years hence by the competition of an interoceanic canal. Between now and the opening of the canal the position of the railways as carriers will have become stronger, and, whatever their business may be at the time of the completion of the waterway, their policy with reference to the retention and development of their business will doubtless be much modified by the inauguration of water competition by the new route.

NATURE OF THE COMPETITION OF THE CANAL WITH THE RAILWAYS.

In addition to finding it impracticable to determine the amount of railway business that would be subject to competition by a canal were it in existence at the present time, it has likewise been impossible to draw a sharp line between the classes of commodities that would be liable to move by water and those that will move by rail after both agencies have become available to the shipper. An intelligent railway official replied in response to the question: What kinds of traffic would be diverted from the railways to the canal?—

All kinds of traffic would be diverted except that which is perishable or which demanded dispatch, unless the railroads met the competition of the canal by a reduction in rates.

Similar opinions were expressed by several other railway officials who were conferred with.

It seems probable that the competition of the canal route will not be confined entirely to the bulkier commodities of comparatively low value per unit of weight or bulk articles universally recognized to be especially adapted to water transportation, but that the isthmian route will be available for the shipment of practically all articles except those whose perishable nature or whose unusually high value demand a quick service and a prompt delivery. The distance between our two seaboards by the isthmian canal will be about 5,000 nautical miles and the time required to make the run will be about three weeks for the slow freight steamers of 10 knots an hour, and about two weeks for the 15-knot vessel. The ordinary freight service of the railroads will be only a few days' shorter than the service by the faster steamers using the water route.

At the present time the American-Hawaiian Steamship Company, which is running steamers between New York and San Francisco through the Straits of Magellan, is carrying a large variety of commodities. The time required for the passage between the two seaboards by this route is from sixty to sixty-three days, but even this length of time does not restrict the freight to a limited number of articles.

On the other hand, the practice of a New York firm that manufactures a large quantity of structural steel and iron work for buildings and bridges and all classes of ornamental steel and iron shows that heavy freight must frequently be shipped by the quickest route. The firm states:

It costs about $8 per ton to ship from New York to the Hawaiian Islands around the Horn, $12 per ton to send the freight by way of Panama and San Francisco to Honolulu, and about $19 per ton to ship across the United States by rail to San Francisco or Vancouver and thence to Honolulu. The first way of shipping takes about four to five months; the second way of shipping about three months, and the third way of shipping takes at least two months. The element of time very often enters into the question of whether it is possible to build buildings in the time for the requirements, and often parties are compelled to ship by the most expensive lines in order to gain time. In fact, probably seven or eight thousand tons of materials will be shipped by us in this season via the transcontinental lines, and only two or three thousand tons around the Horn.

When the canal has been opened the railways will not permit their traffic to be taken away from them if they can hold it, and they will unquestionably so adjust their business as to retain the maximum amount of business. It is the belief of many railway officials that they will be able to hold most of their traffic against water competition. Whether that is so or not is not just now under consideration, the present purpose being to illustrate the nature and extent of the competition that the opening of the canal will inaugurate. The competition will be keen and will not be restricted to a limited number of commodities.

THE CANAL AND THE TRAFFIC OF THE ATLANTIC ROADS.

From the nature of the subject under discussion the treatment can not be statistical. The only bases upon which rest conclusions are theoretical analysis and the opinions of traffic experts. The main purpose of the following pages will be to present impartially the views of transportation experts whose opinions are worthy of consideration. Several officials of the Atlantic lines were asked the following question: "Will the canal promote the commerce and industries of the Atlantic slope in such a way as to give the railway lines to the Atlantic a larger traffic in coal, iron and steel manufactures, machinery, and other commodities?"

Two traffic managers of the Atlantic railroad handling the largest volume of freight expressed the opinion that the opening of the canal by giving American manufactures readier access to western South America and the Far East would largely increase the exports of manufactured commodities. The major share of the manufacturing done in the United States is carried on within the territory of the lines leading to the North Atlantic ports; and those roads, accordingly, expect to secure a greater volume of traffic when the canal has become available. It was said that the amount of freight that now moves from seaboard to seaboard by rail is comparatively small; consequently the trunk lines to the Atlantic will receive more than they will lose from the operation of the isthmian waterway. Much the same view was expressed by a traffic manager of one of the Pacific railways.

Some railway officials, particularly those whose roads lead to the Gulf ports, believe that one effect of the canal on the railway traffic in the United States will be to divert a considerable share of the business at present done through the Atlantic ports to the cities situated on the Gulf. This view, however, seems not be shared by the officials of the North Atlantic trunk lines, for the reason that the railway lines to the Atlantic are shorter from points east of Chicago and north of Kentucky and Virginia than those to the Gulf are, and for the reason that the ocean rates from Atlantic ports to the Pacific coast of the United States and the foreign Pacific countries will be practically the same as those from Gulf ports.

Officials of the Atlantic lines were also asked whether "one result of the canal will be to cause a larger share of total imports of the United States to enter the country through the Gulf ports;" and whether "the canal will divert to the Gulf gateways imports that would otherwise enter through the Atlantic ports." The opinion seemed to be that the Atlantic lines will be able to retain their present strong position in the import traffic, in competition with the Gulf lines, partly because most of the export business will continue to be handled at the Atlantic. Both the Atlantic and Gulf roads load light from the seaboard to interior points, the heavier volume of traffic being outbound. The North Atlantic ports have a much larger ship tonnage at their service than the Gulf cities now have or will secure. The Northeastern section of the United States being the most important manufacturing region will continue to be the chief importing section. Thus, while it was believed that the imports by way of the Gulf cities will probably be larger after the canal has been constructed than they can be before that event, it was not thought that this larger trade would be secured by drawing traffic away from the North Atlantic cities and to the railroads serving them.

Another question asked the officials of the North Atlantic lines was whether "the roads to the Atlantic will exchange less traffic with the Pacific lines as the result of the canal." The replies indicated that the Atlantic lines did not expect the canal to have the effect of reducing the volume of business exchanged between Atlantic lines and Pacific roads. The railways will not permit their business to be taken away without an effort to retain it, and wherever possible arrangements will be made for transcontinental shipments on through bills of lading to the west coast of the United States and to countries beyond. The present volume of business exchanged between the Atlantic and Pacific roads is comparatively small. It will not be less after the canal has been put into operation.

While the officials of the Eastern roads are by no means unanimous in their opinions, the foregoing statement of their opinions is believed to represent fairly their views.

THE CANAL AND THE TRAFFIC OF THE GULF ROADS.

It seems uncertain how much of the import and export business of the section north of the Ohio and east of the Mississippi will be done by way of the Gulf ports; the testimony is not unanimous. Probably some of the trade of this region will be handled by the Gulf ports; and the competition of the Gulf lines will affect the rates on a large share of the business that is handled by the Atlantic roads and ports. The opening of the isthmian canal will give the people of the States north of the Ohio and the Missouri rivers the choice of three routes for their trade with our west coast and Pacific countries, and the volume of their trade will be a prize for which the Atlantic, the Gulf, and the Pacific lines may be expected to strive with zeal.

There can be little uncertainty as to the general effect of the canal upon the traffic of the railways located in the Southern and Southwestern States. The railways serving the Southern States will have the same measure of benefits that may come to the industries and trade of the region. The canal can take no business away from the South or the Southern railways. It can only increase existing railway business and draw new industries and trade to the section.

The import business handled by the Gulf lines is small at present, and it will doubtless always remain less than the volume of outbound traffic, although the opening of the canal may be expected to increase the amount of inbound business handled by the Gulf cities. The officials of the Gulf lines who were consulted believe that the canal will cause a moderate though not a large volume of imports to enter through the Gulf cities.

THE CANAL AND THE TRAFFIC OF THE RAILWAYS OF THE CENTRAL WEST.

In that large stretch of country north of the Ohio and Missouri rivers and west of Chicago, that is to say, in the region west of the territory served by the trunk lines to the Atlantic Ocean and north of the States occupied by the railway systems terminating at Gulf ports, there is a network of important railways having a large volume of traffic. Until recently the traffic of these railways in the central West consisted almost exclusively of agricultural products, but the diversification of industries in that part of the United States is now proceeding with great rapidity. There is an immense volume of export business, the major part of which is now handled by the lines leading to the Atlantic Ocean, although latterly the lines to the Gulf have handled a portion of this traffic, and the volume of business handled from the central West by the transcontinental railways has grown to considerable dimensions. The imports brought into the central West from foreign countries come mainly by way of the Atlantic gateways. A certain amount of fruit comes through the Gulf cities, and an appreciable volume of oriental goods is brought in by way of Pacific ports.

As to the effects of the canal upon the railway traffic in the central West opinions are not unanimous. Manufacturers and most, though not all, railway officials anticipate that the canal will develop a large volume of new business. The views of those railway officials who expect but small results from the canal were well summarized by a prominent official of one of the strongest roads of the central West—a system that ramifies in seven States. He said that inasmuch as the industries of the territory served by this road were chiefly agricultural, no large volume of traffic would ever be exchanged with the agricultural States of our own Pacific slope. This gentleman said that if the canal were to affect the business of railroads situated as his system is, it must be accomplished by the creation of manufacturing industries, and it was his opinion that the volume of this kind of business would not and could not become very large. If the canal should divert this new business from the Pacific roads to the Atlantic trunk lines, or to the roads leading to the Gulf, that result would not affect the roads of the central West, because this diversion would do little more than to change the direction in which the traffic was hauled by his and similarly situated roads. Believing that the development of manufacture would be limited to small proportions, and that any diversion of traffic would simply change the direction in which the outbound and inbound business was handled, it was the opinion of this gentleman that the canal could not affect the business of his railway and other similarly situated systems to any large extent.

The traffic manager of another equally strong railway system in the central West was of the opinion that an isthmian canal would help build up the Upper Mississippi Valley and be a benefit to the railways of that section. As a general proof of this proposition he cited the Lake Shore and Michigan Southern Railway as one that was particularly subject to water competition, and which was nevertheless one of the most profitable freight roads in the United States. The canal, he said in substance, will doubtless take from the railroads some shipments they would otherwise secure, but by increasing the total volume of business by causing the centers of distribution and manufacturing to grow and multiply, and population to increase, the water route will add to the traffic seeking transportation by the railroads. This gentleman believes that water competition is a help instead of an injury to the railroad because of the larger industrial development made possible by the cheaper water transportation. He called attention to some of the large wholesale and jobbing houses in St. Louis, and said that the prominence of that city as a wholesale jobbing center was partly due to the cheap transportation from the East by way of the Gulf and the Mississippi River. This official also laid down the proposition that the best conditions for a heavy railway traffic are produced by the existence of a large number of manufacturing and distributing centers. Some railway officials, he said, seem to believe it better for the railroads to favor the concentration of business in a few large centers; but such a policy, he said, experience had shown would restrict the possible development of railway traffic within unnecessarily narrow limits. Believing that the canal will develop the territory, diversify and distribute industry, he was of the opinion that the effect of the waterway upon the business of the railway lines situated in the central West would be beneficial.

While these views regarding the efficacy of water competition to develop the industries of the interior part of the United States and to increase the traffic of the railways of that part of the country are not shared by all the railway officials that were consulted, the history of transportation, the evidence afforded by a study of business conditions in different parts of the United States, and the opinions entertained by the manufacturers and large shippers of commodities tend to substantiate the accuracy of the position taken by those railway officials who expect their lines to profit rather than suffer injury by the opening of the proposed isthmian canal. No one can visit the great industrial centers of the central West, study the vast resources of the States of that section, and acquaint himself with the activities of the business men without feeling certain that increased transportation facilities are certain to result in a very large expansion of industry. The history of the great central West shows that the measure of its industrial development has always been the measure of its transportation facilities. New facilities mean new business; and this is more true to-day than it was twenty-five or even ten years ago.

EFFECT OF THE CANAL UPON THE TRAFFIC OF THE PACIFIC RAILWAYS.

The railway systems that will feel the competition of the new water route across the Isthmus most severely are those whose lines connect the Mississippi Valley with the Pacific coast. This competition may apply to nearly all kinds of traffic. The only articles wholly exempt will be the perishable fruits and those goods of high value sent by express and as fast freight. The more southerly Pacific lines will feel this competition more keenly than will those situated farther north. The northern lines, moreover, will be able to meet the canal competition more readily than will those farther south, because the territory crossed by the southern roads includes such a wide belt of relatively unproductive country. The northern half of the Cordilleran highland is not only rich in mineral resources, but is also capable of raising considerable quantities of agricultural products. In some parts of this region irrigation is necessary and in others not. The southern part of this great highland, however, is capable of but a limited development. The mineral resources are less extensive. Wherever agriculture is possible it is dependent upon irrigation, and the irrigable areas are very limited. Thus the northern lines have a territory capable of producing a much larger amount of local traffic than can be secured by the southern lines from the country across which they are located.

Traffic officials of the three southern lines tothe Pacific stated their views with frankness and in some detail. The opinions of these gentlemen, however, differ largely. The views of those who believe that the effect of the canal will not be to create business, but that it will compel a large reduction in railway rates without affording compensation to the railroads, were fully stated by an official in charge of the traffic business of one of the Pacific roads. He said in substance:

During the early years of the transcontinental railways the traffic from the Atlantic section of the United States to the Pacific section was drawn almost entirely from the Atlantic seaboard. Before the railways were built the traffic was all handled by the sea route, and the costs of transportation from the interior to the ocean were such that the traffic was drawn almost entirely from the seaboard cities. The effect of the transcontinental railways has been to cause a large part—three-fourths, it is estimated—of the business carried across the country westward by the transcontinental railways, to originate in and west of Pittsburg. The effect of the canal will be to tend to cause traffic to originate nearer the Atlantic seaboard again, and thus affect deleteriously not only the business of the transcontinental railways, but the general industries of the middle section of the United States.

The traffic of a canal will consist of all kinds of commodities except those of a perishable nature. The competition of the waterway with the railway lines will be very severe, but the railways will not permit their traffic to be taken away from them by the canal. The competition will necessitate a reduction in rates—such a reduction as may throw the transcontinental railways into insolvency and require the scaling down of capital. The railways will continue in business, however, after the owners of the property have suffered a great reduction in the value of their holdings.

As far as the export trade across the Pacific is concerned, the canal would be an injury to the Pacific coast seaboard, because the export traffic very largely originates in the central and eastern part of the United States. That traffic would be carried directly to the Eastern and South American countries by way of the canal.

The establishment of industries along the transcontinental railway lines as a result of the opening of the canal was held to be possible only to a small extent by any of the transcontinental railways south of the Northern Pacific. The Southern roads cross such a long stretch of arid country that general industries can not be developed except relatively near the termini. California and the Pacific coast generally do not constitute a manufacturing section, nor will they become such.

Before criticising the remarks contained in the foregoing statements, the views of a traffic manager of one other Pacific line may be stated. This traffic manager says that the canal will compel a reduction in rail rates to Pacific terminal points below the charges that would otherwise prevail, and that the adjustment of charges will probably result in the establishment of blanket or identical rates between Pacific ports and all points in the central and eastern part of the United States. The effect of this will be to take from the cities in the central part of the United States the advantages which they have over the Eastern cities for trade with the Pacific coast. This official does not believe that the canal will be of much help to California, because the trade in grain, which is and will always be the principal item of export, is going to be carried on less with Europe and more and more with China and Japan, where the consumption of wheat is even now taking the place of rice.

He believes that the surplus grain products of the Pacific coast will be milled and shipped to the Orient, and that the canal will not be of benefit to this industry. Concerning the general effects of a canal upon the commerce and industry of the United States as a whole, this traffic official is more optimistic than the others above quoted. He says, and very accurately, that the transportation business of this country is so organized that if touched at one point the effect is felt everywhere. The opening of the canal will afford a new transportation agent of importance, and while it will compel an adjustment of business, a revision, and in some cases a reduction, of rates, the railroads will nevertheless find business to do, and the travel and traffic of this country and the business done at home and abroad will so increase as ultimately to make both the railways and the canal a necessity. The construction of the canal is regarded by this traffic official as inevitable, as something which the American people have decided to be necessary for naval reasons and for the purpose of securing the quickest and best transportation facilities for their domestic and foreign trade. The transcontinental railways, in his opinion, would temporarily suffer from the reduction in rates, but the growth of the country will be such that twenty-five years from now the railways will have nothing to fear from the canal.

In the opinion of the Pacific railway officials above quoted, and of others, the isthmian canal will be an active and rate-controlling competitor. That this is true will hardly be questioned, and if the canal can not compensate the railways with a larger volume of business they will not share with the producing and manufacturing interests in the benefits accomplished by the water route. Whether the canal will give the Pacific railroads a larger traffic than they would otherwise have is partly a matter of judgment and partly a question of safe deduction from past experience.

The belief entertained by one of the officials above referred to that the isthmian canal will draw traffic and the centers of industry back from the central section of the United States to the Eastern States is based on an inadequate conception of the industrial strength of the Central States as compared with the Eastern. The Central States possess vast stores of coal, iron, and timber, and these and their other natural resources are causing the population and industrial activities of our country to become generally distributed. The railways that serve the Central States are wisely fostering this tendency, and these railway systems are among the strongest and most efficient of any in the United States. After ten or twelve years more of progress on the part of the industries and railway systems of the central portion of the country, they will be quite secure against defeat from competition with the East. Indeed, the canal will so facilitate the foreign trade of the Central States as to make them stronger than they now are as compared with the Eastern section.

It is asserted by one of the railway officials whose opinions are given above that the isthmian canal will injure the Pacific States by diverting from them the imports destined for points east of the Rocky Mountains. The present volume of these imports by way of the Pacific coast cities, however, is small and will probably remain so. Without an isthmian canal the goods brought in from foreign Pacific countries will be imported into the eastern half of the United States, as most of them now are, by way of New York and other Atlantic ports. The importations of teas, silks, mattings, and curios by way of our Pacific ports and the transcontinental railroads is increasing, it is true, and may be expected to grow in volume as the costs of railway transportation decline. After the canal route has been opened the railways will be obliged to share this traffic with the steamers using the canal. Here again, however, it is probable that additional facilities for transportation will be accompanied by a larger demand for commodities and an increased traffic for the old routes as well as the new. If the isthmian canal produces any changes of importance, one effect will be to give greater prosperity to the western third of the United States, where the Pacific railroads must always perform the transportation service, to stimulate the growth of population there, and to increase the consumption of such articles as are imported from the Orient.

One of the witnesses above quoted thinks that the wheat exported from the Pacific coast will, within a few years, be sent entirely to Pacific instead of Atlantic markets. There is a growing trans-Pacific trade in flour and an increasing quantity is required at home oy the growing population of the Rocky Mountain and Pacific slope States. This, moreover, is being accompanied by a diversification of agriculture and the production of other cereal crops and of fruits and vegetables. Nevertheless, the western section, particularly the States of Washington and Oregon, may be expected to remain large exporters of wheat and also of barley to Atlantic countries for several decades to come.

CONCLUSIONS.

The competition of the canal will affect, first, the volume and rates of the through business of the Pacific railroads, and secondly, the amount of their local traffic. At the beginning of their existence these railways depended almost entirely upon their through traffic; but their chief aim throughout their history has been to increase the local business, which is always more profitable than the through traffic; and although the great stretch of country crossed by them is still in the infancy of its industrial development, the local traffic of some, if not all, of the Pacific roads has already become of chief importance. A vice-president of one of the railway systems states that since 1893 "the increase in business of the transcontinental lines has not come from the seaports, but from the development of the intermediate country." The canal can certainly in no wise check the growth of this local traffic, and the evidence strongly supports the belief entertained by many persons that the canal will assist largely in the industrial expansion of the territory served by the Pacific railways.

If this be true, the proximate effect of the isthmian canal in compelling a reduction and readjustment of the rates on the share of the transcontinental railway business that will be subject to the competition of the new water route will be more than offset by the ultimate and not distant expansion of the through and local traffic that must necessarily be handled by rail. It seems probable that the increase in the population of the country and the growth in our home and foreign trade will early demonstrate the need of the transportation service of both the canal and the railways.

Chapter XI.—*The trade and industries of western South America and the effect of the canal upon them.*

The benefits of an isthmian waterway will be felt in varying degrees by more than half the countries of the world. In some regions this influence will be slight and indirect, or will modify only a small part of the trade, while in others it will affect the greater part of the commerce and will work changes that will be almost revolutionary. The United States will obtain the most direct and far-reaching results from the canal; South America will probably be the second greatest recipient of its advantages.

AREA AND POPULATION COMPARED WITH NORTH AMERICA.

South America is but slightly smaller than North America. It is wider between Pernambuco and Guayaquil than the United States between Oregon and Maine, long enough to reach from the isthmian canal to Baffin Bay, a thousand miles beyond the southern point of Greenland, yet none of her shores are frozen. These rather surprising dimensions are seen more clearly by a glance at the globe, which will correct the erroneous impressions that flat maps make by exaggerating the size of countries of high latitude and diminishing the area of equatorial regions. Viewed on a wall map, North America appears much larger than South America, when, in reality, there is but slight difference in the area of the continents. By drawing a map on the polyconic projection, as has been done in plate 75, the relative areas of the two continents can be shown.

Brazil alone is larger than the combined area of England, France, and the United States, exclusive of Alaska, while each of five other South American Republics exceeds in area the original thirteen States of North America with Maine, Vermont, and Florida added, and the State of Massachusetts with its irregular shape could be completely hidden away by being put down in the midst of the unexplored areas of the great forests of the Amazon Valley. Although large, South America does not have a greater proportion of worthless territory than have most of the other continents. There are deserts in Peru and and Chile, and mountain wastes and swampy forests in the center of the continent; but these areas are small compared with the unoccupiable parts of North America. Canada and Alaska, comprising a third of the continent, are largely uninhabitable because of the cold climate. The plains and plateaus west of the Missouri River embrace a third of the territory of the United States that can be only sparsely inhabited because of its aridity. The proportion of arid land in Mexico is greater than in the United States.

In South America the present sparse population has but touched the resources that can support commonwealths as populous as those of Europe when immigration and settlement shall have occupied the country. The present sparseness of population and backward development of South Amertca are due to three causes. The first is the difference in character of the races inhabiting England and Spain—a difference as marked in their colonies as in the mother countries. England and her colonies have prospered, while Spain and her dependencies have languished. Had England, not Spain, possessed South America after the sixteenth century, the continent would now be more highly developed, although its social institutions might have differed from those of North America, as the result of climatic dissimilarities.

South America's sparse population is furthermore due to the fact that Europe has not yet needed South America as a home for overcrowded peoples. Canada is still giving away farms, the United States has scarcely ceased doing the same, and in the old-settled commonwealths of the Eastern and Southern States hardly more than half of the available area is cultivated. The United States is still a comparatively empty country. The emigrating races of Europe, which have been chiefly the Teutonic, have found stable and friendly governments, fellowship of race, and familiar climate in the United States, Canada, and Australia. These attractions were not offered by South America. Settlement there was impeded by the tropical climate of a large part of the continent, and by the fact that the most suitable districts for white colonization were on the inland plateaus, separated from the ocean by unhealthy lowlands which must be crossed by railroads before commercial relations could be established with the rest of the world. Under these conditions an extensive occupation of the country has waited for corporate enterprises to provide the needed transportation facilities. There have been no large European emigrations except to Argentina and southern Brazil, where the climate is similar to that of the temperate latitudes of North America, and where the governments have been fairly stable, and have provided the political prerequisites for industrial growth.

THE TRADE ZONES OF SOUTH AMERICA.

In discussing the industries and trade of South America, and the manner in which they will be affected by an isthmian canal, it is necessary to divide the continent into trade zones. The various countries do not form a satisfactory division, because in some cases two or three adjoining States have similar climate, resources, and trade connections. Nor is a separation of the continent into zones or latitude helpful, because very disimilar regions are found in the same latitude. The shape of the continent and the lack of internal communication make it necessary to treat the Pacific and Atlantic sections separately, and each of these sections has a temperate and a tropic division calling for separate treatment. In the discussion that follows the continent has been divided into (1) the Temperate Pacific section; (2) the Tropic Pacific section; (3) the Temperate Atlantic section, and (4) the Tropic Atlantic section. The political divisions comprised in each section are shown in the accompanying map of South America.

From the standpoint of the world's trade, the Atlantic sections of South America are more important than the Pacific side, but as regards the traffic and effects of an isthmian canal the western third of the continent is of greater consequence. The effect of the canal on the trade of the Atlantic region will be slight, but on the Pacific side the canal will change the routes and in some measure the destination and origin of the larger part of its foreign commerce. The references to the Atlantic sections will be brief in the following discussions, the space given to the four trade divisions of South America being in proportion to the importance of the canal to the economic development of each.

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Western South America will be considered first.[a] This section of the continent includes the Pacific coastal strip and also the Andean plateau, and reaches from the southern limits of the habitable part of the temperate zone northward well into northern tropical latitudes. The Republic of Chile, in the temperate zone, is as large as our New England and middle Atlantic States with Maryland and the Virginias added. Northward in Peru and Bolivia the ranges of the Andes broaden, so that in addition to the coastal plain, often 60 miles across, there is an extensive plateau a thousand miles long and in places several hundred miles wide. On this broad highland is the Titicaca Basin, with a system of rivers flowing into a lake about half the size of Lake Erie, and furnishing hundreds of miles of navigable waterways.

INADEQUATE TRANSPORTATION FACILITIES OF WESTERN SOUTH AMERICA.

The Pacific frontage of South America has more than double the population and area of our Pacific coast States of California, Oregon, and Washington. The western sections of the two American continents are, however, very differently situated commercially. Our Pacific slope has the advantage of seven transcontinental railroads; the Pacific coast of South America has but one, and that is incomplete. The foreign commerce and to a large extent the domestic trade of the west coast of South America is dependent upon inadequate and circuitous water transportation. The building of the Panama Railroad has been of comparatively small importance to the trade of South America. The costs of transshipment at the Isthmus and the high freight rates charged limit the use of this route mainly to passenger traffic and the freighting of articles that need quick transportation. Cheaper commodities take the longer route around the continent. A prosperous industrial growth requires transporting agencies that can profitably and cheaply move such commodities as coal, iron and other ores, grain, etc. This the Panama Railroad can not do, and such commodities, if moved at all, must go through the Straits of Magellan or around the Horn.

The great distance that must be traversed by the ship passing between the commercial countries of the North Atlantic and the west coast of South America, has caused the commerce of those countries until recently to be chiefly dependent upon the sailing vessel. The introduction of regular steam connection promises better transportation facilities for the future, especially after the canal shall have been completed. Callao, Peru, is now farther by steam from New York than is the South Pole, but an isthmian canal will bring the city 1,000 miles nearer to New York by steam than San Francisco will then be.

The present difficulties of transportation restrict travel, and thus prevent the people of the United States and Europe from becoming acquainted with the people and trade conditions of western South America. Commercial exchanges prosper only when knowledge and intimacy break down mistrust and reveal the commercial needs of the trading nations.

In Pacific South America generally, as in other Latin American countries, the difficulties of inland transportation are a great hindrance

[a] Consult Pls. 76, 77, and 78, upon which are located the places, resources, and industries mentioned in this chapter.

to industrial and commercial progress. Excepting a few lines of railroads, there are practically no means of communication in western South America save the pack mule. This state of affairs makes the commerce of the interior districts similar to that of Europe in the Middle Ages, when international trade was limited to silks and spices and other light commodities of high value that could be carried long distances by caravan and to the few bulkier articles produced along the seacoast and navigable rivers. The inland districts of England, France, and Germany then had considerable populations, but each community raised its own food, made its own clothing, and knew little of the products of other countries. The improvements that have transformed the European countries have not yet had much effect upon the tropic section of Pacific South America. Only a small proportion of the population contributes anything to the foreign trade. The rest live in isolated communities, each of which is practically self-supporting.

DEPENDENCE OF WESTERN SOUTH AMERICA UPON FOREIGN CAPITAL AND LARGE ORGANIZATIONS OF CAPITAL.

The nineteenth century witnessed an enormous expansion of commerce throughout the greater part of the world, largely because industries developed in new countries by means of the capital that Europe had slowly accumulated through several preceding centuries. The foreign trade which South America now has is almost entirely the result of European investments. Foreign capital has worked the coffee plantations of Brazil, and built her railroads and those of Argentina. The flocks of Argentina are owned by Englishmen and Scotchmen, the nitrate works of Chile are in the hands of English and German owners, and the sugar plantations of Peru are the property of Americans and other foreigners.

The capitalistic development of western South America, particularly the northern part, has, however, not yet progressed very far. It has great stores of natural wealth, but the obstacles in the way of their utilization have not been overcome. Large organizations of capital are especially necessary in the Andean region and on the west coast. In Argentina the European owner can cultivate his grain and pasture his flocks in a level country watered by rainfall, but in Peru irrigation is necessary to agriculture. The building of a railroad across the level pampas, to carry away the wool and grain of Argentina, is a very much easier task than building a line up the defiles of the Andes to tap the mineral wealth of the plateau. Operation on the east side can be conducted with moderate capital, but on the west side the large capitalist, the mining expert, and the complicated machine are necessary. The return to capital, however, promises to be liberal.

Foreign capital has made less headway than would otherwise have been made in western South America, because of the frequency of political disturbances and civil wars. The deleterious effects of frequent revolutions and unstable political conditions are known to be great, and are felt even more by the merchant than by the capitalist who is engaged in mining, agriculture, or transportation. The manager for a strong corporation, which has for years operated a large sugar plantation in the Peruvian irrigated belt, reports that the per cent of loss that has actually occurred from civil wars has been, on the whole, surprisingly small. The country, however, suffers greatly because capitalists are deterred from making investments.

The western part of South America has been lying idle while more accessible resources elsewhere have been levied upon. But a new era seems to be at hand. The constant tendency everywhere is to organize capital on a large scale, and it seems probable that the development of western South America will be undertaken by organizations of capital similar to those that are giving the United States its industrial preeminence. In fact, a substantial beginning has already been made, and that beginning is responsible for the present importance of western South America to the world's trade. In 1899 Chile exported more tons of nitrate of soda than the port of New York exported tons of wheat. This nitrate was produced by large foreign corporations owning their own nitrate beds and reducing plants, the railroads to carry the product to the seacoast, and the piers and warehouses from which to ship it. In 1899 Peru exported 110,000 tons of sugar, which had been produced by firms that could irrigate their plantations, install expensive machinery, build lines of railway to the port or to some main line, and, in some cases, the product was exported in the ships of the producers. By the increase of enterprises of this character the west coast can double and treble the amount of her contributions to international trade.

The first step to be made in the direction of these changes will be in bettering the means of transportation by the building of railways, or starting industrial undertakings which include, as a part of the enterprise, an improvement in the existing method of transportation. This will come about easier after the opening of an isthmian canal, which will tend to quicken the industrial and commercial life of the west coast of South America. Cheaper freights will enable the commodities now exported to be marketed more cheaply and other articles not now utilized will find their way into commerce. With the greater possibilities of securing freight will come new inducements to build railways and make other improvements in transportation. Railway materials and the machinery necessary for the equipment of industrial plants will be cheaper because of lower freight rates from the iron-producing countries north of the Isthmus.

The supply of capital for South America will in the future come from the United States as well as from Europe. We have become large exporters of the iron and steel and machinery needed by new countries. Our increasing wealth and population will furnish money and men for industrial enterprises in foreign lands. American ownership and direction of railroads, mines, and other enterprises in Mexico have been chiefly responsible for the industrial revolution in that country during the past twenty years and for the accompanying expansion of her commerce, the chief part of which has been with the United States. This work is still going steadily forward in Mexico, but we shall probably welcome opportunities lying beyond the Isthmus of Panama.

DISADVANTAGES OF THE UNITED STATES IN TRADING WITH WESTERN SOUTH AMERICA—EFFECT OF THE ISTHMIAN CANAL.

With very few exceptions the industries of western South America may be classed as mining and agricultural. This is the case even in the seacoast regions engaging in foreign trade. There are, of course, local manufactures of various articles in the towns and villages, such work as is done locally in any community, but the nature of the resources of western South America is such that the region is likely to continue permanently in the extractive stage of industry, or at least until a period too remote for consideration here. Pacific South America is now but half of an industrial unit; the other half, the manufacturing complement, is in Europe and the United States. Each one of these industrial half units needs better facilities for marketing its produce in the other. One important service of an isthmian canal will be to bring these separated commercial and industrial complements into closer relation.

The west coast of South America bears a relation to the manufacturing centers of Europe and the United States similar to that which Montana, Colorado, and Texas, with their raw products, bear to the manufacturing States of the East. The countries of the North Atlantic need and are buying the export products of the west coast of South America—the nitrate and the ores of copper, silver, and gold, the grain, sugar, cotton, cocoa, coffee, wool, hides, rubber, and woods. In return for this export these South American Republics are importing from many countries, but chiefly from the United Kingdom, all kinds of manufactures, from steel rails to jewelry and fine clothes. Both parties will be benefited by increasing this trade. The production of raw material will be stimulated no less than the production of manufactures. For any gain that comes to South America the rest of the world must receive an accompanying or complementary advantage.

The United States will derive especial advantage from the shortening of the roundabout path of this large and increasing commerce. Because of the present route around the continent the trade of the west coast is mainly with Europe, but on the opening of the canal there will be a change of front toward the United States. Both European and American traders will have greatly improved opportunities, but the larger relative improvement will come to the east coast of North America. Our ports will then have from 2,000 to 3,000 miles advantage over Europe in the journey to the west coast, whereas at present the distance from New York and the ports of the English Channel to that section of the world are nearly equal, the southern cities of Europe having a slight advantage over the ports of the United States. Nearly all of South America lies east of North America. The meridian of Washington is that of Callao, on the coast of Peru. Antofagasta and Iquique, the chief nitrate ports of Chile, have the longitude of Boston. Valparaiso is 71° 40′ west longitude and New York 74° 03′. The eastern point of Brazil lies 2,600 miles east of New York, and is equidistant from New York Bay and the English Channel.

The sailing vessels bound from New York for the west coast of South America must go eastward nearly to the Canaries so as to be able to take advantage of the trade winds and get past Cape St. Roque, on the coast of Brazil. The European sailer goes directly past the Canaries and has an advantage of ten days over the American in a voyage to any part of South America south or west of the eastern point of Brazil. For many decades our direct commerce with South America has been chiefly by sail, and we have competed with Europe under most unfavorable conditions. The small part of our trade that has not gone by sail has gone by steamers to Panama for transshipment to the two lines of steamers going down the west coast. These lines have combined to keep the rates at such a figure that for most of the time during the last thirty-five years it has been cheaper to ship American goods to South America via England or Germany. It has often cost the American shipper from 30 to 50 per cent more to send freight 3,500 miles direct to western South America by Panama than to send it 14,000 miles indirectly by way of Europe. Shipping around the Horn by sail is such a slow and irregular means of reaching the markets as to prevent the development of a satisfactory commerce in these modern times, when expedition is the order of business. Our share in the trade of the west coast of South America has not been gratifying to national pride; indeed, we have done little more than to sell in those countries the commodities that they could not secure elsewhere. Europe has taken nearly all of their exports and supplied them with most of their imports.

Since 1890 two American companies have been running chartered British vessels around to Guayaquil, and during this period the value of our exports to the west coast has increased 16 per cent; this, however, is less than one-third the rate of the increase of our total exports. Fortunately the steamer is rapidly taking the place of the sailing vessel. In 1890 steam vessels carried, largely via Panama, 36 per cent of our exports to the countries of western South America. In 1900 81 per cent of our exports to those countries went by steam, a gain of 225 per cent in the proportion carried by steam.

The starting of the lines of steamers from New York has not, however, given our manufacturers an even chance with those of Europe. American merchants and consuls on the west coast complain that the steamers from New York charge higher rates than those from Europe, and nearly as high as the Panama lines. Nevertheless, these steamers always leave New York full loaded with export freight and the profitableness of the business is attested by the frequent addition of more vessels to the fleets. This suggests what may be expected to occur when the isthmian canal and more lines of steamers give us shorter and better means of communication with Pacific countries.

We have a thriving trade with the American countries near to us. Fifty-nine per cent of Canada's imports come from the United States. The ocean route to Mexico is longer than to Canada, and the railroad connections over the land frontier are much less satisfactory, yet we furnish 49 per cent of the Mexican imports. The northern countries of South America are about 2,000 miles from New York, but we have fairly good steamship connection and a growing trade, Colombia and Venezuela drawing about 30 per cent of their imports from this country. In contrast with this, however, the United States furnishes less than 10 per cent of the imports into the countries of the west coast of South America; and our trade there has increased slowly at a time when the growth of our exports as a whole has been rapid. Under the present adverse conditions our share in the trade of the west coast of South America is only one-third as great as it is in the South American countries bordering on the Caribbean Sea, one-fifth as great as in Mexico, and only one-sixth of the percentage which we control of the trade of Canada. An isthmian canal, and the lines of communication that it will open up, may be expected to give this country a larger share in the trade of the Pacific.

This conclusion is strengthened by some incidents in the history of the foreign trade of Chile. In years past, the British share of that trade was greater than it is at the present. Her commissioners sent in 1898 to investigate the cause of this decline reported as the first cause that British merchants did not secure as good freight rates for their commodities as were obtained by their continental rivals, the difference in favor of Antwerp and German ports being sometimes 25 per cent. It was found that English merchants sometimes sent British goods to those ports for reshipment to Chile. The lower rates from Germany were due to the nitrate trade. Germany being the largest importer of Chilean nitrate of soda, the ships returning from that country to Chile could offer the best rates on outgoing freight, and this was one of the causes that had enabled the German merchant to build up a large South American trade.

A similar advantage will come to the traders of this country when the canal has been opened. By that time the United States will have a larger consumption of nitrate, our vessels will go directly down the South American coast, and the favorable shipping facilities that are now giving Germany an advantage over the United Kingdom will be possessed in a more marked degree by American merchants. Moreover, it is probable that the vessels en route from Europe to South America will aid our exporters by calling at our ports for coal and other cargo.

The advantage of cheaper transportation is already shown in the export cotton trade of the United States to Chile. At certain times nitrate ships returning to South America offer very favorable rates from New York, and exporters then dispose of cotton cloth in large lots at Chilean ports, thereby securing a trade which the regular conditions of freight would not permit.

The future trade between our east coast and the west coast of South America will have the advantage of a heavy traffic both ways, a phenomenon rarely met with in international commercial movements. Our east coast trade with Europe consists mainly in the exchange of large quantities of agricultural and other heavy produce for a small quantity of manufactured products, and this necessitates a large ballast movement westward across the North Atlantic. Our exports from New York to Australia are but partly balanced by the small return trade. Our exports to the Orient of iron, cotton, and foodstuffs are exchanged for light curios, tea, and mattings. Our trade to South America is certain to give rise to an increasing exportation of articles similar to those we are sending to China and Australia, with the probable addition of coal, and these commodities will be exchanged for Peruvian sugar, Chilean nitrate, ores, and heavy produce, so that vessels will readily secure cargoes both ways. This will be an advantage both to the steamship companies and the shippers.

GEOGRAPHY, RESOURCES, AND INDUSTRIES OF CHILE.[a]

Having discussed the general industrial and commercial conditions of Western South America as a whole, it will be profitable to examine the temperate and tropical regions separately and with some detail. The temperate division of the continent, for the purposes of this discussion, may be considered practically coextensive with Chile; for although the northern boundary of Chile extends beyond the Tropic of

[a] Consult Pls. 76 and 77.

Capricorn the aridity of that part of the country makes mining the only industry. Mining industries being independent of climate, the activities of Chile that are determined by climate are located within the temperate zone. Chile is long and narrow, but her area is large—larger, in fact, than that of France, Germany, or the United Kingdom, or the combined area of the New England and Middle Atlantic States with Maryland and the Virginias added. Her length of 2,600 miles would reach from New York to Utah. The country extends from a tropic district to Tierra del Fuego, where the latitude and climate are like those of Scotland. Nitrate of soda is the chief product of the arid northern part of Chile, which is the source of supply for the entire world. The agricultural districts and the center of population are farther south, the products being similar to those of our Pacific Coast States, with which Chile possesses many points of similarity.

The temperate shores of the Pacific show a succession of similar geographic and climatic features in both North and South America. These resemblances would appear plainly if Chile could be inverted and placed beside the coast of North America. The lower end of the inverted Chile would be opposite the city of Mexico, and Tierra del Fuego would be about the latitude of Sitka, Alaska. The 800 miles of Chilean desert with its nitrate beds would lie against the arid coast of Mexico where its silver is mined. Patagonia would be opposite British Columbia and Alaska, both regions being damp, fringed with rugged islands, and cut into sharp fiords walled in by forest-clad mountains having snowfields on their summits and glaciers on their sides. The tropical and cold sections are unproductive agriculturally, but in the temperate belt of each region civilization and diversified industry are possible. The climate is that of western Europe and the United States.

It is by comparing the productive region of the north temperate Pacific with the south temperate Pacific that the greatest resemblances and likewise the difference of the two coasts appear. Their difference is due to the absence of a South American duplicate for the State of Washington. California and Oregon are reproduced, but the Antarctic current, sweeping up the coast of South America, shortens the temperate section of Chile so much that the region corresponding to the State of Washington is replaced by a longer continuation of the rugged and forest-clad coast similar to that of Alaska and British Columbia.

Near the Mexican boundary of the United States the resemblances to the corresponding agricultural parts of Chile are obvious. In Chile the arid country, by means of irrigation, produces grapes and raisins, citrus and other fruits, and alfalfa, the alfalfa being used as a supplementary fodder for the cattle pasturing on the higher hills. The arid belt extends several hundred miles, and is succeeded on the south by wheat fields and general agriculture. The Chilean forests corresponding to those of central and northern California, Oregon, Washington, and British Columbia exist in the lower half of the Chilean agricultural region and along the extensive coast of Patagonia.

The best section of the western slope of both Chile and the United States is found in a large interior valley. The valley of California, bounded on the east by the Sierra Nevadas, on the west by the Coast Range, and drained by the Sacramento and the San Joaquin rivers, is of high fertility. Chile also has a valley similar to this, but larger and superior to it in several particulars. It is inclosed by the Andes on the east and by a coast range near the shore of the Pacific; but this coast range is not so continuous as that of California, being broken at frequent intervals where rivers make their way to the ocean. Instead of being drained by two rivers flowing lengthwise, and having outlet to the sea, the Chilean Valley has several small rivers flowing across it and discharging into the ocean. The basins of these rivers are not separated by high divides, but are practically continuous, so that the whole district is properly spoken of as one great valley. The Andes are higher than the Sierra Nevadas, and westerly winds bring a larger amount of moisture than California has. The streams have a larger and more constant flow of water from the mountain snows and furnish an abundant supply for irrigation, and in some places provide good power.

As in most arid countries where irrigation can be practiced, the soil is fertile. The crops produced are identical with those of California. All of the cereals, vegetables, and fruits thrive and provide a food supply sufficient both for the present and prospective home demands and for a large export trade. This valley is about 700 miles in length—a distance equal to that from New York to Charleston—and is divided into thirteen prosperous provinces, which had a population in 1895 of 2,400,000 people—as many as there were in California, Oregon, and Washington in the census year 1900. California has less than ten persons to the square mile, while the Chilean Valley has from three to five times as many, and is about equal in density of population to Maine, New Hampshire, and Vermont, or to our Southern States, exclusive of Florida.

The great trunk line of the Government railway goes through most of this region from north to south. It is being extended in both directions, and will eventually connect Coquimbo, in latitude 29°, with Porto Montt, in latitude 41°. The line to the last point is already surveyed. This road, most of which is now completed, will be about 1,300 miles long, and will connect with many branches and private lines from the various mining and agricultural centers. The several rivers breaking through the coastal mountain range make it easy for the railroad to connect with seaports, and there are now railway lines to six harbors giving the producing centers of the country opportunity to take advantage of the water transportation supplied by the lines of coasting steamers that are doing a large business in both directions. In the valley of California the coast ranges make necessary a much longer railway haul to reach the ports.

The northern part of the agricultural region, the district around Valparaiso and Santiago, is older and more fully developed. Of this section the Aconcagua Valley, which may be taken as a type, is a plain highly irrigated, famed for its agriculture. The grape crop of this valley alone, it is estimated, would make 1,000,000 gallons of claret wine were it so used instead of being manufactured into the local drink called "chica." Potatoes are exported to the nitrate deserts of the North and to Panama, alfalfa hay to Brazil, and honey and wax are sent to Europe. Local canneries preserve the fruit crop, which is mainly marketed in other sections of the country. There is pasturage on the neighboring hills above the level of irrigation, where a peculiar kind of wiry grass, well adapted to its dry surroundings, grows for months after a soaking rain.

The sides of the Andes throughout this whole belt are forest clad.

In latitude 37° south the forest growth becomes general, and the country is similar to many parts of the eastern United States. This latitude is now the Chilean industrial frontier, the opening up of the region having been recently begun as the result of the advent of better means of transportation. New railroads are being built, forests are being cleared, and stock raising and cereal agriculture are increasing. The forest regions have tanning industries, sole leather being exported to Europe.

The agricultural and mining regions of Chile are north of 40 degrees. South of that there is as yet practically nothing of commercial importance except the sheep pastures of Terra del Fuego. The 1,000 miles of intervening coast is as little known as is the coast between the port of Vancouver and the mainland of Alaska. Nearly all of the present and prospective Chilean commerce and population are from 1,000 to 2,000 miles north of the Straits of Magellan, through which their commerce must find its way to the Atlantic until the canal provides a shorter outlet.

Chile exported something over 3,000,000 bushels of grain to Europe in 1898–99, but the larger part of the exports of the country consists of the minerals mined in the northern and arid part of the State. The agricultural part of the country sends large quantities of food products to the mining regions of the northern provinces. The greater part of Chile's export wealth originates in regions that are almost a desert. Their dryness causes their richness; indeed, a moist climate, instead of being a blessing, would cause the disappearance of the greater part of the wealth of this section, which consists of such soluble minerals as nitrate of soda, iodine, borax, and common salt.

Nitrate of soda, the chief export of Chile, lies in a nearly continuous deposit parallel to the seacoast, extending 150 miles from north to south, with scattering deposits reaching 250 miles farther, the total covering 220,356 acres, and estimated to contain about 228,000,000 long tons, a quantity sufficient to last the world for many decades to come. The nitrate is found under the surface layer of sand, and when shoveled out has the consistency of cheese. It is refined in numerous and extensive plants requiring large capital. The crude product is dissolved, chemically treated, and crystallized to get rid of the impurities. Among these impurities are iodine and common salt, which are separated for export.

The city of Iquique, the most important nitrate port, may be taken as a type of the towns that depend upon the nitrate industry for their existence. Here 30,000 people, having the conveniences of a modern city, live in the desert, where every supply for man and beast must be imported from other ports of Chile or from foreign countries. Water for the city is brought by pipe-line 200 miles from the Andes. A railroad zigzags up to the plateau and winds around among numerous nitrate works situated in the desert. The railroad company is English, and most though not all of the nitrate plants are owned by foreigners. Borax is obtained in the dry districts, and in some places common salt is taken from the surface of the earth by sawing it out in cakes that are handled like ice. Besides these desert mineral products the same region contains a large amount of copper, silver, and lead. Antofagasta is the port of this section and is also the outlet for the mines of Bolivia, which ship their antimony, bismuth, tin, mercury, and sulphur over the Antofagasta railroad. Most of these products are in the form of ores, some of which are refined at Antofagasta and the rest exported, mostly to Europe, for treatment.

The rise in the price of copper has greatly increased the copper mining industry of Chile, and the deposits of copper promise to contribute largely to the world's supply of this metal. Low-grade copper ores have been found in abundance in the district near Santiago, near to the ocean. Copper now ranks second among Chile's exports, amounting in 1899 to 25,400 tons. In coal Chile has an asset that will assist with the development of other resources, although she has small prospects of ever becoming a coal exporter. In the south, about latitude 37°, the ports of Coronel and Lota are the points of shipment for mines located near by. The deposits are large, but the quality is inferior to English and American coal, and the output is insufficient for home demands, although it is largely used by steamers going up and down the coast and to Europe.

THE CANAL AND THE TRADE OF THE UNITED STATES WITH CHILE.

The interest of the American people in the commerce of Chile is greater than our present share of that trade would indicate. The foreign commerce of Chile now amounts to about \$100,000,000 and is increasing. In 1899 the exports were \$59,000,000 and the imports \$39,000,000; about nine-tenths of the imports came from Europe, while nineteen-twentieths of the exports went to that continent. Our trade is slight compared with that of the United Kingdom, Germany, or France. An examination of the elements of the trade of Chile shows why the canal will increase our share. Of the Chilean exports, nitrate of soda comprises nearly 60 per cent, although the percentage is slightly declining, owing to the increased export of copper and copper ores. Next in the order of importance come silver and silver ores, then wheat and barley, wool, hides, and other scattering and agricultural and mineral products, most of which are needed in the United States. We need the nitrate for our fertilizers and chemical manufactures, we have the coal to smelt the copper and silver ores, we need the wool for our carpet manufactures, and the hides to furnish raw material for our leather manufactures. Of course, the grain products are needed only in Europe.

Of the Chilean imports cotton manufactures comprise by far the largest part. Then come machinery of all kinds, kerosene, woolens, coal, bagging, and all kinds of miscellaneous manufactures and supplies. The cotton manufactures are made from the raw material grown in the southern part of the United States and carried to Europe for manufacture, whence the goods are shipped through the Straits of Magellan. Much of that cotton cloth will in the future go direct from American mills via New York, Charleston, Mobile, or New Orleans, and save transshipments and 7,000 miles or more of transportation. We have the materials and manufacturing ability to furnish the Chileans their machinery. We are now furnishing them with kerosene, and when the canal is opened we will probably be able to send them coal and many miscellaneous manufactures.

The reduction of freight rates that may be expected to follow the opening of the canal will not only extend our present trade with western South America, but will increase the number of the articles that enter into it. With a few exceptions the goods Chile secures in this country are those which we produce under especially favorable circumstances—lard, lumber, kerosene, breadstuffs, patented articles, like medicines, firearms, electrical appliances, farming machinery, and improved hardware. These articles can be sold readily in Chile after the canal has been opened. We have just begun to send Chile iron and steel. The bulk of the pig, bar, and hoop iron, rails, and castings now come from Europe, although we can make them more cheaply than our European rivals can. The railroads of Chile have iron rails that must soon be exchanged for steel. The towns and cities of Chile will use an increasing amount of structural iron for building purposes. The growing favor of electricity in a country having many mountain streams for water power is opening up a demand for electrical machinery which American manufacturers are already able to supply. We are sending small quantities of many other articles in which transportation is a large factor, such as earthenware, glass and glassware, cordage, paper, and coal. Our cotton exports to Chile consist mainly of one or two plain staple grades made without reference to the Chilean market and shipped in bulk, as chance opportunities occur. With attention to the demands of the market and cheaper transportation that business can be greatly extended.

It is probable that some of the trade of the western part of Argentina, lying on the east slope of the Andes, will be handled through Chilean ports and will use the canal. The foothill provinces of Argentina, like those of Chile, produce fruit, wine, and grain, and are a prosperous region. This region being from 700 to 900 miles from the Atlantic ports of Argentina and within 200 miles of the ports of the Pacific, which, when the canal has been opened, will be much nearer North America than Buenos Ayres will be, the mails, passenger traffic, express business, and some classes of freight may be taken across the Andes and sent north from Valparaiso or some other Chilean port. A boundary controversy has delayed the completion of the Trans-Andean Railroad, but contracts have been let for the completion of the work.

TROPICAL SECTION OF WESTERN SOUTH AMERICA—GENERAL DESCRIPTION.[a]

The tropical section of western South America is nearly double the area of the temperate Pacific region, and includes practically all of Bolivia, Peru, Ecuador, and a part of Colombia. In this discussion of the trade of the Pacific, however, the portion of each of these States is omitted that lies in the almost unexplored forest plain extending eastward from the Andes. The region here considered has an area of nearly half a million square miles. It is more than twice as large as France, is greater than our Middle Atlantic States and Southern States east of the Mississippi River, and is equal to our three Pacific Coast States with the addition of Idaho, Wyoming, and Colorado.

The region consists of a coastal plain and a high plateau. The plain is either matted with tropic vegetation and drenched with rain or is a sandy desert, and neither of these conditions favors the establishment of communication with the plateau 30 to 100 miles inland, which must be surmounted by ascending a steep and forbidding mountain wall. The mineral wealth of the plateau is abundant, but is at present available only to a small extent.

[a] See Pl. 78.

This South American region has a population of over 6,000,000, but is made up chiefly of Indians and half-breeds, with a comparatively small proportion of the dominant Spanish race. The latter race lives in the towns, devoting itself to political and mercantile affairs, the proportion of Spanish blood decreasing as the distance from the towns increases. All the labor of the country is done by the half-breed Indians or by imported Chinese and Japanese labor. Industrially, the South American Indian is said to be superior to the North American Indian, and when properly supervised to be nearly equal to the negro as a laborer. The social and economic conditions do not tend to make the laborers ambitious. Some of the natives own the lands from which they glean a living, but throughout Ecuador, Peru, and Bolivia a system of industrial servitude exists that places the majority of the laboring classes in a condition similar to that of the English serf in the Middle Ages. The laborer is in debt to his employer, who manages to keep him so. Theoretically, every man can work for whom he wishes, but the debtor is practically prevented from changing masters by legal difficulties.

The Andean region of South America now has but little international trade, because the development of its natural resources has been prevented by untoward political conditions, by the mountainous character of the country, and the absence of an isthmian canal.

THE PERUVIAN COAST—ITS INDUSTRIES AND THE EFFECTS OF THE CANAL UPON THEM.

Taking Guayaquil as a center, it will be found that the coast running 800 miles to the north of it includes a coastal plain sparsely populated by a few Indians and negroes, who can inhabit its unwholesome forests. To the south extends some 1,200 miles of seacoast, known as "Zona Seca," or dry zone, which has considerable industry at present, has had more in the past, and promises to be the scene of greater activity in the future.

The Peruvian coast for 1,200 miles is too dry for ordinary agriculture. Regular crops can be raised only by irrigation, the supply of water being the rainfall on the Andean slopes at an elevation of 7,000 feet and more. During the winter months the fifty streams crossing the plain are raging torrents, overflowing their banks, but during the heat of the summer they dry away to mere rivulets, only two of the northern ones having sufficient depth to be of any use for navigation.

If the Peruvian coast had abundant rains, it would be so malarious and unwholesome as to be unsuitable for white men, whereas its climate is said to be healthful and cooler than that of other regions in the same latitude, owing to the Antarctic current flowing up the west coast and to the sea breezes.

The Peruvian coast is desolate except where irrigation has produced green fields in the dry plains. Its present population and the amount of land cultivated are doubtless much smaller than they were before massacres, slavery, and white men's diseases, particularly smallpox, had greatly reduced the native population.

The soil in this coast plain is fertile when irrigated, and well-suited to the production of sugar, cotton, and rice. Experts claim that sugar can be produced here as cheaply as in any other place in the world. The sugar industry, indeed, had made a good start before 1885, when the desolating war with Chile destroyed many of the plantations. The business has now recovered, 110,000 tons having been produced during the season of 1898 and 1899. This was nearly all taken by the United States, and much of it crossed the Isthmus.

The cotton crop of this section is one in which the United States is particularly interested. Some of the valleys of the north, particularly those of the Piura and Chira rivers, grow a peculiar kind of rough fiber cotton of a reddish color, that will not grow in any other part of the world, and is valuable because it mixes well with wool. The irregular supply of about 10,000 tons a year grows largely without cultivation along the rivers. At the present the United States imports much of this cotton by way of Liverpool. We can use many times as much of this product as we now receive, and its cultivation can be largely extended by the introduction of proper irrigation works.

Some rice is exported from the port of Trujillo, and farther south, at Pisco, there is some shipment of the wine and grape products which grow in the irrigated orchards near the Andes. Aside from these crops, however, the agricultural products of this plain will be used to supply food products for the Peruvian population.

As agriculture advances there must be a reorganization and extension of the railroads from the coast inland. Several lines now extend a short distance from the Pacific, but as industry and traffic increase these scattered pieces of roadway must be combined into one or two systems centering at a harbor or harbors that can be improved by the construction of piers suitable for the easy handling of the freight. When these improvements are made, they will require materials with which the United States is well supplied.

Petroleum fields are located near the Ecuadorean boundary at the west point of South America, the deposits lying along the coast for a distance of 200 miles, extending inland a considerable distance, and reaching outward under the sea. The development of this resource has not met with much success up to the present time, although the oil deposits are said to be rich. An English company is now operating there with an American director, and is securing a constantly increasing output, which reached about 2,000 tons a month in May, 1900. Thus far only 3 or 4 square miles situated on the seacoast have been prospected, and that not thoroughly, in a field which is supposed to be extensive in area. The oil is not suitable for illumination, but makes a valuable fuel. It is used on all the railroads of Peru, and may give much assistance to the industrial development of the Pacific coast of South America.

THE ANDEAN PLATEAU.

The Andean Mountain system, with its plateaus, may be compared with the Rocky Mountain region of the United States. Beginning in northern Colombia and reaching to the boundaries of Argentina and Chile, it has greater length than our Rocky Mountain region, an equal or greater width, and probably more individual mountain ranges. In point of population the Andean region exceeds its North American counterpart, for our seven Rocky Mountain States and Territories—not including the Pacific Coast States—contained in 1900 only 1,500,000 people, while the Andean region contains at least 4,000,000. The industrial capacities of the people of the United States, it need hardly be mentioned, are far greater than those of the Andes.

The great elevation of the plateau, situated in tropical latitudes, gives it a variety of agricultural produce. On the intermediate heights beans, potatoes, and wheat are grown, while in the hot valleys, which here and there intersect the plateau, the people raise sugar cane, oranges, and bananas. There are single estates on which the owner grows all of the crops of both tropical and temperate climates.

The plateau of Ecuador may be taken as a typical section of this Andean region. The Ecuadorian plateau has an elevation of 8,000 to 10,000 feet and is really an inclosed valley some 400 miles long and about 50 miles wide, hemmed in on both sides by the high chains of the Andes. The rainfall is scanty on the whole plateau, and agriculture usually depends upon irrigation, for which the snows of the mountains furnish abundant water. The soil is largely of volcanic origin and is very fertile. The climate is mild and springlike. The population is about 900,000.

This Ecuadorian population of nearly a million depends for its connection with the outside world upon a neglected and dangerous mule trail to Guayaquil. During the rainy season this precarious route sometimes becomes impassable and the interior is left entirely without means of communicating with the outside world. A railroad 350 miles in length is being built from Guayaquil to Quito, and the American company constructing it confidently expects that it will be completed long before the opening of the isthmian canal.

With the coming of the railroad the people of interior Ecuador will use much larger quantities of imported manufactures than they have been able to get in the past, and they will want various kinds of machinery. They will secure the money to buy these things by working for the foreign capitalists engaged in developing the mines, by supplying the coast regions with food products, and by exporting hides and other agricultural commodities. The railroad will also enable them to secure the wood and lumber needed on the whole plateau region, which is in many places destitute of timber. The railroad will help in the introduction of modern industrial methods. The old wooden plow will gradually disappear; shovels and wheelbarrows will come into use; the people will thrash and clean their grain with machines instead of treading it out with animals and winnowing it in the wind. Their huts, made of reeds or poles and put together without a bolt or a nail, will gradually give way to houses, and in time the towns will be better built.

This description of the plateau of Ecuador would apply to many districts in Peru and Bolivia, the climate, people, and industrial conditions being very similar throughout the Andean plateau; the high parts of one country resemble those of another just as the plateaus of Colorado resemble those of Montana.

The plateau region reaches its greatest width near the boundaries of Peru and Bolivia, where such a State as Pennsylvania might easily be put down and be in every part at least 10,000 feet above the level of the sea. Lake Titicaca is as large as Connecticut, and drains into Lake Poopo, which is as large as Rhode Island. These lakes are connected by the Desoguadero River, 180 miles long, and navigated a part of the way by steamers. These lakes are the center of a great treeless plain, chiefly devoted to stock raising. The Bolivian part of this plain supports about 7,000,000 sheep, a number one-sixth as great as all of those in the United States, and there are in addition many cattle, mules, and swine. Barley and potatoes are grown—the surplus crops of the Indian agriculturist being marketed in the mining towns.

The people of the Andean plateau are now very poor. They make their own clothes, raise their own food, receive low wages, have a low standard of living, and buy but little from the outside world. But their needs and standards can and will change. On this point the experience of Mexico is interesting. Twenty years ago foreign merchants in the interior of Mexico despaired of the people ever becoming large consumers. Five-sixths of them were Indians, who received for their wages 5 cents per day in cash and 5 cents in rations. Communication was by stagecoach. The people wore sandals, unbleached cotton, and straw hats, and bought practically nothing. Since that time railroads have been built through these districts and the laborer is receiving from 50 cents to $1.50 a day as an agricultural or mining laborer, and every Indian wants a watch. With their higher wages they have become good buyers of manufactures from their own and foreign countries. The Andean plateau offers conditions to-day similar to those of interior Mexico twenty years ago, and there is reason to believe that what happened in Mexico will happen in Sonth America.

Attention was called above to the general resemblance of the Andean plateau to our own Rocky Mountain region. The tropic Andes are admitted to be richer in mineral resources than the Rocky Mountains, but the present industrial development is very different. Our Rocky Mountain States and Territories are served by a good network of railroads, the State of Colorado alone having nearly 5,000 miles, while the whole Andean plateau has less than 500 miles, and the lines have not penetrated to the richest mineral deposits.

In spite of their poor connection with the outside world, the Andes have produced enormous wealth. The bullion from their mines furnished the civilized world with the greater part of its money during the centuries of Spanish dominion. Between 1630 and 1803 Peru sent out $1,250,000,000 worth of silver. Bolivia has produced about $4,000,000,000 worth. Of this enormous sum the famous mines of Potosi, which to-day can be reached only by a bridle path, yielded $3,000,000,000.

Mining operations have changed but little during the past century. The mining district of Hualgayoc, Peru, for instance, has 400 silver mines in an area of 40 square leagues. Some of these mines are now yielding ores having 300 ounces of silver per ton. The work is done by the Indians, who burrow around through the veins as best they can, getting out the ore with a drill and hammer and carrying only the richest of it to the surface in rawhide sacks. It is then picked over, crushed, reduced to a sulphate by crude methods, and taken on muleback to the coast and shipped to Europe for refinement. At Huallanca, Peru, 200 miles from the coast, ores worth $30 per ton are thrown upon the waste heap because they are not worth transportation to the seaports. Yet to-day, in our own Western States, companies with large capital and expensive machinery are profitably reducing ores yielding from $4 to $7 per ton. In the copper mines at Corcoro, Bolivia, to the south of Lake Titicaca, the ores are blasted out and then hammered to pieces by women, who pick out the best portions. Owing to the scarcity of fuel, little of the ore can be treated on the spot, and that above 70 per cent pure is carried away on pack animals.

In many mines of the United States, ores with but 3 or 4 per cent copper are smelted.

The Bolivian mineral districts, in some places 200 miles wide, rich in tin, copper, silver, and gold, extend north and south for a distance of 700 miles. The Antofagasta Railroad has but just touched a corner of this field. The terminus of its line at Oruro is 195 miles south of Lake Titicaca, and as the greater part of the Bolivian minerals are in the eastern ranges of the Andes, the railroads have not reached them. The city of La Paz, with a population of about 100,000, is dependent upon a stage road 45 miles long, and Cochabamba, with 25,000 people, has no outlet except a bridle path of greater length.

The improvements resulting from better transportation facilities are illustrated in the limited district that the Antofagasta Railroad has reached, where changes have been made in the methods of operating the mines, and large quantities of ore are sent to the coast. One English company connected its mines with the railroad by building a branch line 15 miles long, including 2 miles of tunnel. The venture is said to have paid well.

The railroad connecting the Peruvian seaport of Mollendo with the lake port of Puno carries out large quantities of mineral products, but, like the Antofagasta Railroad, it has not tapped the main fields. The railroad has connections with the lake steamers that carry the products of the interior across from Chililaya, the port of La Paz, and many similar towns. Some of these places are hundreds of miles away, and all freighting is done by pack animals.

A successful mining industry requires rail or water transportation. Mining machinery is costly and heavy and can not be introduced where pack-mule transportation is necessary. The securing of fuel and supplies and the marketing of the product are nearly as dependent on good transportation as is the introduction of machinery. Only the choicest ores can be carried on mule back, while the metal in such ores is almost infinitesimal in comparison with that contained in the low-grade ores.

When the railroads thoroughly open up the Andean Plateau to the American capitalist and mining engineer there will be abundant opportunities for their enterprise. There are numerous mines that have been worked and abandoned at various times during the past three centuries, and in many cases their refuse ores are rich enough to yield good dividends. Not only can the old tailings be worked at a profit, but many of the abandoned mines themselves can be reopened, and the ores the early workers were forced to leave will make a good return when scientifically treated. The mines are now rarely worked beyond a few hundred feet, because they are not ventilated, and the ore is taken out by man power. With modern hoisting machinery, crushers, mills, furnaces, and railroads, the mineral output can be very greatly increased.

The water power obtainable from mountains of the plateau makes possible the use of electricity instead of coal, as has been done in California where coal is scarce. The great elevation of the mountains, and the frequent falls in the constant streams that flow from their snow fields and glaciers, combine to furnish the best conditions for the installation of electric plants driven by water power. Some of the most important mines of Mexico are now being operated by electricity supplied by the mountain streams, although the water power of Mexico is slight as compared with that of the Andes.

A description of the conditions in the Cerro Pasco mining district in Peru will show more definitely what is to be done in the new era of railroads that the canal will help to introduce. The Cerro Pasco deposits are supposed by some to be an old volcanic crater, covering an area 1½ miles long and three-fourths of a mile wide. Here are 2,000 veins of silver, making a network through the hill in which there are no less than 360 mines. From 1630 to 1824 these mines yielded 27,200 tons of pure silver. These deposits have been worked only 250 feet and could be drained by a tunnel of smaller magnitude than a number that have been made in various mines in the Rocky Mountain States. After the building of a railroad the introduction of the necessary machinery to complete this tunnel will become easy, the silver deposits will again become workable, and a new lease of life will be given to the Cerro Pasco mines, which have not yet been worked to a tenth of the depth reached in many mines in this country.

Underlying the silver of the Cerro Pasco district are valuable deposits of low-grade copper. The ore containing more than 30 per cent of copper is now carried 90 miles to Casapalca, on the Oroya Railroad, where it is smelted by American smelters or sent by rail to Callao for export to Europe by way of Magellan. At the present time more than a thousand tons of ore per month are being shipped from Cerro Pasco by this method, and some of the lower grade ores are being treated on the spot by using coal brough from good deposits but a few miles distant. The present difficulties encountered in working these rich mineral deposits are shown by the fact that the railroad ties for tram lines at the mines had to be brought by pack mules from the railroad, 90 miles away.

A railroad will ere long join the Cerro Pasco mines with the Oroya line at the town of Oroya, the city which promises to become the railroad center of that part of the plateau, and to be connected by a line eastward with the head of navigation on the Perene, one of the branches of the Amazon, where tropical products can be secured for the mining regions around Cerro Pasco. Another line of road may possibly start from Oroya southward through some of the already populous valleys of Peru possessing mineral resources.

RELATION OF CANAL TO INDUSTRIES AND TRADE OF EASTERN SLOPE OF ANDEAN PLATEAU.

The thorough development of the resources of the plateau by the building of railroads and the investment of foreign capital will necessarily be accompanied by an enlarged commerce with the eastern slope of the Andes. The people of the greater part of the plateau can produce only the food products of the temperate zone, and considerable quantities of tropic products are now brought up from the east slope at great expense. Any thorough industrial development of the plateau will make necessary the building of railroads to carry on this trade in food products needed on the plateau. There are many fertile valleys in the east slope having an elevation of over 5,000 feet, and resources and climate suitable to a great variety of tropical and semitropical products. Some of these products now cross the Andes and are exported. The eastern Andes are the source of the world's supply of coca leaves for the manufacture of cocaine, and there are many coca plantations scattered for hundreds of miles along the east slopes of Peru and Bolivia. This is also the region that furnished the world's supply of quinine before its systematic cultivation in the British East Indies and the Dutch colony of Java reduced the price of the article to one-thirtieth the former figure and ruined the owners of the Peruvian and Bolivian plantations.

The province of Cuzco, in eastern Peru, is famous for its cacao, of which some 600 tons per annum are already sent over the Andes for export. These same valleys produce coffee, about 1,500 tons of which now cross the Peruvian Andes for shipment to the outside world. The most favored part of the east slope is in Bolivia, near La Paz, where, owing to a bend in the highlands, the slope is toward the north rather than toward the east, causing the trade winds to bring less mist and rain than they do to the eastern parts of Colombia and Ecuador. The rainfall of 40 to 75 inches is the same as that of the most favored parts of the United States, and the climate is said by American travelers to resemble that of California and to produce the same fruit products. The Yungas Valley in this section is noted for its coffee.

The eastern slopes of the Andes are so steep as to make an ordinary steam railroad expensive to build and operate. Coal would have to be brought from the Pacific coast, and the grades would make the hauling of heavy freight expensive. An electric railroad can be built here more cheaply, can ascend steeper grades, and can be operated by the unlimited supply of water power obtainable from the La Paz River. This stream, even in the dry season, is a rushing torrent 20 feet wide and 3 feet deep, falling 10,000 feet between La Paz and the head of navigation at Reyes, 200 miles below. In some places rapids have a fall of 200 feet in half a mile. The valley through which the electric line would run contains several towns, one with 6,000 and another with 10,000 people. Trade is carried on through this valley to La Paz and the treeless plateau. In the vicinity of La Paz alone there are 100,000 people who secure a part of their food supply and all of their wood from down the river by expensive pack-animal transportation. This electric railroad, however, can not be economically built or profitably operated until the city of La Paz itself is connected by rail with the Pacific. Such an extension (155 miles) is planned by the Antofagasta Company.

When a railroad has been built across the plateau and connected with an electric line coming up from the plains of Bolivia, there will probably be a considerable export by the Pacific of products from this source. The alternative route is by the Madeira River and the Lower Amazon, but the engineering difficulties at the Madeira Rapids are as great as those that lie in the way of the railroad to the Pacific. The heat and dampness of the Amazon route are deleterious to many products, such as hides, coffee, cocoa, and cacao. This region is now exporting these products by way of the Pacific ports, and their movement in that direction would be greatly increased by the opening of such a railroad.

On the edge of the Sandia and Carabaya region, on the east slope of the Peruvian Andes, near Bolivia, an American company not long since paid $285,000 cash for a mine, carried machinery to it at a cost of $250 per ton, and is now crushing quartz ores and paying dividends. In the past the Spaniards secured much gold from the eastern rivers of Ecuador, Peru, and Bolivia.

One of the easiest regions to reach east of the Andes is northern Peru, where it is planned to cross the narrowest part of the plateau and connect the Pacific ports with the headwaters of the Amazon. This road is partly surveyed and has been begun by a company having concessions to work a large coal field located near the summit of the Andes. The quality of this coal is reported to be good, and the deposits extensive and easily workable. The location of this field near the divide of the Andes will make it possible to send coal to the Pacific and to the navigable parts of the Amazon, thereby facilitating steam navigation in interior Brazil.

As the Upper Amazon is a swift river, and the head of navigation ten times as far from the Atlantic as it is from the Pacific, some of the trade of the Upper Amazon country will come and go by Pacific ports after the opening of the isthmian canal.

Industrial changes on the plateau and eastern slope can not be expected to make much progress until better connections with the Atlantic shall have been provided. After this event, the exploitation of the mineral wealth of the plateau may be expected to follow, and that will require the opening up of the eastern slope as a source of food supply for the laborers who work the mines.

INDUSTRIES OF PACIFIC SLOPE OF ECUADOR AND COLOMBIA.

At the western point of South America the climate of the coast changes, and to the northward the desert gradually gives way to regions of increasing rains. The transition is made gradually. The southern part of the Ecuadorian coast is a fertile region with a tropic climate more healthful than many tropical localities. It has a population of about a quarter of a million, and is practically the only part of Ecuador engaging in foreign trade, the interior being almost entirely cut off.

The greater part of the population of the coast plain of Ecuador lives in the valley of the Guayas River, on which is situated the city of Guayaquil. The only districts at present productive are those of the lowlands, served by water transportation on the rivers centering at Guayaquil. This river system is navigated by many native boats and a number of small American-built paddle-wheel steamers of the Mississippi River type. In the rainy season they can go 200 miles inland and bring to the coast the export produce. The soil of this valley produces tropical products in abundance, and the country is in a prosperous condition. The exports are cacao, ivory nuts, rubber, sugar, coffee, tobacco, and hides.

The cacao is of excellent quality and is the chief crop. It is exported to the amount of 20,000 to 30,000 tons per year, and constitutes one-third of the world's supply. At present more than half of the crop is produced in one small district, but it is estimated that 19,000 square miles in Ecuador are suitable for the production of cacao, an article of which the world's consumption is increasing about 5 or 6 per cent annually.

The ivory nut is the seed of a variety of palm that grows wild. Seventeen thousand tons were exported in 1898, chiefly to Europe, where it is used in the manufacture of buttons. In the same year about 2,500 tons of coffee were exported, $50,000 worth of tobacco, and considerable quantities of other tropical produce. The only manufactured export is the so-called Panama hat, and there are practically no manufactures of home products, all kinds of manufactured articles as well as Temperate Zone food products being imported from the United States and Europe.

Ecuador seems to have mineral wealth, but there are as yet no wagon roads and no railways, nor have the mineral regions been much explored. There are quartz gold mines in the south and placer mines in the north, both being operated by foreign companies, one of which is an American firm, said to be doing well. Petroleum, copper, silver, and coal are reported, but at present they are not being developed. The railroad now building between Guayaquil and the interior will bring about the exploration and possibly the working of the various mineral resources. This railroad will bring from the hills to the lowlands Temperate Zone products which must now be imported, and will stimulate the trade of the country by giving nearly a million people their first chance to trade with foreign countries. Any increase of Ecuadorian commerce means an increase in the traffic through the canal.

The rainfall increases from northern Ecuador to the Isthmus of Panama, the shore plain of Colombia being marshy and unhealthful. Its forests are uninhabited save by a few Indians and half-breeds, and the only export is a small amount of timber, although in some places vanilla and cacao are indigenous. The forbidding character of the coastal region has prevented the settlement of the higher lands on the foothills of the Andes, where in Ecuador and northward there are valleys above the malaria level with a salubrious climate and fertile soil.

THE CAUCA VALLEY, IN THE COLOMBIAN ANDES.

The Andean Mountains divide, near the Ecuadorean boundary, into three great ranges, the easterly one bending around into Venezuela, the western one trending toward the Isthmus of Panama, and the central one separating the valleys of the Magdalena and the Cauca rivers. The Magdalena Valley has its trade outlet by way of the Caribbean; but the mountains of Antioquia, in Central Colombia, cut off the valley of the Upper Cauca from the Atlantic and make it necessary for all commerce to come and go by way of the Pacific through the port of Buenaventura.

This Cauca Valley is in the Andean region, but, unlike the other parts of the Andes of which we have spoken, it is both tropical and subtropical, having an elevation of from 3,300 to 6,000 feet. The valley is larger than the State of New Jersey, and contains one of the densest populations in South America. There are half a million people, comprising negroes, in the lower portion of the valley, and Indians and a considerable white population in the adjacent highlands. This section is truly Andean, however, inasmuch as it is cut off from the ocean by a range of mountains and has to depend upon pack-mule transportation for all of its commerce. The people do a little gold mining, but live chiefly by agriculture, importing nearly all of their merchandise, except some domestic manufactures of straw hats, coarse cloths, and utensils.

All the internal traffic of the valley, as well as its foreign trade, is carried over trails, the exports of agricultural products being limited to the most valuable articles, such as coffee and cocoa of the best grades, although corn, sugar, tobacco, and fruits are cultivated and cattle are raised. Concessions have been given for a railroad to go through the valley from the port of Buenaventura, and 20 miles of the line have been built, but the enterprise has come to a standstill. The completion of this line and the opening of an isthmian canal would bring the producing districts of the valley into close connection with the commercial world.

At present Buenaventura is in the traffic territory of the Panama railroad and steamship lines, whose freight charges are high. During the year 1900 such typical articles as wire and nails were taken from New York to China for $8 a ton, but it cost $15 to land them at Buenaventura, 7,000 miles nearer. From there the costs were $8 per ton to the end of the railroad and $40 per ton additional by pack mule over the pass of the Andes, 6,000 feet in elevation, to Cali, 77 miles from the ocean. The mule transportation cost 70 cents per ton per mile. After reaching Cali some of the goods had to double the freight charges of $63 per ton by being carried many miles up and down the valley. At the same time the steel manufacturers of Pittsburg were paying an unusually high freight charge of $3.60 per ton to the seaboard.

The opening of the isthmian canal, the building of the railroad, and the introduction of foreign capital would be revolutionary in their effect upon the trade of the Cauca Valley. The first effect of the building of the railroad would be to increase the importation of machinery for agriculture and the smaller industries. The continuation of the railroad up and down the valley would make it the route of transportation to the promising gold mines in the adjacent provinces of Colimo and Antioquia. The valley would export coffee, cacao, animal products, and raw sugar.

SUMMARY OF THE EFFECT WHICH THE CANAL WILL HAVE ON WESTERN SOUTH AMERICA.

Each of the five industrial divisions, discussed above, of the tropic Pacific section of South America is rich in resources and backward in industrial development. Capital is only beginning to overcome the difficulties that political and geographical conditions have placed in the way of progress. Nearly all of this region is still in the pack-mule stage of its industrial life. The present trade conditions there are more backward than were those prevailing in the trans-Missouri territories of the United States fifty years ago. At that time Kansas City and Fort Leavenworth were the entrepôts of a brisk and thriving trade with the far western frontier. Every spring trains of covered wagons, "prairie schooners," went across the great plains to the Spanish settlements of New Mexico, distributing supplies en route at the distant settlements and isolated ranches and trading posts of the hardy pioneers and trappers who had pushed on toward the Rocky Mountains. Freight rates, ranging from $40 to $200 per ton, excluded from trade all articles except necessities and limited the return cargo to such valuable commodities as furs, skins, and bullion. If we substitute the pack mule for the more efficient prairie schooner, the above description applies to most of the tropic Pacific section of South America. Limited areas are served by the few lines of railroad and by some river steamboats.

The tropical Pacific section has twice the population and but little more than half the trade of the temperate Pacific section. The 3,000,000 people of the temperate region carry on a foreign commerce amounting to $100,000,000, and the rest of the west coast commerce amounts to about $55,000,000. The exports exceed the imports by about $4,000,000. As in the case of Chile, the trade is nearly all with European countries.

Like the temperate section, the tropic region produces the raw materials we need and buys manufactures we might supply. The British cottons, for instance, purchased by Ecuador in 1898 were more valuable than all her imports from this country. After the isthmian canal is opened our cotton mills will secure that trade. The canal will facilitate the development of the resources of the tropic Pacific section, and thus enlarge the sale of American railway supplies and agricultural and mining machinery. The purchasing power of the South American people will increase, and trade with the United States will grow, not rapidly, but steadily, and to ultimately important dimensions.

EFFECT OF CANAL UPON ATLANTIC SOUTH AMERICA WILL NOT BE GREAT.

The isthmian canal will not greatly affect the Atlantic countries of South America. There is at present no direct trade between the two coasts of South America, except some little trade between Chile and the eastern countries of South America by way of the Straits of Magellan.

The exports of the South American and Central American countries are nearly all raw products, and there is no raw material produced on one coast that need be imported by the countries of the other coast. Rubber is the great staple of northern Brazil, but Ecuador and Central America are exporting some rubber across the Isthmus to the Atlantic. They also produce coffee, the great export of southern Brazil, and cacao, the staple of Ecuador, is also grown on the Atlantic coast. The temperate zone products needed by the tropic Atlantic countries of South America can be supplied by Argentina and the United States. The nitrate of Chile is not used on the east coast of South America except in the form of manufactured articles made in the North Atlantic countries. The canal may have some slight influence in reducing the cost of these. Should Argentina and Uruguay need nitrate or other Chilean products, the natural route of the trade will be through the Straits of Magellan. There is but little commerce, present or prospective, that might advantageously go from the one coast of South America to the other by way of an isthmian canal.

The countries on the Pacific between the United States and South America have exports and imports that are almost identical with those of western South America, and the statements that apply to the trade between the two coasts of South America will apply to any commerce between western Central America and Mexico and the Atlantic countries of South America.

The Western United States and Canada export some products to Atlantic South America. There have been occasional shipments of wheat, but this trade has about disappeared because of the competition from Argentina. Our Pacific coast lumber is used in Atlantic South America, and this is probably the only trade that will require the passage of ships directly from the Pacific through the canal to these countries. The temperate part of the Atlantic coast of South America, however, will get its lumber via the Straits of Magellan or Cape Horn because the eastern projection of Brazil makes those routes shorter. There is some demand on the Atlantic coast of South

America for our canned goods and wine from the Pacific coast, but such imports will not be sufficient to require a direct trade. They will probably be distributed from New York, London, or some West Indian port. There is also a prospect that before the canal is opened this demand for wine and fruit products will be wholly or in part supplied by Argentina, which is similar in climate and products.

Australia will have little, if any, trade with the Atlantic countries of South America. In the oriental countries the conditions for trade are somewhat better, although they will not need to import from Atlantic South America, because Eastern tropical countries are much nearer. The people of Atlantic South America will import oriental articles—tea, mattings, silks, and curios—but these articles will hardly be desired in such quantities as to require the passage of vessels directly from the Orient through the canal to these countries. The countries of that part of South America below the mouth of the Amazon will draw their supplies from European ports or from New York.

The countries between the Amazon River and the American Isthmus will also trade with the Orient more or less indirectly, although they will not be so dependent as countries farther south upon London and New York for their supplies of Pacific products. Some West Indian city, such as St. Thomas or Kingston, will doubtless become a distributing point for goods that come through the canal and are destined for the ports of the West Indies and northern South America. The ports are now visited by vessels touching at various places in northern South America, Central America, the West Indies, and Mexico.

The isthmian canal will bestow but few benefits upon the Atlantic countries of South America, because nearly all of their trade is with the North Atlantic. The greater part of their small commerce with the Pacific will probably come by the new route, and there will be some direct cargoes of Pacific coast lumber. The cost of securing oriental products, Pacific coast canned goods, and wine will be somewhat reduced. These commodities, however, will probably be distributed in large part from such centers as New York, London, or Kingston, Jamaica.

CHAPTER XII.—*Japan and the isthmian canal.*

THE SALIENT CHARACTERISTICS OF JAPAN'S RESOURCES.

The 4,000 mountainous islands of Japan[a] stretch northeastwardly along the coast of Asia in the latitude comprised between South Carolina and Maine. The climate, like that of our own Atlantic coast, is changeable, because of the uncertain direction of the winds from the great land mass to the westward, although extremes are less in Japan than on the Asiatic mainland. The winter winds blow from Siberia across the Japan Sea and produce heavy snowfalls on the west side of the islands, but the high mountains shelter the more populous eastern slopes, which are warmed by the Kuro Siwo, or the tropic Japan current.

In the summer both coasts receive winds from the ocean, which bring abundant rain, amounting to 80 inches per annum in the south, nearly double the amount that falls at Philadelphia or New York. The

[a] Consult Pl. 79 in connection with this chapter.

humidity of the climate of Japan is nearly equal to that of England. The ocean currents along the Asiatic shore are similar to those of our Atlantic coast. The Japan current meets an arctic stream along the northern islands of Japan and gives the shores and seas of that part of the Empire a foggy climate. The fishing banks, as well as the climate of that latitude, correspond with those of Newfoundland.

The agricultural resources of Japan are relatively meager because of the infertility of the soil and the small amount of tillable ground. The cultivable ground—12 per cent of the total area of the country—is fully and carefully tilled, mainly by hand labor. The cultivation of tea occupies a prominent place in the agriculture of the country. The chief food crop is rice, although wheat, barley, potatoes, and tobacco are grown. Fertilizers have to be used abundantly, fish from the northern islands of the Empire and bean cake from Manchuria having long been employed. Latterly some South Carolina phosphates have been purchased, a few shiploads of which are now annually imported. The phosphate fertilizers seem well adapted to the Japanese needs, and the construction of an isthmian canal would doubtless largely increase their importation.

The moist climate gives Japan a varied flora, but good forage is everywhere scarce, owing to the preponderance of the bamboo type of vegetation. There are only a million and a half horses in the Empire, while the number of cattle is slightly less, and there are no sheep. Japan is consequently obliged to import all the wool and woolens used and most of the hides, leather, dairy and meat products required.

Japan is becoming a food-importing country. The domestic supply of rice is now frequently insufficient. There is no sugar grown in the Empire. There is now some flour imported from the United States, and with the progress of the manufacturing industries of the Empire increasing quantities of American and Australasian breadstuffs and provisions will be required. The American breadstuffs will come from the Pacific slope; the provisions (meat and dairy products) will probably come, in part at least, from the central section of the United States.

Many of the raw materials required for the larger manufacturing industries are deficient or entirely lacking in Japan. Nevertheless the country is certain to become an important manufacturing center. The materials of industry of which Japan possesses the most abundant supply are timber, raw silk, and the grasses used in making straw braid and mattings. Such forest products as camphor, vegetable wax, lacquer, and bamboo are the basis of a considerable share of Japan's industries and exports. The prevalence of the mulberry tree in many parts of the Empire makes possible the growth and favors the manufacture of silk.

The mineral resources of Japan are especially deficient. There is a small export of copper, but there is no prospect of its increasing. At present very little gold or silver mining is carried on, but the introduction of western machinery may result in some development of the mines. Japan has petroleum fields, but the exports are small and the imports are much larger and are increasing rapidly. New fields are being opened, but there is no indication that they will be able to supply the requirements of the country. The coal exports of Japan, as is shown in Chapter VI of this report, are increasing, but the fields are limited, and the demands of the manufacturer of the country are rapidly growing. The price of coal in Japan is not cheap, it being too expensive to permit much development of iron and steel industries, although there are iron-ore deposits in the northern and southern parts of the Empire. The recent industrial progress of Japan has necessitated the importation of large quantities of iron and steel products, the home supply in 1898 being only one-ninth of the total consumption.

JAPAN AS A MANUFACTURING AND COMMERCIAL COUNTRY.

To become a manufacturing nation, in the modern sense of the term, required the Japanese to make great changes, but they possess the faculty of adaptation to such a marked degree that it required only thirty years for them to adopt the ideals of western civilization and many modern processes and to change from an isolated nation to one ambitious to participate largely in international trade. The limited area of Japan, its insular position, and the density of its population make its future progress conditional upon a large development of manufactures and commerce. The area of the Japanese Empire, exclusive of Formosa, is 147,655 square miles, or about 27,000 more than that of the British Isles; the population being 44,000,000, or 3,000,000 more than the inhabitants of the United Kingdom. The population averages 296 to the mile, being as dense as that of France and eleven times as dense as our population.

The people of the country constitute the nation's most valuable economic resource. They are skillful, artistic, and industrious artisans, and their high birth rate assures the country an abundant supply of labor. The chief obstacle to be overcome by Japan in the development of her industries is the insufficient supply of the raw materials required in the textile and iron and steel manufactures. She will need to import increasing quantities of materials, and for this reason, if for no other, the construction of the isthmian canal is a matter of much consequence to her.

The chief industrial activity of Japan centers about the inland sea, or Japanese Mediterranean, about which live nearly half of the people of the Empire. Surrounded by the three southern islands, it is a quiet, safe body of water, upon which commerce is active. There are three entrances from the ocean, many indentations into the land, and supplies of coal exist upon its southern shores. Where the most northerly arm of the inland sea reaches toward the center of the mainland of Hondo stand the cities of Osaka and Hiogo, which were fishing villages when Japan was opened to foreign trade. Now they contain more than a million people and have secured the commercial supremacy of the Empire. They are growing in population at a rate equal to that of the manufacturing cities of the United States and Germany. Osaka is the manufacturing center of the country, and within a radius of 100 miles are to be found 16,000,000 people and most of the cities of Japan. It manufactures large quantities of mattings and rugs and is the chief exporting point for tea. In 1895 it received more that half of the total imports of foreign commodities, besides having a heavy local traffic in rice, fish, timber, and edible seaweed.

Thirty miles inland from Osaka is Kioto, the old capital city of Japan, now connected with the seaboard by railroad, telegraph, and canals.

The city is located in the center of a fertile and densely populated plain and is an important center of manufactures. There are three other Japanese cities of importance not located on the inland sea—Tokyo, Nagasaki, and Hakodate. Hakodate is the fishing, lumber, and mining port of the north and is located near the northern coal fields. Nagasaki is at the southwestern corner of the Empire, near the southern coal fields. It exports nearly 2,000,000 tons of coal per year, has a good landlocked harbor, capacious docks, and, being located on the commonly used trade route between Europe and Asia, is a port of call for nearly all merchant ships and transports connected with our commercial and military relations with the East. Midway along the eastern coast is Tokyo, the capital of the Empire, which had about 700,000 people in 1872 and now has about 1,200,000, its area and population being nearly the same as Philadelphia. Besides being the capital of the Empire, it is the main center of distribution for the eastern part of the country and has many native manufactures. On account of the shallow harbor of Tokyo, most of its foreign trade is handled at Yokohama, the chief exporting city of the Empire, with a population of 100,000. Its foreign trade consists of silks, tea, camphor, lacquer ware, and other Japanese goods.

The growing foreign trade of Japan will make her a competitor with America and Europe in oriental markets, but in all probability the seriousness of this competition has been greatly exaggerated. This, however, need hardly be considered in this discussion of the relation of the isthmian canal to our trade with Japan, because the expansion of Japanese industry must inevitably be accompanied by large purchases and sales in the Central, Southern, and Eastern sections of the United States. The most serious rivalry between Japanese and American manufactures will probably be in cotton textiles, but that can hardly be felt for some time to come, because Japan is still a large importer of cotton goods, and her numerous population is rapidly enlarging its purchases.

The industrial progress of the Japanese is widening their range of imports very greatly. Wages are rising and enabling the people to satisfy new wants, and compelling capitalists to introduce labor-saving machinery. Although much has been said of the economic changes going on in Japan, her industrial revolution is only begun. The complete modernization of the industrial and social life of Japan will yet require several decades, and its accomplishment will necessitate a large trade with the United States and Europe.

ANALYSIS OF JAPANESE TRADE WITH REFERENCE TO EFFECTS OF THE CANAL.

The combined imports and exports of Japan were $13,000,000 in 1868, $28,000,000 in 1878, $65,000,000 in 1888, and more than $200,000,000 in 1898. She exports silk, straw braid, mattings, cotton yarns, cotton cloth, coal, tea, camphor, rice, mushrooms, and miscellaneous manufactures, and imports raw cotton and cotton manufactures, woolens, sugar, rice, beans, peas, oil cake, steamships, locomotives, steel rails, iron manufactures, and machinery. The chief countries with which she trades are China, Cochin China, and India, the United Kingdom, the United States, and Germany. From Asiatic countries she obtains rice, cotton, beans, and peas. From Europe and the United

States come mainly metal manufactures, dry goods, raw cotton, and food stuffs. The percentage of the total exports consisting of manufactures is increasing, and the imports are made up of a decreasing percentage of manufactures, as would naturally be expected from what has been said concerning the diversification of industries in progress.

While the development of Japan's foreign trade has been very rapid, the growth of our share in that enlarging trade has been still more rapid. In 1881 we sold Japan less than 6 per cent of her importations, but in 1898 our sales comprised 15 per cent, while during the same period the part furnished by England declined from 52 per cent to 23 per cent of the total. In 1896 our exports to Japan increased 84 per cent; in 1897, 57 per cent; in 1898, 45 per cent, and during the first six months of 1899, the latest period concerning which statistical data are obtainable, the United States occupied the first place among the nations supplying Japan with imports. There has also been a steady growth in our importations from Japan, and while they have not grown as rapidly as our sales to that country, they have a higher total, and we are Japan's best customer. Her raw silk is the chief supply for our mills, and her tea, mattings, and bric-a-brac are important items. The growth of Japan's trade with the United States during the six years 1892–1898, was remarkable. The exports to the United States gained more than those to Europe; the imports increased over sixfold, although this was a period of a large increase in home industries.

The growth that has taken place in Japan's imports has been most rapid in the case of raw cotton, woolen goods, flour, railway materials, fertilizers, tobacco, leather and leather manufactures, cotton-spinning machinery, and paper, and it is especially interesting to note that many of these commodities of increased import are furnished by the United States and are the articles in which we have decided advantages of production or manufacture, to wit: Leather goods, flour, railroad supplies and machinery among the manufactures, and meat, cotton, tobacco, and phosphate rock among the raw materials. A brief reference to iron goods, cotton, and phosphates will illustrate our interest in the Japanese import trade.

In 1896 we furnished one-sixth of the rails imported into Japan; in 1898 our share had grown to two-thirds. We already have a large part of the trade in electrical supplies, and also furnish a growing proportion of nails and bridge materials. European countries lead in other classes of iron manufactures. The growth of our iron trade with Japan is mainly a question of cheaper transportation. As freight costs are reduced the Japanese will draw upon us in larger measure for railway materials, and for the steel needed in rebuilding their cities and in equipping their factories with machinery.

The importations of raw cotton into Japan have increased very largely. The cotton ports of New Orleans and Galveston are the most distant of our seaboard cities from the Pacific by existing water routes. At the present time our cotton sales in Japan consist almost entirely of the raw staple, but this should not always continue. In 1898 Japan imported 60,000,000 yards of unbleached muslin, worth $2,100,000, and less than one-thousandth of it came from this country. Direct communication between our Southern mills and Japan would doubtless enable us to furnish a large share of it.

The soil of Japan is not rich, and the number of farm animals is very small. The increasing population and rising standard of consumption will necessitate the highest attainable degree of intensive cultivation, and this will require larger supplies of fertilizers. We have begun exporting to Japan oil cake and phosphate, of which articles we have most of the world's supply, but they are commodities of such low value that the trade can not increase greatly until the canal has lowered the costs of transportation. Phosphate rock, worth one-fourth of a cent a pound at the seaboard is a good illustration of the class of cheap goods necessary to industrial progress which can be carried long distances only by water transportation of the most economical character.

With the exception of the Pacific coast flour and canned goods the trade of this country with Japan originates in the manufacturing East and in the Southern States. By present routes Europe has the advantage. The canal will enable us to supply Japan with larger amounts of bulky articles in whose cost to the consumer the charges for freight are an important item. We are now supplying a limited quantity of such articles, but under better freight conditions there is no reason why that trade may not greatly increase. Examples of this class are cement, alcohol, condensed milk, glassware, small agricultural implements, iron manufactures, mining machinery, locomotives and other engines, wire, paint, and paper. Cheaper transportation would, moreover, enable the United States to sell some of the lighter as well as the heavier commodities to Japan, and increase both the variety and quantity of our exports to that country.

Chapter XIII.—*China and the isthmian canal.*

An analysis of the resources and industrial conditions of China presents many difficulties. The Chinese Empire is a large region, with a great diversity of resources, concerning which present information is partial and indefinite. During the last few years a large amount of descriptive literature has been written regarding China, but definite statistical information, whether of a private or an official nature, is very scanty. The assertions of all well-informed people agree in representing China as a country with a great variety of valuable natural resources. The population, moreover, is usually represented as being industrially efficient.

Speaking generally, China[a] is to be thought of as a densely populated and industrially undeveloped country, possessing varied and abundant resources, which, under the supervision of capable captains of industry, can be made the basis of a wide range of economic activities. The questions uppermost in this discussion are whether these resources and activities are such as will be affected by the American isthmian canal, and whether the economic progress of China will be accompanied by a larger trade between that country and the Atlantic section of the United States—that section whose trade with trans-Pacific countries will come most directly under the influences of the canal.

GEOGRAPHICAL DIVISIONS OF CHINA.

China proper, or, as it is sometimes called, the Kingdom of China, and the dependency of Manchuria consist of a coastal plain and a

[a] Consult Pl. 80 in connection with this chapter.

plateau of mountainous upland region, which increases in elevation toward the west and finally merges into the lofty arid plateaus of central Asia. The coastal plain is mainly of alluvial origin and is 200 miles in length and about 400 miles in breadth near the Yangtse, below which region it rapidly narrows until in southern China it extends inland but a short distance. This coastal plain is extremely fertile, is well watered and highly cultivated. Probably half the people of the entire Chinese Empire dwell in this section, the density of whose population may be illustrated by reference to the province of Kiangsu, which is reputed to have 40,000,000 inhabitants within an area of 40,000 square miles.

The broad mountainous upland region lying between the coastal plain and the arid plateaus of Tibet and Mongolia are supposed to be relatively fertile and are known to possess abundant stores of coal, iron, copper, and other valuable mineral resources. This part of China has as yet been brought but little under the influences of international trade and western civilization.

China[a] occupies the eastern part of Asia between the parallels of 20° and 50° north latitude. It is the geographical counterpart of that portion of the eastern part of North America lying between Cuba and Labrador. Manchuria is in the latitude of northern Quebec, and Canton, situated just within the Tropics, has the latitude of Habana. Northern China has the severe winter climate of Canada, while Hongkong and Canton have the climate of southern Florida and Cuba. China, consequently, like the United States, has a great variety of agricultural products and can, within its own borders, produce nearly all the articles required by its people. This fact explains why it has been possible for China to remain for four thousand years practically without intercourse with outside nations.

For the purposes of this discussion of the industries and trade of China, and the effect which a canal will have upon them, it will be helpful to divide China into three geographic zones. The basis of division is a dual one, resting partly upon differences in climate and partly upon the physiography of the country. These three divisions are (1) northern China, including Manchuria,[a] the Peiho and Hoangho valleys, and the peninsula of Shantung; (2) central China, comprising the valley of the Yangtse River, and (3) southern China, comprised mainly within the valley of the Siho, or West River. The northern district has its commercial outlets on the Gulf of Pechili and corresponds in latitude and industrial products to our North Atlantic States and Canada. Pekin is on the fortieth parallel, the one that passes through Philadelphia. Central China corresponds more nearly to the South Atlantic and Gulf States of our country. Shanghai, its metropolis, is in the latitude of Savannah, Ga. Southern China corresponds in latitude and production with the extreme southern portions of the United States and with the West Indies.

The boundaries of these divisions are not everywhere clearly defined physiographically, because they merge into each other in the coastal plain. They are, however, sufficiently distinct for the purposes in hand.

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[a] In this discussion China will be considered to include Manchuria, although, strictly speaking, that is a dependency of the Kingdom of China.

RESOURCES AND TRADE OF NORTH CHINA—MANCHURIA, HOANGHO VALLEY, AND SHANTUNG.

Manchuria lies to the north and east of the Great Wall, mainly between the fortieth and fiftieth parallels of north latitude. It extends from the Gulf of Pechili to the Amur River. The population of this district is said to be 22,000,000.

It is in the wheat belt of China, adapted by climate and fertility of soil to general agriculture, and is reputed to be a region of a fair degree of fertility. It possesses extensive forests, some of which contain valuable hard woods.

Eighty miles north of Niuchwang, in Manchuria, are coal deposits, presumably rich and extensive. These coal fields are crossed by the railroad now being built from Siberia to Port Arthur. Mining operations will doubtless follow the completion of this railroad, and will include not only the development of the coal mines, but also the mining of gold, lead, and copper. Gold is now exported from Manchuria.

The agricultural, and particularly the mineral, resources of Manchuria, like those of China generally, have received but little development, because of the lack of means of communication and transportation and because modern methods of production have not yet been introduced. The people of Manchuria seem less adverse to change than do those of other parts of China, and it is probable that the present activity of Russia in that section will result not only in the establishment of railway transportation, but also in the introduction, to some extent at least, of modern methods of production.

The present commercial importance of Manchuria can best be illustrated by reference to the trade of its principal port, Niuchwang. The commerce of this city averages over 30,000,000 taels ($24,000,000) per year and is rapidly increasing. It is the distributing point for Manchuria, the imports consisting chiefly of cotton and woolen goods, kerosene, iron and steel, and general manufactures. Its exports comprise agricultural and mineral products. Niuchwang is in the part of China nearest to the United States, and our export trade to China is mainly with Manchuria, about half of the imports of that district being from our country. The things we sell in Manchuria consist chiefly of cotton goods, petroleum, and iron and steel products, commodities produced in the eastern part of the United States.

With the completion of the trans-Siberian railway Niuchwang will become an exporting point and distributing center for an extensive district reaching as far inland as Lake Baikal in Southern Siberia. The trade of eastern Siberia and of Manchuria will always be handled through the Pacific rather than Baltic ports. Lake Baikal is farther from St. Petersburg than San Francisco is from New York, and the railway from St. Petersburg has the Ural Mountains and heavy grades to overcome. This fact makes it certain that the heavy commodities imported into the region east and southeast of Lake Baikal will be handled through Niuchwang, Vladivostok, and other Pacific Asiatic ports. The imports of this region will continue to come largely from the United States. In discussing the iron and steel industries of the United States attention was called to the fact that four full ship loads of locomotives had been shipped from Philadelphia to Vladivostok during the two years 1898–1900. The eastern third of the Siberian railway is being built with rails rolled in Pittsburg and ties exported from Oregon.

The Peiho and Hoangho Valleys, the second subdivision of the northern section of China, are supposed to contain between 80,000,000 and 100,000,000 people. The region consists of a coastal plain, most of which is included in the province of Pechili, the mountainous district comprised within the province of Shansi, and the pastoral and agricultural upland provinces of Shansi and Kansu lying to the west of the mountains of Shansi.

The coastal province of Pechili is drained by the river Peiho, upon which the cities of Tientsin and Pekin are situated. This region and the lower course of the Hoangho is made up largely of fertile alluvial soil, from the products of which a dense population supports itself. In the mountainous province of Shansi are located the richest coal fields of China, concerning which much has been said by Richtofen and all travelers who have explored this region. It is probable that one of the earliest resources of China to be developed in the future will be the coal fields of Shansi. In order to accomplish this it will be necessary to extend the railroad which now runs from Tientsin to Pekin into the mountains lying west of those cities.

In the westerly part of the Hoangho Valley is the province of Kansu, which extends far into the arid Mongolian plateau. The province is well adapted to grazing, and large sections of it can be cultivated. There are, moreover, numerous deposits of coal, and better means of communication and production would enable the province to develop a domestic and foreign trade of considerable proportions. This province is the present gateway to Mongolia and is crossed by the caravan route from Pekin to Turkestan. The exports and imports of the region west of the Shansi Mountains are handled over this caravan route.

The city of Tientsin is in the commercial center for the Peiho and Hoangho valleys. The railroad connecting Tientsin with Pekin, and by means of a line extending northeast with the coal fields of the Gulf of Pechili, was causing the population and commerce of Tientsin to increase rapidly before the outbreak of the Boxer rebellion. The city of Tientsin has a population said to number 1,000,000. Its commerce doubled between 1887 and 1897, when it amounted to 55,059,017 taels, or $44,000,000. In 1899 the value was 77,604,562 taels, or $61,000,000. With the restoration of stable political conditions in this part of China and the continuation of the industrial development that the present rebellion has interrupted, the commercial importance of Tientsin must inevitably increase. Probably the most important imports of this city will always be cotton goods and iron and steel manufactures. Our ability to supply those goods and the effect which the canal will have upon that trade have been sufficiently emphasized in another place in this report.

The province of Shantung comprises that part of the coastal plain crossed by the lower course of the Hoangho and the mountainous peninsula having the same name as the province. One-half of this district is tillable and the other half contains a variety of minerals, the most valuable of which is coal. There are four coal fields now being worked in a feeble way by the natives, but which the Germans, who now control the larger part of Shantung, expect to make highly productive.

The Germans have taken hold of the development of the peninsula of Shantung in a vigorous way, extensive improvements having been made at the harbor of Kiaochau, and a railroad 280 miles in length having been planned and partly constructed. The supplies for the entire railway line were delivered in December, 1899, but the completion of the road has been delayed by the recent insurrection. It is expected that German capitalists will develop the mineral and other resources of Shantung at an early date.

Shantung has two ports, Chifu and Kiaochau, the latter of which will in all probability become the more important one. The exports will consist mainly of minerals, silk, and tobacco, and the imports will comprise flour and provisions, cotton goods, iron and steel, and other manufactures. The Germans will doubtless endeavor to control the major share of the trade, and during the early years of their occupation they will in all probability supply most of the iron and steel and other commodities imported. It seems probable, however, that the cotton goods will, after a few years, at least, be supplied largely by the United States, and also that the iron and steel manufactures will come in part from this country. If the Germans succeed in organizing efficiently the 30,000,000 people said to dwell in Shantung, they will give rise to a large foreign trade in which the United States will unquestionably have a share.

RESOURCES AND TRADE OF CENTRAL CHINA—THE YANGTSE VALLEY.

The great central portion of China is included within the Yangtse Valley, which in general occupies a strip of country extending 250 miles on each side of the thirtieth parallel of latitude. It is the largest of the three sections in which China has been divided in this chapter, and possesses the greatest variety and abundance of natural resources. The Yangtse Valley is divided into two rather distinct parts by the gorges in the river just above the city of Ichang, about 1,100 miles from the ocean.

Probably one-half of the valley below the gorges consists of the coastal plain, the other half being upland country. The great silk and tea districts of China are crossed by the lower course of the Yangtse River. Rice and cotton constitute other productions of great value. The population of certain sections of the lower course of the Yangtse is probably more dense than that of any other section of the Kingdom.

Although the most valuable resources of the lower valley are agricultural, there are large stores of minerals, particularly coal, which is known to exist in large quantities in the province of Hunan south of the river. In the mountainous regions, where the tributaries of the Yangtse originate, are reported to exist deposits of copper, gold, silver, and lead.

The Yangtse Valley above the gorges is an extensive rolling country, most of which is included within the province of Szechuan, north of the river, and Kweichau, on the south side of the stream. Both provinces have abundant stores of coal, copper, iron, tin, lead, and the precious metals. Kweichau is a more distinctively mineral region than Szechuan is. In the latter province the rice crop is the most important one, but wheat, sugar, opium, and fruits can be, and are, produced to some extent. The climate is very much like that of France. Cotton, the chief material from which clothing is made, can not be produced in the province. The exports from the Upper Yangtse Valley consist of hemp, opium, hides, bristles, wool, wax, and some silk. At the present time the chief imports into the region consist of cotton goods.

Very little credence is to be given to the statistics of Chinese population, which must always be regarded as estimates. There are, however, said to be 70,000,000 people in the Yangtse Valley above the gorges, and whether this figure be right or not, it can not be doubted that this interior portion of China must in time become the center of a large domestic and foreign trade. At the present time the only commercial highway is the Yangtse River, which is obstructed not only by the gorges above Ichang, but also, and more seriously, by the tax officials of the various local governments along the river.

The city of Shanghai, at the mouth of the Yangtse, is the port of entry for the whole valley and the most important commercial center of all China. Fifty-five per cent of all the Chinese imports and 48 per cent of the exports are handled in this city. There is, moreover, some prospect that manufacturing industries will be successfully developed at this point; some beginnings have already been made. It is an interesting fact that most of the trade of the United States with China, although our chief markets are in Manchuria and the northern part of the Kingdom, is handled through Shanghai, that city being the distributing point not only for the Yangtse Valley, but for North China as well.

About seven hundred miles up the Yangtse River is the city of Hankau, the most important interior distributing point in the Kingdom. By means of the Yangtse and its branches from the north and south it has water connection extending in all directions, and from it nine provinces of China can be reached. The city is accessible to seagoing vessels and, consequently, has a large trade directly with foreign countries. The city is the market place for traders from various parts of China, and its central location in the fertile section of the Kingdom makes it the point of shipment for a large part of the export trade of central China.

The evidence is conclusive that the great Yangtse Valley of central China, comparable as regards area and wealth of agricultural and mineral resources with our Mississippi Valley, is destined to become industrially and commercially important when its resources and great supply of labor can be organized. The time can not be far distant when capital will provide means of transportation and develop the natural resources of the country. When this is done the region will surely have a large import trade in the class of manufactures produced in the Eastern and Southern sections of the United States. Those parts of the United States, moreover, will require the silk, wool, and other raw materials of industry from the Yangtse Valley, the present exportations of which are but a fraction of what they might be made.

RESOURCES AND TRADE OF SOUTHERN CHINA.

The southern district of China is situated on both sides of the Tropic of Cancer, and includes the coastal region of the province of Fukien and the territory drained by the Siho or West River and its tributaries.

The products are almost entirely agricultural, and are those of the tropical and subtropical regions. Silk, tea, rice, sugar, opium, camphor, and various medicinal plants are grown and exported in greater or less quantity. The manufactures of the region are all handmade, and consist of mattings, silks, lacquer ware, embroideries, and the sails required for the domestic shipping.

The upper valleys of the West River and its tributaries contain mineral resources, and these might, without great expense, be made accessible by improvements in the river navigation. Southern China, like the rest of the country, however, is still industrially undeveloped, and must remain so until a government can have been established that will be strong enough to protect personal and property rights.

The city of Hongkong, on an island at the mouth of the West River, is the main port of southern China, and next to Shanghai the most important one on the Pacific coast of Asia. Besides Hongkong, the cities of Amoy and Fuchau, on the coast to the east and north of Hongkong, are growing centers of commerce.

It is said that Hongkong is the distributing point for 80,000,000 people, and its position is such that its trade must grow pari passu with the development of southern China. The city is about equally distant from New York by the Suez and American isthmian routes. At the present time its trade with the Atlantic part of the United States as well as with Europe is handled by way of the Suez. After the American canal has been opened the trade of Hongkong and all southern China generally will probably be divided between the easterly and westerly canal routes. One reason why the westerly route will obtain a share of the trade is that Hongkong is the terminal port for vessels outbound across the Pacific from the United States. At present nearly all the lines from British Columbia and our west coast ports call at Japanese ports, Shanghai, and Hongkong. After the canal has been opened vessels crossing the North Pacific from America to Asia will naturally call at Japanese and central Chinese ports and proceed to Hongkong or Manila. Southern China and the Philippines are in the region whose commerce will be competed for by both routes. When the American canal has been opened the traffic will be divided between the two canals and the exporters of that region will profit by the competition of the two routes.

THE FOREIGN TRADE OF CHINA.

The aggregate foreign trade of China in 1899 was valued at 475,000,000 taels ($380,000,000), of which 280,000,000 taels were imports and 195,000,000 were exports. In 1897 the total foreign trade amounted to 367,000,000 taels ($294,000,000). While this total seems fairly large, the amount of trade per capita is extremely small, barely one dollar per person. There are some countries with natural resources inferior to those of China whose foreign trade is from twenty-five to one hundred times as much per person. The foregoing analysis is sufficient to show that the resources and labor supply of China are ample to support extensive industries capable of giving rise to a large foreign trade, were the political and social conditions favorable to economic progress.

Whether and to what extent the present untoward political and social conditions of China can be improved constitutes the Chinese question. To the solution of that question the powers of Europe and the United States are devoting their best endeavor. It can hardly be said, however, that the ultimate outcome of their efforts can be clearly foreseen. If the powers succeed in securing for China a stable and fairly progressive government under which the individual and society may develop industrially, there can be no question but that the foreign commerce of China will reach large proportions.

The truth of this statement is clearly shown by what occurred during the five years preceding the outbreak of the Boxer revolution. During those years comparatively rapid progress was being made in the work preparatory to rendering the natural resources of the country available. Mining concessions were obtained by various capitalists, railroads were under construction, and there was every indication that the natural wealth of China was to be made to contribute largely to international trade. In 1899 the total trade was 24 per cent more than that of the preceding year and double that of the year 1890.

The most important imports into China are cotton goods, which comprise over a third of the total inbound trade. The commodity next in rank is opium, which is followed by kerosene, metals, coal, woolen goods, and a variety of other commodities. Silk, raw and manufactured, ranks first among the exports, tea being next in importance. Among the other exports of consequence are straw braid, sugar, hides, clothing, paper, and pottery. At the present time Great Britain controls more of this trade than any other country, but her share of the total is decreasing. An analysis of our trade with China will show that the opposite is the case with our commercial relations.

TRADE OF UNITED STATES WITH CHINA AND EFFECTS OF CANAL.

The trade of the United States with China included $27,000,000 worth of imports into this country and $15,000,000 worth of exports to China during the year ending June 30, 1900. This total of $42,000,000 indicates an increase of 50 per cent within a decade. The most rapid growth has taken place in our exports of cotton goods. The value of cotton sheetings sent to China in 1899 exceeded the value of our total annual exports to that country for the years preceding 1896. Next to cotton goods, our leading article of exportation is kerosene oil, but in addition we are selling increasing quantities of iron and steel, breadstuffs, lumber, and general manufactures. Among the articles which we import from China, silk, raw and manufactured, holds first place, and tea occupies the second position. These two articles comprise over half the total value of the imports. Raw wool, hides, skins and furs, straw braid, and a variety of curios make up the larger share of the other articles imported.

The rapidity with which our trade in China is growing may be shown by a few comparisons. During the three years ending in 1899 the total imports of Shanghai increased 50 per cent and those from the United States were doubled. In 1895 Great Britain exported to China five times as much as we did, but in 1899 her trade was less than twice ours. Our imports of Chinese goods direct from China (i. e., exclusive of the Hongkong trade) are now nearly double what those of the United Kingdom are. Moreover, the Chinese statistics do not give us credit for all the trade we have with the country. Some of our trade is handled by way of Europe and credited to European countries, while another large share goes from New York by way of the Suez Canal to Hongkong, whence it is distributed in China. It appears as imports into Hongkong and as exports from that city to China. All nations, both oriental and western, handle more or less of their trade with China through Hongkong. Apparently the trade of the United States with Hongkong direct is two-thirds as large as Great Britain's is. A French commission sent out to China in 1895 to study the trade situation added 63 per cent to the figures of American trade to cover the amount that entered China by indirect routes, and there is no indication that any important change has taken place since then in the routing of trade such as would have changed the percentage of our indirect as compared with our direct shipments.

The general relation of an isthmian canal to our trade with China may be easily and briefly stated. The breadstuffs and lumber which we export across the Pacific will unquestionably be sent from the Pacific coast. The same will be true of the lighter manufactures of high value per bulk. Should we develop any considerable trade in provisions, the main source will be east of the Rocky Mountains. The iron and steel, general manufactures, kerosene, and cotton goods will be exported from the eastern and southern sections of our country. They will unquestionably constitute canal traffic, and their sale will be largely facilitated by that waterway.

Our kerosene trade in China is already feeling very keenly the competition of Java and Russia, and our exporters are able to hold their trade only because they have developed unusually economical means of transportation.

Probably our exportation of cotton goods will be affected more favorably by the canal than will any other class of goods sent to China, with the possible exception of heavy manufactures of iron and steel. It is estimated that 70 per cent of the cottons exported from this country to China are manufactured in the Southern States, the section nearest to the canal. At the present time four-fifths of these exports go by way of the Suez Canal, the other fifth being sent across the continent, largely by way of the Canadian Pacific Railway. Moreover, the foreign destination of these goods is nearly all in northern China, that part of the country nearest to the United States by way of the isthmian canal and most remote from us by way of the Suez. Even under the present unfavorable conditions of competition we are securing control of the larger part of the cotton-goods trade of northern China. During the past decade the imports of cotton goods into that section from England and Dutch countries declined over 50 per cent, whereas ours increased 400 per cent during the same period. With the canal to assist us in the development of this trade, it seems certain that we can not only control the business, but can do it with a large margin of profit.

Should the anticipated industrial development of China occur, will the country become independent of foreign trade? Will it supply its own needs? Not a little has been heard regarding the danger of Chinese development to American labor and American industries. The fear has no basis in experience. In general it may be said that our trade is greatest with those countries whose industrial development has reached the highest stage of evolution, and that our commerce increases in proportion to the economic progress of the country traded with. Japan is a case in point. The large development now in progress in that Empire is being accompanied by a very rapid growth in her trade with the United States. The same is true in a less degree of Chile, and would be true in a much greater degree if we were able to trade with Chile under favorable conditions of transportation.

Industrial development and economic progress are always accompanied by an increase in wages and a rise in the standard of life. If foreign nations succeed in organizing the industrial forces of China, they will also succeed in greatly multiplying the wants of the people and laying the foundation for a much larger trade between that country and all parts of the world.

CHAPTER XIV.—*The canal and the industries and trade of Australasia.*

There is possibly no part of the world outside of Europe and the United States that has a more promising commercial future than Australia. The area of the island continent of Australia is about equal to that of the United States, exclusive of Alaska and the colonies, each having somewhat less than 3,000,000 square miles of territory. The density of the population of the two countries is, however, very different, for at the beginning of 1899 there were but 3,556,000 people in all Australia, a smaller number than there are in Illinois or Ohio, not to mention the still more populous States of Pennsylvania and New York. In spite of its small population, Australia is a region having an enormous commerce, the average trade per capita being one hundred times that of the Chinese people. This enormous trade results partly from the nature of the industries of the country, and partly from the character of the population, which is nearly all British. The people have a very large average per capita wealth, and their standard of living is high. They consume large quantities of manufactures, which they are able to purchase because of the vigor and energy employed in the development of the abundant natural resources of the virgin continent.

AUSTRALIAN INDUSTRIES REQUIRE A LARGE FOREIGN TRADE.

The rapid development of the natural resources of Australia could not take place without an immense foreign trade. The chief industries[a] are pastoral, agricultural, and mineral, all of which can be carried on with a comparatively limited supply of labor. The vast area of the country, and the fact that but a small portion of the territory has yet been occupied make certain the continuance, without very great change, of the present industrial conditions of the country for several decades. Although the country possesses liberal stores of minerals other than the precious metals, there is little prospect of the early development of industries upon which highly developed manufactures must rest. The three most essential requisites to diversified manufactures are cheap labor, cheap and abundant coal and iron, and surplus capital seeking investment. Although Australia has coal and iron, labor and capital are so scarce that fuel and steel must necessarily be more expensive than they are in Europe and the United States, where most of the world's manufacturing is done at the present time. For some time to come the profits in the pastoral and agricultural industries and in the mining of precious metals will continue to offer greater inducement than can the manufacturing industries. This is equivalent to saying that Australia will, for several decades at least, continue to export great quantities of food supplies and raw materials in exchange for manufactures.

In Australia's total foreign commerce of $350,000,000 worth of goods annually the United States has a large and rapidly increasing share.

[a] See Pl. 81.

The development of our manufactures will require constantly larger quantities of the exports of Australia, and our export trade to that country is certain to be of constantly increasing importance to us.

THE CANAL AND DISTANCES TO AUSTRALIA.

The distances from New York and our North Atlantic ports to Australia by way of the Suez Canal and by way of the Cape of Good Hope are practically the same, consequently all our direct commerce with Australia moves around the Cape. In the tables included in Chapter XVII, the distances from our Atlantic and Gulf ports to Australian cities by way of the Cape of Good Hope route and the proposed Nicaragua Canal are compared. By referring to the table it will be seen that New York is 3,982, or in round numbers 4,000, miles nearer Sydney by way of the Nicaragua Canal than by way of the route followed by vessels going to Sydney by way of the Cape of Good Hope. Adelaide, the most westerly port of the industrially important part of Australia, will be 1,816 miles nearer New York and 3,587 miles nearer New Orleans by way of the Nicaragua Canal than by Good Hope.

A map[a] accompanying Chapter XVII shows the line connecting the points equidistant from New York by way of the Nicaragua and Suez routes, and it will be seen that the line crosses the western part of Australia and touches the continent of Asia west of Hongkong. These references to distances are sufficient to show that the industrially and commercially important half of Australia will be brought from eight to fifteen days nearer our eastern seaboard by the construction of an isthmian canal.

The tables of Chapter XVII show that the entire continent of Australia is nearer Liverpool by way of the Suez Canal than it will be by way of the American isthmian route. Attention may be called to the fact, however, that Sydney will be only 172 miles farther from Liverpool by the Nicaragua route than by the Suez. The line connecting points equidistant from Liverpool by way of the two routes passes between New Zealand and Australia and east of the main island of Japan.

The Suez route to Australia is shorter for European commerce than is the Good Hope route, but the difference is not enough to induce slow freight steamers to use the canal, the tolls of which amount to about $2 per net ton, British measurement. Letters received from European steamship companies show that about the only steamers between Europe and Australia using the canal are those which carry passengers and mails. The slow-going freighters practically all go around the Cape. As compared with the Good Hope route between Europe and Australia, the American canal line would be shorter. The east coast of Australia will be almost equidistant from Liverpool by the easterly and westerly canal routes. The significance of this is enhanced by the fact that over half the commerce of Australia is handled at Sydney, which port is made by all vessels, whether from Europe or from the United States. The references to distances are not intended to imply that distance is the only fact determining the routes taken by vessels.

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[a] See Pl. 86.

GENERAL GEOGRAPHY OF AUSTRALIA.

The continent of Australia is situated between 10° and 40° south latitude, somewhat over half of the continent being south of the Tropic of Capricorn. The island is regular in shape, has a coast line but little broken, and consists of a comparatively narrow rim of well-watered and fertile country, within which is a vast stretch of semiarid and arid country, much of which has an annual rainfall of 10 inches or less. Almost all the mountains are situated near the coast, the highest ones being the Australian Alps, which run parallel to the eastern and southeastern shore about 50 to 75 miles from the ocean. The average height of this range is 1,500 feet, the peaks rising to 5,000 and 6,500 feet. The eastern slopes are everywhere well watered, and this portion of Australia is the most fertile and thickly settled part of the continent.

The western slopes of these mountains are very gradual, and are drained by the Murray and Darling rivers and their tributaries, which together have a basin as large as that of the St. Lawrence or the Danube. This is the great grazing section of Australia. The eastern and southern sections of the basin, however, have a rainfall of 25 to 40 inches, and are adapted to cereal agriculture.

The eastern third of Australia is divided into three political divisions, Queensland occupying the northern half of this eastern section. South of Queensland is New South Wales, below which is Victoria. The most populous and productive parts of Australia are New South Wales and Victoria. These colonies occupy a region corresponding in latitude to that of the United States between New York City and Jacksonville. South Australia consists of the central third of Australia, west of which is the great tract of western Australia. Both of these divisions are arid except within the narrow rim near the ocean, and in the tropical northern sections where the trade winds, unobstructed by any coastal mountains, give the country abundant rainfall. But little of the tropical section of Australia has as yet been occupied because the British colonists have not found the region healthful.

PASTORAL AND AGRICULTURAL RESOURCES.[a]

From the first years of its settlement Australia has been celebrated as a grazing region. Everywhere, with the exception of the tropical lowlands and the interior desert sections, the climate is favorable to sheep and cattle, and the forage is abundant.

The most important grazing district of Australia is the large interior basin of the Murray River and its tributaries, where a large part of the country is taken up with the cattle and sheep ranches. The more populous sections of the country between the Australian Alps and eastern and southern coasts are changing from grazing to dairying, Australia having become an exporter of large quantities of dairy products.

A few statistics regarding the number and value of the cattle and sheep of Australia will serve to illustrate the importance of the grazing and dairying industries of the country. After three years of most destructive drought, there were 112,000,000 sheep and 14,000,000 cattle in Australia in 1899. The figures for the United States are in

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[a] See Pl. 81.

round numbers 40,000,000 sheep and 27,000,000 cattle. New South Wales alone has as many sheep as the whole of the United States. The Australian wool furnishes one-fourth of the world's supply, and is of the finest quality. During the past decade it has been worth at least $120,000,000 per annum, and in addition to this, $80,000,000 have been annually derived from the meat and other animal products. This total of $200,000,000 per year amounts to over $50 for each person in Australia.

The agricultural industries of Australia include the raising of grain, the growing of fruits, and the production of sugar. The grain-producing districts lie on both sides of the Cordilleran Alps in New South Wales and in Victoria and on the shores of Spencer Gulf, in South Australia.

The colony of Victoria, whose area and population are about the same as those of Nebraska, had a wheat crop of 20,000,000 bushels in 1898. Half as many bushels were raised in the neighborhood of Spencer Gulf. Australia can not, however, be regarded as a very favorable wheat-growing country because of the uncertainty of the rainfall in many parts of the wheat-growing sections. Irrigation is being extensively resorted to, and it will doubtless enable the country to support a great many more cattle and sheep, to increase the annual grain production, and to enlarge the acreage of its fruit orchards.

Horticulture is rapidly developing in Australia. The lower regions of the subtropical and tropical districts produce the fruits usually grown in the climate of those regions, and the upland districts of the more southerly and temperate colonies are adapted to the production of grapes, apples, pears, plums, and similar fruits. In the Victorian part of the Murray River Valley there are said to be forty corporations holding concessions aggregating 2,000,000 acres, under which they are developing irrigation projects, mainly for the purpose of growing fruits. In the neighborhood of Wallaroo, north of Adelaide, there is an irrigation system using 670 miles of iron and steel pipe, by which water is distributed to places 25 to 75 miles distant. This region produced 1,080,000 gallons of wine in 1898. The exports of fruit from the region are growing and promise to constitute an important industry.

The tropical portion of Queensland has the beginnings of what will doubtless become a large sugar industry. In 1899 the crop amounted to 164,000 tons, a total of more than half the average annual product of Louisiana.

The agricultural resources of Australia are such that the country must continue to be an important exporter of food products for many decades. There is, and will long continue to be, a surplus of breadstuffs. Wool, meat, hides, and dairy products will long be produced in such abundance as to necessitate a large sale of them abroad. Other promising future agricultural exports are wine, tobacco, and sugar. One-fourth of the world's wool is now grown in Australia. In the future we shall want increasing quantities of this article and of hides and skins.

MINERAL RESOURCES.

The mineral industries[a] of Australia rank high in the statistics, both of production and of foreign commerce. Gold, silver, copper, and coal are the most extensively mined, although by no means the only minerals existing in the country.

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[a] See Pl. 81.

The annual export of gold from Australia is, in round numbers, $60,000,000. The industry has passed the uncertain stage of placer mining and now consists mainly of the reduction of quartz ore. Most of the gold fields are in the mountains of eastern Australia, but quartz reefs situated in the arid plains of the western part of the continent are now yielding a large percentage of the total output. These mines in western Australia have added much to the annual production of the country.

Australia ranks third among the silver-producing countries of the world, being outclassed only by the United States and Mexico. Her product is about one-tenth that of the entire world. The mines are located mainly in the eastern part of the country.

The copper mines of Australia yielded 18,000 tons of the metal in 1898, the product having doubled in four years. Lead and tin are both exported, and various other metals are produced in small quantities.

In Chapter VI, dealing with the coal supply for the commerce of the Pacific, the coal trade of Australia was discussed at some length. The field from which the present supplies are mainly drawn is a comparatively small one of 3,000 square miles in area, situated close by the city of Newcastle, 62 miles north of Sydney, the most important port of Australia. There are other larger fields in the mountainous sections of the country, of which use will be made as the demand for fuel increases The present exportation of coal from Australia, as has already been explained, is facilitated by the large tonnage of vessels leaving the country in ballast. This explains why the western part of the United States, South America, Hawaii, and the Philippines, as well as the East Indies, use more or less Australian coal.

The value of the minerals exported from Australia equals $100,000,000 per year, more than $25 for each person.. This is a very large amount of trade for any one class of industries to give rise to, and it shows the great productive capabilities of the Australians. The chief significance to the United States of this great Australian mineral industry is that it necessitates a large foreign trade in mining machinery and general manufactures. As was stated at the beginning of this chapter, the industrial conditions of Australia are not such as to make profitable the development of the iron industries and of the manufactures based upon crude iron and steel. Consequently, the expensive machinery for the development of the mines, the railway material, and the manufactures required by the mining population must be imported. American manufacturers have been especially successful in making mining machinery, and their products have gone all over the world. In Chapter IV, on the Central West, the experience of a Chicago manufacturer was cited. This, and numerous other firms in different parts of the United States, now have a large foreign trade in mining machinery in many sections of the world.

THE CANAL AND THE COMMERCE OF AUSTRALIA WITH THE UNITED STATES.

In considering the foreign trade of Australia, the fact must be kept in mind that the statistics of the commerce of the various Australian states include not only the trade which they have with countries outside of Australia, but with the various Australian commonwealths. The statement made at the beginning of this chapter that the foreign trade of Australia amounted to $350,000,000 per annum—a sum equal to $100 per capita—referred only to the trade of the various Australian states with countries outside of Australia. This total of the foreign commerce of Australia equals half that of all South America, and is as large as our foreign trade was fifty years ago. The per capita average is nearly four times that of the United States at the present time. There is, moreover, no doubt of the continuance of this large foreign commerce. The nature of the industries being such that a heavy foreign trade is requisite to their development, the fact that the various Australian commonwealths have constructed efficient railway systems, which are being extended as necessity requires, the industrial aptitude of the people—all these factors combine to assure the future commercial importance of Australia.

Although the Australian imports are increasing rapidly, our share in those imports is growing more rapidly than their total. In fact, our export trade into Australia is increasing faster than that to any other country except those of eastern Asia. Between 1890 and 1900 our exports to Europe increased 52 per cent, those to South America one-half of 1 per cent, while our exports to Oceania increased 157 per cent. The greater part of this commerce with Oceania was with the continent of Australia, in every State of which the use of our manufactures is increasing. New South Wales, for instance, during the last decade increased its total trade 40 per cent, but the imports from the United States rose 184 per cent during the ten years. In 1900 our total exports to Australia were valued at $26,725,702; in 1889 their value was $12,252,147. Our direct imports from that country have not increased during the decade. It is probable, nevertheless, that we are using a larger quantity of Australian wool than we did ten years ago. Most of this wool, however, comes to us by way of London, and appears in the statistics of our trade with the United Kingdom. We are now sending to Australia a large variety of commodities, the nature and value of which are indicated by the following list:[a]

Mineral oils, $1,720,000; lumber, furniture, and wood manufactures, $1,423,000; paper, $1,100,000; cotton manufactures, $413,000; boots and shoes, $409,000; agricultural machinery, $780,000; naval stores, $200,000, and millions of dollars worth of iron and steel manufactures, of which the following are instructive examples: Steel rails, $661,000; locks and builders' hardware, $630,000; miscellaneous machinery, $863,000; scientific instruments, $177,000; typewriters, $77,000; sewing machines, $321,000.

The preeminent rank of the city of Sydney in the foreign trade of Australia is a fact of much significance in this discussion. Ninety-seven per cent of the trade of New South Wales is handled through that port, and nearly one-half of the total commerce of the Australian states with nations outside of the continent of Australia is carried on at the port of Sydney. This city is the commercial metropolis of Australia, and is the point from which a large share of the imports from Atlantic countries is distributed throughout Australia and the adjacent islands. The city of Melbourne is another distributing point, but its importance has declined as compared with Sydney, because of the greater facilities possessed by the latter port for the transshipment of commodities.

[a] The figures are for 1899 and include Australia, Tasmania, and New Zealand. The New Zealand figures are not kept separate in our statistics.

The fact that the coasting trade of Australia centers so largely in Sydney and Melbourne is interesting in this connection, because those ports are so situated that they will be brought many days nearer to the eastern half of the United States by the construction of the isthmian canal.

The influences of the isthmian canal upon our Australian commerce will affect our trade in a large variety of commodities. Our growing exports of iron and steel manufactures and other heavy articles are being supplemented by an increasing exportation of lighter commodities, and when the canal has removed our present handicap arising from the disadvantages regarding distances which we at present have in competing with Europe our commerce with Australia will be carried on under much more favorable conditions. The traffic between Australia and the eastern and southern sections of the United States by way of the canal will be large, unless the tolls of that waterway should be placed so high as to be prohibitory. In Chapter XXII the question of tolls is considered at length, and it is there shown that a toll of $1 per vessel ton net register would not much restrict the use of the canal by our Australian commerce. The maintenance of the present Suez Canal tolls, which are equivalent to $2 per net register ton, British measurement, and the imposition of the toll of $1 per ton or less for the use of the American canal would be of much assistance to the American waterway. In the chapter on tolls emphasis is laid upon the necessity of adopting a schedule of tolls for the American canal that will not prevent its being used by the traffic of Australia and western South America.

NEW ZEALAND AND THE CANAL.

New Zealand is almost exactly antipodal to the United Kingdom. The construction of an isthmian canal will bring Wellington 1,503 miles nearer Europe by that route than by the Suez. That city will be 2,698 miles nearer New York by a Nicaragua Canal than by way of the Straits of Magellan.

The islands of New Zealand[a] bear some resemblance to the United Kingdom in shape, area, and climate. Within their area of 104,500 square miles there are at present less than 800,000 people. The climate is admirably adapted to raising grain, cattle, and sheep.

The chief industry of the islands is the raising of sheep and the exportation of mutton and wool. The islands now have 20,000,000 sheep, half as many as there are in this country, and the annual exports of mutton to the United Kingdom reach nearly 2,000,000.

The mountains of New Zealand, like those of Australia, are well stocked with minerals. The output of the gold mines amounted to $5,500,000 in 1898. Most of this, however, was secured from placer mines, although the working of the quartz deposits has been begun. The mountain streams of the country furnish an abundant supply of water power for mining and other industrial purposes.

Somewhat less than a million tons of coal are annually mined, the output of which can and will be increased in proportion to the demand for fuel. It hardly need be said that the iron deposits of New Zealand have not yet been worked. A country that is still mainly in the grazing stage of industry is several decades ahead of the exploitation of its iron mines.

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[a] See Pl. 82.

The mineral resource of New Zealand which is of interest to the people of the United States is the kauri gum, from which varnish is made. This gum is a fossil resin dug up from the sites of old forests, and the supply, it is said, is sufficient to last for several decades. In 1899 9,900 tons of this gum, valued at $3,000,000, were exported, and a large part of it came to the United States.

The commerce of New Zealand is larger per capita than that of Australia, being over $120 per person. The total commerce, with a value of over $100,000,000 per year, is mainly controlled by Great Britain, but the United States has a respectable and increasing share of the trade. During the nine years ending in 1898 our trade with New Zealand increased 108 per cent, our total trade in 1898 amounting to about $7,000,000.

New Zealand has good shipping facilities for foreign trade, the Government is developing the railway system rapidly, and the natural resources of the country may be expected to contribute increasing quantities to international trade. There is no more probability of the development of manufactures in New Zealand than in Australia. The islands will continue to export food products and raw materials in exchange for manufactures.

The opening of the isthmian canal will bring the city of New York 5,617 miles nearer to New Zealand than it is by the Good Hope and Australia route, and the distances between the Eastern cities of the United States and that country will be 2,068 miles shorter than by way of Magellan. In 1899 more than seven-eighths of our exports to New Zealand were sent from the Atlantic coast. These exports included mineral oils, tobacco, machinery, hardware, wire and wire nails, carriages, carriage materials, patent medicines, and boots and shoes. The volume and variety of our present commerce carried on by the circuitous route around Africa is evidence that the opening of the American canal will have important effects upon our New Zealand trade.

Chapter XV.—*The canal and the Philippines and Hawaii.*

I. THE PHILIPPINES.[a]

Our present commerce with the Philippines is carried on mainly by the Suez Canal route and frequently by way of some European port. A minor but increasing share of the trade is shipped through our west-coast ports and across the Pacific Ocean to Hongkong. A glance at pl. 86, accompanying Chapter XVII, will show that the line connecting points equally distant from New York City by way of the Suez Canal and the proposed Nicaragua route runs somewhat to the west of the Philippine Islands, indicating that they are slightly nearer New York by way of the Nicaragua Canal than the Suez route. The difference in distance by the easterly and westerly canal lines will, however, be slight, and the Philippine Islands, as well as Malaysia generally, will constitute a section whose commerce with North Atlantic countries will be divided between the American and Suez canals.

THE GEOGRAPHY AND INDUSTRIES OF THE PHILIPPINES.

The information concerning the geography of the Philippines is scanty and must necessarily be very incomplete until the islands can

[a] Consult Pl. 83 in connection with this chapter.

be surveyed. The location of the Philippines is between 5° and 20° north latitude, their latitude being that of the Guianas and Haiti. Their climate is tropical and humid, and, being situated with a general north-and-south trend in the latitude of the trade winds and monsoons, both the eastern and western slopes of the islands have alternate rainy and dry seasons.

The area of the islands is estimated to be about 115,000 square miles and the population to be 8,000,000. Over one-half of the people live on the island of Luzon.

The resources of the Philippines are agricultural, forest, and mineral. Concerning the agricultural conditions of the islands, information is fairly satisfactory. The forest resources are known to be varied and abundant, and it is supposed that the mineral deposits are important. There is, however, very little authentic information at hand regarding the mineral wealth of the country. The industrial conditions of the Philippines are in an extremely backward and undeveloped condition, the islands being at the time of the American occupation practically without highways. Only one short railroad has yet been built, and the industries are still in an unorganized state.

At the present time the agricultural product of most commercial importance is hemp, the exports of which in 1900 were valued at $11,399,000. The production and exportation of this article are steadily increasing with the growth in the demand for it in the United States and other agricultural countries. More than half of the hemp comes to the United States. Some of it is used for cordage, but much more is used as binder twine. The principal competitor of Manila hemp is that from Yucatan, sisal hemp, the quality of which is much inferior. The plant from which the fiber is taken is grown in the shade of half-cleared woods, and its cultivation requires very little intelligence and only a moderate amount of diligence and thrift on the part of the producer.

Before the insurrection the most valuable export from the Philippines was sugar, of which $10,368,000 worth was exported in 1893. The exports in 1900 amounted to about $3,022,000. Sugar can be produced in very great quantity in the Philippine Islands, and with the establishment of civil order and the investment of foreign capital in the exploitation of the resources of the islands will probably regain first rank in the list of Philippine industries.

Like the islands of the West Indies, the Philippines produce tobacco abundantly, the soil and climate of the northern provinces of Luzon being adapted to its culture. The quality is said to be fairly good. The home consumption of tobacco is large, and considerable quantities both of manufactured and leaf tobacco are exported. Most of the unmanufactured article is sent to Spain. The other important article of export from the Philippines at the present time is copra, the dried meat of the cocoanut. The cocoanut palm grows in many parts of the island and might be made to contribute much more largely to the wealth of the islands than it does at the present time.

Next to the cotton manufactures the most important article of importation into the Philippine Islands is rice. This important article of food might all be grown in the islands, and a surplus might be exported if the industry were properly organized. The indifferent agriculture of the Philippines was largely devoted to the growing of rice, until the production and exportation of sugar became more profitable. Whether it is possible to apply capitalistic organization to the production of rice is not altogether certain. In all probability the organizers of the industry would be obliged to use coolies for a part of their labor force.

One of the first natural resources of the islands to be drawn upon will be the forests. Nearly all of the forest lands belong to the Government, and concessions for the cutting of timber are now being granted. The variety of hard woods is large; seventeen valuable dyewoods are known to exist, and gutta-percha, camphor, and other gum trees may be included among the important timbers.

While but little can be confidently asserted regarding the mineral resources of the Philippines, it is supposed that there are large deposits of gold, copper, and iron. The mining of gold is now being carried on to a slight extent. The development of both gold and copper resources, however, must be delayed until machinery can be introduced and the enterprise organized in an efficient manner. The working of iron mines must necessarily be deferred until there is a good supply of cheap fuel. Lignite has been found upon several of the islands, and the quality is such that it can be used for locomotives and on steamers. Some of these lignite deposits are near the seashore and can be readily worked. At the present time, however, the entire coal supply is imported.

In considering the industrial resources of the Philippines and their probable future development, one of the most important considerations is the labor supply. Whether the present inhabitants of the Philippine Islands can be successfully organized in industrial undertakings is uncertain. It is probable, however, that education and training in industry may make of them a valuable and reliable labor supply. It is possible that more or less use must be made of coolie labor. The near-by continent of Asia can furnish an unlimited supply of efficient labor, but whether the Asiatic labor supply should be drawn upon or not raises a social as well as an industrial question.

THE COMMERCE OF THE PHILIPPINES.

Having acquired political control of the Philippine Islands, their foreign trade becomes of additional importance to the United States. In order to present the information regarding the Philippine trade completely and definitely, the following tables have been prepared. The imports and exports of the islands are shown by countries and by articles for the years 1893 and 1900. The imports and exports for the year ending June 30, 1900, are shown in a separate table. The figures for 1900 are taken from the Monthly Summary of Commerce of Philippine Islands, United States War Department, Division of Insular Affairs. The figures for previous years are from Bulletin No. 14, United States Department of Agriculture, Section of Foreign Markets.

TABLE No. I.—*Imports of Philippine Islands by articles, calendar year 1893 and fiscal year 1900.*

Articles.	Calendar year 1893.	Fiscal year 1900.
Cotton manufactures	$5,866,000	$6,019,000
Rice	628,000	3,113,000
Iron and steel manufactures	672,000	715,000
Malt liquors and cider	105,000	638,000
Chemicals	....	605,000
Glass and glassware	174,000	525,000
Opium	....	476,000
Coal	....	468,000
Paper, and manufactures	376,000	462,000
Silk manufactures	367,000	462,000
Flour	526,000	399,000
Wines	1,060,000	320,000
Distilled liquors	176,000	303,000
Vegetables	189,000	243,000
Wood, and manufactures	....	225,000
Flax, hemp, and jute manufactures	494,000	209,000
Pork, bacon, lard	175,000	195,000
Mineral oils	1,084,000	161,000
Boots and shoes	120,000	149,000
Woolens	215,000	139,000
Earthenware and china	212,000	132,000
Olive oil	114,000	47,000
All other articles	3,338,000	4,840,000
Total	15,891,000	20,597,000

TABLE No. II.—*Imports of Philippine Islands by leading countries, 1893 and 1900.*

Countries.	Calendar year 1893.	Fiscal year 1900.
China, including Hongkong and Indo-China	$2,754,000	$8,210,000
United Kingdom	4,247,000	3,941,000
Spain	5,104,000	2,093,000
United States	956,000	1,656,000
Germany	1,246,000	1,210,000
France	477,000	485,000
Japan	183,000	259,000
All other countries	923,000	2,743,000
Total	15,890,000	20,597,000

TABLE No. III.—*Exports of Philippine Islands by leading articles, calendar year 1893 and fiscal year 1900.*

Articles.	1893.		1900.	
	Quantity.	Dollars.	Quantity.	Dollars.
	Pounds.		*Pounds.*	
Hemp	[a] 92,262	7,697,000	[a] 75,476	11,399,000
Sugar	576,557,000	10,368,000	173,630,000	3,022,000
Copra and cocoanuts	26,223,000	414,000	81,799,655	1,693,000
Cigars and cigarettes	....	969,000	....	1,362,000
Leaf tobacco	23,687,000	463,000	14,010,356	818,000

[a] Tons

TABLE No. IV.—*Exports of Philippine Islands by leading countries.*

Countries.	Average for 1892–1896 (calendar years).	Fiscal year 1900.
United Kingdom	$8,844,000	$6,227,000
China, including French Indo-China and Hongkong	31,000	4,415,000
United States	6,053,000	3,522,000
France	986,000	1,392,000
Spain	3,855,000	1,226,000
Japan	616,000	1,032,000
Germany	201,000	97,000
Other countries	1,896,000	2,110,000
Total	22,482,000	19,751,000

TABLE No. V.—*Imports and exports of merchandise, Philippine Islands, year ended June 30, 1900.*

Countries.	Imports.	Exports.
United States	$1,656,469	$3,522,160
United Kingdom	3,941,422	6,227,259
Spain	2,092,530	1,226,475
France	485,299	1,392,439
Germany	1,209,953	1,397,548
Japan	259,461	1,032,462
China	5,570,683	1,458,729
Hongkong	2,639,620	2,686,168
British East Indies	2,216,914	938,470
Other countries	1,524,816	1,169,558
Total	20,597,167	19,751,068

One-half of the imports into the Philippine Islands, as is shown by Table No. I, consists of cotton manufactures and rice. Among other important articles are iron and steel manufactures, liquors, and chemicals. By comparing the trade of the year 1893 with that of 1900 several important changes will be seen to have taken place in the Philippine trade. During both years cotton manufactures held first place, but the importation of rice is shown to have increased nearly fivefold. The importation of mineral oils has fallen off very greatly, and the same is true of wines. The decreased purchases of wines, however, are largely offset by the increased importation of distilled and malt liquors. On the whole, the trade shows a rather large growth in view of the insurrection. There is a general tendency toward a larger purchase of manufactured commodities, and the establishment of civil order throughout the islands will unquestionably result in a much larger purchase of such articles.

An examination of Table No. II shows that important changes are taking place in the distribution of the Philippine purchases among foreign countries. As might be expected, the transfer of the islands from Spain to the United States and the abolition of the preferential tariffs maintained by Spain have resulted in a great decrease in her trade with the Philippines. Our exports to those islands are shown to be increasing. The exports from the United Kingdom to the Philippines appear to be declining, while those from China and Hongkong appear to be increasing. The trade of Hongkong, however, is only that of a distributing center, and the increase in its exports to the Philippines means only that the United Kingdom, the United States, and other countries are sending greater quantities of commodities to Hongkong for distribution in the Philippines and elsewhere.

In the exports of the Philippine Islands the hemp now has first place, although in 1893 the value of the sugar exports was 50 per cent more than that of hemp. The war with Spain and the subsequent insurrection have greatly interfered with the sugar production. The exportation of hemp, cocoanut products, and tobacco seems to have been less interfered with. The consumption of hemp is increasing so fast that the exportation of this commodity from the Philippines must unquestionably increase rapidly in the future. It is probable also that improved machinery will be introduced for the manufacture of sugar and that some of the plantations, at least, will be organized in accordance with efficient modern methods. At the present time the sugar exports consist of a very crude unrefined product, most of which is sold in Asiatic countries. Table No. IV, giving the destination of the foreign exports, shows that Great Britain and the continent of Asia received over half of the total in 1900. Here again the trade of Great Britain and the United States seems to have fallen off, and that of Hongkong and China to have greatly increased. This is obviously due to the fact that Hongkong is credited with trade that is merely transshipped at that port. The exports from Spain to the Philippines have fallen off, as might have been expected. Those to the United States are also less than they were, but how much less it is impossible to say, because a part of the trade is handled through Hongkong. The influence of the Philippine insurrection upon the total exports of the islands, and upon their export trade to the United States is clearly indicated by Table No. IV.

The imports into the Philippine Islands from the United States constitute but a small portion of the purchases by the people of those islands. The total value of our exports to those islands is, however, increasing, the goods exported directly from the United States amounting to $1,655,469 during the year ended June 30, 1900. During the five years 1892–1896, when our trade relations were normal, our exports to the islands averaged only $135,228 per annum. As has already been stated, a very large part of the imports into the Philippines are reported as coming from Hongkong, which is merely a center of distribution. The value of American flour included in the imports from Hongkong during the fiscal year 1900 was $318,193, and, in addition to flour, mineral oils, meat products, general manufactures, and other commodities are known to have been imported indirectly by way of Hongkong. It may be well, moreover, to state that the total of $1,656,469 does not include the goods imported by the commissary or quartermaster for the use of the American army.

The imports directly from the United States consisted chiefly of the following articles. The value of the articles is also included. Malt liquors, $477,000; glass and glassware, $232,000; spirits, distilled, $177,000; books and printed matter, $175,000; paper, $54,000; wines, $51,000; cotton, $34,000; cheese, $30,000.

What are the chances for increasing our export trade to the Philippine Islands? Is it probable that the Filipinos will increase their total imports, and if they do, will a larger share of the total be supplied by the United States? This will depend more upon the facilities for shipment than the cost of production in this country as compared with cost of production in Europe. At the present time Great Britain and Germany control the larger share of this trade, but it would seem that in the future the heavier iron and steel manufactures, as well as the electrical machinery, tools, bicycles, sewing machines, and similar articles, will be purchased in considerable and in increasing quantities from this country. Our ability to sell cotton goods extensively in Manchuria would indicate that we can compete with Europe in supplying the Filipinos with those goods. The growing demand for flour, provisions, and dairy products will be supplied by the United States if shipping facilities are favorable. At the present time the petroleum used by the Filipinos is supplied mainly by Russia, but the opening of the canal and the establishment of better shipping facilities between the eastern part of the United States and the Orient will enable the American exporters of oil to control at least a part of this trade.

The opening of the canal will not greatly reduce the distances from our Atlantic seaboard to the Philippine Islands, but it will give us another route to the East and one that will probably be more economical. One of the consequences of the canal will be a larger commercial intercourse between the United States and oriental countries generally, and this will be accompanied by better facilities for trading with all oriental countries, the Philippines included. At the present time the European exporters have more favorable facilities for shipping to the Philippines and other points in the East than Americans have.

LOCATION OF THE PHILIPPINES WITH REFERENCE TO TRADE ROUTES FROM THE UNITED STATES.

Present conditions make Hongkong the point from which the imports into the Philippine Islands are distributed, and is the point from which a large part of the exports is dispatched to North Atlantic countries. At the present time the trade of the Philippines is not large enough to cause many vessels outbound from Europe for Hongkong, Shanghai, and Japanese ports to make the detour required in order to call at Manila. Moreover, the wharves will not now accommodate large ships, and nearly all the traffic has to be handled by lighters. The improvements in progress in the harbor will remove this obstacle, and it is probable that as the total trade of Manila increases the inducements for making the city a port of call will become sufficient to cause a large share of the Manila trade to be handled at that port instead of being transshipped at Hongkong.

The location of Manila and the Philippines with reference to trade routes from New York by way of the Nicaragua Canal is shown by the following table. In Chapter XVII the length of routes from Europe and the United States to the Philippines is discussed more in detail.

	Miles.
1. New York to Manila via Brito, San Francisco, Great Circle, and Yokohama	11,207
2. New York to Manila via Brito, Honolulu, and Guam	11,274
3. New York to Manila via Brito, San Francisco, Yokohama, Shanghai, and Hongkong	11,994
4. New York to Manila via Brito, Honolulu, Yokohama, Shanghai, and Hongkong	12,368
5. New York to Hongkong via Brito, Honolulu, Guam, and Manila	11,902
6. New York to Hongkong via Brito, San Francisco, Yokohama, and Shanghai	11,366
7. New York to Shanghai via Brito, San Francisco, and Yokohama	10,505
8. New York to Shanghai via Brito, Honolulu, Guam, and Manila	12,509

The distance from New York to Hongkong and Shanghai (compare routes 5, 6, 7, and 8) are respectively 536 and 2,002 miles shorter by way of the northerly route and Japan than by the southerly route and the Philippines. The distance from New York to Manila is shorter by way of San Francisco and Japan (routes 1 and 2) than by Honolulu and Guam. In Honolulu, moreover, the price of coal is higher than in San Francisco. Coal is also dearer in Guam than in Yokohama. San Francisco and Yokohama also have more freight to offer than Honolulu and Guam have. The price of coal will always be high at Guam, because the island will not be an exporting point. Vessels engaged in the commerce between America, Asia, and the Philippines will tend to take the northern route to get Japanese coal and freight.

II. THE HAWIIAN ISLANDS.

SOIL AND CLIMATE OF THE HAWAIIAN ISLANDS.

The Hawaiian Islands have a fertile soil in the limited areas where cultivation is possible. The islands being situated in midocean between 19° and 23° north latitude, the northeast trade winds blow over them during the greater part of the year, and the eastern side of the islands is copiously watered, but on the opposite slopes the rainfall is much less and irrigation is necessary to agriculture. The leeward side of the islands, moreover, is calmer and warmer than the windward side. The islands are volcanic, hilly, and well drained, and hence not malarial. In most parts of the islands the climate is not especially enervating, and Europeans, as well as Japanese and Chinese, find sustained effort to be possible. The islands are of small area and very mountainous, and the foreign immigrant has a large range of choice as regards climate.

The Hawaiian group consists principally of seven islands, having a total area of 6,449 square miles. The largest island of the group is Hawaii, although Oahu, upon which the city of Honolulu is located, is the most populous one. Although the Hawaiian Islands have nearly twice the area of Porto Rico, their population is only one-sixth as great. According to the census taken by the United States Government in 1900 the inhabitants of the islands number 154,000, the increase from 1896 having been 44,981, which was equivalent to over 41 per cent. This very rapid growth in population was due to the sudden expansion of business resulting from the annexation of the islands to the United States.

Until the statistics of the census of the Hawaiian Islands taken in 1900 have been analyzed and published it will not be possible to speak definitely in regard to the various elements of the present population. By the census of 1896 the population numbered 109,020, and of this total 31,019 were natives, 8,485 half-castes, 21,616 Chinese, 24,407 Japanese, 15,191 Portuguese, 3,086 Americans, 2,250 British, the rest of the population being made up of Germans, Norwegians, French, and Polynesians. The immigrants into the islands from the United States comprise a comparatively small share of the total population. They have, however, the industrial and political control of the islands. The laboring classes consist largely of Japanese and Chinese. It is estimated that there were 27,000 Chinese in the islands in 1899, and 6,000 of them were employed on the sugar plantations. The Japanese were estimated to have numbered 58,000 at the close of 1899, and it is said that about 26,100 of them were employed on the sugar plantations. Nearly five-sevenths of the plantation laborers consisted of Japanese in the year 1899.

THE RESOURCES OF THE HAWAIIAN ISLANDS.

The resources of Hawaii are almost exclusively agricultural. There are no minerals of consequence and manufactures are and will always be insignificant.

The sugar industry is of overshadowing importance. The decomposed lava soils of the islands, when properly irrigated and treated with a small quantity of fertilizers, are exceedingly productive, the yield of sugar per acre being especially high, ranging from 3 to 5 tons per acre on the average. The total crop of 1891 is reported to have amounted to 146,000 tons, while that of 1899 was about 300,000 tons, and numerous additions have been made to the acreage of the plantations since that date. The capital invested in sugar is said to amount to $40,000,000. There are about 60 plantations on the islands. The plantations are organized on a large scale and in accordance with most economical methods. The rainfall on the leeward side of the island being light, irrigation is necessary, and extensive irrigation works have been constructed.

While the large development of the sugar industry in Hawaii has added to the wealth of the islands, it has not been altogether fortunate for their economic progress. The climate and soil of the islands are such that the industries might be diversified, and it is probable that a population consisting to a large extent of small independent farmers might be developed if the sugar plantations did not include such a large share of the islands. In the early eighties the best sugar lands were leased for thirty and forty year periods to a small number of planters, and the American capital invested in Hawaii has gone almost entirely into the sugar industry. The population connected with the sugar plantations consists of Japanese, Chinese, and Portuguese laborers, who probably will always constitute a dependent population.

Rice is the second crop in value, and in former years it has been an important article of export. The rapid growth in the population, particularly in the number of Japanese, has so increased the home demand as nearly to put an end to the exportation of rice. The industry is carried on by the Chinese according to very primitive methods.

Large quantities of tropical fruits, oranges, pineapples, bananas, etc., could be successfully grown in Hawaii. The exportation of bananas has begun, over $80,000 worth of them having been sent to California in 1899.

At one time it seemed probable that the production of coffee would constitute the most important industry of the Hawaiian Islands, but the reciprocity treaty between Hawaii and the United States made the cultivation of sugar so profitable that capital has gone more and more into sugar plantations. Some of the coffee estates have been converted into sugar plantations, and at the present time it is estimated that there are less than 20,000 acres of coffee under cultivation. The annual production is larger than the home demand and a limited quantity is exported. The exports in 1897 amounted to 337 pounds, and those of 1899 were 779,796 pounds.[a] It seems probable that the

[a] Later figures are not available because our commerce with Hawaii is now coasting trade, concerning which statistics are not kept.

annual production will grow less rather than increase, unless the coffee and sugar industries should be developed together on the same plantations. Those who have studied the question have suggested that the two crops might advantageously be produced on the same plantation, because coffee grows at a greater elevation than the sugar does, and the season when coffee requires the largest labor force comes at a time when the sugar plantation has a surplus of workmen. Anything that can bring about the diversification of industries in Hawaii will be of advantage to the islands.

Whether the industries of Hawaii can be diversified and the social conditions accompanying large plantation life can be changed is a matter of great importance to the economic future of Hawaii. There seems to be a tendency in all tropical countries toward the organization of industries upon a large scale. The corporation with abundant capital at its command seems in a measure to be taking the place formerly occupied by the slave owner. In the time of slavery the planters organized and directed the labor force of the natives, and under the present capitalistic régime the corporations, in a different manner, are performing a similar task. Whether or not the capitalistic organization of labor will result in a social betterment of the laboring classes and in the development of intelligent, self-supporting artisans remains to be seen. If it is possible to develop desirable social conditions anywhere in the Tropics, Hawaii would seem to offer more opportunities than most of the island countries. The United States Government has established an agricultural experiment station in Hawaii that will doubtless be of assistance in varying the productions of the islands. General education will in time assist in the same work.

THE CANAL AND THE TRADE OF HAWAII.

The Hawaiian Islands have a large and rapidly increasing foreign trade. The annexation of the islands to the United States was followed by a great expansion in business. The imports of 1897 were valued at $8,838,000, while those of 1899 amounted to $19,058,000. The exports of the islands increased from $16,029,000 in 1897 to $22,628,000 in 1899. The trade of the first half of 1900 was fully up to that of 1899. It is impossible to speak of the trade of the islands since that time, because the trade is nearly all with the United States, and our commercial statistics, as was stated above, do not include domestic trade.

The share of the Hawaiian trade controlled by the United States is especially large. In 1898, 99.62 per cent of the exports of the islands came to the United States, and we furnished them 76.94 per cent of their imports. In 1899 the United States purchased 99.52 per cent of the Hawaiian exports, and supplied the islands 78.81 per cent of their imports. Our most important rival in the import trade of Hawaii is Great Britain, which supplies the islands with between 9 and 10 per cent of their purchases. Our exports to the Hawaiian Islands in 1899 consisted mainly of the following articles and values:

Machinery	$2,089,000
Railroad materials	282,000
Iron and steel	289,000
Hardware, agricultural machinery, and tools	940,000
Building materials	547,000
Fertilizers	957,000
Provisions	1,284,000

Practically all of the iron and steel products imported by Hawaii come from the Eastern States. The owner of one of the largest Hawaiian sugar plantations states that its water supply is handled through pumps and pipes purchased in Birmingham, Ala., and that its sugar machinery was manufactured in St. Louis. A single firm near New York already sends $500,000 worth of machinery annually to Hawaii. Of the fertilizers, a part comes from Germany, but the larger share is from the phosphate beds of our Southern States, and the canal will aid Hawaiian agriculture by cheapening the cost of these commodities as well as by furnishing a shorter route by which to market the exported produce. At present our Atlantic States import 40,000 to 80,000 tons of Hawaiian sugar per year by way of Magellan and Cape Horn. This will be cheapened by the shorter route, and as the price of sugar on the Pacific coast is determined by its price in New York and London, the canal will enable the sugar grower to obtain a higher price for the bulk of the crop marketed in our Pacific States.

In their trade relations the Hawaiian Islands may be considered as a part of our Pacific coast. They belong to the United States, the dominant race is American, English is the common language, our capital controls the industry of the islands, and their commerce is almost all with this country. An isthmian canal must have a great effect on Hawaii. The one-sidedness of her resources makes Hawaii especially dependent upon commerce. Sugar is the only product extensively exported; agriculture the only industry, and that is in an undiversified state. All manufactures and many of the food products needed by her increasing population must be imported. The complex demands of the islands can be supplied only in part by the industries of our Pacific coast States, and everything not originating there must be brought from our Eastern States or Europe. Some of the Hawaiian imports from the eastern part of the United States now move by the transcontinental railroads and thence by water, but the heavier articles usually go by Cape Horn or the Straits of Magellan. Some goods are sent by the Panama lines and transshipped at San Francisco. After the canal has been constructed, the traffic, both import and export, will be divided between the transcontinental railroads and the all-water canal route.

Chapter XVI.—*The canal and Central America and western Mexico.*

I. CENTRAL AMERICA.

POPULATION AND GENERAL GEOGRAPHY.

The population of Central American countries has not been accurately determined by careful censuses, but the following table, compiled from the Statesmen's Yearbook, doubtless gives approximately accurate figures regarding both the area and population of each of the Central American countries:

Area and population of Central American countries.

Country.	Area.	Population.	Capital city.	Population of Capital city.
	Sq. miles.			
Costa Rica	23,000	300,000	San José	25,000
Guatemala	63,400	1,532,000	Guatemala City	75,000
Honduras	46,250	407,000	Tegucigalpa	12,600
Nicaragua	49,200	420,000	Managua	20,000
Salvador	7,225	[a] 915,000	San Salvador	50,000
Total	189,075	3,574,000		

[a] Bulletin Bureau of American Republics, March, 1901.

The population of the Central American countries[a] is nearly all upon the plateaus adjacent to the Pacific. The climate of the Caribbean coastal regions of Central America is humid, and the tropical vegetation grows so rank as to add much to the difficulty of occupying and cultivating the country.

The plateau on which the Central American population and industries are centered extends with varying width and elevation from Mexico to southern Costa Rica. West of the continental divide and parallel to it is a succession of volcanoes extending through all the region to the north of Costa Rica. In Guatemala they raise a barrier that walls in a series of upland lakes, in Salvador they inclose a high valley where most of the people of the country reside, and in Honduras and Nicaragua they are near the Pacific between the lakes and the ocean. This double mountain range widens the plateau and increases the habitable area. The plateau from Costa Rica northward is made up in large part of decomposed lava, which has formed a fertile soil. Like the lava soils of Hawaii, those of Central America are well adapted to sugar, coffee, and other crops of tropic agriculture.

The Central American plateau is most closely connected commercially with the Pacific Ocean. The Caribbean outlets are the Costa Rica Railroad, from San José to Port Limon, and the San Juan River. To the Pacific, however, four railroads have been constructed, not including the short line terminating at Punta Arenas, Costa Rica. Two of these four railroads are in Guatemala, one in Salvador, and one in Nicaragua. Numerous wagon roads have been constructed, and an English company is constructing a railroad in Costa Rica between San San José and Tivives.

THE CENTRAL AMERICAN INDUSTRIES.

The industries[a] of Central America are mainly agricultural. Forest products are exported to some extent. The mineral resources of the country are beginning to be developed, but as yet on a comparatively small scale.

Throughout Central America coffee is the staple product, the leading State in its production being Guatemala. In that State the coffee belt is in the plateau, the western edge of the belt being some 10 or 15 miles from the Pacific Ocean. It is 50 to 80 miles wide. This is the part of the country where most of the population is to be found.

[a] See Pl. 84.

The coffee in this region is carefully cultivated and extensively exported, two railroads to the Pacific having already been built, and a third line near the Mexican boundary will probably be constructed in the near future. The western plateau of Salvador, Honduras, Nicaragua, and Costa Rica has numerous valleys where coffee culture is extensively carried on. The main coffee belt of Nicaragua is situated in the neighborhood of Jinotepe, northwest of Lake Nicaragua. In Costa Rica the valley in which the city of San José is located constitutes the most important coffee-growing region.

The lowlands of the eastern coast, particularly of Nicaragua and Costa Rica, are well adapted to banana culture, and the United Fruit Company has extensive banana plantations in the neighborhood of Port Limon, Costa Rica, and Bluefields, Nicaragua. The San Juan River Valley is another region in which banana culture could be extensively carried on, and should the Nicaragua Canal be constructed a large amount of fruit will doubtless be grown in this valley.

In the western part of Central America, where the soil is largely of volcanic origin, sugar can be very successfully grown. Several sugar plantations are now in successful operation, but their output is practically all consumed within the country. In the future development of Central America the production of sugar will in all probability have a prominent place.

There is at the present time a limited amount of cocoa produced in various sections, and this is a product which could readily be increased. It is also probable that rubber trees can be and will be profitably cultivated in the future. At the present time the world's rubber supply is mainly secured from the natural forest trees, but the growing demand for rubber and the increasing difficulty of securing adequate supplies from the present uncertain sources make it probable that rubber will in the future be a cultivated product. When that time comes the lowlands will offer a favorable region.

Throughout the uplands of Central America cattle are raised in large numbers, and one of the important exports at the present time is hides. Indeed, coffee, bananas, and hides are the leading articles of export. At the present time, with the exception of bananas and timber, the leading exported commodities leave the country mainly by the Pacific ports.

The lumbering industries are mainly located on the eastern shore, and the opening of a canal across the country will but indirectly assist them. The same is true of the exportation of dyewoods and other forest products.

The mining of gold, silver, and copper has made some headway in Central America, and with the establishment of stronger governments and the development of additional facilities for transportation these mineral industries will doubtless develop. When it is possible to reach the mines in the western part of Costa Rica, Nicaragua, Salvador, and Guatemala by improved means of transportation, and when it is possible to secure supplies and dispose of the product with moderate transporstation costs, there is reason to believe that the Central American countries will regain some of the prominence which they once held as a source of precious metals. Possibly the most valuable mineral resource of the region will prove to be copper, the world's demand for which seems to increase more rapidly than does the supply of the metal.

As to the productive capabilities of Central America, there is no doubt that when foreign capital can be invested freely and safely in industrial enterprises the progress of that region will be steady and eventually reach large proportions. The construction of the canal will increase the shipping facilities of the eastern part of the country and will bring the western half of the region into close commercial relations with its chief markets, the countries of the North Atlantic.

THE CANAL AND THE FOREIGN TRADE OF CENTRAL AMERICA.

The opening of a canal across the American Isthmus, either at Panama or at Nicaragua, would enlarge the foreign commerce of Central America and increase the share of the trade controlled by the United States. A waterway across Nicaragua would, however, have a greater effect upon the industries and commerce of Central America than would one at Panama, because of the great assistance the Nicaragua Canal would give to economic and political progress in the States adjacent. Nicaragua and Costa Rica would contribute tropical products to the traffic of a canal passing through their territory and to the commerce of Europe and the United States. Fruits and forest products would be shipped from the San Juan Valley and the northern part of Costa Rica. In the uplands of Costa Rica and on the plateau of Nicaragua the exportation of cattle, coffee, fruits and vegetables, sugar, and probably tobacco would be stimulated by the canal and the facilities for shipping at all times to all important commercial countries. Nicaragua would be especially favored by the canal because of the facilities which Lake Nicaragua would afford for collecting and distributing commodities. The interoceanic waterway would bring the interior basin of the country, where most of the industrial activity is centered, into close connection with the world's commerce.

The commerce of the eastern ports of Central America is largely controlled by the United States while most of that of the western slope is with Europe. We supply 55 to 60 per cent of the imports of British Honduras or Belize on the Atlantic coast. To Guatemala as a whole we furnish only 39 per cent, including our direct shipments to the east coast, and the flour, lumber, and provisions from San Francisco to the west coast. Great Britain supplies most of the $558,000 worth of cottons purchased by Guatemala, and nearly all of the manufactures imported by that country come from Europe by the Straits of Magellan. The same conditions prevail in western Honduras, although we have most of the trade of the eastern ports where there are good steamer connections with New Orleans. Salvador has a foreign trade of $20 per capita, divided between San Francisco and Europe. The last importation of steel rails came from England. In 1895 the United States supplied Nicaragua with but 23 per cent of the imports of the Pacific side, and the goods sold by us consisted largely of California lumber, wines, and flour. In 1897 we furnished the following percentage of the imports of eastern ports of Nicaragua: Cape Gracias a Dios, 85 per cent; Bluefields, 83.6 per cent; Greytown, 53 per cent. Fifty-eight per cent of the goods forwarded from Greytown to the interior were from the United States. We are now furnishing 45 to 50 per cent of the imports of Costa Rica, and the share has increased considerably since the railroad to Port Limon changed the commercial outlet from Punta Arenas on the Pacific to Port Limon on the Atlantic.

The total imports of Central America and the shares of the United States, the United Kingdom, and Germany are shown by the following table taken from the publications of the United States Bureau of Statistics:

Imports of Central America.

From—	1887.	1897.
Total	$15,800,285	$23,999,561
United States	2,935,447	7,739,907
United Kingdom	4,941,464	5,266,444
Germany	[a] 1,739,304	1,781,666

[a] 1889.

The Central American trade has not reached large proportions, but it is growing. Our share has more than doubled in a decade while that of the United Kingdom and Germany has remained nearly stationary. Under present conditions, the Pacific coast of the United States trades with the Pacific coast of Central America and our Atlantic coast ports with the Caribbean section. The canal will enable each of our coasts to find a market on the opposite seaboard of Central America. This and the industrial development of the American Isthmus resulting from the canal will largely promote the commerce of the United States with Central America.

II. WESTERN MEXICO.[a]

The area of that part of Mexico draining directly into the Pacific Ocean comprises over 300,000 square miles, and is equal in size to California, Oregon, and Washington. The northern half of this Pacific slope of Mexico resembles the southern part of California and Arizona in climate and general physical conditions. The southern half of the region is tropical in character, the section beyond Tehuantepec being physiographically a continuation of Guatemala.

According to the census of 1895 the section under consideration contained approximately 4,000,000 people, and until the construction of the railways about the City of Mexico and on the Mexican Plateau stimulated the growth of population in that part of the Republic the rate of increase was greater on the Pacific slope than in the country as a whole.

The Pacific slope of Mexico is more geographically isolated than are the west coast States of our own country. Seven transcontinental railway lines connect our Western States with the Mississippi Valley and the eastern section of our country, but as yet there is only one railway, a spur of the Southern Pacific, joining the western part of Mexico with the region east of the Cordilleras. While the railway system of Mexico has been rapidly extended, the construction of lines connecting the plateau with the Pacific coast has made slow progress, because the western slope of the great Mexican Plateau is so steep as to make railroad building extremely difficult. The result of this lack of railway lines connecting western Mexico with the United States and with Mexico east of the mountains has been that the region is in the main commercially tributary to Europe.

[a] See Pl. 85.

AGRICULTURAL RESOURCES OF WESTERN MEXICO.

The western slope of Mexico, being situated in temperate and tropical latitudes and having a variation of several thousand feet in altitude, is capable of producing a great variety of agricultural products. The Tropic of Cancer divides the region under discussion into two nearly equal sections, the most important port of the region in the temperate latitude being Mazatlan, situated just north of the tropic. In the irrigated portion of the temperate section wheat can be grown to advantage and also subtropical fruits. In the tropical latitudes sugar, coffee, and other tropical products are grown.

North of the twentieth parallel irrigation is everywhere necessary for agriculture, but south of that line the natural rainfall is usually sufficient. In this temperate region the amount of cultivable land is limited to the portions for which water can be secured, but those sections, as is usual in irrigated regions, are highly productive. Several valleys of western Mexico have already been irrigated, and a reference to two of them will illustrate the results that are being accomplished.

In the valley of the Yaqui River, which flows into the Gulf of California a few miles south of Guaymas, an American corporation has constructed an irrigation ditch 40 miles in length, by which 400,000 acres of land can be watered. In this irrigated valley corn, cotton, tobacco, wheat, and subtropical fruits can be and are raised. The wheat produced is usually sold in Mexico, although in 1892 some of it was exported by way of New Orleans to Europe. Oranges are exported from the Yaqui Valley and other sections of the State of Sonora to the United States.

Somewhat farther south, in the State of Sinaloa, a short railway has been built from the port of Altata to Culiacan, and along the line of this railroad irrigation works have been constructed, and a sugar estate established upon which 900 people are employed. A few years ago this region was an uninhabited waste. The valley in which this sugar estate is located is said to be capable of producing 40,000 to 50,000 tons of sugar annually.

A reference to Lower California will afford another illustration of the agricultural resources of the temperate latitude of western Mexico. This peninsula has an extremely arid climate and is everywhere infertile except in the limited sections where irrigation is possible. The food supply for the inhabitants has to be imported to a large extent, although some sugar is exported to the mainland from the irrigated district in the southern part of the peninsula. The most important vegetable product of Lower California is the agave, a plant that grows in many parts of Mexico. There are several species of the plant, one producing the soft pita fiber and another the hemp of commerce. Henequin, or sisal, the species of agave that grows in Yucatan, and from which the so-called hemp is obtained, also grows in Lower California, although it has not yet been cultivated for exportation. It seems, however, that the production of hemp in Yucatan is nearing its possible maximum, and that the hemp of Lower California will soon become commercially important. An American corporation is now arranging to develop the enterprise. In view of the fact that the largest market for sisal is in that part of the United States east of the Rocky Mountains, and that the article is a bulky one, whose costs for transportation are comparatively large, it would seem that the opening of the isthmian canal would have a very favorable effect upon the development of the hemp industry of Lower California.

In the tropical part of western Mexico the most important agricultural product is coffee. In the neighborhood of Mazatlan and Manzanillo there are some estates from which coffee is now exported. The industry seems, however, to be in a backward state of development.

The resources of tropical Mexico from Manzanillo east are now of but small importance to international trade. The economic and social conditions of Chiapas, the State next to Guatemala, will illustrate this fact. This State of Chiapas is the continuation of the coffee belt that crosses Guatemala, but of the 20,000,000 acres of land comprised within the State only 6,000,000 acres have as yet become private property, and it is said that only 70,000 acres are under cultivation. The population of the State, including foreigners, comprises only 320,000 people. A beginning has been made in the cultivation of rubber trees, but there is neither railroad, bank, nor electric light in the State, nor are there any modern agricultural implements used. The construction of an isthmian canal would bring this part of Mexico into close commercial connection with the countries of the North Atlantic.

MINERAL RESOURCES.

The Republic of Mexico is a very mountainous country, possessing extensive deposits of gold, silver, copper, lead, and other metals. Up to the present time foreign capital has gone more largely into mining than into any other enterprises. As the transportation system of the country is developed and the population becomes denser a larger diversification of industries may be expected, but for some time to come the mineral industries will be of chief consequence. They will always rank high.

The western Cordilleras of Mexico contain the richest mineral deposits of the country, and it is the northern half of these western Cordilleras that possesses the greatest mineral wealth. Thus far the mining operations of this section have been confined mainly to the eastern slope. Some mining operations are being carried on near the Pacific coast, but the larger part of the mountainous region has yet to be developed by mining operations.

The location of these western Cordilleras is such that they are naturally tributary to the Pacific rather than to the Gulf of Mexico. Some of the mountains are within 50 miles of the Pacific, and practically all of these western ranges are within 300 miles of that ocean. They average from two to three times the latter distance from the Gulf. At the present time four railroads are being constructed from the plateau westward across these ranges to the Pacific, but it will probably be several years before any of them can be completed. One of the great drawbacks to the mineral development of western Mexico at the present time is the high cost of fuel on the Pacific. Coke is now brought from Europe by way of Cape Horn to western Mexico. It is possible that by the time the canal has been opened good coal will be found in sufficient quantity in the mountains of western Mexico. Should this not happen, it will be possible to export coal from our Southern cities by way of the canal to western Mexico for sale at about half the price at present prevailing in that locality.

Without attempting to speak in detail of the mining operations now being conducted in the western part of Mexico, reference may be made to the fact that there is a large number of gold and silver mines in operation in the neighborhood of Mazatlan. The output from this region, both of gold and silver, is rapidly increasing. Old mines are being reopened, the cyanide process is being introduced, and the construction of the railroad from Durango through to the coast is being pushed. Ninety miles east of Culiacan an American company has erected a water-power plant that furnishes 500 horsepower throughout the year. The power is converted into electricity for use in the mines. In the northwestern part of the State of Durango, in the Topia district, there is a region possessing silver ores, lead, iron, and limestone in abundance. In southwestern Chihuahua are valuable deposits of gold and silver. This district is at present 300 miles from a railroad, and the Topia district, just mentioned, is now 106 miles distant from the railway. The consequence is that in both sections mining operations can now be carried on only on a small scale. Mention is made of these districts to call attention to the fact that the construction of railways and better facilities for shipment from Pacific ports can add very much to the already important mining industries of western Mexico. Mention might be made of numerous other mining industries; those spoken of are merely illustrative.

The peninsula of Lower California has valuable resources of gold, silver, copper, and salt. Some American companies are now mining gold and silver, and a French corporation, the Baleo Copper Company, at Santa Rosalia, is now annually shipping 18,000 tons of copper and copper matte to Europe. Some of this product goes across the Gulf of California to Guaymas and is sent in bond to New Orleans and thence to Europe. More of it, however, is sent around the Horn. The company imports about 60,000 tons of coke by way of the cape, and its mining supplies come from the same source by the same route.

THE CANAL AND THE COMMERCE OF WESTERN MEXICO.

The character of the trade of western Mexico and the effects which the canal will have upon that trade can best be illustrated by reference to the trade of Mazatlan, the most important port of the region. The information herein given in regard to the industries and trade of Mazatlan is taken from an excellent special report prepared for the Isthmian Canal Commission by the United States consul located in that city.

The commercial connections of Mazatlan with the United States are by steamers running to San Francisco and to Panama. A minor share of this trade is handled by the Southern Pacific Railway. The facilities for shipping between Mazatlan and Europe are much better. The Chilean line carries some of Mazatlan's exports to Valparaiso where they are transferred to vessels bound for Europe. A French line and a German line of steamers make regular calls at Mazatlan. There are also two sailing vessels carrying coal from England to Mazatlan, and from time to time other sailing vessels, as occasion requires, are operated under charters from England, France, and Germany. Having better and cheaper connections with Europe, the trade of Mazatlan is mainly with that Continent.

A New York exporter of machinery says:

> At present a planter in the Pacific countries of Central America and Mexico can ship coffee and rice machinery from any European port and secure freight rates which would involve a saving of from 5 to 10 per cent on the value of his purchase, provided the cost price was equal to that quoted here.

The total foreign trade of Mazatlan in 1899 amounted to $42,000,000 Mexican silver, and at the present time this trade is mainly controlled by the merchants of Hamburg, Liverpool, and Bordeaux. The vessels that take out coal and other commodities from Europe load back with ore, tropical woods, and the other exports of Mazatlan. In 1899 Mazatlan sent to Europe $500,000 worth of logwood and mahogany, whereas our imports of those woods amount to $16,000. An interesting contrast to this is offered by the trade of Tampico, on the opposite side of Mexico. The commerce of that city is larger with the United States than with any other country, three-eighths of the city's imports being from our country.

Although the present trade of Mazatlan is comparatively large, it is much less than it will be when the means of communication with the tributary country have been improved. At the present time there are no railway connections with the interior, all the trade being handled by coasting vessels or by wagons and pack mules. The completion of a railroad now being built westward from Durango will greatly enhance the commercial importance of Mazatlan.

Our manufacturing cities in the eastern part of the United States will be between 1,000 and 2,000 miles nearer to western Mexico by way of the canal than to San Francisco and Seattle. This region, moreover, is so situated that the vessels engaged in our interoceanic coasting trade can conveniently engage in its commerce. The isthmian canal will cheapen the cost of constructing railroads in western Mexico and will lower the cost of machinery needed in the development of the mines and plantations. It is quite probable also that the coal from the southern part of the United States will be taken to western Mexico through the canal, and it is possible that the canal will make profitable the development of the great iron deposits of Durango. This vast deposit of iron ore in Durango is situated within 125 miles of the Pacific, with which it might readily be connected by rail.

At the present time the commerce of western Mexico is mainly with Europe and the most important commercial route is that around South America. The opening of the isthmian canal will give it closer connections with the United States than with Europe, and it seems probable that its trade will eventually be handled largely by our merchants.

CHAPTER XVII.—*Comparison of distances by the isthmian canal and other routes.*

In determining what commerce would use an isthmian canal, the fact of most fundamental importance is the effect which the new waterway will have on the ocean distances between the trade centers adjacent to the Atlantic and those in and about the Pacific. The length of the route determines the time of the voyage, and in general the commerce of the world is so conducted as to minimize distances as much as the conditions of ocean navigation and international exchanges permit. It is accordingly desirable to preface the discussion of the traffic of an isthmian canal with a comparison of the distances between the Atlantic and Pacific by way of the American isthmus with those by way of the various routes now followed. This comparison can best be made by means of a series of tables giving the distances by alternative routes[a] between the most important commercial centers. In most respects

[a] Consult pl. 74 for a chart of ocean routes by way of existing trade lines and by way of the Nicaragua and Panama canals.

the tables are self-interpretative. The distances are expressed in nautical miles, and the figures used in compiling the tables were furnished by the United States Hydrographic Office. The length of each canal is reckoned in nautical miles, the Nicaragua Canal being 161 nautical miles long, the Panama 41, and the Suez 88.

In the first table a comparison is made between the distances by the Nicaragua Canal with those by the Straits of Magellan and the west coast of North, Central, and South America.

TABLE I.—*Distances via the Nicaragua and Magellan routes between the eastern ports of the United States and the ports of the west coast of North, Central, and South America.*

From—	Via—	To Sitka.	To Port Townsend.	To Portland.	To San Francisco.	To San Diego.	To Acapulco.	To San José de Guatemala.
Portland, Me	Nicaragua	6,418	5,891	5,766	5,116	4,668	3,291	2,736
	Magellan [a]	15,021	14,494	14,369	13,719	13,342	11,896	11,466
Boston	Nicaragua	6,373	5,856	5,731	5,081	4,633	3,256	2,701
	Magellan [a]	14,986	14,459	14,334	13,684	13,307	11,861	11,431
New York	Nicaragua	6,223	5,696	5,571	4,921	4,473	3,096	2,541
	Magellan [a]	15,016	14,489	14,364	13,714	13,337	11,891	11,461
Philadelphia	Nicaragua	6,171	5,636	5,511	4,861	4,413	3,036	2,481
	Magellan [a]	15,066	14,539	14,414	13,764	13,387	11,941	11,511
Baltimore	Nicaragua	6,143	5,616	5,491	4,841	4,393	3,016	2,461
	Magellan [a]	15,078	14,551	14,426	13,776	13,399	11,953	11,523
Norfolk	Nicaragua	6,013	5,486	5,361	4,711	4,263	2,886	2,331
	Magellan [a]	14,942	14,415	14,290	13,640	13,263	11,817	11,387
Charleston	Nicaragua [b]	5,803	5,276	5,151	4,501	4,053	2,676	2,121
	Magellan [a]	14,951	14,424	14,299	13,649	13,272	11,826	11,396
Savannah	Nicaragua [c]	5,809	5,282	5,157	5,704	4,059	2,682	2,127
	Magellan [a]	14,980	14,453	14,328	13,678	13,301	11,855	11,425
Jacksonville	Nicaragua [d]	5,767	5,240	5,115	4,465	4,017	2,640	2,085
	Magellan [a]	14,955	14,428	14,303	13,653	13,276	11,830	11,400
Port Tampa	Nicaragua	5,280	4,753	4,628	3,978	3,530	2,153	1,598
	Magellan [a]	15,116	14,589	14,464	13,814	13,437	11,991	11,561
Pensacola	Nicaragua	5,386	4,859	4,734	4,084	3,636	2,259	1,704
	Magellan [a]	15,320	14,793	14,668	14,018	13,641	12,195	11,765
Mobile	Nicaragua	5,413	4,886	4,761	4,111	3,663	2,286	1,731
	Magellan [a]	15,362	14,835	14,710	14,060	13,683	12,237	11,807
New Orleans	Nicaragua	5,420	4,893	4,768	4,118	3,670	2,293	1,738
	Magellan [a]	15,416	14,889	14,764	14,114	13,737	12,291	11,861
Galveston	Nicaragua	5,603	5,076	4,951	4,301	3,853	2,476	1,921
	Magellan [a]	15,598	15,071	14,946	14,296	13,919	12,473	11,043

From—	Via—	To Honolulu.	To Guayaquil.	To Callao.	To Iquique.	To Valparaiso.	To Coronel.
Portland, Me	Nicaragua	6,626	3,441	3,946	4,588	5,173	5,356
	Magellan [a]	14,854	10,428	9,707	9,226	8,866	8,135
Boston	Nicaragua	6,591	3,403	3,911	4,553	5,138	5,321
	Magellan [a]	14,819	10,393	9,672	9,199	8,431	8,100
New York	Nicaragua	6,431	3,246	3,751	4,393	4,978	5,171
	Magellan [a]	11,489	10,423	9,702	9,221	8,461	8,130
Philadelphia	Nicaragua	6,371	3,186	3,691	4,333	4,918	5,101
	Magellan [a]	14,899	10,473	9,752	9,271	8,511	8,180
Baltimore	Nicaragua	6,351	3,166	3,671	4,313	4,898	4,581
	Magellan [a]	14,911	10,485	9,764	9,283	8,523	8,192
Norfolk	Nicaragua	6,221	3,036	3,541	4,191	4,768	4,951
	Magellan [a]	14,775	10,349	9,628	9,147	8,387	8,056
Charleston	Nicaragua [b]	6,011	2,826	3,331	3,973	4,558	4,741
	Magellan [a]	14,784	10,358	9,637	9,156	8,396	8 065
Savannah	Nicaragua [c]	6,017	2,832	3,337	3,979	4,564	4,747
	Magellan [a]	14,813	10,387	9,666	9,185	8,425	8,094
Jacksonville	Nicaragua [d]	5,975	2,790	3,295	3,937	4,522	4,705
	Magellan [a]	14,788	10,362	9,641	9,160	8,400	8,069
Port Tampa	Nicaragua	5,488	2,303	2,808	3,450	4,035	4,218
	Magellan [a]	14,949	10,523	9,802	9,321	8,561	8,230
Pensacola	Nicaragua	5,594	2,409	2,914	3,556	4,144	4,324
	Magellan [a]	15,153	10,727	10,006	9,525	8,765	8,434
Mobile	Nicarague	5,621	2,436	2,941	3,583	4,168	4,351
	Magellan [a]	15,195	10,769	10,048	9,567	8,807	8,476
New Orleans	Nicaragua	5,628	2,443	2,948	3,590	4,175	4,358
	Magellan [a]	15,249	10,823	10,102	9,621	8,861	8,530
Galveston	Nicaragua	5,811	2,626	3,131	3,773	4,358	4,541
	Magellan [a]	15,431	11,005	10,284	9,803	9,043	8,712

[a] Via Pernambuco, Callao, and San Francisco for points beyond these ports.
[b] Vessel going by west end of Cuba will shorten voyage 69 miles for Charleston.
[c] 104 for Savannah.
[d] 136 for Jacksonville.

The above table compares the distances by way of the Nicaragua Canal with those through the Straits of Magellan from the chief ports of our Atlantic and Gulf seaboard extending, from Portland to Galveston, to thirteen representative ports on the west coast of the American continents. Coronel, the most southerly of the west coast ports mentioned in the table, is situated within two or three hundred miles of the southern limits of the industrial section of Chile. It is also an important coaling port at the present time. It will be observed that the distance from New York to Coronel by way of the Nicaragua Canal is 2,959 miles less than the present route through the Straits of Magellan.

The effect of an isthmian canal upon the length of ocean routes connecting our eastern seaboard with the west coast of the three Americas is well shown by comparing the distances by way of the Nicaragua Canal and the Straits of Magellan from New York, the largest Atlantic port, and from New Orleans, the largest Gulf port, to San Francisco, the representative west coast city of the United States, to Iquique, the center of the nitrate of soda section, and to Coronel, in southern Chile. This comparison is shown in the following table:

To—	From New York via—		From New Orleans via—	
	Nicaragua.	Magellan.	Nicaragua.	Magellan.
San Francisco	4,921	13,714	4,118	14,114
Iquique	4,393	9,221	3,590	9,621
Coronel	5,171	8,130	4,358	8,530

In the following table (II) the distances from representative European ports to the west coast of the American continents by the Nicaragua and Magellan routes are given:

TABLE II.—*Distances from Europe to Pacific ports via the Nicaragua Canal and the Straits of Magellan.*

To—	From Liverpool via—		From Hamburg via—		From Antwerp via—		From Bordeaux via—		From Gibraltar via—	
	Nicaragua.	Magellan.[a]	Nicaragua.	Magellan.[a]	Nicaragua.	Magellan.[a]	Nicaragua.	Magellan.[a]	Nicaragua.	Magellan.[a]
Sitka	8,953	15,386	9,470	15,836	9,191	15,557	8,941	15,073	8,675	14,455
Port Townsend	8,426	14,859	8,943	15,309	8,664	15,030	8,414	14,546	8,148	13,928
Portland	8,301	14,734	8,818	15,181	8,539	14,905	8,289	14,421	8,023	13,803
San Francisco	7,651	14,084	8,168	14,534	7,889	14,255	7,639	13,771	7,373	13,153
San Diego	7,214	13,707	7,718	14,157	7,439	13,878	7,189	13,394	6,923	12,776
Acapulco	5,840	12,261	6,343	12,711	6,064	12,432	5,814	11,948	5,548	11,330
San Jose de Guatemala	5,285	11,831	5,788	12,281	5,509	12,002	5,259	11,518	4,993	10,900
Honolulu	9,175	15,219	9,678	15,669	9,399	15,390	9,149	14,906	8,883	14,288
Guayaquil	5,975	10,722	6,493	11,172	6,214	10,893	5,964	10,409	5,698	9,791
Callao	6,481	10,072	6,998	10,522	6,719	10,243	6,469	9,259	6,203	9,141
Iquique	7,123	9,591	7,640	10,041	7,361	9,762	7,111	9,278	6,845	8,660
Valparaiso	7,708	8,831	8,225	9,281	7,946	9,002	7,696	8,518	7,430	7,900
Coronel	7,891	8,500	8,408	8,950	8,129	8,401	7,879	8,187	7,613	7,569

[a] Via Pernambuco, Callao, and San Francisco for ports north of those cities.

The European ports included in the above table are so situated that the distances from them to Pacific ports typify the distances from the leading industrial and commercial centers of Europe. It will be observed that the distance from Liverpool to Coronel by way of the Nicaragua Canal will be 609 miles less than by the route through the

Straits of Magellan. The route to the nitrate port of Iquique will be shortened 2,468 miles. San Francisco will be brought 5,433 miles nearer to Liverpool and 5,780 miles nearer to Gibraltar.

In Tables III, IV, and V the distances from the Atlantic American ports to Pacific countries by way of the Nicaragua Canal and by way of existing routes are compared.

TABLE III.—*Distances, in nautical miles, from Atlantic American ports to Yokohama, Shanghai, and Hongkong via the Nicaragua and Suez routes.*

From—	To Yokohama via—			To Shanghai via—			To Hongkong via—			
	San Francisco and Great Circle.	Honolulu.	Suez,[a] Colombo, Singapore, Hongkong, and Shanghai.	San Francisco, Great Circle, and Yokohama.	Honolulu and Yokohama.	Suez,[b] Colombo, Singapore, and Hongkong.	San Francisco, Great Circle, Yokohama, and Shanghai.	Honolulu, Yokohama, and Shanghai.	Honolulu, Guam, and Manila.	Suez, Colombo, and Singapore.
Portland	9,652	10,026	13,330	10,702	11,076	12,280	11,561	11,935	12,097	11,421
Boston	9,617	9,991	13,370	10,667	11,041	12,320	11,526	11,900	12,062	11,461
New York	9,457	9,831	13,564	10,507	10,881	12,514	11,366	11,740	11,902	11,655
Philadelphia	9,397	9,771	13,707	10,447	10,821	12,657	11,306	11,680	11,842	11,798
Baltimore	9,377	9,751	13,852	10,427	10,801	12,802	11,286	11,660	11,822	11,943
Norfolk	9,247	9,621	13,727	10,297	10,671	12,677	11,156	11,530	11,692	11,818
Charleston	[c] 9,037	[c] 9,411	13,982	[c] 10,087	[c] 10,461	12,932	[c] 10,946	[c] 11,320	[c] 11,482	12,073
Savannah	[d] 9,043	[d] 9,417	14,057	[d] 10,093	[d] 10,467	13,007	[d] 10,952	[d] 11,326	[d] 11,488	12,148
Jacksonville	[e] 9,001	[e] 9,375	14,137	[e] 10,051	[e] 10,425	13,087	[e] 10,910	[e] 11,284	[e] 11,446	12,228
Port Tampa	8,514	8,888	14,629	9,564	9,938	13,579	10,423	10,797	10,959	12,720
Pensacola	8,620	8,994	14,833	9,670	10,044	13,783	10,529	10,903	11,065	12,924
Mobile	8,647	9,021	14,875	9,697	10,071	13,825	10,556	10,930	11,092	12,966
New Orleans	8,654	9,028	14,929	9,704	10,078	13,879	10,563	10,937	11,099	13,020
Galveston	8,837	9,211	15,111	9,887	10,261	14,061	10,746	11,120	11,282	13,202

[a] Direct voyage from Singapore to Yokohama reduces this distance by 393 miles.
[b] Direct voyage from Singapore to Shanghai reduces this distance by 66 miles.
[c] Vessels going by west end of Cuba will shorten voyage 69 miles for Charleston.
[d] 104 miles for Savannah.
[e] 136 miles for Jacksonville.

In Table III the distances from representative ports of the Atlantic and Gulf to Yokohama, Shanghai, and Hongkong by way of the various alternative routes are given. The distances given in the table are those which a vessel would take in going by actual commercial routes. It has been deemed more important to deal with distances by commercial routes rather than by the shortest possible course. The shortest route from the American Isthmus to Japan or China is by way of the Great Circle. The distance from Brito to Yokohama direct is 7,122; via Magdalena Bay, Lower California, 7,144; via San Francisco, 7,236, and via Honolulu, 7,610 miles. By the Great Circle route a vessel can call at San Francisco by adding only 114 miles to its voyage; and with this call at San Francisco included, the distance from New York to Shanghai by the Great Circle and Yokohama is 374 miles less than via Honolulu and Yokohama. The Nicaragua route is shorter than the Suez route for all Asiatic points mentioned in the table, the advantages of the Nicaragua route being greater for our Gulf ports than for those on the Atlantic. Especial note may be made of the fact that the distance to Hongkong by way of Honolulu, Guam, and Manila is considerably greater than by a route which enables a vessel to call en route at San Francisco, Yokohama, and Shanghai. The latter route is 536 miles less for a vessel starting from New York.

In order to compare the distances by various routes connecting our eastern seaboard with Manila, Table IV has been prepared.

TABLE IV.—*Distances, in nautical miles, from American Atlantic ports to Manila via Nicaragua and Suez routes.*

From—	Via San Francisco, Great Circle, and Yokohama.	Via Honolulu and Yokohama.	Via Honolulu, Yokohama, Shanghai, and Hongkong.	Via Honololu and Guam.	Via Suez, Colombo, Singapore.
Portland	11,402	11,776	12,563	11,469	11,367
Boston	11,367	11,741	12,528	11,434	11,407
New York	11,207	11,581	12,368	11,274	11,601
Philadelphia	11,147	11,521	12,308	11,214	11,744
Baltimore	11,127	11,501	12,288	11,194	11,889
Norfolk	10,997	11,371	12,158	11,064	11,764
Charleston [a]	10,787	11,161	11,948	10,854	12,019
Savannah [b]	10,793	11,167	11,954	10,860	12,094
Jacksonville [c]	10,751	11,125	11,912	10,818	12,174
Port Tampa	10,264	10,638	11,425	10,331	12,266
Pensacola	10,370	10,744	11,531	10,437	12,870
Mobile	10,397	10,771	11,558	10,464	12,912
New Orleans	10,404	10,778	11,565	10,471	12,966
Galveston	10,507	10,881	11,668	10,574	13,148

[a] The route to Greytown via west end of Cuba is 69 miles less.
[b] The route to Greytown via west end of Cuba is 104 miles less.
[c] The route to Greytown via west end of Cuba is 136 miles less.

It will be seen in the table that the distance from New York to Manila by way of San Francisco, the Great Circle, and Yokohama, is 11,207 miles, and that the distance by way of Honolulu and Guam is 11,274 miles. The Suez route is longer than either of these routes, being 11,601 miles. A vessel bound from New York or New Orleans, or any other eastern seaport to Manila can call at San Francisco, Yokohama, and Hongkong en route by adding 720 miles to the length of a voyage by way of Honolulu and Guam. Manila, it will also be noticed, is somewhat nearer the eastern part of the United States by way of the Nicaragua Canal than by way of Suez.

The manner in which the Nicaragua Canal will affect the distances between our eastern seaboard and Australia is shown by Table V:

TABLE V.—*Distances, in nautical miles, between the eastern seaboard of the United States and Australia via the Nicaragua and Suez routes.*

From—	To Adelaide via—		To Melbourne via—		To Sydney via—		To Wellington via—		
	Brito, Tahiti, Sydney, and Melbourne.	St. Vincent and Cape of Good Hope.	Brito, Tahiti, and Sydney.	St. Vincent, Cape of Good Hope, and Adelaide.	Brito and Tahiti. [a]	St Vincent, Good Hope, Adelaide, and Melbourne.	Brito and Tahiti. [a]	St. Vincent, Good Hope, and Melbourne.	Straits of Magellan.
Portland	10,954	12,446	10,446	12,954	9,871	13,529	8,911	14,204	11,419
Boston	10,919	12,459	10,411	12,967	9,836	13,542	8,876	14,217	11,384
New York	10,759	12,575	10,251	13,083	9,676	13,658	8,716	14,333	11,414
Philadelphia	11,699	12,611	10,191	13,149	9,616	13,724	8,656	14,399	11,464
Baltimore	10,679	12,736	10,171	13,241	9,596	13,819	8,632	14,494	11,476
Norfolk	10,549	12,614	10,041	13,122	9,466	13,697	8,510	14,372	11,140
Charleston	10,339	12,761	9,231	13,269	9,256	13,844	8,296	14,519	11,349
Savannah	10,345	12,821	9,837	13,329	9,262	13,904	8,302	14,579	11,378
Jacksonville	10,303	12,846	9,795	13,354	9,220	13,929	8,260	14,601	11,353
Port Tampa	9,816	12,243	9,308	13,751	8,733	14,326	7,773	15,001	11,514
Pensacola	9,922	13,447	9,414	13,955	8,839	14,530	7,879	15,205	11,718
Mobile	9,949	13,489	9,441	13,997	8,866	14,572	7,906	15,247	11,760
New Orleans	9,956	13,543	9,448	14,051	8,873	14,626	7,913	15,301	11,814
Galveston	10,139	13,725	9,631	14,233	9,056	14,808	8,096	15,483	11,996

[a] The course from Brito to Sydney direct, omitting call at Tahiti, would be 52 miles less.

The distance from New York to Australia by the Cape of Good Hope is practically the same as by the Suez Canal, and the Cape route has the advantage of more favorable winds and currents and of a cooler temperature. Vessels going from our eastern coast to Australia always round the Cape; accordingly, the comparisons of Table V are between the Nicaragua and Good Hope routes. Steamers bound for Australia via the Cape usually call at St. Vincent for coal; hence the distances given in the table include a call at that island. The route between the American isthmus and Australia and New Zealand is by way of the centrally located island of Tahiti, which will doubtless become an important coaling station upon the opening of the isthmian canal.

New York is 3,982 miles nearer Sydney by way of Brito and Tahiti than via St. Vincent, Good Hope, Adelaide, and Melbourne. Adelaide is 1,816[a] miles nearer New York and 3,587 miles nearer New Orleans by Brito and Tahiti than by Good Hope. Wellington will be brought 5,617[b] miles nearer New York by the Nicaragua Canal.

The places in Australia, the East Indies, and southern China equally distant from New York by the Nicaragua and Suez routes are shown on pl. 86. It will be observed that the line passing through points equidistant from New York via the two canals crosses the western part of Australia, runs west of the Philippines, and touches the continent of Asia in the neighborhood of the island of Hainan considerably to the west of Hongkong.

In Table VI the distances from Liverpool to Australasia and the Orient by way of the Nicaragua and Suez routes are contrasted.

TABLE VI.—*Distances from Liverpool to the East by the Suez and Nicaragua routes.*

To—	Suez route.		Nicaragua route.		Difference—Suez —; Nicaragua +.
	Ports of call.	Nautical miles.	Ports of call.	Nautical miles.	
Adelaide	Aden,[a] Colombo, King George Sound.	11,151	Brito, Tahiti, Sydney, Melbourne.[b]	13,489	−2,338
Melbourne	Aden,[a] Colombo, King George Sound, Adelaide.	11,659	Brito, Tahiti, Sydney[b]	12,981	−1,322
Sydney	Aden,[a] Colombo, King George Sound, Adelaide, Melbourne.	12,234	Brito, Tahiti[b]	12,406	− 172
Wellington	Aden,[a] Colombo, King George Sound, Melbourne.	12,949	do[c]	11,446	+1,503
Manila	Aden,[a] Colombo, Singapore	9,677	Brito, San Francisco, Yokohama.[d]	13,937	−4,260
Hongkong	do	9,731	do[e]	13,777	−4,046
Tientsin	Aden, Colombo, Singapore, Hongkong, Shanghai.	11,362	Brito, San Francisco, Yokohama.	13,554	−2,192
Yokohama	do	11,640	Brito, San Francisco	12,187	− 547

[a] Direct voyage from Aden to King George Sound would shorten these routes 540 miles.
[b] Direct voyage from Brito to Sydney would shorten these routes 52 miles.
[c] Direct voyage from Brito to Wellington would shorten this distance by 185 miles and make the difference 1,688 miles.
[d] A stop at Shanghai would add to this route 535 miles.
[e] A stop at Shanghai would add to this route 319 miles.

With the exception of Wellington, the Pacific ports named in Table VI are nearer Liverpool via the Suez Canal than by way of Nicaragua. From Liverpool to Sydney, however, the distance via Brito and Tahiti

[a] Omitting stop at Tahiti would add 52 miles to this figure, and if Melbourne were reached by Wellington rather than by Sydney, it should be increased by 232 miles.
[b] Omitting stop at Tahiti would add 185 miles to this figure.

is only 172 miles more than via Suez, Colombo, Adelaide, and Melbourne. Yokohama is but 547 miles farther from Liverpool via Brito and San Francisco than via the easterly route.

The route from Liverpool to Japan and China by way of the American Isthmus passes close to both the Atlantic and Pacific seaboards of the United States. A vessel would add but 323 miles to the length of the voyage from Liverpool to Greytown by calling at New York City, the port having the largest foreign commerce of any city in the world and an export traffic going in all directions. By calling at the south Atlantic or Gulf ports of the United States, the raw and manufactured cotton, which is exported in large quantities from the United States across the Pacific, could be added to the vessel's cargo. A call at San Francisco, or some other west coast port of the United States, would enable the vessel to participate in the grain and lumber trade from the United States to Oriental countries. If the vessel making the trip from Liverpool to Asia is sailed under the American flag, it can participate in the coasting trade between the two seaboards of the United States.

By consulting pl. 86, on which the points in Australasia and the East Indies equally distant from Liverpool are located, it will be seen that the line connecting the places equidistant from Liverpool by way of the Nicaragua and Suez routes passes between New Zealand and Australia, runs east of the main island of Japan, and touches the continent of Asia on the Manchurian coast some distance north of Vladivostok. As far as distance alone is determinative, the commerce of Liverpool with Australia and the Far East is tributary to the Suez route; but the commercial factors other than distance will, in all probability, so affect the routes of trade as to cause some of the outbound and inbound trade of Liverpool with the East to make use of the westerly route.

For the purpose of showing the relative advantages, as far as distance is concerned, which New York and Liverpool will possess for the Eastern trade after the isthmian canal has been completed, Table VII has been prepared:

TABLE VII.—*Comparisons of distances, in nautical miles, from New York and Liverpool to Australasian and Asiatic ports via the Nicaragua and Suez routes.*

To—	From New York (via Nicaragua).		From Liverpool (via Suez).		Difference—(Suez, −; Nicaragua, +).
	Route.	Miles.	Route.	Miles.	
Wellington	Brito, Tahiti	8,716	Aden,[a] Colombo, King George Sound, Melbourne.	12,949	+4,233
Sydney	do[b]	9,676	Aden,[a] Colombo, King George Sound, Adelaide, Melbourne.	12,234	+2,558
Adelaide	Brito, Tahiti,[b] Sydney,[c] Melbourne.	10,759	Aden,[a] Colombo, King George Sound.	11,151	+ 392
Manila	Brito, San Francisco, Great Circle, Yokohama.	11,207	Aden, Colombo, Singapore	9,677	−1,530
Hongkong	do	11,047	do	9,731	−1,316
Shanghai	do	10,507	Aden, Colombo, Singapore, Hongkong.	10,590	+ 83
Tientsin	do	10,824	Aden, Colombo, Singapore, Hongkong, Shanghai.	11,362	+ 538
Yokohama	Brito, San Francisco, Great Circle.	9,457	do	11,640	+2,183

[a] Omitting stop at Colombo will shorten voyage 540 miles.
[b] Omitting stop at Tahiti will shorten voyage 52 miles.
[c] If vessel goes by Wellington and Melbourne voyage will be shortened 232 miles.

New York will be nearer than Liverpool to New Zealand and the commercially important half of Australia. Liverpool by way of the Suez route will be nearer than New York by way of the Nicaragua route to the Philippines, Hongkong, and southern Asia. Shanghai will be almost the same distance from New York as from Liverpool, the advantage in favor of New York by way of Brito, San Francisco, the Great Circle, and Yokohama being 83 miles—the route from Liverpool by way of the Suez including a call at Colombo, Singapore and Hongkong. Northern China, Manchuria, and Japan will be considerably nearer New York than to Liverpool.

Pl. 86 shows that the line connecting the points equally distant from Liverpool and New York by the Suez and Nicaragua routes, respectively, runs through the central part of Australia, through the western part of New Guinea, east of the Philippine Islands, and touches the mainland of Asia a little north of Shanghai.

The foregoing seven tables have shown the effect which a Nicaragua Canal would have upon the ocean distances from our eastern seaboard to the Pacific countries of America, Australia, and Asia. These tables have also shown the manner in which the comparative distances from our eastern seaboard and from Europe would be modified by the Nicaragua Canal. In Table VIII the Nicaragua and Panama Canal routes are contrasted and the distances from typical Atlantic and Gulf ports of the United States and from representative European cities to the western coast of the American continents and to trans-Pacific countries by way of each canal route are given:

TABLE VIII.—*Comparison of distances, in nautical miles, from American and European Atlantic ports to Pacific ports via the Nicaragua and Panama canals.*

From—	Via—	To Port Townsend via San Francisco.	To San Francisco.	To Guayaquil.	To Callao.	To Iquique.	To Valparaiso.	To Coronel.
New York	Nicaragua	5,696	4,921	3,246	3,751	4,393	4,928	5,161
	Panama	6,074	5,299	2,864	3,359	4,021	4,630	4,838
Norfolk	Nicaragua	5,485	4,710	3,035	3,540	4,182	4,767	4,950
	Panama	5,872	5,097	2,662	3,157	3,819	4,428	4,636
Charleston	Nicaragua	5,276	4,501	2,826	3,331	3,973	4,558	4,741
	Panama	5,673	4,898	2,463	2,958	3,638	4,229	4.437
Port Tampa	Nicaragua	4,753	3,978	2,303	2,808	3,450	4,035	4,218
	Panama	5,328	4,533	2,098	2,593	3,255	3,864	4,072
New Orleans	Nicaragua	4,893	4,118	2,443	2,948	3,590	4,175	4,358
	Panama	5,473	4,698	2,263	2,758	3,420	4,029	4,237
Galveston	Nicaragua	5,076	4,301	2,626	3,131	3,773	4,358	4,541
	Panama	5,574	4,799	2,364	2,858	3,520	4,129	4,338
Liverpool	Nicaragua	8,426	7,651	5,975	6,481	7,123	7,708	7,891
	Panama	8,813	8,038	5,603	6,098	6,760	7,369	7,577
Hamburg	Nicaragua	8,943	8,168	6,493	6,998	7,640	8,225	8,408
	Panama	9,242	8,467	6,032	6,527	7,189	7,798	8,006
Antwerp	Nicaragua	8,664	7,889	6,214	6,719	7,361	7,946	8,129
	Panama	8,963	8,188	5,753	6,248	6,910	7,519	7,727
Bordeaux	Nicaragua	8,414	7,639	5,964	6,469	7,111	7,696	7,879
	Panama	8,713	7,938	5,503	5,998	6,660	7,269	7,477
Gibraltar	Nicaragua	8,148	7,373	5,698	6,203	6,845	7,430	7,613
	Panama	8,447	7,672	5,237	5,732	6,394	7,003	7,211

TABLE VIII.—*Comparison of distances, in nautical miles, from American and European Atlantic ports to Pacific ports via the Nicaragua and Panama canals.*

From—	Via—	To Yokohama via San Francisco.[a]	To Shanghai via San Francisco[a] and Yokohama.	To Manila via San Francisco[a] and Yokohama.	To Sydney via Tahiti.[b]	To Melbourne[b] via Tahiti[c] and Sydney.	To Wellington via Tahiti.[d]
New York	Nicaragua	9,457	10,507	11,207	9,676	10,251	8,716
	Panama	9,835	10,885	11,585	9,852	10,427	8,892
Norfolk	Nicaragua	9,246	10,297	10,997	9,466	10,041	8,505
	Panama	9,623	10,684	11,384	9,650	9,858	8,690
Charleston	Nicaragua	9,037	9,957	10,505	9,250	9,831	8,296
	Panama	9,344	10,367	10,809	9,451	10,006	8,491
Port Tampa	Nicaragua	8,514	9,564	10,264	8,733	9,308	7,773
	Panama	9,069	10,119	10,819	9,086	9,661	8,126
New Orleans	Nicaragua	8,654	9,704	10,404	8,873	9,448	7,913
	Panama	9,234	10,284	10,984	9,251	9,826	8,291
Galveston	Nicaragua	8,837	9,887	10,587	9,056	9,631	8,016
	Panama	9,335	10,385	11,085	9,352	9,927	8,392
Liverpool	Nicaragua	12,187	13,237	13,937	12,406	12,981	11,446
	Panama	12,574	13,624	14,324	12,591	13,166	11,631
Hamburg	Nicaragua	12,704	13,754	14,454	12,923	13,498	11,963
	Panama	13,003	14,053	14,753	13,020	13,595	12,060
Antwerp	Nicaragua	12,425	13,475	14,175	12,644	13,219	11,684
	Panama	12,724	13,774	14,474	12,741	13,316	11,781
Bordeaux	Nicaragua	12,175	13,225	13,925	12,394	12,969	11,434
	Panama	12,474	13,524	14,224	12.491	13,066	11,471
Gibraltar	Nicaragua	11,909	12,959	13,659	12,128	12,703	11,168
	Panama	12,208	13,258	13,958	12,225	12,800	11,265

[a] Via Honolulu add 374 miles for Nicaragua and 252 for Panama.
[b] Omitting Tahiti reduces voyage from Brito by 52 miles.
[c] Voyage from Brito to Sydney by way of Wellington is 232 miles less than by way of Tahiti; from Panama it is 405 miles less.
[d] Voyage from Brito to Wellington direct is 185 miles shorter than via Tahiti, and from Panama it is 358 miles shorter.

Table VIII shows very clearly that the Panama route is the more advantageous for the west South American trade, both with Europe and the United States. For the commerce of Europe and the United States with every other Pacific country with the exception of New Zealand, to which the distances are practically equal, the Nicaragua is shorter than the Panama route. If the call be made at Tahiti on the voyage between Wellington and the American Isthmus, the Nicaragua route is somewhat shorter than the one across Panama for the trade of North Atlantic countries with New Zealand. If this voyage be made without the call at Tahiti, distance by way of the two canal routes is practically the same.

For convenience of comparison, the following brief table is serviceable. The distances from New York, New Orleans, and Liverpool by way of the Nicaragua and Panama Canal routes to San Francisco, Yokohama, Hongkong, Sydney, Wellington, and Iquique are shown:

	New York.		New Orleans.		Liverpool.	
	Nicaragua.	Panama.	Nicaragua.	Panama.	Nicaragua.	Panama.
San Francisco	4,921	5,299	4,118	4,698	7,651	8,038
Yokohama	9,457	9,835	8,654	9,234	12,187	12,574
Hongkong	11,366	11,744	10,563	11,143	14,096	14,483
Sydney via Tahiti	9,676	9,852	8,873	9,251	12,406	12,591
Wellington via Tahiti	8,716	8,892	7,913	8,291	11,446	11,631
Iquique	4,393	4,021	3,590	3,420	7,123	6,760

CHAPTER XVIII.—*Cargo tonnage of the existing maritime commerce that might use an isthmian canal, 1898–99.*

The attempt is made in the following chapters to measure with all possible accuracy the amount of the ocean shipping and commerce which would use the isthmian waterway at the present time if the route were in existence. The latest statistics of ocean shipping and of the commodity traffic of which maritime commerce is composed have been carefully examined and are analytically set forth in these chapters for the purpose of determining the volume of the traffic reservoir from which the commerce of the canal would be drawn.

The results of three distinct statistical investigations are here presented, two of which were made by the Isthmian Canal Commission and one by the new Panama Canal Company. The investigations having been made without reference to each other, afford an exceptional opportunity for a comparison of results obtained by different methods and for testing the accuracy of the conclusions reached by the several inquiries.

One of the two studies made by the Isthmian Canal Commission examined the statistics of the imports and exports of our own country, and those of several European countries, for the purpose of determining how many tons of cargo or how much freight the trade of those countries might have contributed to the traffic through an American interoceanic canal in 1899. The investigation, the results of which are presented in this chapter, has gone fully into every essential detail concerning which information was obtainable; and in the comparatively limited field where estimates were unavoidable because of insufficient official data, the figures have been subjected to such critical tests as were applicable.

The other statistical investigation conducted by the Isthmian Canal Commission was made for the purpose of finding out the tonnage of the vessels which would pass through the canal if it were now in existence. This inquiry involved a study of the statistics kept by the leading commercial nations of the entrances and clearances of the vessels now engaged in the commerce between the ports so situated that their maritime trade might have made use of an interoceanic canal. The third investigation described in the following chapters is the one made by the new Panama canal company to ascertain the tonnage of the vessels that during recent years have been engaged in commerce that might have passed through a canal across the Isthmus of Panama, the new Panama canal company having courteously permitted the Isthmian Canal Commission to present in this report the results of an elaborate study.

NATURE AND LIMITATIONS OF THE INFORMATION AVAILABLE FROM OFFICIAL STATISTICS.

The statistics of the internal commerce of the United States and of other countries give the volume of business in tons. The traffic of the railways, rivers, and canals, and the productions of our mines and furnaces are measured by the ton unit, and the same is true of the products of our farms and forests when in the possession of the transportation agent. The statistical units of weight most familiar to the people of the United States are the short ton of 2,000 pounds and the "long" ton of 2,240. The long ton is not employed so much in this country as it formerly was, but in the United Kingdom the ton of 2,240 pounds is still more generally used than the short ton. In countries that have adopted the metric system of weights and measures the ton weighs 2,204 pounds.

In the Government statistics of ocean commerce no record is made of the cargo or weight tonnage of the commodities carried, and the volume of business done is expressed in terms of vessel tonnage. The "gross register tonnage" of a ship is its capacity in cubic feet divided by 100, and its "net register tonnage" is determined by dividing by 100 the cubic feet of space available in the vessel for cargo. Maritime commercial statistics are usually given in net register tonnage. To those who are directly concerned with maritime commerce the statistics of vessel tonnage are a readily understood index of the volume of commodity traffic; but to many if not most men engaged in industrial pursuits the cargo ton of 2,000 or 2,240 pounds is the customary unit employed in measuring the volume of trade, and figures of net tonnage have little significance until they have been converted into tons of weight.

It was believed that a statement of the cargo tonnage or the amount of freight that would make use of an isthmian canal if it were now in existence would be of value for several reasons. The business world being accustomed to consider the amount of traffic in terms of the cargo ton, a statement in that unit of the volume of available canal traffic would, it was thought, convey definite information that would be readily comprehended without being translated. The statistics of the cargo tonnage of ocean commerce permit comparisons to be made with the statistics of internal traffic, while statements of vessel tonnage do not. The saving in freight rates, furthermore, that the opening of an isthmian canal would make possible can be more intelligently considered by knowing the volume of cargo freight that would now use the waterway. Ocean rates, like railway freight charges, are levied on the cargo ton of weight or measurement, but unlike the statistics of railway traffic, those of maritime commerce give no data regarding freight tonnage.

The United States Bureau of Statistics in the Department of the Treasury collects the statistics of our foreign trade, and in its monthly and annual publications gives the value of imports and exports by classes of commodities and by ports. Tables are also published giving the values and, in many cases, the quantities of the commodities exported from each port to foreign countries as a whole; similarly, the values and usually the quantities of the imports entering our several ports from foreign countries, taken collectively, are given. Though these tables are elaborate and of great value, they do not give the amount of trade by articles and quantities carried on between our several ports and the countries with which we exchange commodities.

It is not possible to obtain the actual cargo tonnage of the total foreign trade of the United States directly from our official statistics, because the published tables seldom give the weights of the commodities, frequently do not state the quantities, and in no instance is the ocean freight tonnage stated. This is equally true of the commercial statistics compiled by foreign countries.

It is likewise impossible to ascertain from the published tables the kinds and quantities of commodities that constitute the trade carried on through and by our several ports with different countries. Our published statistics indicate the foreign trade carried on at each port of the United States; and the distribution of our entire trade among the several countries is shown, but it is in the form of total values. The Bureau of Statistics possesses the data necessary for this analytical presentation, by articles, of the trade of our respective ports with each foreign country, but the tables which such a presentation would require would be so voluminous as to make their publication for all ports impracticable. A table would need to be constructed for each port or customs district, showing its trade with each foreign country in each article or class of articles imported and exported. There are at the present time more than 50 maritime custom districts, trading more or less with 92 foreign countries, by exchanging some or all of the 661 articles in the classified list of the commodities.

Not being able to obtain from the published tables the data necessary for the calculation of the cargo tonnage of our ocean commerce that would now make use of an isthmian waterway, the resort was had to the unpublished folios, access to which was courteously given by the United States Bureau of Statistics. The facts concerning the trade of each port were copied from these folios, and two sets of tables were constructed, one for the Pacific ports of the United States and one for the Atlantic. The tables constructed for the Pacific ports showed for each port the values and, when obtainable, the quantities of each class of articles imported and exported in the trade carried on with each foreign country on the Atlantic. Similar tables were made, giving the trade of each Atlantic port with each Pacific country.

Having secured the mass of data contained in these compilations, the work of converting quantities and values of commodities into their cargo tonnage equivalents was begun, and the results of the calculations were four comparatively small tables giving the values and the cargo tonnage of the imports and exports composing the trade which our Pacific ports had with the Atlantic countries in 1898–99, and which our Atlantic ports had with Pacific countries the same year. These four tables give the value and the cargo tonnage of the maritime foreign commerce of the United States which might have used the isthmian canal had it been in existence during the year ending June 30, 1899.

The discussion of methods as well as results can be given more advantageously with the tables in hand. The four tables present (1) the value and cargo tonnage of the imports into each of our Atlantic ports from the Pacific foreign countries traded with; (2) the exports from each Atlantic port to those countries; (3) the value and cargo tonnage of the imports into each Pacific port from each Atlantic foreign country dealt with, and (4) the value and cargo tonnage of the exports from each of our Pacific ports to each Atlantic country to which commodities were sent. Table V is inserted in a later connection, where the totals of the first four tables are discussed.

I.—*Atlantic coast imports from foreign Pacific countries, values and cargo tons, year ending June 30, 1899.*

Customs districts.		Chile.	Ecuador and Peru.	Salvador and British Columbia.	Hawaii.
Baltimore	value	$76,393			
	tons	4,204.1			
Beaufort, S. C	value				
	tons				
Boston and Charlestown	value	$61,640	[a]$70,307		$5
	tons	14,520	[a]3,140		.1
Bridgeton	value	$61,340			
	tons	3,921.9			
Charleston, S. C	value	$93,308			
	tons	3,413.9			
Delaware	value	$101,701			
	tons	8,479.2			
Georgetown, D. C	value				$25,000
	tons				564.3
Hartford	value				
	tons				
Newark	value				
	tons				
New York	value	$2,245,533	$2,301,984	[b]$296,693	$7,954,770
	tons	103,490.3	29,140.3	2,107.2	95,866.4
Norfolk and Portsmouth	value	$11,723			
	tons	879.4			
Perth Amboy	value				
	tons				
Philadelphia	value	$109,542			$463,672
	tons	15,547.6			5,486.6
Portsmouth and Falmouth	value				$300
	tons				5
Providence	value				
	tons				
Richmond	value				
	tons				
Savannah	value	$35,295			
	tons	1,364.7			
Wilmington, N. C	value				
	tons				
Galveston	value				
	tons				
Key West	value				
	tons				
Mobile	value				
	tons				
New Orleans	value				$43,240
	tons				488.1
Pearl River	value				
	tons				
Pensacola	value				
	tons				
Tampa	value				
	tons				
Saluria	value				
	tons				
Total	value	$2,796,475	$2,372,291	$296,693	$8,486,987
	tons	155,821.1	32,280.3	2,107.2	102,410.5

Customs districts.		British Australia and Aukland.	China.	Japan.	Hongkong.
Baltimore	value		$7,999	$125,680	$190,215
	tons		89.8	2,501.8	13,602.9
Beaufort, S. C	value				
	tons				
Boston and Charlestown	value	$461,011	$145,232	$94,265	$242,292
	tons	1,607.2	784.5	2,567.5	7,118.3
Bridgeton	value				
	tons				
Charleston, S. C	value			$13,628	
	tons			350.9	
Delaware	value				
	tons				
Georgetown, D. C	value	$20	$4,305		
	tons	.5	44.3		
Hartford	value		$462	$5,921	$328
	tons		8.5	77.8	2.5

[a] Peru.

[b] British Columbia, $14,168.

I.—*Atlantic coast imports from foreign Pacific countries, etc.*—Continued.

Customs districts.		British Australia and Aukland.	China.	Japan.	Hongkong.
Newark	value	$133,828		$234	$1,424
	tons	116.5		4.7	20.2
New York	value	$3,072,191	$8,510,473	$7,079,664	$1,437,966
	tons	29,469.1	95,802.2	109,557.4	15,070.4
Norfolk and Portsmouth	value				
	tons				
Perth Amboy	value				
	tons				
Philadelphia	value	$163,011	$68,212	$110,189	$9,279
	tons	576.8	1,935	2,306	521.4
Portsmouth and Falmouth	value				
	tons				
Providence	value			$270	
	tons			3	
Richmond	value	$582		$313	
	tons	7.6		3.4	
Savannah	value				
	tons				
Wilmington, N. C.	value			$200	
	tons			3	
Galveston	value				
	tons				
Key West	value			$472	
	tons			6.2	
Mobile	value				
	tons				
New Orleans	value	$76	$44,982	$49,186	$5,292
	tons	1	2,717.2	1,510.6	30.3
Pearl River	value				
	tons				
Pensacola	value				
	tons				
Tampa	value				
	tons				
Saluria	value				
	tons				
Total	value	$3,833,719	$8,781,665	$7,480,024	$1,886,796
	tons	21,778.7	101,381.5	118,892.3	36,369

Customs districts.		Philippine Islands.	Total Hongkong and Philippines.	Total all others.	Grand total.
Baltimore	value		$190,215	$210,072	$400,287
	tons		13,602.9	6,795.7	20,398.6
Beaufort, S. C	value				
	tons				
Boston and Charlestown	value	$850,578	$1,092,870	$835,460	$1,928,330
	tons	18,216.7	25,335	22,619.3	47,954.3
Bridgeton	value			$61,340	$61,340
	tons			3,921.9	3,921.9
Charleston, S. C	value			$106,936	$106,936
	tons			3,764.8	3,764.8
Delaware	value			$101,701	$101,701
	tons			8,479.2	8,479.2
Georgetown, D. C	value			$29,325	$29,325
	tons			609.1	609.1
Hartford	value		$328	$6,383	$6,711
	tons		2.5	86.3	88.8
Newark	value		$1,424	$134,062	$135,486
	tons		20.2	121.2	141.4
New York	value	$3,100,485	$4,538,451	$31,461,308	$35,999,789
	tons	41,468.5	56,538.9	455,437.9	511,971.8
Norfolk and Portsmouth	value			$11,723	$11,723
	tons			879.4	879.4
Perth Amboy	value				
	tons				
Philadelphia	value	$221,819	$231,098	$914,626	$1,145,724
	tons	3,142.2	3,670.6	25,852	29,522.6
Portsmouth and Falmouth	value			$300	$300
	tons			5	5
Providence	value			$270	$270
	tons			3	3
Richmond	value			$895	$895
	tons			11	11
Savannah	value			$35,295	$35,295
	tons			1,364.7	1,364.7
Wilmington, N. C.	value			$200	$200
	tons			3	3

I.—*Atlantic coast imports from foreign Pacific countries, etc.*—Continued.

Customs districts.		Philippine Islands.	Total Hongkong and Philippines.	Total all others.	Grand total.
Galveston	value				
	tons				
Key West	value			$472	$472
	tons			6.2	6.2
Mobile	value				
	tons				
New Orleans	value		$5,292	$137,484	$142,776
	tons		30.3	4,716.9	4,747.2
Pearl River	value				
	tons				
Pensacola	value				
	tons				
Tampa	value				
	tons				
Saluria	value	$44	$44		$44
	tons	.5	.5		.5
Total	value	$4,172,926	$6,059,722	$34,047,852	$40,107,604
	tons	62,831.9	99,200.9	534,371.6	633,572.5

II.—*Atlantic coast exports to foreign Pacific countries, values and cargo tons, year ending June 30, 1899.*

Customs districts.		Chile.	Bolivia, Ecuador, and Peru.	Salvador and British Columbia.	Hawaii.	British Australia and Auckland.
Baltimore	value	$6,000			$33,248	$524,099
	tons	3,000			12,335	20,691
Beaufort, S. C	value					
	tons					
Boston and Charlestown	value					$89,408
	tons					835.2
Bridgeton	value					
	tons					
Charleston	value					
	tons					
Delaware	value					
	tons					
Georgetown, D. C	value					
	tons					
Hartford	value					
	tons					
Newark	value					
	tons					
New York	value	$1,984,661	[a] $1,936,464	[b] $282,072	$659,387	$15,865,902
	tons	44,480.7	[a] 27,802.4	[b] 6,339.3	12,359.5	337,017.1
Norfolk and Portsmouth	value	$6,638	[c] $7,700		$16,813	
	tons	3,250	[c] 4,400		8,407	
Perth Amboy	value				$24,420	
	tons				2,267.5	
Philadelphia	value	$3,888			$5,400	
	tons	2,350			452.7	
Portland and Falmouth	value					
	tons					
Providence	value					
	tons					
Richmond	value					
	tons					
Savannah	value					$68,242
	tons					11,214
Wilmington	value					
	tons					
Galveston	value					
	tons					
Key West	value					
	tons					
Mobile	value					
	tons					
New Orleans	value					
	tons					

[a] Bolivia and Ecuador, value, $806,592; tons, 12,051.8.
[b] New York to British Columbia, value, $4,144; tons, 65.8.
[c] Norfolk and Portsmouth to Peru, value, $7,700; tons, 4,400. Pensacola to Peru, value, $5,525; tons, 997.5.

II.—*Atlantic coast exports to foreign Pacific countries, etc.*—Continued.

Customs districts.		Chile.	Bolivia, Ecuador, and Peru.	Salvador, and British Columbia.	Hawaii.	British Australia and Auckland.
Pearl River	value		[a] $22,631			
	tons		[a] 3,485.4			
Pensacola	value		[b] $5,525			$11,150
	tons		[b] 997.5			1,122.4
Tampa	value					$23,304
	tons					3,884
Total	value	$2,001,187	$1,972,250	$282,072	$739,268	$16,582,105
	tons	53,080.7	36,685.3	6,339.3	35,821.7	374,763.7

Customs districts.		China and Hongkong.	Japan.	Asiatic Russia and Korea.	French and German Oceania.
Baltimore	value				
	tons				
Beaufort, S. C	value		$30,416		
	tons		11,739		
Boston and Charlestown	value				
	tons				
Bridgeton	value				
	tons				
Charleston	value				
	tons				
Delaware	value				
	tons				
Georgetown, D. C	value				
	tons				
Hartford	value				
	tons				
Newark	value		$185		
	tons		2		
New York	value	$12,073,176	$4,841,684	$807,935	$17,763
	tons	[c] 301,835.5	170,856.7	8,954.3	993.3
Norfolk and Portsmouth	value		$10,000		
	tons		1,000		
Perth Amboy	value		$348		
	tons		8		
Philadelphia	value	$628,048	$970,369		
	tons	4,220.8	80,650.3		
Portland and Falmouth	value				
	tons				
Providence	value				
	tons				
Richmond	value				
	tons				
Savannah	value		$10,000		
	tons		1,000		
Wilmington	value				
	tons				
Galveston	value		$440,971		
	tons		11,902		
Key West	value		$73,860		
	tons		7,386		
Mobile	value	$13,898	$14,289		
	tons	421.2	433.1		
New Orleans	value		$444,696		
	tons		12,097.2		
Pearl River	value				
	tons				
Pensacola	value		$8,400		
	tons		2,100		
Tampa	value		$23,574		
	tons		3,929		
Total	value	$12,715,122	$6,868,792	$807,935	$17,763
	tons	306,477.5	303,103.8	8,954.3	993.3

[a] Pearl River to Bolivia and Ecuador, value, $22,631; tons, 3,485.4.
[b] Norfolk and Portsmouth to Peru, value, $7,700; tons, 4,400. Pensacola to Peru, value, $5,525; tons, 997.5.
[c] Of this total, Hongkong's share was $1,775,634 and 105,704.7 tons of cargo. New York was the only customs district of the Eastern seaboard that exported to Hongkong in 1899.

II.—*Atlantic coast exports to foreign Pacific countries, etc.*—Continued.

Customs districts.		Philippine Islands.	Total Hongkong and Philippines.	Total all other.	Grand total.
Baltimore, Md	value	$29,690	$29,690	$563,347	$593,037
	tons	13,151.6	13,151.6	36,026	49,177.6
Beaufort, S. C	value			$30,416	$30,416
	tons			11,739	11,739
Boston and Charlestown	value			$89,408	$89,408
	tons			835.2	835.2
Bridgeton	value				
	tons				
Charleston	value				
	tons				
Delaware	value				
	tons				
Georgetown, D. C	value				
	tons				
Hartford	value				
	tons				
Newark	value			$185	$185
	tons			2.5	2.5
New York	value	$84,315	$1,859,949	$36,693,340	$38,553,289
	tons	1,988.9	107,693.6	804,934.1	912,627.7
Norfolk and Portsmouth	value	$70,336	$70,336	$41,151	$111,487
	tons	30,695	30,695	17,057	47,752
Perth Amboy	value			$24,768	$24,768
	tons			2,275.5	2,275.5
Philadelphia	value			$1,607,705	$1,607,705
	tons			87,673.8	87,673.8
Portland and Falmouth	value				
	tons				
Providence	value				
	tons				
Richmond	value				
	tons				
Savannah	value			$78,242	$78,242
	tons			12,214	12,214
Wilmington	value				
	tons				
Galveston	value			$140,971	$440,971
	tons			11,902	11,902
Key West	value			$73,860	$73,860
	tons			7,386	7,386
Mobile	value			$28,187	$28,187
	tons			854.3	854.3
New Orleans	value			$444,696	$444,696
	tons			12,097.2	12,097.2
Pearl River	value			$22,631	$22,631
	tons			3,485.4	3,485.4
Pensacola	value			$25,075	$25,075
	tons			4,219.9	4,219.9
Tampa	value			$46,878	$46,878
	tons			7,813	7,813
Total	value	$184,341	$1,959,975	$40,210,860	$42,170,835
	tons	45,835.5	151,540.2	1,020,514.9	1,172,055.1

Total, plus 873 tons of miscellaneous *foreign exports* not included in the table, 1,172,928.1 tons.

III.—*Pacific coast imports from foreign Atlantic countries, values and cargo tons, year ending June 30, 1899.*

Customs districts.		Austria-Hungary.	Belgium.	Denmark.	France.	Germany.	Italy.	Netherlands.
Los Angeles	value	$1,742	$28,559		$10,580	$76,348	$574	$2,193
	tons	65.8	2,908.1		112.4	3,910.1	1	21.3
Oregon, Oreg	value		$12,352					
	tons		1,678.1					
Puget Sound	value	$2	$41,917	$81	$1,444	$10,331	$19	$92
	tons	0.1	5,542.4	1.6	7.3	148.2	0.8	1
San Diego	value				$69	$42,929		
	tons				3	2,852.3		
San Francisco	value		$885,502		$678,731	$880,382	$188,650	
	tons		45,946.9		7,815	41,988.9	3,646.4	
Willamette	value		$124,960		$2,555	$17,601	$39,503	
	tons		11,583.8		19.5	5,085.6	2,107.2	
Total	value	$1,744	$1,093,290	$81	$693,379	$1,057,594	$228,716	$2,385
	tons	65.9	67,659.3	1.6	7,957.2	53,985.1	5,755.4	22.3

III.—*Pacific coast imports from foreign Atlantic countries, etc.*—Continued.

Customs districts.		Sweden and Norway.	Switzerland.	United Kingdom.	East Canada.	West Indies.	Brazil.	Total.
Los Angeles	value	$1,377	$1,080	$74,322	$100	$30	....	$197,015
	tons	7.5	3	6,838.6	3	....	....	13,870.8
Oregon, Oreg	value	....	....	$716	....	....	....	$13,068
	tons	....	....	79.3	....	....	....	1,757.4
Puget Sound	value	....	$46	$26,860	$68	....	....	$80,860
	tons	....	2	1,891.1	2.6	....	....	7,597.1
San Diego	value	....	....	$89,588	....	....	....	$132,586
	tons	....	....	12,293.5	....	....	....	15,148.8
San Francisco	value	....	....	$1,806,509	....	$213,604	$3,650	$4,657,028
	tons	....	....	137,236.3	....	310.5	12.1	236,456.1
Willamette	value	$6,994	$176	$131,697	$957	....	....	$354,446
	tons	179.5	7	6,482.1	34.9	....	....	25,499.6
Total	value	$8,371	$1,302	$2,129,702	$1,125	$213,634	$3,650	$5,435,003
	tons	187	12	164,820.9	40.5	310.5	12.1	300,829.2

IV.—*Pacific coast exports to foreign Atlantic countries, values and cargo tons, year ending June 30, 1899.*

Customs districts.		United Kingdom.	Germany.	Belgium.	Italy, Switzerland.
Oregon, Oreg	value	$92,324	[a] $10,200	....	....
	tons	1,612	95.6	....	....
Puget Sound	value	$2,815,647	$28,000	$311,500	....
	tons	124,183.8	....	[b] 15,483.6	....
San Francisco	value	$6,918,817	$650	....	[c] $37,340
	tons	173,084.2	11	....	[c] 5,184.8
Willamette	value	$6,249,843	$17,931	$60,000	[d] $176
	tons	274,689.9	([b])	[b] 5,572.7	[d] 6
Total	value	$16,076,631	$56,781	$371,500	$37,516
	tons	573,569.1	106.6	21,056.3	5,190.8

Customs districts.		South Africa.	East Canada.	Argentina.	Total.
Oregon, Oreg	value	....	....	....	$102,524
	tons	....	....	....	1,707.6
Puget Sound	value	$648,723	$3,252	$37,693	$3,539,679
	tons	56,519.2	594.8	12,497.6	191,312.3
San Francisco	value	$346,839	....	....	$7,605,530
	tons	13,032.3	....	....	209,279
Willamette	value	$776,767	....	....	$7,104,717
	tons	32,048.4	....	....	312,317
Total	value	$11,772,329	$3,252	$37,693	$18,352,450
	tons	101,599.9	594.8	12,497.6	714,615.3

[a] Including Denmark.
[b] Including Germany.
[c] All trade with Italy.
[d] All trade with Switzerland.

Estimates of total scattering foreign exports, value, $1,078; tonnage, 715,693.

In constructing these tables the trans-Atlantic trade of our Gulf and Atlantic ports was omitted because it would not be tributary to the canal, and the figures include only the ocean foreign commerce now carried on by our Atlantic and Gulf ports with Pacific countries, and between our Pacific ports and countries on the Atlantic. In the case of each port named only that part of its foreign trade is given that might be directly affected by the opening of the canal.

According to the classification of the United States Bureau of Statistics, the imports number 333 classes and the exports 328. For each item in this list of 661 commodities the value was obtainable; for some of the classes the number or quantities of articles were reported, and, for many commodities, weights were given in the official statistics.

In all cases, however, the weights given were net, covering only the commodity and not the packing or "tare" which constitutes a part of the freight cargoes whose weights were to be ascertained.

In order to determine the weight of the tare corresponding to the weight or value of the ordinary unit of each of the many commodities considered, a large amount of detailed information had to be secured from business men concerning the manner of shipping the various articles. The difficulties of this and other parts of the investigations were somewhat complicated by the fact that many commodities of bulky character are handled by ocean vessels as measurement cargo, 40 cubic feet being reckoned as a ton instead of 2,240 pounds, the weight ton commonly employed in maritime traffic. In determining the true cargo tonnage of goods shipped by the measurement ton it was necessary to ascertain the cubic contents, boxing included, of some unit of quantity.

To reduce commodity values to weights, to find the average tare for net weights, to learn whether shipments were made by weight or measure, and, if by measure, to find the weight or value of a measurement ton, an extensive correspondence was carried on with men engaged in foreign trade. Representative business men of the leading commercial cities were requested to give the assistance needed, and by means of personal interviews and a large correspondence a mass of information was secured covering the great bulk of both our import and export trade. In order to insure the greatest possible accuracy for the tables of cargo tonnage, inquiries regarding each line of foreign trade have been made of representative firms of several of the large seaports, and in some instances several firms were corresponded with concerning each commodity about which information was required.

This correspondence extended over several months and required the sending out of several thousand individual letters; but by means of the knowledge obtained from the business men, who generously gave the time required to reply to the requests for information, it was possible to prepare the above tables by converting, item by item, into equivalent cargo tons, the values of nearly all of the articles that our various ports would have imported and exported by way of an isthmian canal during the fiscal year ending June 30, 1899. Although it was not possible to get the requisite data for converting every item, there are but 5.7 per cent of the imports, and 2.4 per cent of exports included in the above tables that were not converted according to the method just described. The small quantity of imports and exports for which it was not possible to secure satisfactory factors to use in changing values to cargo tons were converted by using for the multiplier the average ratio of values to tons.

These residuary values and quantities consisted largely of these unclassified articles of import and export. In classifying the multitude of commodities handled in international trade, it is often necessary to include in the larger divisions of the classification a group entitled "All other." For instance, in the general classification of the exports of the United States the division "Iron and steel and manufactures of" contains 42 specific classes and also such general groupings as "All other manufactures of iron and steel," "All other machinery," and "Tools not otherwise specified." For converting the indefinite or unspecified classes it was necessary to assume that the relation of the values to the cargo tonnage was the same as it was for the specified classes of their general division of the classification. The value of "All other machinery," for example, was converted by assuming that the ratio of value to weight and bulk was equal to the average for the 11 specified classes of machinery; and it is probable that the results obtained in this manner were nearly correct. This same method of conversion was applied to the unspecified classes of imports.

It was not practicable in the case of every general grouping entitled "All other, etc.," to secure an average ratio to use as a factor for converting values to tons; consequently, a part of the values comprised within these general groups was included with the residuary quantities that were dealt with according to the method described in the following paragraphs:

After having converted the specified classes of imports and exports and as many as possible of the classes or grouping entitled "All other" or "Not otherwise specified," it was found that 96 per cent of the total value of the maritime foreign trade of the United States available for canal traffic during the fiscal year ending June 30, 1900—in round numbers, $101,000,000 out of $105,000,000—had been accounted for.

The remaining 4 per cent unaccounted for consisted partly of the unclassified imports and exports—the general residuum placed at the end of the tables of imports and exports published by the Bureau of Statistics, and designated "all other articles not elsewhere specified"—and were also made up partly of the commodities concerning which the Commission secured no information in regard to the relation of values to cargo tons.

A classification of commodities could hardly be constructed that would find an appropriate class for every article listed in the merchants' invoice or sales book, and a final grouping of "all other articles not elsewhere specified" is practically necessary in making up tables of imports and exports such as are published by the United States Bureau of Statistics. The total value of the unclassified commodities that had to be dealt with in constructing the above tables of cargo tons of the traffic available for an isthmian canal was small, and the change from value to tons was made by assuming these articles to have the same average weight and capacity as had equal values of typical and carefully selected classified articles. The average of these other commodities was taken as the standard.

The classified commodities concerning which no information was secured to assist in the conversion of their values into equivalent cargo tonnage consisted to a limited extent of shipments so small in quantity as not to justify an investigation of them, but most of these commodities were made up of articles which varied so much in value, bulk, and packing that no reliable estimates regarding them could be secured from shippers.

Imported commodities constituted the greater part—65 per cent—of the values that had to be converted by means of general averages. This was to be expected in view of the fact that our exports consist so largely of such articles as raw materials and heavy manufactures whose weight and measurement are readily ascertainable, while our imports contain a large variety of manufactures and other articles whose weight and bulk are difficult to determine.

This fact is well illustrated by comparing the import and export trade of our Pacific ports. The exports from the Pacific ports were made up so largely of raw materials or food products that over 99.9 per cent could be converted from values and quantities to tons. On the contrary, in the case of the imports from Europe to the Pacific coast—a rich agricultural section with but little manufacturing activity—data could be secured to convert only 88 per cent of the total. The amount of these imports, however, is small, and the necessity of converting 12 per cent of their total value by indirect methods was consequently not a serious matter. Ninety-five per cent of the Atlantic imports from the Pacific was directly converted, and for the Atlantic exports to the Pacific the percentage was 96.5 per cent.

The commodities for which no specified data could be secured—$4,000,000 worth—were converted by means of general averages, obtained in the manner described below. The imports and exports of the Atlantic and Pacific seaboards were converted by using different factors because of the diverse characteristics of the trade of the two coasts.

For all the exports of the Pacific coast, except a few from San Francisco, factors were obtained for the direct conversion of each commodity from values to tons, and the San Francisco exports not otherwise accounted for were assumed to average the same as the other exports from that city to Europe.

Twelve per cent of the imports to the Pacific coast from Atlantic countries had to be converted by securing an acceptable average ratio of values to tons. More than 25 per cent of the imports came from England to San Francisco and comprised a wide range of articles. These San Francisco imports from England included coal and precious stones as two important items, and after deducting the values of these two commodities the remaining San Francisco imports were used to obtain the factor by which the values of the unconverted 12 per cent residuum of Pacific coast imports from Atlantic countries was changed from values to cargo tons.

Of the Atlantic coast exports to Pacific countries those sent to British Australasia are the most typical and the most important, amounting to over one-third of the whole. Inasmuch as these exports to Australasia consisted of substantial amounts of nearly all classes of commodities shipped from the Atlantic coast to the Pacific, it was thought that their average was the best one to take for converting from values to tons the small share of the export trade to the Pacific that had not been directly accounted for.

The unconverted Atlantic imports from the Pacific were reduced to tons by making the Chinese and Japanese imports the standard. This was done because from those countries the widest range of the most typical articles was received.

The methods and standards followed in changing the values of the imports and exports here under consideration into cargo tons of weight or measurement have been fully explained because it is upon those methods and standards that the accuracy of the results primarily depends. While the results obtained are necessarily approximately rather than absolutely exact, it is believed that the figures contained in the foregoing tables are as close to the truth as they can be brought by careful statistical work. Having described the manner in which the tables were constructed and how the results presented in them were obtained, attention may now be directed to an analysis of the tonnage totals. To facilitate comparison the totals of Tables I to IV are summarized in the following Table V:

V.—*Value and cargo tonnage of the trade which the United States would have had through an isthmian canal during the fiscal year ending June 30, 1899.*

	Pacific coast.		Atlantic coast other than with Hongkong and Philippines.		Atlantic coast with Hongkong and Philippines.		Total Atlantic.	
	Values.	Cargo tons.	Values.	Cargo tons.	Values.	Cargo tons.	Values.	Cargo tons.
Imports	$5,435,003	300,829.8	$33,751,161	534,371.6	$6,059,678	99,200.9	$39,810,839	633,572.5
Exports	18,352,450	715,682.9	40,210,860	1,020,514.9	1,959,975	151,540.2	42,170,835	1,172,055.1
Total	23,787,453	1,016,512.7	73,962,021	1,555,886.5	8,019,653	250,741.1	81,981,674	1,805,627.6

Grand total: Values, $105,769,127; tons, 2,823,013.3 (including 873 tons miscellaneous exports of foreign exports).

The total value of the maritime commerce of the United States that might have used an isthmian canal to advantage during the fiscal year ending June 30, 1899, was $105,769,127. Of this total trade the Pacific ports had $23,787,453 worth, and the Atlantic, including their trade with the Philippines and Hongkong, $81,981,674 worth. Whether all the trade carried on between our eastern ports and the Philippines and Hongkong may properly be included in this total value of the commerce of the United States available for canal traffic is an important question that is considered at length in the discussion which follows regarding the entrances and clearances of the vessels that would have used a canal during the past year. In this connection it is sufficient to note that the value of the trade of the Atlantic coast ports of the United States with Hongkong and the Philippines has been stated separately.

The value of the exports from our west coast to Europe in 1899, $18,352,450, and the corresponding cargo tonnage, 715,682.9 tons, were abnormally small because of the severe drought of the year 1897–98. The larger part of tonnage export of that section consists of grain, and during the year 1898–99 the grain exports were less than 50 per cent of their average for the five years preceding. If the value of the grain exports of the Pacific coast for the fiscal year 1898 be substituted for those of 1899 in the above table, the total value of the west coast exports would have equaled $40,299,881.

The exports other than grain had practically the same value in 1898 and in 1899. Had the grain exports of 1899 been equal to those of 1898, or, in other words, had their amount been normal, the cargo tonnage of the west coast exports would have been 1,328,757 tons instead of 715,682.9 tons, the figures in the above table; and the total cargo tonnage, instead of having been 2,823,013.3 tons, as stated in the table, would have been 612,874.1 tons more, or 3,435,887.4. This larger total is a much more accurate expression than is the smaller total of the cargo tonnage of maritime foreign commerce available for canal traffic during the last two years. This larger sum will be used in the comparison that will subsequently be made with the tonnage estimates derived by other methods of investigations that will be described later.

THE AVERAGE VALUES OF THE CARGO TON.

Besides revealing the total value and total cargo tonnage of the import and export trade which our country might have had by way of the proposed isthmian waterway in the fiscal year ending June 30, 1899, the tables indicate some interesting differences in the characteristics of the trade of our Atlantic seaboard as compared with the commerce of the Pacific coast.

The value of the Atlantic coast exports listed in the tables was $42,170,835, and the cargo tonnage of these exports amounted to 1,172,055 tons. This makes the average value of the cargo ton to have been $35.98. In the case of the Atlantic coast imports considered in the tables the total value was $39,810,839, the total cargo tonnage 633,572.5 tons, and the average value of the ton $62.84.

The average values of the cargo ton will doubtless seem low to many persons. It must not, however, be forgotten that the tonnage here given is made up of the commodities packed for shipment. A large amount of weight and space are taken up by the packing. Moreover, in the case of many commodities, 2,240 pounds of the articles would be much more valuable than 40 cubic feet of it would be, even when no allowance is made for the space occupied by the packages containing the goods. The average values just cited are those of the ton of freight as found in the holds of the ocean vessel.

The cargo ton in these tables and throughout this discussion, it may be well to note, is in some cases 2,240 pounds; but in other instances, and more frequently, it is the measurement ton of 40 cubic feet. It was impossible to make a distinction between the weight ton and the measurement ton in compiling the above tables, because both are used by shippers and ocean carriers without distinction.

The difference between the average values of the cargo ton of imports and that of the exports is explained by the fact that the exports to the Pacific markets consist largely of bulky manufactures of iron and wood, of coal and petroleum oil, whereas the average value of the imports from Pacific countries is kept high by the Manila hemp, the products of Japan and China, Australian wool, and the hides, skins, and furs from Australia and South America.

The cargo ton values of both the import and export trade of the Pacific coast with Atlantic countries are low. The total value of the imports considered was $5,435,003, and, their cargo tonnage being 300,829.8 tons, the average ton value was $18.07. The $18,352,450 worth of exports included in the tables comprised a cargo tonnage of 715,682.9 tons, the average ton value being $25.64.

The principal Pacific coast exports were wheat, flour, barley, and lumber, and these commodities tended to lower the average ton value. Their effect, however, was to some extent offset by the exportation of canned salmon and vegetables and canned and dried fruits. The small ton value of the Pacific coast imports from Atlantic countries is accounted for by the fact that the greater part of the tonnage is made up of coal, salt, cement, and glass. The textiles, gloves, and other high-priced European articles have but a small influence on the ton value.

The amount of cargo tonnage which vessels can carry per gross or net register tonnage varies with different ships, but the ordinary ratio between cargo and register is well known. In the following chapter tables are given which show the net register tonnage of the vessels engaged in the commerce that would have used an isthmian canal in 1899. A comparison of the figures of cargo tonnage of the part of our foreign trade that has been studied with the net register tonnage of the ships that carried that trade will roughly check the accuracy of both the cargo and the vessel tonnage statistics presented as the result of this investigation. Before making this comparison, however, it will be best to wait until the tables of vessel tonnage contained in the discussion that follows later have been presented and analyzed.

TONNAGE OF THE COMMERCE BETWEEN EUROPE AND THE WEST COAST OF SOUTH AND CENTRAL AMERICA AND BRITISH COLUMBIA AND HAWAII.

Up to this point the cargo tonnage discussed has been that of the United States only. Our own present trade that would pass through the canal merited a detailed study because of the importance of securing as much information as possible regarding the industrial and commercial value of the canal to the people of the United States; but it was not thought that the cargo tonnage of the trade which Europe now has with the west coast of South and Central America, and with British Columbia and Hawaii, need be changed from values and quantities into cargo tons in the same detailed way that the values of our own available canal commerce were converted into their tonnage equivalents.

The large mass of information which the investigation of American trade had furnished regarding the relation of values and quantities to cargo tonnage was equally applicable to the commerce of foreign countries; and this information enabled the conversion of the greater part of the trade of other countries to be made easily and quickly. The commodities not changed from values to tons by the direct method were converted by means of averages chosen in a manner similar to those methods used in the conversion of American imports and exports.

It was not considered necessary to determine the cargo tonnage which every foreign country now has available for canal traffic. By taking the nine European countries—the United Kingdom, France, Germany, Belgium, Holland, Austria-Hungary, Italy, Spain, and Sweden—nearly all the commerce which foreign nations would have with the west coast of America and Hawaii was reached. Norway has no commerce with this section, and that of Greece and Russia is slight. The trade of Europe with our west coast was included in the study of our canal commerce.

The first of the following tables gives the cargo tonnage of the trade which the nine European countries just named had with the west coast of South and Central America in the calendar year 1898—the figures from Belgium being for 1899—and shows how the countries shared in this commerce. It also indicates how the trade was divided among the several west coast American nations. The table is divided into two sections for the purpose of showing both the import and export cargo tonnage for South America and Central America separately. In another table the trade of Europe with Hawaii and British Columbia is shown.

Cargo tonnage of the trade between Europe and the Pacific coast of South and Central America, 1898.

EUROPEAN IMPORTS.

American countries.	United Kingdom.	France.	Germany.	Belgium.[a]	Holland.	Austria-Hungary.	Italy.	Spain.	Sweden.	Total.
SOUTH AMERICAN.										
Bolivia	....	....	9,522	....	....	....	....	....	....	9,522
Chile	294,037	293,668	954,792	124,519	12,461	39	5,063	5,715	4,141	1,694,435
Ecuador	4,832	6,397	15,292	4	....	....	....	1,888	....	28,413
Peru	126,567	30,342	54,083	16,876	68,547	1	11,814	547	....	308,777
Total	425,436	330,407	1,033,689	141,399	81,008	40	16,877	8,150	4,141	2,041,147
CENTRAL AMERICA.										
Guatemala	3,770	[b] 4,330	48,895	215	....	....	....	1,752	....	58,962
Honduras	390	....	[c] 10,130	....	....	....	....	....	....	10,520
Nicaragua	3,107	....	....	130	....	....	....	89	....	3,326
Salvador	2,395	....	....	....	....	....	....	117	....	2,512
Total	9,662	4,330	59,025	345	....	....	....	1,958	....	75,320

EUROPEAN EXPORTS.

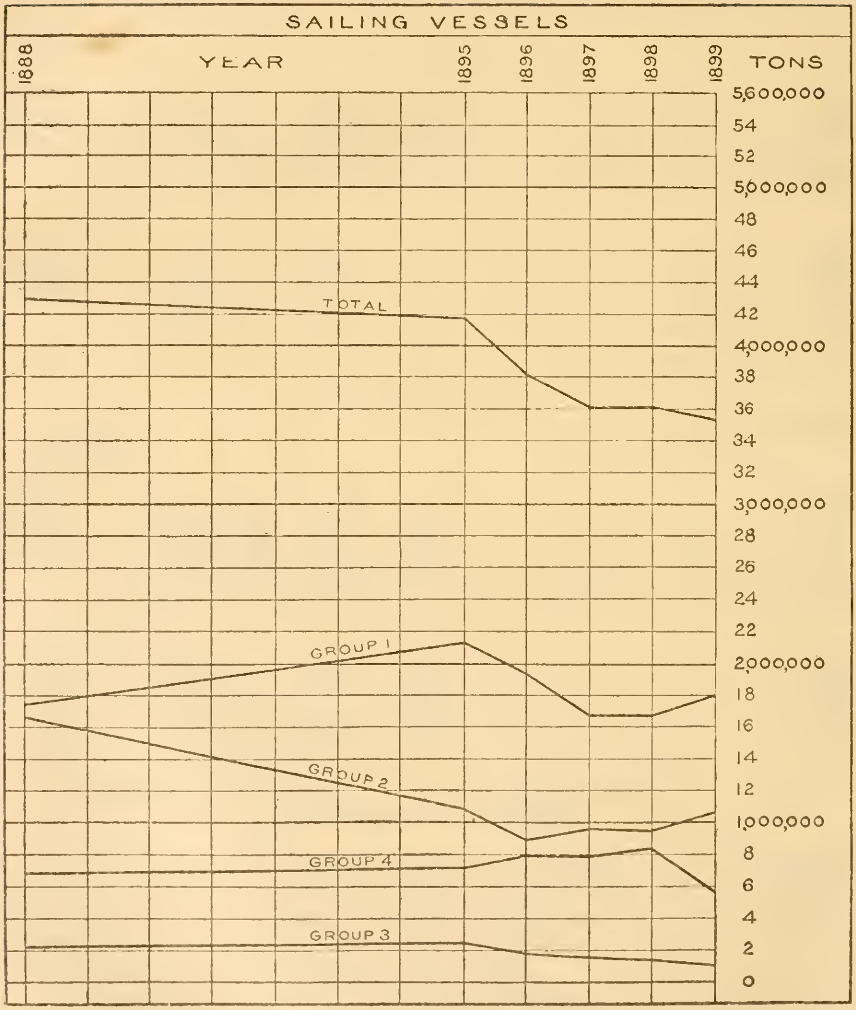
American countries.	United Kingdom.	France.	Germany.	Belgium.[a]	Holland.	Austria-Hungary.	Italy.	Spain.	Sweden.	Total.
SOUTH AMERICAN.										
Bolivia	....	....	10,870	....	....	....	....	45	....	10,915
Chile	460,255	64,473	119,348	118,862	....	2	14,745	3,812	....	781,497
Ecuador	11,303	6,140	17,443	1,798	....	....	....	778	....	37,462
Peru	97,440	13,158	43,320	4,900	....	1	9,798	1,314	....	169,931
Total	568,998	83,771	190,981	125,560	....	3	24,543	5,949	....	999,805
CENTRAL AMERICAN.										
Guatemala	11,221	....	10,224	596	....	....	....	939	....	22,980
Honduras	2,081	[d] 2,105	[e] 7,783	44	....	....	....	....	....	12,013
Nicaragua	7,583	....	....	3,421	....	....	....	1	....	11,005
Salvador	7,970	....	....	500	....	....	....	88	....	8,558
Total	28,855	2,105	18,007	4,561	....	....	....	1,028	....	54,556

[a] Belgian figures are for 1899.
[b] Including Costa Rica and Honduras.
[c] Nicaragua and Salvador.
[d] Including Nicaragua and Salvador.
[e] Including Nicaragua and Salvador.

It will be seen that nearly two-thirds of the entire cargo tonnage of the trade between the nine European countries and the west coast of Spanish America consisted of imports from South America, and that four-fifths of these imports were from Chile. This indicates the present prominence of the nitrate of soda trade.

In cargo tonnage Germany ranks first among the nine nations in the trade with the west coast of Spanish America, but in value of commerce the United Kingdom is much ahead of Germany because of the high value of the British exports. Germany's large import tonnage is made up mostly of nitrate of soda for use in her chemical industries, and her exports contain some coal, but consist largely of manufactures. The coal exports of the United Kingdom are heavy, but the exports, as a whole, derive their value mainly from the manufactures.

DIAGRAM OF TONNAGE 1888 AND 1895-1899



The cargo tonnage of the total exports of the nine European countries to the section of the American continents under discussion was 1,054,361 tons, and the imports 2,116,467 tons. The following table shows how the trade was divided between the South American and Central American countries:

Summary of cargo tonnage of European imports and exports—Trade with South and Central America, 1898.

	South America.	Central America.	Total.
	Tons.	*Tons.*	*Tons.*
Imports	2,041,147	75,320	2,116,467
Exports	999,805	54,556	1,054,361
Total	3,040,952	129,876	3,170,828
Grand total			3,170,828

Whether the entire commerce of Europe with the west coast of South America would make use of the isthmian canal will be considered in the chapter devoted to the discussion of the vessel tonnage that would now pass through the canal, and to the consideration of the question of tolls. In general, the canal will secure nearly all of this trade unless the tolls should be so high as to make the longer and less desirable route around the Horn or through the Straits of Magellan more profitable. The only trade that would not pay a moderate toll for the privilege of using the canal is that of Chile south of the fortieth parallel of latitude, and the commerce of that section is not, and can hardly become, of much consequence.

The cargo of freight tonnage of Europe's trade with Hawaii and British Columbia in the fiscal year 1899 is shown in the following table:

Cargo tonnage.—European trade with Hawaii and British Columbia.

	Hawaii.	British Columbia.	Total.
	Tons.	*Tons.*	*Tons.*
Imports	33,793	37,334	71,127
Exports		24,699	24,699
Total	33,793	62,033	95,826

In this table the figures are based on statistics kept by Hawaii and British Columbia. The vessels entering Hawaii take cargoes mainly of sugar to the United States, hence there are no exports from Hawaii given in the table. The British Columbia trade during the year ending June 30, 1899, was but little more than two-fifths that of the previous year, and for that reason the totals of the above table are unduly small, but for the sake of presenting the latest data it has been thought best to retain the figures for the year 1899.

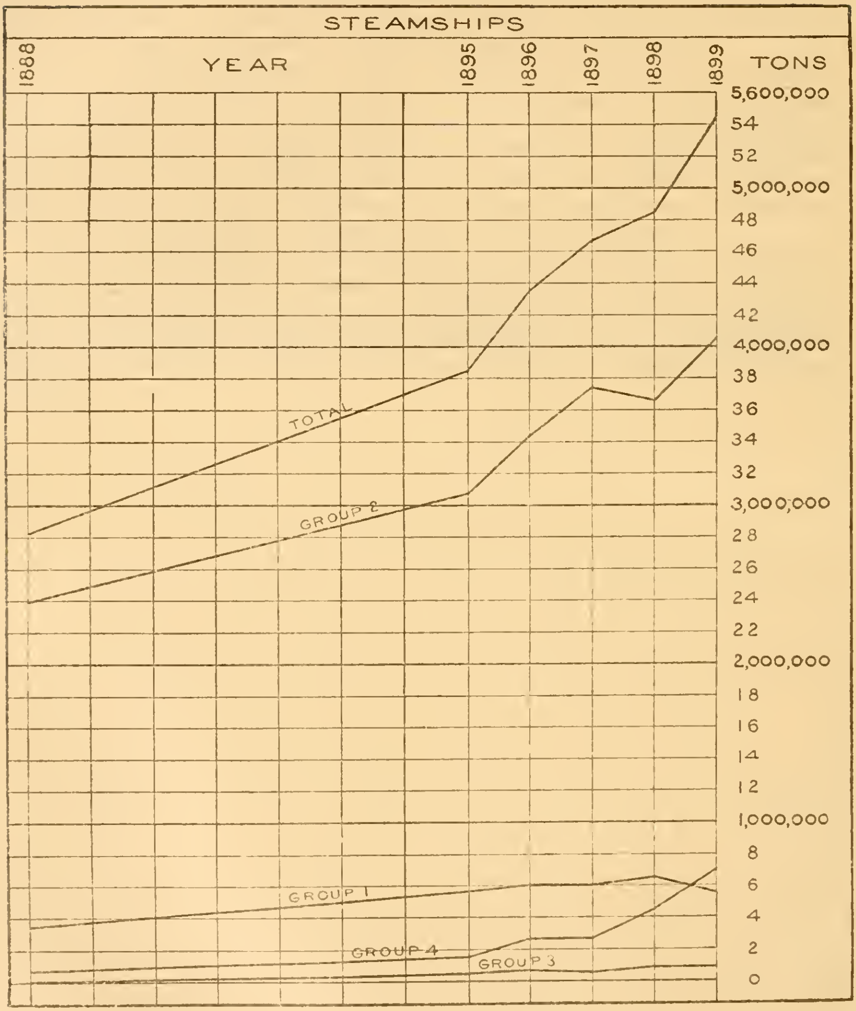
The cargo tonnage of the European trade with the west coast of Mexico is not obtainable because the European statistics do not separate the commerce with the east coast of Mexico from that with the west coast.

The total freight tonnage of the trade between European countries and western South and Central America, British Columbia and Hawaii, during the latest statistical year for which information was obtainable, was 3,266,654 tons. This total does not comprise the commerce with the west coast of Mexico. Moreover, it does not include any of the commerce between Europe and Eastern countries—a part of which, for reasons stated later, would pass through the American canal. In studying the tonnage of cargo that the commerce of the United States might have furnished the canal in 1898 and 1899, the total was found to be 3,435,887 tons. The sum of these two totals is 6,702,541.

This represents the tons of cargo which the commerce of the United States and the commerce between nine European countries and the west coast of America might have passed through an American isthmian canal during Europe's fiscal year 1898 corresponding with the calendar year, and our fiscal year ending with June, 1899. These are figures applying to the commerce of the past, carried under the conditions then prevailing. They do not refer to the future.

(Note.—The totals in this and the subsequent statistical chapter differ somewhat from those published in the preliminary report of the Isthmian Canal Commission, November 30, 1900. In several instances the statistics of the final report of the Commission are for a different year than were the figures comprised in the totals given in the preliminary report.)

DIAGRAM OF TONNAGE 1888 AND 1895–1899



CHAPTER XIX.—*Tonnage of the vessels employed in the commerce that would have used an isthmian canal in 1899.*

In ascertaining the tonnage of the vessels now engaged in the world's commerce that would make use of an isthmian canal two methods may be employed. One source of information is the records of entrances and clearances of vessels kept by the leading commercial nations, and this information is fairly satisfactory, although, as will be shown presently, careful analysis is necessary to avoid erroneous conclusions. The other method of getting at the vessel tonnage now available for the use of a canal is to make a record of the movements or the voyages of all ships whose routes are such that the vessels would naturally pass through the canal.

This latter method of recording vessel movements and computing the tonnage from the records thus made was adopted by the New Panama Canal Company six years ago, and the conclusions reached by their elaborate investigation are set forth in the chapter which follows the present one. In this chapter is presented a discussion of the statistics of entrances and clearances of the vessels whose commerce would have taken them through the canal had such a waterway been in existence during the calendar year 1899. In a few instances it was necessary to take the figures for the year 1898.

Inasmuch as all important commercial nations record the entrances and clearances of the vessels trafficking at their ports and state with which countries the vessels trade, it is theoretically a simple matter to determine the tonnage of the vessels at present following routes for which the canal route would be substituted. As a matter of fact, however, the statistics of entrances and clearances have certain important limitations, due to the fact that different countries follow dissimilar rules in making their statistical records. In some cases also the records are incomplete—as, for instance, the figures recording the tonnage of vessels trading between Europe, Mexico, and Central America do not indicate whether the European entrances from those countries are from the Atlantic or from the Pacific coast. The same limitation exists as to European clearances to that section of the world.

The lack of uniformity of methods of collecting statistics of entrances and clearances may either result in a duplication of tonnage records or in an understatement of the tonnage engaged in the commerce of certain countries, and it is unfortunate that the statistics of international trade are not compiled in accordance with uniform rules. A vessel entering a German port is recorded as coming from the country that supplied the vessel with the largest share of its cargo. If this vessel were to enter a British port, she would be recorded as having sailed from the most distant country from which cargo was brought. The French practice is the same as the English. In compiling the statistics of clearances it is the practice of Great Britain to record a vessel as clearing for the most distant country for which she has cargo. The German figures credit the clearances to the country to which the most cargo is bound. The French practice is like the English.

Correspondence with the collectors at a number of the ports of the United States reveals the surprising fact that our statistics of entrances and clearances are compiled by various methods at different ports. The New York statistics record a vessel as clearing for the first or nearest country to which cargo is taken. The vessel is entered from the most distant country. At other ports, however, different practices prevail, four variations in methods having been reported by our collectors of customs.

A German vessel en route from Chile may call at a Belgian or Dutch port and appear both in their statistics of entrances and in the German records. Likewise a vessel outbound from Germany might be duplicated in European statistics. A vessel from a European port may, and usually does, call at a number of Pacific American countries. However, the avoidance of duplication because of the numerous stops made in American ports is a comparatively easy matter, because only the records of the entrance and clearance at the European end need to be considered. In the following tables and discussion no figures have been used except those taken from the statistics kept in Europe and in the United States.

There is, furthermore, some danger of confusion because of the difficulty of keeping Europe's trade with the east coast of South America separate from that with the west coast. This danger, however, is only slight, because most of the lines, both European and American, carry nothing for east coast ports. It is over 2,000 miles between Chilean and Argentina ports, consequently vessels find it unprofitable to run part loaded between the ports of those two countries. Vessels load full cargoes from the North Atlantic to the west coast, and also full cargoes from the west coast to the North Atlantic. The trade of the east coast is mainly handled by vessels that do not go around to the west side.

Although the American statistics of entrances and clearances are not compiled in accordance with uniform rules, there are probably no duplications in the figures. In fact, the practice of New York, from which the major share of our commerce moves, of recording a vessel as clearing for the first port of call for the discharge of cargo, is apt to lead to understatement rather than an exaggeration of the volume of outbound traffic destined for countries that will be reached by way of an isthmian canal. In the case of European statistics the following duplications are possible:

1. German vessels outbound, as suggested above, may call at Holland or Belgium and be recorded there. These German vessels outbound might possibly, though, as a matter of fact, they seldom if ever do, call en route at British ports. One German line calls at a French port.

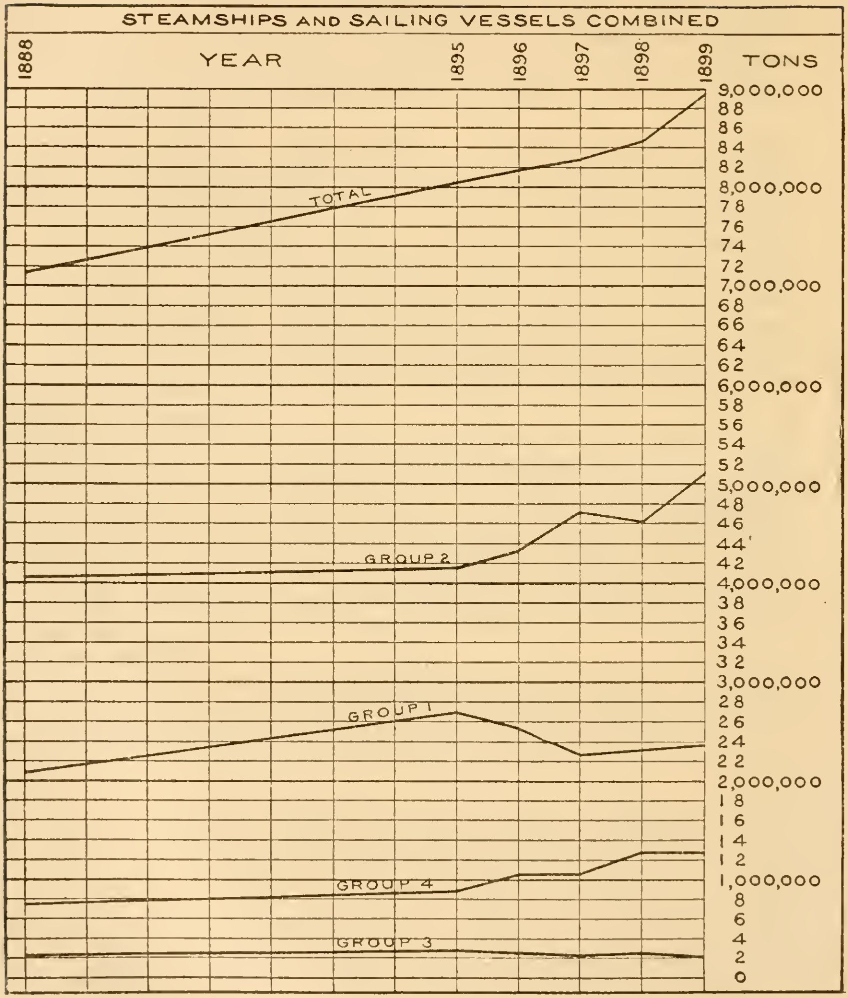
2. German vessels inbound may call at a French, Belgian, or Dutch port, but, as a matter of fact, they do not call at Belgian or Dutch ports. Most of the trade from the west coast of South America to Europe is carried in full cargoes, and German vessels are not apt to make calls en route at European ports. This is indicated by the fact that the Belgian clearances in the South American trade consists almost entirely of steam tonnage, while the entrances are made up mostly of sailing vessels. The same is true of the Netherlands. In regard to the French statistics there is some uncertainty.

3. Two British lines to and from the west coast of South America call at French ports. Thus the French statistics are liable to include some tonnage entered in the British and some contained in the German figures. The probable amount of such duplication will be considered below in the discussion of the tables which follow.

4. In the case of Spanish statistics of entrances and clearances, it is possible that some British, some French, and some Italian tonnage may be included.

Such are the possible kinds of duplication. It is, however, only in

DIAGRAM OF TONNAGE 1888 AND 1895-1899



the statistics of the west coast of South American trade that duplications are possible, and to assist in determining the extent to which duplications probably occur it will be best to study a table showing the figures of entrances and clearances in the trade of European countries with the west coast of South America. The following table summarizes the apparent vessel tonnage of the trade of European countries with western South America. It is compiled from the latest available figures, which in the case of the United Kingdom, France, Belgium, the Netherlands, and Italy were for the year 1899, and for the other countries were for 1898. The totals of the table are subject to such modification as may be found necessary in order to eliminate the results of duplication.

European entrances and clearances, vessels trading with west coast of South America.

	Entrances.				Clearances.				Total entrances and clearances.
	Chile.	Peru.	Ecuador.	Total.	Chile.	Peru.	Ecuador.	Total.	
United Kingdom	227,260	68,343	2,149	297,752	372,053	70,513	10,066	452,632	750,384
Belgium	94,570	16,180		110,750	102,789	788		103,577	214,327
Netherlands	45,312	[a] 14,635		59,947	3,348			3,348	63,295
German Empire	252,792	[b] 4,078		256,870	128,125	13,452		141,577	398,447
Italy	12,416	802		13,218	4,924	5,256		10,180	23,398
Spain	77,156			77,156	139,599			139,599	216,755
France	276,306	28,896	20,156	325,358	122,667	8,496	22,088	153,251	478,609
Sweden	2,272			2,272	472			472	2,744
Total	988,084	132,934	22,305	1,143,323	873,977	98,505	32,154	1,004,636	2,147,959

[a] Entered as Peru and Bolivia.

[b] Pacific South America other than Chile.

The table shows that the European statistics of entrances and clearances of the vessels engaged in the trade with western South America apparently comprise a total of 2,147,959 tons. In order to determine more nearly what the actual vessel movement was, it is necessary to eliminate duplications as far as it is possible to do so. Efforts have been made to secure information from the statistical departments of European Governments, not only regarding the regulations which they follow in the compilation of their statistics, but also concerning the movements of vessels. The information obtained, however, was not sufficient to make possible the avoidance of a resort to estimates in making reductions from the statistical tables above given.

Great Britain and Germany are so situated that they are the European termini of vessel movements between Europe and South America. Accordingly, the German and British figures for entrances and clearances may well be taken without alteration. Such, however, is not the case with Belgium, the Netherlands, France, and Spain, at whose ports both German and British vessels call en route. At Spanish ports French and Italian vessels, as well as British, make more or less frequent calls. An examination of the Dutch and Belgian entrances and clearances shows that the vessels arriving consist of sailing vessels, and that those departing are nearly all steamers. This would indicate that the incoming traffic is carried by chartered sailing vessels with full cargoes. These sailing vessels, after discharging their cargo, doubtless depart for a British port in search of outbound coal cargoes. The steamers clearing from the Belgian and Dutch ports are in all probability mostly German vessels, although some British tonnage may be represented. In view of these facts, it seems that the Belgian and Dutch figures for entrances should be retained in the total without alteration, but that some reduction should be made in the clearances to avoid recording a vessel a second time whose tonnage has already been included in German clearances. The total clearances from Belgium and the Netherlands are 106,995 tons, but these clearances can not all have been entered in the German figures, because the German clearances are much less than the entrances. It seems probable that the larger part of the tonnage of German vessels recorded as clearing for South America goes in ballast to Antwerp and is not recorded in the German clearances. Just how much reduction should be made in the clearances of Belgium and the Netherlands must be entirely a matter of judgment, but it has been thought proper to take 30,000 tons from the total.

The largest amount of duplication in the tonnage figures doubtless occurs in the French statistics. There is one French line of steamers plying between France and the western coast of South America; English vessels call at French ports, and one German line makes calls en route at two French ports. The French entrances are 172,107 tons greater than the clearances, and it is probable that this excess of entrances over clearances is to be accounted for by the tonnage of chartered sailing vessels which bring full cargoes, mainly nitrate of soda, to France. This difference, then, ought to be included in the French figures. Furthermore, the figures which cover the entrances and clearances of the French line ought to be included. Probably 50,000 tons of entrances and a like amount of clearances will cover the vessel movements of that line of steamers. It is probable that the remainder of the total entrances and clearances as shown in the French figures is also comprised in the British and German statistics. It has therefore been thought proper to deduct from the French figures as shown in the table 206,502 tons—that is, the difference between 272,107 (the sum included) and 478,609, the total shown in the table.

Both British and French vessels call at Spanish ports, and probably Italian vessels occasionally do. The amount of commerce which Spain has with the west coast of South America is not much, and probably the figures for the entrances, 77,156 tons, cover all the commerce which that country has with the American section under consideration. The clearances are very much larger than the entrances, but the amount of outbound commerce is slight. It seems certain that the Spanish figures for clearances represent English and French vessels that have already been recorded in clearance statistics before reaching Spanish ports. Accordingly, it is believed that accuracy demands the subtraction of the Spanish clearances from the totals of the above table. The entrances and clearances of Italy are small, and doubtless represent the actual vessel movement between Italy and western South America. The same may be said of Sweden. Russia does not appear in the table because there were no vessel movements between her ports and western South America during the year under consideration.

The reductions which the foregoing analysis suggests ought to be made amount to 376,101 tons, which, taken from 2,147,959 tons, the total of the table, makes the revised total 1,771,858 tons. The absolute accuracy of this corrected total can not be asserted. At best it is only approximately accurate, and must be so considered. It may possibly be as much as 100,000 tons in error, although that is hardly probable. There are various ways of checking these figures so as to determine whether they are approximately correct or whether they are largely in error. One method of checking them will be discussed in a later chapter where the totals reached by the three separate and distinct statistical investigations presented in this report are compared. A study has been made of the importation of nitrate of soda into European countries, the most important export from western South America; and the tonnage of British coal exports have also been considered. The figures of nitrate and coal movements are in general accord with the distribution of vessel tonnage suggested in the above revision of the totals of the table of entrances and clearances. Furthermore, the information that has been obtained regarding the routes of steamers owned by European companies operating vessels in the South American trade has supplemented the data supplied by foreign governments in such a way as to make it probable that the revised total of 1,771,858 tons fairly approximates the facts.

IMPORTANCE OF THE CHILEAN COMMERCE.

Every student of the industries and commerce of western South America must be impressed with the great importance of that region to the industries of Europe and the eastern part of the United States, and also to the prospective traffic that will make use of an isthmian canal. In 1899, according to the above figures, this section had a commerce with Europe of 1,770,000 tons, an amount equal to nearly one-fifth of the heavy tonnage then passing the Suez Canal.

The greater part of this west coast South American trade consists of Chile's foreign commerce, and Chile's prominent place is due to the nitrate of soda beds in the northern part of that country. Over three-fourths of the Chilean exports consist of nitrate of soda, and more than a million tons of shipping were employed in carrying that commodity. The export of that article, moreover, is rapidly increasing, and there is every reason to believe that it will continue to grow for several decades to come.

The average annual exports of nitrate of soda from Chile for the three calendar years 1897, 1898, and 1899 were 1,226,000 metric tons of 2,204 pounds, the exports for the year 1899 having been 1,360,000 metric tons. The increase during the previous fifteen years amounted to 940,000 tons. If the growth in the export of this commodity during the succeeding fifteen years should prove to be no greater than it was during the previous period of equal length, the nitrate tonnage in 1914 will amount to 2,300,000 weight tons.

This estimate of the increase in the use of nitrate is a conservative one, because it assumes that only an equal quantity increase will take place during the coming period, and not a proportional percentage increase. If it were assumed that the same percentage of growth would continue until 1914, the figures for nitrate shipments of that year would amount to 4,250,000 tons, and the Chilean export trade as a whole would exceed 5,000,000 cargo tons. Estimates based upon the assumption of a geometric ratio of increase might properly be considered excessive, but those which result from the application of the arithmetical rate of increase will doubtless be accepted as moderate, in view of the constantly enlarging demand for nitrate in the manufacture of fertilizers.

Besides being an exporter of nitrate of soda, Chile is the outlet for the mines of Bolivia, and also has copper and other mineral deposits of its own, as well as a variety of industrial resources which, together with the characteristics of the people, combine to make the country industrially and commercially progressive. During the past decade the nitrate of soda has comprised approximately three-fourths of the cargo tonnage of the exports of Chile.

VESSEL TONNAGE OF EUROPEAN TRADE WITH WESTERN CENTRAL AMERICA AND MEXICO.

It is impossible to determine the amount of the trade and shipping passing around the Horn or through the Straits of Magellan between Europe and the west coast of Central America and Mexico, because Mexico and all the Central American countries except Salvador have ports on both oceans, and Germany and Italy are the only European countries whose statistics designate to which coast of these countries the published figures apply. The figures for Salvador and the German and Italian entrances and clearances for the trade with the other ports on the west coast of Central America and Mexico are shown in the following table. German figures are for 1898; others for 1899.

Tonnage of European entrances and clearances of vessels engaged in European trade with western Central America and Pacific coast of Mexico.

Country.	Entrances, Central America.	Clearances.	
		Central America.	Pacific Mexico.
	Tons.	*Tons.*	*Tons.*
German Empire	15,512	13,118	31,502
Italy	....	5,873	....
United Kingdom with Salvador	363	1,595	....
Portugal from Salvador	2,504	....	....
Total	18,379	20,486	31,502

Total entrances and clearances, 70,367 tons.

The combined entrances and clearances recorded in this table amount to but 70,367 tons. The figures refer only to vessel movements around South America. The vessel tonnage engaged in the traffic across the Isthmus of Panama is considered in a later connection. The statistics of other European countries indicate that commerce is carried on with Central American and Mexican ports, but an estimate only can be made of the share of the tonnage that should be credited to the Pacific shore. Considering the importance of the United Kingdom in the maritime and commercial world and the independent ship-charter trade from Central America and Mexico to the United Kingdom and the other European countries not mentioned in the tables, it is safe to double the total of the above figures, and probably 140,000 tons may be taken as a fair estimate of the direct vessel movement between Europe and Pacific Central America and Mexico. A large part of the trade between Europe and western Central America and Mexico is handled via Panama. The vessel tonnage of the Panama trade is considered in a later connection. Reference is here made only to the direct vessel movement between western Central America and Europe around South America. In connection with this estimate of 140,000 tons, attention may be called to the fact that the larger part of the population, industry, and trade of Central America is on the Pacific side, where for climatic reasons the growth in population has thus far mainly occurred.

TRADE OF THE WEST COAST OF THE UNITED STATES, BRITISH COLUMBIA, AND HAWAII WITH EUROPE.

The reports of the United States Bureau of Statistics give in detail the entrances and clearances of vessels engaged in the foreign trade of each of our customs districts. The statistics of the tonnage of vessels engaged in the foreign trade of the United States that would avail itself of the isthmian canal are taken from our Government records. The figures taken are for the fiscal year ending June 30, 1899. In the following table is given the trade of the west coast of the United States, of British Columbia, and of Hawaii with Europe in the year 1899. The Canadian and United States figures are for the year ending June 30; the Hawaiian are for the calendar year. The Hawaiian and British Columbian statistics are taken from the official publications of those countries.

Entrances and clearances, trade of the Pacific coast of the United States, British Columbia, and Hawaii with Europe, 1899.

European trade with—	Entrances.	Clearances.
	Tons.	*Tons.*
Pacific United States	213,798	360,258
British Columbia	26,655	15,437
Hawaii	25,032	None.
Totals	266,485	375,695

Combined total, 642,180 tons.

The trade between the Pacific coast of the United States and Europe comprised 213,798 tons net register of entrances and 360,254 tons of clearances, a total of 574,052 tons. During the same year the commerce between our Pacific coast and South Africa employed 55,074 net tons of shipping, but that is not included in the totals reached in this chapter. That trade would find the canal route about 1,500 miles shorter, and if the tolls were low the canal would probably be used.[a] A large number of vessels cleared for Panama with traffic for Europe by way of the Panama Railroad, but that traffic is not being considered here.

The total entrances and clearances for the trade of British Columbia with Europe in 1899 amounted to but 43,092 tons; the previous year they were 106,485 tons. There are no clearances from Hawaii to Europe recorded. The ships take Hawaiian sugar to the United States and clear thence for Europe or elsewhere.

UNITED STATES ATLANTIC COAST TONNAGE WITH PACIFIC COUNTRIES.

Vessels trading between our Atlantic coast and the west coast of South America, eastern Australia, Oceania, Japan, and China will use the isthmian canal, with the possible exception of a part of the vessels passing to and from Hongkong and the Philippines. A portion, and probably the larger share, of the Hongkong and Philippine trade will use the canal.

[a] In the preliminary report of the Isthmian Canal Commission the vessel tonnage totals included this item of 55,074 tons.

The records kept at the United States customs offices show the following entrances and clearances in the trade between our Atlantic and Gulf seaboard and the foreign Pacific countries. The first table refer to the Pacific countries of South America; the second to the Orient, i. e., to Japan, Siberia, China, Hongkong, the Philippines, Australia, and New Zealand:

Entrances and clearances, United States Atlantic coast trade with Hawaii and foreign countries of Pacific America, year ending June 30, 1899.

Country.	Entrances.	Clearances.
	Tons.	*Tons.*
Ecuador	1,608	2,057
Peru	9,045	4,229
Chile	68,277	31,274
Hawaii	23,919	25,955
Total	102,849	63,515

Total entrances and clearances, 166,364 tons.

Entrances and clearances, United States Atlantic coast trade with oriental countries, fiscal year 1899.

Country.	Entrances.	Clearances.
	Tons.	*Tons.*
Japan	51,284	174,036
Siberia	....	6,975
China	39,536	49,347
Hongkong	32,621	42,996
Philippines	44,999	25,696
Australia	....	115,564
New Zealand	4,912	39,456
Total	173,352	454,070

Combined total, 627,422 tons.

The total entrances and clearances between our eastern seaboard and Hawaii and the countries of western South America for the year ending June 30, 1899, were 166,364 tons. There was no direct vessel movement during that year between our Atlantic coast and British Columbia and Pacific Mexico or Central America.

The table of vessel movements between the eastern ports of the United States and trans-Pacific countries shows a total of 454,070 tons of clearances and 173,352 tons of entrances, a combined total of 627,422 tons. There were special difficulties encountered in securing the statistics of the vessel movements between our eastern seaboard and Eastern countries, because the published figures of entries and clearances do not truly record the actual movements of vessels. This is due both to our practice of recording the statistics and to the fact that vessels stop going and coming at European and other countries on their voyages between the United States and the Orient.

The figures of the above table comprise only the tonnage of vessels which the records of our custom-houses show to have made a voyage from our eastern ports to countries east of Singapore, or to have entered direct from those countries. As a matter of fact many vessels take cargoes from the United States to Europe, then load for the East, whence they may return to the United States either by way of

Europe or by sailing in the opposite direction. A large part of our exports to the East are sent to Europe and there reshipped. Likewise a good portion of our imports from trans-Pacific countries comes to us by way of Europe. The above table is defective for two reasons. It gives no information concerning the vessel tonnage employed in carrying our exports that went to Eastern countries by way of Europe and our imports that came from those countries by some European city. Again, it understates the tonnage of the ships that come from Eastern countries to the United States. Many of them come by way of Java and are entered from the Dutch East Indies; others come by way of Europe and are entered as from there. Some come from Chile.

A more adequate measure of the tonnage of the shipping engaged in commerce with oriental countries would be secured by doubling the tonnage of vessels making the voyages directly to those countries. This larger total, 908,140 tons, is probably too small, but it has been adopted as the best figure obtainable by the study of the statistics of entrances and clearances and the known facts regarding commercial movements. One reason foı thinking it unduly small is that the vessel tonnage of the commerce between our Pacific coast and the trans-Pacific countries east of Singapore in 1899 amounted to 1,591,000 tons. While the vessel tonnage of this Pacific trade was doubtless greater than the vessel tonnage of the American Atlantic trade with the countries east of Singapore, it does not seem probable that the latter tonnage was less than three-fifths of the former. Another reason for thinking that the vessel tonnage engaged in the commerce between our eastern seaboard and Eastern countries was fully as much as, if not more than, 908,140 tons during the fiscal year 1899 is that the Panama Canal Company's record of vessel movements between the American Atlantic seaboard and the Pacific section east of 90 degrees east of Paris makes the total tonnage for the calendar year 1,271,357 tons. This total includes Singapore and Sumatra and Java, and should be larger than the total of 908,140 tons, but probably less than 363,000 tons larger. By their method of study, which is described in the following chapteı, they could follow the movements of each ship engaged in the trade, and consequently a chartered vessel that engaged in the trade of a European or some other intermediate country in going from our eastern seaboard to the East or in returning would be included in their record, whereas it probably would not in the American entrance or clearance records. It is of course possible that the records of the New Panama Canal Company may overstate the tonnage that would be required to handle the commerce between the Atlantic seaboard of the United States and the countries east of Singapore, if all the vessels engaged in this trade were to confine themselves to this traffic alone, but their records presumably accurately state the tonnage of the vessels which annually get from our eastern seabord to Australia, the Philippines, Hongkong, China, Siberia, Japan, and come back again. The discussion of the effect which canal tolls may have upon the commerce between our Atlantic seaboard and Australia, southern China, and the Philippines is deferred to a subsequent chapter, where it is considered in detail.

Our exports to Australia are growing rapidly, and the present clearances to that continent and New Zealand comprise a fair-sized total. The canal may be expected to facilitate our export trade to Australia, and will probably cause our imports from that region to come to us more directly. The vessel that takes American goods to Australia usually loads there with Australian products for Europe, returns thence to this country with pick-up cargo or ballast, and the American importer gets his Australian wool and other products at the London sales. The opening of a direct canal route between New York and Australia may change this, at least to some extent, and lead to a more direct return trade from Australia. Direct importation would enable us to secure the goods from Australia more quickly and cheaply and be of assistance to our manufacturers, who are requiring increasing quantities of the raw materials obtained in Australia, New Zealand, and Oceania.

From New York and the North Atlantic ports of the United States the distance to the Philippines and Hongkong by the American canal route will not be very much less than by Suez; consequently the trade of our eastern seaboard with those and other places so nearly antipodal will be divided between the easterly and westerly routes. The shipper will have the advantage of the competition of the carriers using the different canals. The coast between Shanghai and possibly Yokohama on the east, and Singapore and possibly India on the west, will be traversed in both directions by vessels bound for American ports.

The overlapping of trade routes in the East, and the tendency of vessels to follow the routes where the greatest volume of traffic can be secured, may possibly bring some of the East Indian trade across the Pacific and through the American canal. One of the advantages of the route by the American Isthmus will be the cheaper coal, and another inducement to vessel owners will be the shorter trip in tropical latitudes, where many commodities are liable to be injured by heat and humidity.

Although a part of the Hongkong and Philippine trade with our Atlantic seaboard will unquestionably make use of the Suez route, the figures in the above table have been allowed to stand without reduction, because the statistics of entrances and clearances collected at our Atlantic and Gulf ports do not include all of the present commerce of the eastern half of the United States with trans-Pacific countries that might use the American canal were it available.

In considering the vessel tonnage of the existing commerce that might use an isthmian canal some account should be taken of the shipping that now plies between Asiatic countries and our Pacific coast. With China, Japan, and Siberia this amounts to 333,689 tons. With Hongkong and the Philippines the tonnage is 464,978, and for both sections combined 798,667 tons. A large but indeterminable part of this trade between the Pacific coast and trans-Pacific countries originates and ends east of the Rocky Mountains. Doubtless the greater share of this trade will always go overland to and from the Pacific coast; but some considerable portion will be diverted to the isthmian route after the canal has been opened. If this diverted trade and tonnage should amount to but 20 per cent of the total, it would equal about 160,000 tons, a tonnage nearly equal to that which the table above shows our Atlantic coast vessel movement to and from Hongkong and the Philippines to have been in 1899.

While the Suez Canal will get some of the commerce of eastern Asia and the Philippines with our Atlantic seaboard after the isthmian canal has been opened, it is believed that this traffic through the Suez may be offset by the amount of the vessel tonnage of our present Pacific coast import and export trade that would use an American canal. Furthermore, while the Suez route will draw from Manila and points north and east, the isthmian route will also secure tonnage from the territory lying south and west of Manila. It is thought that these facts warrant the inclusion of all the Atlantic coast tonnage to and from China, Japan, Hongkong, and the Philippines in the estimate of the vessel tonnage that would find use of the canal advantageous. Such an estimate as this can be only approximately correct, because it is impossible to predict closely the routes which the East Indian and south Asiatic trade will actually follow after the American interoceanic canal shall have completed the water route round the world.

The foregoing discussion has made no reference to the effect which the canal will have in diverting from its present rail and water routes a portion of the commerce now carried on by way of our Pacific coast ports between the eastern half of the United States and Australia, Hawaii, and the rest of Oceania. There are excellent steamship connections between the west coast of the United States and Canada, Hawaii, and Australia, and the traffic and travel of the Eastern United States to and from those countries is in part conducted through Pacific coast gateways. The isthmian canal and the steamship connections by way of it will undoubtedly affect the present routes for some of the traffic now carried on between our Eastern States and those countries.

The entrances and clearances of the vessels trafficking between our Pacific coast and Australia, Hawaii, and other islands of Oceania are shown in the following table:

IX.—*Entrances and clearances, United States Pacific coast trade with Australasia and other Oceania, fiscal year 1899.*

	Entrances.	Clearances.
	Tons.	*Tons.*
Hawaii	246,432	205,987
Australasia	148,876	94,037
Other Oceania	8,351	7,960
Total	403,659	307,984

Combined total, 711,643 tons.

Although there is no doubt but that a portion of the traffic covered by the above table would have gone through the canal had it been in existence in 1899, there is no way of deciding what percentage would have taken the isthmian route. None of this tonnage has been included in making up the totals reached in this chapter.[a]

[a] The statistical total of vessel tonnage published in the preliminary report of the Isthmian Canal Commission included 79,218 as the tonnage of our Pacific coast trade with Australasia and other Oceania which it was estimated would be at once diverted to the canal. Communications received from several officials of the transcontinental railways express the opinion that a considerable share of the foreign traffic now carried over the mountains by rail will be diverted to the canal line, that is to say, is traffic at present available for the canal. However, in order to be conservative and to avoid assumptions whenever possible, there is none of this Pacific coast Oceania tonnage included in the totals of this report.

VESSEL TONNAGE ENGAGED IN THE PRESENT TRAFFIC ACROSS THE ISTHMUS OF PANAMA.

In none of the preceding tables is there a statement of the tonnage engaged in the traffic now carried across the Isthmus of Panama by rail. This transisthmian traffic is a part of the Atlantic-Pacific trade of both Europe and America. Four lines of steamers now run north from Panama on the west coast, two lines run south, and the business of those steamers would become canal traffic.

More than a million tons of shipping enter the port of Colon each year, but that tonnage would not be a fair index of the amount that would go through the canal. Colon is a port of call for nearly all the lines of steamships connecting the Gulf, West Indian, and Caribbean waters with the United States and with all the leading European countries. A call at Colon is but an incident in the voyage of the steamers trafficking in the Gulf and Caribbean, but the situation at Panama is different. The geographical location of that city is such that a large part of the steamers from the North or South make Panama the beginning or end of their voyages. Before the year 1899 the lines from the South did not go north of Panama and none from the North went south of Panama. Since then the lines from the South have extended their route beyond Panama, and that city has now become a port of call as well as a terminal point. If, however, the year 1898 be taken, the tonnage of Panama may be considered as indicative of the tonnage which the present transisthmian trade would cause to use the canal.

During the year 1898 149 steamers, with an aggregate tonnage of 336,998 tons, entered this port. Panama has some sail tonnage, which is omitted from the calculations here made because most of the sailing vessels are either local or are employed in bringing coal from Australia for the steamship lines. This business would disappear with the opening of the canal and the establishment at the Caribbean entrance of coaling stations supplied with coal from the United States.

Whether both the entrances and clearances at Panama should be included in computing the canal tonnage which the commerce at Panama would have contributed to the traffic of an isthmian waterway in 1898, or whether only the entrances should be counted, constitutes an interesting question in statistics. The clearances were practically identical with the entrances, and if they were included, the above total would be doubled. Reasons for doubling the entrances may be found in the fact that there were presumably no vessels engaged in the traffic entering at Panama that did not find the business profitable, and that these vessels in taking cargo from the west coast of North or South America for the American or European Atlantic stopped their eastbound voyage at Panama instead of at some Atlantic port simply because there was no waterway across the Isthmus. They would have made a round trip through the canal and back to the west coast had they been able to do so.

The reasons why only the entrances have been counted in the statistical calculations of this chapter are:

1. That the existence of a canal and the avoidance of transshipment of cargo at Panama would have enabled the same tonnage of vessels to have carried a larger amount of traffic.

2. The vessels entering and clearing Panama are also engaged en route in a coasting trade of some importance. The through business done at Panama included only a part of the transportation business of

the vessels which entered that port, even in 1898, when it was a terminal instead of a point of call en route.

3. This last fact is shown by the total tonnage of freight, northbound and southbound, handled by the Panama Railroad in 1898—268,156 tons of freight. In most cases the net register vessel tonnage is considerably less than the cargo tonnage; and for this reason, principally, it has been thought best to count only the entrances at Panama, 336,998 tons, in arriving at the total available canal traffic.[a]

COASTING TRADE OF THE UNITED STATES AVAILABLE FOR THE CANAL.

The coasting trade between the two seaboards of the United States carried on by way of Cape Horn or the Straits of Magellan is the only additional tonnage item requiring examination. The Horn route has been followed since the days of '49, and while it will probably be deserted after the completion of the canal, it or the Straits of Magellan will be increasingly used until that time. Until recently this traffic has been handled by sailing vessels, but the line of seven new steamers recently installed in this trade will largely displace the sailing vessels that have had a practical monopoly of the traffic for a half century.

Owing to the large annual fluctuations to which this trade has been subject, an average of Pacific entrances from Atlantic ports and Atlantic entrances from Pacific ports during the last ten years has been taken. These averages combined give a total of 109,312 tons per year. The Atlantic entrances averaged 26,323, and those of the Pacific 82,989, showing that Europe is the selling market of the Pacific States and our Atlantic States are the buying market. Two-thirds of the vessels sailing to our west coast from our Atlantic seaboard clear from our west coast to Europe, cross thence to our Atlantic ports to load for the Pacific slope.

The entrance and clearance totals for the various categories of commerce studied in the preceding pages are summarized in the following table. It will be remembered that the figures are for the latest available statistical year, which in most instances was 1899.

Summary of entrances and clearances, commerce of Europe with Pacific America, and commerce of eastern seaboard of the United States with Pacific countries.

	Tons.
Europe with—	
Western South America	1,771,858
Western Central America and Mexico	140,000
Pacific coast of United States, British Columbia, and Hawaii	642,180
Eastern seaboard of United States with—	
Western South America and Hawaii	166,364
Pacific coast of the United States	109,312
Trans-Pacific countries	908,140
Panama traffic (1898)	336,998
Total	4,074,852

The total of the above summary, 4,074,852 tons net register, comprises the vessel tonnage of the trade of Europe with Pacific America, and of our Atlantic seaboard with Pacific countries. Every possible effort has been made to analyze, verify, and correct the statistical data consulted. It was thought better to err, if at all, on the side of understatement.

[a] The tonnage totals published in the preliminary report of the Isthmian Canal Commission included both the entrances and clearances at Panama.

The above total differs somewhat from the total published in the preliminary report of the Canal Commission, mainly because three items have been omitted that were included in the former statement. The sums omitted amount to 471,290 tons net register. Had they been included the vessel-tonnage total of this report would have differed from that of the preliminary report by only 35,986 tons, the total here given being that much less. Since publishing the preliminary report it has been possible to substitute 1899 figures for those of 1898 for a few foreign countries. For some of the countries the figures for 1899 were larger than those for 1898, but in the case of British Columbia the tonnage for 1899 was 63,393 tons less than 1898.

Attention was called in the previous chapter to the abnormally small export of grain from our Pacific coast during the year 1899. If the grain exports of the normal year 1898 were substituted for those of 1899, the above vessel-tonnage total would need to be increased over 400,000 tons. The grain exports of 1898 exceeded those of 1899 by 612,874 cargo tons, and this, according to the ratio of cargo tonnage to net register tonnage for the Pacific coast exports as a whole, would be equivalent to 408,723 vessel tons.

In closing this discussion of vessel tonnage reference should be made to the fact that this chapter has not considered the commerce of Europe with the western half of the Pacific Ocean, a part of which, it is believed, for reasons elaborated in the succeeding chapter, will make use of the American canal instead of the Suez or Cape of Good Hope route. In stating the entire amount of vessel tonnage that was available for the use of the canal in 1899 some share of the European commerce now using the Suez or rounding the Cape of Good Hope should be included. What that share should be is considered at length in the next chapter.

CHAPTER XX.—*Traffic investigation by the New Panama Canal Company—Comparison of the results of the three investigations.*

PLAN OF THE INVESTIGATION.

The New Panama Canal Company divided that part of the world's commerce capable of being affected by the proposed canal into the four groups that had been adopted in 1890 by the Commission d'Etudes appointed by the receiver of the Compagnie Universelle du Canal Interoceanique. These four groups were: (1) The commerce between Europe and the Pacific coast of the American continent; (2) the commerce between Europe and the Far East, i. e., China, Japan, Australasia, and Oceania, and the French and Dutch East Indies; (3) the commerce between the Atlantic and Pacific coasts of America, and (4) the commerce between the Atlantic coast of America and the Eastern countries included in group 2.

Briefly stated, the plan adopted by the New Panama Canal Company to determine what part of the world's present ocean tonnage would make use of an American interoceanic canal was to record and follow the movements of all vessels engaged in the commerce being carried on between the Atlantic and Pacific oceans. This record of vessel movements was taken from Lloyd's two publications, the Daily Shipping and Mercantile Gazette and the Weekly Shipping Index, where the canal company was able to secure information concerning the arrivals, departures, and whereabouts of all ocean vessels, about 12,500 in number, as their records subsequently showed.

During the years 1895 and 1896 the plan followed in making up the record was to go through each issue of Lloyd's daily and weekly publications and place against each vessel whose route was such as to bring it within one of the four groups of commerce just mentioned a check indicating to which group the ship was to be accredited.

Lists of the vessels thus checked were arranged alphabetically, showing for each of the four classes, and for sailing vessels and steamers separately, the facts regarding each ship that were given in Lloyd's Gazette and Index. These eight alphabetical lists—four for steamers and four for sailing vessels—were then turned over to draftsmen, who charted the movements of the vessels named in the eight lists by using sheets of paper which had the names of the ships in a column at the left, and which were divided into perpendicular columns headed with the names of the twelve months and with the weeks of the year by number from one to fifty-two.

The movements of a vessel were shown on the sheet by entering in the column of the proper week the name of the port and the day of the month of the arrival of the vessel if it was entering the port, or of the departure of the ship if it was clearing. Horizontal lines were drawn connecting the entries of clearances with those of arrivals. During 1895 eight sets of charts were prepared, sailing vessels and steamers being separately classified according to the four groups into which the commerce being studied had been divided; but after that year the groups of commerce were shown on the charts by using four different colors of crayon, and only two sets of charts were made, one each for sailing vessels and steamers. From these sets of charts and the vessel lists from which the charts were prepared it was an easy matter to make an annual computation showing the steam and sail tonnage of the traffic of each of the four groups of commerce.

Experience showed that the plan of checking off and copying from Lloyd's lists the vessels according to groups was somewhat defective, because on the charts some vessels would disappear from one group and appear in another in such a way as not to indicate what the intermediate movements of the vessel had been. It also happened that some vessels disappeared from the record after they had touched at a Pacific port, and that other ships appeared on the record as clearing from a Pacific port, without there being any record regarding their previous voyages. To obviate this defect it was decided at the beginning of 1897 to discontinue checking the names of vessels in the Gazette and Index and preparing lists of the ships thus checked, and instead of doing this work to make a card catalogue (fiches) of every ship named in the Lloyd publications. In this catalogue each ship had its card, and on this card all desired information regarding the vessel was entered and a record kept of the movements of the ship. The graphic charts of the voyages of the vessels were prepared from these cards.

During the year 1897 the canal company further improved its methods of conducting the traffic investigation. From Lloyd's Shipping and Mercantile Gazette tables were prepared showing for each Pacific port, separately for steamers and sailing vessels, and classified according to the four groups of commerce, the name, flag, tonnage, etc., of all the vessels entered and cleared. These tables gave full information regarding the steam and sail commerce of each Pacific port.

These tabular statements are said by the New Panama Canal Company to have "confirmed the correctness of the former work." The preparation of these tables also "established the fact that the graphic method, based upon the use of the Weekly Shipping Index, which has the disadvantage of requiring much more time, is more exact, complete, and reliable." The company further states:

The justification of the method of statements by ports is that it has the advantage of dividing among the ports interested the world's tonnage stated for each of the four groups, and thus facilitates the study of the results, especially the inquiry concerning that part of the traffic with ports at the limit of the canal's zone of attraction. This method of statements was employed to verify the statistics of the year 1898.

At the close of the year 1898 the traffic of the year 1888 was studied according to the methods that had been developed, and tables were made comparing the years 1888 and 1898 to show what development had taken place during the decade in the commerce being investigated. The tonnage movements of 1899 have also been charted, totalized, and tabulated. The following table, prepared by the New Panama Canal Company and published here with but slight changes in form, presents the results of the elaborate investigations conducted by that company. The table shows the steam and sail tonnage of each of the four groups of commerce for the calendar years 1888, 1895, 1896, 1897, 1898, and 1899.

Tonnage of vessels engaged in trade between the Atlantic and Pacific oceans, 1888 and 1895 to 1899.

	Group 1. Europe with Pacific America.	Group 2. Europe with the Orient.	Group 3. Between Atlantic and Pacific America.	Group 4. Atlantic America with Orient.	Total for the year.
1888:					
Steam	346,015	2,396,105	4,716	78,994	2,825,830
Sail	1,744,661	1,659,759	217,597	681,877	4,303,894
Total	2,090,676	4,055,864	222,313	760,871	7,129,724
1895:					
Steam	570,637	3,081,479	40,551	162,599	3,855,266
Sail	2,130,876	1,087,250	243,209	721,526	4,182,861
Total	2,701,513	4,168,729	283,760	884,125	8,038,127
1896:					
Steam	601,157	3,430,386	68,420	266,354	4,366,317
Sail	1,944,207	891,404	188,445	792,214	3,816,270
Total	2,545,364	4,321,790	256,865	1,058,568	8,182,587
1897:					
Steam	601,784	3,745,397	58,446	271,455	4,677,082
Sail	1,677,461	976,480	164,891	789,694	3,608,526
Total	2,279,245	4,721,877	223,337	1,061,149	8,285,608
1898:					
Steam	648,568	3,669,091	91,082	441,246	4,849,987
Sail	1,680,573	948,222	148,204	835,682	3,612,681
Total	2,329,141	4,617,313	239,286	1,276,928	8,462,668
1899:					
Steam	570,997	4,059,392	94,319	699,913	5,424,621
Sail	1,804,074	1,053,862	107,830	571,444	3,537,210
Total	2,375,071	5,113,254	202,149	1,271,357	8,961,831

The total traffic in 1899 was larger than in 1898. This, however, was not true of all groups, there having been a slight decline in groups 3 and 4. The decline in the vessel movements of group 3 during 1899 as compared with 1898 was due to scarcity of ships and to the sale of a large line of sailing vessels that had been engaged in this traffic. During the year 1900 a line of steamers, comprising seven ships, capable of handling 126,000 tons of cargo each way annually, was inaugurated to take the place of the sailing vessels that were sold the year before. The slight decrease in the tonnage of group 4 was likewise due to the high ocean rates arising from the scarcity of ships. The shipments from the eastern ports of the United States to the Orient were handled more largely by the transcontinental railroads and the Pacific steamers.

The commerce included in groups 1, 3, and 4 of the above table is considered as certainly tributary to the proposed American canal. The commerce of Europe with eastern countries, group 2, will, for the greater part, make use of the Suez route, but a portion of the traffic will find the American waterway more advantageous. What share of the total for group 2 may properly be credited to the westerly canal route must be a matter of estimate. A careful review of the existing trade routes and a consideration of the forces that will affect the ocean routes after the American canal has been opened leads to the conclusion that a portion of Europe's exports to the western half of the Pacific Ocean—that is, to Japan, Australia, and Oceania—will be sent through the American canal.

CONCERNING USE OF AMERICAN CANAL BY COMMERCE OF EUROPE WITH ORIENT.

The volume of traffic to Europe from the East being larger than that outbound from Europe, vessels are obliged to sail both for the eastern part of the United States and for eastern countries lightly loaded, and sometimes in ballast. Our exports from Atlantic ports to Australia, Oceania, and the Orient are in part carried by ships that cross the Atlantic in ballast. When the American canal has become available vessels will probably not infrequently take on a partial cargo in Europe for countries in the western half of the Pacific, and also take freight for the United States, the West Indies, Central America, or Mexico; that is, vessels finding difficulty in securing cargoes outbound from Europe will sometimes find it advantageous to proceed to the East by way of America for the purpose of discharging such European-American cargoes as may be secured, and loading at one or more American ports a full cargo for the Pacific port or ports of its destination. In addition to permitting vessels in Europe to unite the light outbound cargoes for the East and for the United States, and enabling them to secure full cargoes in America for the East, the westerly route by way of the American canal will have the advantage of cheaper coal, and may possibly impose lower canal tolls upon the shipping than will be exacted by the Suez Canal. The Suez Canal is, and doubtless will remain, a highway managed by a corporation, whereas the American waterway under consideration is to be owned and operated by the Government.

The distance from Liverpool to Sydney, Australia, by way of the Nicaragua Canal and Tahiti will be only 172 miles greater than via the Suez, Colombo, Adelaide, and Melbourne, and this small disadvantage of the westerly course will be partially if not quite offset by two facts favoring the American canal route. From Liverpool via the Cape of Good Hope, Adelaide, and Melbourne and Sydney is 722 miles farther than by way of a Nicaragua canal and Tahiti. The use of the westerly route will enable vessels engaged in the European-Australian trade to avoid the excessive heat of the Gulf of Aden and the Red Sea, and the storms of the tempestuous Indian Ocean. The American route, also, will be favored by the fact that a vessel on its way between Liverpool and the isthmian canal will have to go but 323 miles out of its course to call at New York—the greatest port of the world—whence outbound cargoes are practically always obtainable. With the advantages of cheaper coal, a cooler passage in the Tropics, quieter seas, and the attractive force of America's heavy tonnage, the American isthmus route will be used instead of the course through the Suez Canal by some of the vessels departing from Europe for Australia or other regions on that side of the Pacific Ocean.

Vessels proceeding from Europe by way of American ports and the isthmian canal to Oceania and the East will have the choice of returning to Europe either by way of the Suez or by way of the American route. By whatever route the European vessels reach the oriental and other countries of the western Pacific, the route by which they return to Europe will be determined by the relative opportunities for obtaining cargo by way of the Suez and American routes, respectively.

The reasons for believing that a portion of Europe's imports from the western half of the Pacific will come by way of the American route are stronger than the reasons just cited regarding the use of the American canal for the European export trade. A vessel finding itself in the East Indies, Japan, China, or Australia may either take on cargo for Europe and for intermediate points along the Suez route, or it may load with such cargo as may be available for Europe and American countries and proceed—in most cases but partially loaded—across the Pacific to the western coast of the United States, where a great abundance of cargoes destined for Europe may be obtained, or the ship may go to Central America and West Indian ports, where a fair amount of freight for Europe will usually be available, or the vessel may proceed to Chile or some other west South American country, where there is always a heavy amount of outbound traffic. Besides being certain of securing freight from South America or North America for Europe, a vessel returning from the Orient by the American canal will also have the advantage above referred to of being able to secure coal more cheaply than it can be obtained along the Suez line.

It would seem probable, upon a priori ground, that vessels leaving Europe, whether by way of the Suez or by way of the American canal, will frequently find the return trip via America more profitable than by the route in the opposite direction. This general proposition, moreover, seems to accord with the evidence regarding the present round-the-world movement of vessels. The entrance and clearance statistics of the vessels engaged in the foreign trade of the west coast of North and South America indicate that a large number of vessels now going out from Europe toward the East return from the west.

EVIDENCE OF INCREASING NUMBER OF ROUND-THE-WORLD VOYAGES.

In the trade of the Pacific coast of the United States with Atlantic foreign countries the tonnage of the entrances direct from the Atlantic was 63.8 per cent of the clearances to those ports in 1889; but in 1898 the entrances direct from the Atlantic were but 25.3 per cent of the clearances to the foreign countries of that section. Stated otherwise, in 1889 something over one-third, and in 1898 about three-fourths of the vessel tonnage employed in carrying our west coast trade to Europe arrived at our western ports from other than European countries.

Many vessels take cargo from Europe via the Good Hope route to Australia, or other eastern countries, whence they proceed across the Pacific in ballast, or with coal to our western ports or to Chile. A to and fro movement of vessels between ports situated at great distances from each other is frequently unprofitable unless there are about equal quantities of merchandise to be carried both ways, and whenever possible, chartered vessels—and at the present time they carry most of the world's ocean freight—seek to avoid voyages in ballast by moving as much of the time as possible in the direction of the larger currents of traffic. Our Pacific coast imports but little and exports great quantities, consequently vessels endeavor to approach that section—and the same is true of Chile—from regions having a larger volume of inbound traffic.

In 1888 more ships entered Chile from North Atlantic countries, Europe, and the United States than cleared from them, but in 1898 the reverse was the case. The figures of the entrances and clearances of the Chilean trade with Europe and our Atlantic coast for the years 1888 and 1898, as recorded by European countries and the United States, are shown by the following table:

Chilean entrances and clearances, direct trade with Europe and east coast of United States, 1888, 1898.

	1888.	1898.
Entrances	767,000	891,000
Clearances	625,000	982,000

Per cent which entrances were of clearances: 1888, 122.7; 1898, 89.7.
Per cent of decline in ratio of entrances to clearances, 1888 to 1898, 28.5.

The ships for the exports of Chile to Europe and the United States were all drawn from Atlantic countries in 1888, and, in addition, vessels entered Chile from the Atlantic and cleared for Pacific countries, but in 1898 the vessels for the exports from Chile to the North Atlantic must have been drawn partly from Pacific ports. According to the table, the tonnage entering Chile from the North Atlantic was 122.7 per cent of the tonnage that cleared for that section in 1888, whereas the per cent was only 89.7 in 1898, an apparent decline of 28.5 per cent in the ratio. This change was mainly due to a movement of vessels from Europe and eastern United States to Australia and thence to Chile.

In compiling the above table the European statistics of entrances and clearances have been taken without making reductions to eliminate duplications. Accordingly neither the figures nor the percentages are strictly accurate. For the purpose of the present argument, however, the value of the table is not lessened by the duplications contained in the statistics, because a study of the European records of entrances and clearances shows very clearly that there is a greater duplication of clearances than of entrances. If the duplications in the figures of the above table were deducted, the tonnage entering Chile from the North Atlantic would bear an even smaller ratio to the clearances to that section than is stated in the table.

Further evidence regarding the increasing movement of vessels around the world is shown by the statistics of entrances and clearances of the Atlantic coast trade of the United States with South America. In the table just given above the European trade with Chile is analyzed. The following table contains the figures of the entrances and clearances of the trade of the Atlantic and Gulf seaboards of the United States with the entire west coast of South America:

Atlantic coast entrances and clearances, trade of United States with western South America.

Year.	Entrances.	Clearances.
1889	44,454	27,176
1899	78,930	37,560
Per cent of increase	77.5	38.2

Our east coast entrances from western South America increased during the decade preceding 1899 more than the clearances did. The clearances to South America were less than half the entrances from that section in 1899.

Mention was made of the fact that vessels clearing from the North Atlantic to Australia and other eastern countries frequently return by crossing the Pacific. In 1899, 155,000 tons of vessels cleared from the eastern ports of the United States for Australia and New Zealand, and the direct entrances, all from New Zealand, were only 4,912 tons. This does not indicate that practically all the outbound vessels returned by way of the Pacific, because many, although not all, of the steamers returned by way of Java or Europe and were entered as from those countries. Some of the steamers and nearly all of the sailing vessels returned from Australia to the United States by way of the west coast of North or South America. Under present conditions the tendency is for an increasing number of vessels starting out from Europe and the eastern part of the United States toward the East to return to their starting point by a continuous voyage around the world.

The effect of the isthmian canal upon ocean routes under consideration will be a double one. It will facilitate a round-the-world movement of commerce and also establish conditions that may cause vessels to pass from Europe as well as from the eastern part of the United States through the American canal to oriental countries, to return, as traffic inducements may determine, by way of the Suez Canal or across the Pacific to the west coast of North and South America and thence to the point of departure. By exercising these influences upon the world's commercial routes the canal will secure a part of the trade of Europe with countries in the western half of the Pacific.

TONNAGE OF AVAILABLE CANAL TRAFFIC.

The records kept by the Panama Company show that during the calendar year 1899 the commerce of groups 1, 3, and 4 might have contributed 3, 848,577 tons net register to the traffic of the isthmian canal. This sum does not include any vessel tonnage for the commerce crossing the Isthmus of Panama. The addition of that tonnage, 336,998, raises the total to 4,185,575. The entrances and clearances for the commerce of the eastern seaboard of the United States with Pacific America and with Australia, Oceania, the Philippines, Japan, China, and Siberia, and the vessel movements between the western coasts of the American continents and the North Atlantic American and European ports were found to amount to 4,074,852 vessel tons net register, including the 336,998 tons for the commerce crossing the Isthmus of Panama.

In addition to this tonnage, which comprises only traffic originating or terminating in America, there should be included most of the commerce of Europe with New Zealand and the other islands of the Pacific east of Australia. New Zealand will be 1,503 miles nearer Liverpool by the Nicaragua Canal than via the Suez route and 2,407 miles nearer than by way of Good Hope. The distances to Liverpool from the most important groups of South Pacific islands north of New Zealand will be from 500 to 5,500 miles less via the isthmian canal than by way of Suez. The entrances and clearances of New Zealand's trade with northwestern Europe—France and countries farther north—amounted to 481,178 tons net register in 1899, and the commerce of that part of Europe with the other islands of the South Pacific east of Australia to 181,743 tons. Of this total traffic of 662,921 tons, probably not less than 500,000 might have advantageously used an isthmian canal, and this amount should be added to the tonnage of the canal traffic originating or terminating in America. This makes the total obtained by the Commission's investigation of the tonnage that might have used an isthmian canal in 1899 4,574,852 tons net register and the total obtained by adopting the New Panama Canal Company's figures for the traffic originating or terminating in America 4,685,575 tons.

The above totals for the tonnage that might have used an isthmian canal in 1899 do not include any of Europe's trade with Australia and Japan, a part of which, for reasons stated above, would have used an isthmian waterway. The distances from Great Britain to Sydney and Yokohama by the Suez and isthmian canal routes are approximately equal, and vessels going by America in either direction en route between Europe and Japan or Australia will pass regions from which there is a heavy export tonnage. If it be assumed that only 10 per cent of the vessel tonnage of the Australian trade with the ports of northwestern Europe and only 5 per cent of the tonnage of the Japanese commerce with those ports would have taken an American canal route, the totals for 1899 should be increased 316,223 tons, and be raised from 4,574,852 to 4,891,075 tons, and from 4,685,575 to 5,001,798 tons, or to approximately 5,000,000 tons.

GROWTH OF TRAFFIC, 1888–1898.

The total vessel tonnage of the four groups included in the tables prepared by the New Panama Canal Company rose from 7,129,724 tons net register in 1888 to 8,462,668 tons in 1898, an increase of 18.7 per cent. There was a large increase in the commerce of groups 1 and 4. The rapid development of the trade of Europe with the west coast of the Americas, particularly in Chilean nitrates, has been dwelt upon elsewhere. The commerce of the Atlantic coast of America with the Orient, group 4, expanded largely during the decade in spite of the hindrance imposed by the length of the present transportation routes.

The ocean commerce, the tonnage of which is comprised in group 3, that is to say, the trade between the two American seaboards, increased but slightly during the decade; but this total of less than a quarter of a million tons includes only the tonnage of vessels which actually make the trip between the Atlantic and the Pacific oceans. It does not comprise the traffic which now moves across the Isthmus of Panama. The traffic around South America was less in 1899 than it had been in previous years, the reason for this being that the sailing vessels that had been engaged in the trade between our two coasts were sold for the purpose of substituting steamers. Those steamships will all be in service before the end of 1901, and the tonnage will then be greater than it was previous to the year 1899. After the isthmian canal has been in use for a few years the commerce of group 3 will probably be as large as that of any other one of the four groups, because it is this group in which the coasting trade between the two seaboards of the United States will fall. The present small proportions of this trade between the two coasts of the Americas and the slow rate of its increase indicate an important, although not the only, commercial reason why the United States proposes to construct an isthmian canal.

In the following table the tonnage of 1888 is compared with that of 1898, and the number of steamers and sailing vessels engaged in the commerce of each group is indicated:

Comparison of the tonnage of 1888 and 1898.

	Group 1. Europe with Pacific America.		Group 2. Europe with the Orient.		Group 3. Between Atlantic and Pacific America.		Group 4. Atlantic America with Orient.		Total for the year.	
	Number.	Tons.	Number.	Tons.	Number.	Tons.	Number.	Tons.	Number.	Tons.
1888:										
Steam....	215	346,015	1,275	2,396,105	7	4,716	46	78,994	1,543	2,825,830
Sail......	1,633	1,744,661	1,595	1,659,759	182	217,597	571	681,877	3,981	4,303,894
Total...	1,848	2,090,676	2,870	4,055,864	189	222,313	617	760,871	5,524	7,129,724
1898:										
Steam ...	265	648,568	1,448	3,669,091	57	91,082	202	441,246	1,972	4,849,987
Sail......	1,101	1,680,573	743	948,222	104	148,204	527	835,682	2,475	3,612,681
Total...	1,366	2,329,141	2,191	4,617,313	161	239,286	729	1,276,928	4,447	8,462,668
Per cent of increase or decrease 1888–1898:										
Steam ...	+	87.4	+	53.1	+	1831	+	458	+	71.3
Sail......	−	[a]3.6	−	[a]42.8	−	[a]31.9	+	22.6	−	[a]16.0
Total...	+	11.4	+	13.8	+	7.6	+	67.8	+	18.7

[a] Decrease.

In showing the growth in the commerce of these four groups individually and collectively during the decade 1888 to 1898, the figures of the above table afford the basis for reasoning regarding the probable amount of tonnage that will be ready to use the canal at the time of its probable completion, but a consideration of this is reserved for a separate section, where all the data bearing upon the subject are analytically presented.

There are two other facts shown by this table that are of indirect importance in connection with the traffic of an isthmian canal. One is that the increased traffic of 1898—18.7 per cent larger than the tonnage of 1888—was carried in 1,077 fewer vessels than were used ten years before. The number of ships decreased 19.5 per cent during the decade, thus affording a good illustration of the well-known fact that the size of ocean vessels is growing rapidly larger. The average net register of the vessels engaged in the four groups of commerce was 1,291 tons in 1888. The steamers at that time averaged 1,831 tons net register. In 1898 the average for all vessels, both steam and sail, was 1,903 tons net register and for steamers 2,460 tons.

THE SUBSTITUTION OF STEAMERS FOR SAILING VESSELS.

The figures contained in the table also indicate the rapidity and extent to which the steamer is supplanting the sailing vessel. The table shows that the sailing vessel lost ground most rapidly in the commerce of group 2, where the Suez route has come to be the main traffic highway. These facts regarding the growth of steam tonnage and the declining use of the sailing vessel are graphically shown in the accompanying charts, which indicate for each of the four groups the changes that have taken place in both steam and sail tonnage. The first chart applies to sailing vessels, the second to steamers, while in the third the changes in the total tonnage, steam and sail combined, are represented.

COMPARISON OF THE RESULTS OF THE THREE TRAFFIC INVESTIGATIONS.

Having now set forth the results of three separate investigations instituted to measure the volume of the existing commerce that would make use of an isthmian canal were such a waterway in existence, it will be profitable to compare the results of the three inquiries to see whether they tend to strengthen each other, or whether they are so different as to cast doubt upon the accuracy of any or all of the three studies. The three investigations were made not only without reference to each other, but also according to entirely different methods. Two of the investigations were made by the Isthmian Canal Commission, and the other under the direction of the New Panama Canal Company. It is not often in statistical and economic investigations that such an opportunity for checking up results is afforded as is possible in the present instance.

In the chapter on cargo tonnage it was found that the freight tonnage of the trade between Europe and Western America and the tonnage going by water between the eastern seaboard of the United States and Pacific countries amounted to 6,703,608 tons in 1899. The total entrances and clearances of the vessels engaged in this trade at that time equaled 3,965,540[a] tons net register. This would make the

[a] This is 4,074,852 tons minus 109,312 tons, the coasting trade between our two seaboards. The 6,703,608 tons of cargo do not include any of our coasting trade, hence the vessel tonnage total is reduced before comparison is made with the total cargo tonnage.

average ratio of cargo tonnage to net register tonnage 1.69. The records of vessel movements kept by the New Panama Canal Company show a tonnage of 3,646,428 net register tons during the calendar year 1899 for the commerce of groups 1 and 4, which correspond in general, although not exactly, with the trade included in the above cargo tonnage total. The ratio of cargo tonnage to the vessel tonnage of groups 1 and 4 is 1.83. This is a somewhat higher ratio than that between the cargo tonnage and vessel tonnage of entrances and clearances.

The tables prepared by the New Panama Canal Company do not include the vessel tonnage of the trade at Panama. Their method of recording the movements of vessels passing from ocean to ocean and totalizing those movements naturally would not take account of the traffic at Panama. In the tonnage total of entrances and clearances obtained by the Isthmian Canal Commission, the Panama traffic was reckoned to be 336,998 tons net register. If this sum be added to the vessel tonnage total of groups 1, 3, and 4 and the cargo tonnage be divided by this larger figure, the ratio becomes 1.60.

The "dead-weight" cargo carrying capacity of American schooners of 500 to 2,000 tons net register averages about 66 per cent more than the net register, but this ratio varies greatly with different vessels. The ordinary modern freight steamer when fully loaded will carry about 2.25 tons of cargo for each ton net register.

Vessels are not fully loaded on all voyages. Some are obliged to make trips in ballast in search of cargo, and many more are but partially laden on the outbound or return voyage of a round trip. There are very few ports of the world where the volumes of exports and imports are equal. Great Britain buys a much larger bulk of commodities than she sends out. The opposite is true of the United States and western South America. Consequently the average cargoes of ocean vessels engaged in international trade are much less than their maximum carrying capacity.

The ratio of cargo to net register tonnage, obtained above by dividing the total available canal freight tonnage by the corresponding net vessel tonnage, are about what might be expected on a priori grounds. The fact that these ratios are apparently correct is not a definite proof of the accuracy of the tonnage totals compared, but it is corroborative evidence. If any one of these three totals compared were grossly in error, there could not be such close correspondence in the ratios.

The total of entrances and clearances in the trade of the year 1899 between Europe and Western America and between the Eastern United States and Pacific countries, 4,074,852 tons, is somewhat less than the new Panama Canal Company's total of vessels engaged in this commerce, if the traffic at Panama be added to their figure for groups 1, 3, and 4. The tonnage of these three groups during the calendar year 1899 was 3,848,577, and this plus the entrances at Panama in 1898, 336,998 tons (the vessel tonnage adopted for the entire Panama traffic), amounts to 4,185,575 tons.

A more detailed comparison of the tonnage figures of tables prepared by the Commission with those made by the New Panama Canal Company would show that the totals for the two coasts of America are not very different. It is uncertain whether the trade of Hawaii is included in group 3 of the Panama Company's tonnage table. If it is, the Commission's figures are larger; if Hawaii is not comprised in group 3, its inclusion there would make the Panama Company's figures greater. For the trade between Europe and the west coast of the Americas the Commission's total is somewhat larger than the Panama Company's—178,967 tons if the trade of Hawaii be included in the Commission's figures, and 153,935 tons if omitted. If group 3 does not include the Hawaiian commerce, the vessel tonnage of that commerce should be subtracted from the figures of "entrances and clearances" before the comparison is made. Concerning this difference of 154,000 or 179,000 tons between totals approximating two and a half millions it should be said that the periods covered by the two totals are not identical, and that the two methods of determining vessel movements could hardly be expected to yield exactly the same results. Vessels do not always make the port they clear for. Accidents may prevent, or telegraphic orders from the owner or charterer may change the course of the vessel.

It is in the vessel tonnage of the commerce between the eastern American seaboard and the countries of the western part of the Pacific (i. e., the Far East), that the largest difference exists between the figures of the Panama Company and the Commission. The total of group 4 in the calendar year 1899 was 1,271,357, while the total of entrances and clearances accepted for the fiscal year ending June 30, 1899, by the Commission for the trade between the eastern seaboard of the United States and the western Pacific countries was 908,140 tons net register. This amount, it will be recalled, is twice the tonnage of vessels clearing direct from the Atlantic seaboard to Japan, Siberia, China, the Philippines, and Australasia. Group 4 of the French tables includes some commerce (that of Singapore and the Dutch East Indies) not comprised in the Commission's figures for the trade between our eastern seaboard and trans-Pacific countries. Moreover, a complete statement of the vessel tonnage of this commerce can not be made from our statistics of entrances and clearances, because a share, not only of the commodity traffic, but also of the vessel tonnage of this commerce, is credited in our statistical records to our trade with Europe. It is quite possible that the vessel tonnage engaged in the commerce between our eastern seaboard and the countries of the western Pacific is somewhat greater than 908,140 tons net register. Group 4 applies to the commerce between the entire east coast of the American continent and the countries of the western Pacific; but there can be but very little vessel movement between the Far East and any Atlantic American countries other than the United States.

The only other tonnage item requiring mention in this comparison is that of the commerce at the city of Panama referred to above. The total of entrances and clearances, as determined by the Commission, credit that traffic with 336,998 vessel tons net register; whereas the methods in accordance with which the calculations of the New Panama Canal Company were made were such as not to include that tonnage.

The results of the three traffic investigations are such as to affirm the essential accuracy of each. The ratio between cargo tonnage and vessel tonnage apparently accords with the facts of ocean commerce. In view of the complexity of the statistical problem, the difference in the methods of dealing with the problem, and the slight difference in periods covered, the vessel tonnage totals obtained by the commission's investigation of entrances and clearances and the New Panama Company's record of vessel movements correspond as closely as could be expected.

CHAPTER XXI.—*Growth of canal traffic, 1899 to 1914 and 1914 to 1924.*

The factors affecting the growth of commerce are so numerous and so interrelated that it is difficult to estimate the growth in traffic that will take place during the decade or more that must intervene before an isthmian canal can be ready for use. The only basis of calculation is the increase of the past under the conditions of production and transportation and the requirements of international trade that then prevailed. All of these conditions are constantly changing and thereby affecting the volume and nature of the commodities exchanged and the routes followed by the commerce of the world.

Of one thing, however, there can hardly be any uncertainty, commercial progress during the near future will be fully as rapid as it has been the past ten or twenty years. The demands of consumers are everywhere expanding, and sections like Africa and Eastern Asia, that have thus far had but slight contact with the rest of the world, are being rapidly brought within the sphere of international commerce. The costs of transportation, both inland and maritime, continue to decline with the improvement of mechanical appliances and the accumulation of capital seeking profitable investment. Nations and individuals are devoting themselves with energy to the extension of trade and commerce. This is particularly true of the people and Government of the United States.

Such being the case, the probable tonnage of the traffic that will be available for an isthmian canal at the time of its completion will doubtless be conservatively estimated by predicating a continuation of the rate of increase that has prevailed during the past decade. In all probability the growth will be more rapid in the future; it surely will not be slower.

RATE OF INCREASE SHOWN BY TABLES OF THE PANAMA CANAL COMPANY.

The statisticians of the New Panama Canal Company found that the tonnage of the vessels trafficking between the two coasts of America, between the eastern United States and the Orient, between Europe and Pacific America, i. e., the available canal tonnage originating or terminating in America, increased from 3,073,860 tons net register in 1888 to 3,845,355 tons in 1898, a gain of 25.1 per cent. In determining whether this rate of increase per decade is one whose use will result in a conservative estimate of the probable available canal traffic in 1914, references to the progress in the vessel tonnage and value of the international trade of a few typical regions will be of assistance.

The growth that has taken place in the commerce between the Atlantic coast of the United States and Pacific foreign countries is shown in the following table, which compares the year 1899 with that of 1889. The facts are shown separately for western South America and all other Pacific countries:

The trade of the United States Atlantic coast with foreign countries on the Pacific—Growth in value, 1889–1899.

	With South America.			With all other Pacific.			Combined total.
	Imports.	Exports.	Total.	Imports.	Exports.	Total.	
1889	$3,325,115	$3,854,341	$7,179,456	$30,107,332	$17,478,531	$47,585,865	$54,765,319
1899	5,168,766	3,942,139	9,110,905	34,642,073	38,228,696	72,870,769	81,981,674
Absolute increase	1,843,651	87,798	1,931,449	4,534,741	20,750,165	25,284,906	27,216,355
Per cent increase	55.4	2.2	26.8	15.1	118.7	53.1	49.7

The value of the imports from South America rose 55.4 per cent. The total value of our import and export trade with western South America increased 26.8 per cent during the decade 1889–1899.

The commerce between the Atlantic and Gulf seaboard of the United States, and Australia, Japan, and the mainland of Pacific Asia has grown more rapidly than our trade with western South America. The growth in the value of the imports was 15.1 per cent, and of the exports 118.7 per cent, the increase in the total trade having been 53.1 per cent Our ability to produce cheaply has enabled us to enter freely into the expanding markets of the western half of the Pacific, although the costs of transportation, except to Australia during the last three years of the decade being studied, have necessarily been higher than our rivals have had to bear. The competition of the three lines from New York to Australia became severe in 1897 and greatly facilitated the development of the large trade which we have latterly secured with Australia.

The total trade of the United States with Australasia more than doubled during the decade 1890 to 1900, having been $32,194,000 in the year ending June 30, 1900, as against $15,544,000 in 1890. Our exports to that continent increased from $11,266,000 to $26,725,000 during the decade.

INCREASE IN TRADE BETWEEN EUROPE AND WESTERN COAST OF AMERICA.

The European entrances from Chile increased from 575,890 tons in 1888 to 914,091 tons in 1898, a gain of 58.7 per cent. These figures contain a certain amount of duplication, but the elimination of those duplications would not much affect the percentage. The duplications in clearances from Europe are greater than in the records of entrances, and for that reason the statistics of clearances are not cited in this connection. On their face the figures of entrances and clearances indicate that the total trade between Chile and Europe was 33.3 per cent greater in 1898 than ten years before, and while neither the statistics nor the per cent of increase are to be taken as absolutely correct, they possess illustrative value. The European entrances from all the west coast of South America increased from 789,278 tons in 1888 to 1,077,346 tons in 1898, a gain of 36.5 per cent.

In the chapter dealing with the vessel tonnage available for the use of a canal, the cargo tonnage of the nitrate of soda exported from Chile was shown to have grown from 420,000 to 1,360,000 long tons during the fifteen-year period ending with the calendar year 1899. This increase of over 200 per cent in the nitrate trade is, of course, due to causes peculiar to it, and not generally operative upon international trade as a whole. Nevertheless, the growth of the foreign trade in such articles as nitrate of soda, phosphate rock, lumber, coal, iron and steel products, and others that might be cited, and the practical certainty that the increase will continue for some decades to come, must have much significance in any reasoning regarding the probable rate of increase that will take place during the coming decade and a half, in the commerce available for an isthmian canal.

The trade of Europe with the Pacific coast of the United States is subject to great fluctuations, because it consists largely, although to a continually less degree, of the exports of grain, the annual volume of which depends upon whether the crop yield is abundant or light, and whether European prices are high or low. The entrances recorded at our Western ports comprise a decreasing number of vessels from Europe, because the majority of the ships reach those ports from trans-Pacific points. The export trade is particularly subject to fluctuation, but the last decade of the last century witnessed a moderate growth in the tonnage in vessels cleared. There was, likewise, an increase in the value of the exports, which amounted to about 25 per cent. The exports of wheat are not so heavy as they formerly were, but other commodities, particularly horticultural products, are acquiring a large place in the foreign trade.

GROWTH IN TRANS-PACIFIC TRADE OF THE WEST COAST OF THE UNITED STATES.

The trade between the Pacific coast of the United States and Hawaii, Japan, China, and Hongkong will not make use of the canal, but for the purpose of discussing the rate at which the Pacific commerce is growing, this trade may be most advantageously considered. In the following table the entrances and clearances of the vessels engaged in that trade are indicated, the absolute increase in the total tonnage during the decade is shown for the five countries separately and collectively. According to the table the total entrances and clearances increased 191 per cent during the decade.

Vessel tonnage trade between west coast of United States and trans-Pacific countries.

Country and year.	Entrances.	Clearances.	Total.
Hawaii:			
1889	43,254	96,200	139,454
1899	246,432	206,887	453,319
Increase			313,865
Siberia:			
1889	1,029	1,980	3,009
1899	7,631	19,639	27,270
Increase			24,261
Japan:			
1889	29,480	2,095	31,575
1899	165,701	44,731	210,432
Increase			178,857
China:			
1889	3,785	3,982	7,767
1899	72,145	23,790	95,935
Increase			88,168
Hongkong:			
1889	107,794	114,507	222,301
1899	183,679	207,430	391,109
Increase			168,808

Total entrances and clearances: 1889, 404,106; 1899, 1,178,065; per cent of gain, 191.

In reading this table it is necessary to bear in mind that a considerable tonnage of vessels enter our Western ports not to secure cargo for the Orient, but to load with grain, lumber, or other freight for the North Atlantic, and if allowances could be made for this the average percentage of gain would be somewhat reduced. However, it will be observed that the clearances from our ports for the five Pacific countries—and the clearances represent the movements of vessels actually engaged in carrying our goods abroad—show a large increase in each instance.

The foregoing paragraphs have referred to the rate of growth prevailing in the commerce of the Atlantic coast of the United States with (1) western South America, (2) with all Pacific countries other than South America, and (3) with Australia; reference has also been made to rate of increase in Europe's commerce (4) with the west coast of South America, (5) with Chile, and (6) with the Pacific States of the United States; and finally attention was called to the progress being made in (7) the commerce of our west coast with Hawaii, Australia, Hongkong, China, Japan, and Siberia. In only one of these seven references to international trade—the commerce between our west coast and Europe—was the rate of increase per decade found to be less than the 25.1 per cent obtained by comparing records of the New Panama Canal Company for 1888 with those for 1898. In most of the seven special divisions of commerce above noted the rate of growth was found to be much more than 25.1 per cent.

PROBABLE AVAILABLE CANAL TRAFFIC IN 1914.

In view of these facts it would seem that an increase of 25.1 per cent per decade up to the time of the opening of the canal may be very safely and conservatively predicated concerning the traffic that might have advantageously used the waterway in 1899. Predictions concerning the future ten or fifteen years must necessarily be based upon the experiences of the past, and unless the decade upon which the calculations here presented as to the future are made to rest was one of abnormally rapid or slow commercial progress it may properly be made the basis.

Taken as a whole the decade preceding 1899 was probably one during which the world made normal industrial and commercial progress. In the United States the earlier years and the last year of the period were characterized by great business activity, but during fully a third of the decade a business depression of unusual severity prevailed. The years from 1893 to 1897 were more trying ones in this country than they were in Europe, but business was dull rather than active in Europe during that time. Consequently it is probable that estimates based upon this decade will not lead to an exaggeration of the facts.

The Panama Canal Company's figures for the vessel movements of the commerce originating or terminating in America, increased by the present transisthmian traffic and 816,223 tons of Europe's trade with Oceania, Australia, and Japan, show that the available canal traffic for the calendar year 1899 was 5,001,798 tons net register. An increase of 25.1 per cent during the decade ending in 1909 would raise the amount to 6,257,249 tons; and the same rate of growth would bring the total to 6,998,733—or, in round numbers, 7,000,000—tons in 1914.

If the tonnage of available canal traffic in 1899, as determined by the Isthmian Canal Commission's study of entrances and clearances, be made the basis of estimate, and the increase of 25.1 per cent per decade be assumed, the figures for 1909 will be 6,118,735 net register tons, and for 1914 6,843,805 tons.

In the foregoing estimates of tonnage the figures refer to the available canal traffic. It is not probable that all of the commerce included in the above totals will at once abandon the routes at present followed and immediately make use of the isthmian waterway. It will take some time to readjust trade with reference to the new conditions which the canal will establish, and possibly two years may be required for merchants and carriers to adapt themselves to all the changes in the routes and methods of international trade that the use of the canal will necessitate. The totals to which the three investigations of available canal tonnage have led may be designated as the measure of all the commerce that would have used the canal in 1899 had the commerce of our own and foreign countries been adjusted to the condition of trade which the canal would have established. There is no tonnage included in the totals which might not advantageously use the canal, except during the temporary period of transition from the existing conditions governing international trade and controlling the commerce between our eastern and western seaboards, to those conditions which will exist after the isthmian route has been opened.

ESTIMATE OF GROWTH OF TRAFFIC DURING FIRST DECADE OF THE USE OF THE CANAL.

The new interoceanic communication will so greatly modify the routes of commerce and the conditions controlling the progress of the industries and commerce of many sections of the world that the problem of estimating the increase that may be expected to take place in the tonnage using the canal during the first decade following the opening of the waterway is a different one from that of predicting the growth of available traffic up to the time of the completion of the canal. The rate of increase will be much more rapid after the canal has been put into service and its economic effects have begun to be realized.

The present small amount of ocean tonnage plying between the two seaboards of the United States affords a most striking instance of the restrictions which the absence of an isthmian canal imposes upon the growth of a traffic that will become large when the isthmian waterway has been opened. During the past decade the vessel movements between our two seaboards have averaged less than 250,000 tons annually, and until the current year have tended to decline, at a time when our domestic and foreign trade has been making rapid progress. Our small trade with western South America, a region with which we should, and some day will, have a large commerce, is another example of the restraints of existing transportation facilities. The effect of the isthmian canal upon the interoceanic coastwise commerce of the United States and upon our trade with western South America will be revolutionary, and the influence upon our commerce with foreign countries of the North Pacific will be, to say the least, highly stimulative.

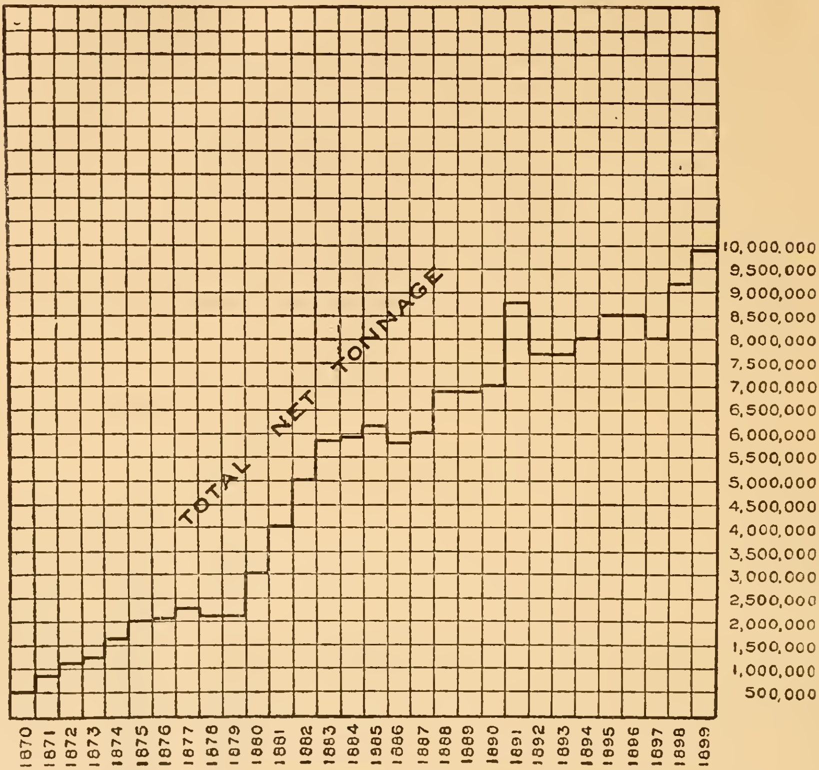
During the decade following the opening of the canal numerous forces will operate to accelerate the growth of American commerce. Besides being influenced by the new isthmian waterway, commerce will doubtless be served by a Pacific cable, and our trade will have the advantage of closer and more direct international banking facilities than now exist. Likewise, there is every reason to expect a large development in our merchant marine during the coming ten or fifteen years. The combined effect of these four commercial agencies will be to supplement our ability to produce cheaply, with facilities as favorable as our rivals possess for communication and transportation and for the settlement of international obligations, and the result will be the sure progress of our coastwise and foreign maritime commerce.

While it is not to be expected that the traffic of the isthmian waterway during the early years of its operation will increase so rapidly as did the tonnage passing the Suez Canal, the best basis for estimating the probable increase that will occur in the tonnage of the American isthmian waterway is the rate of growth that the traffic of the Suez Canal has had. The number of vessels that have passed through the Suez Canal each year since it was opened and the gross and net tonnage are shown by the following table:

Suez Canal traffic.

Year.	Number of vessels.	Gross tonnage.	Net tonnage.
1870	486	654,915	436,609
1871	765	1,142,200	761,467
1872	1,082	1,744,481	1,160,743
1873	1,173	2,085,073	1,367,768
1874	1,264	2,423,672	1,631,650
1875	1,494	2,940,708	2,009,984
1876	1,457	3,072,107	2,096,772
1877	1,663	3,418,950	2,355,448
1878	1,593	3,291,535	2,269,678
1879	1,477	3,236,942	2,263,332
1880	2,026	4,344,520	3,057,422
1881	2,727	5,794,491	4,136,780
1882	3,198	7,122,126	5,074,809
1883	3,307	8,051,307	5,775,862
1884	3,284	8,319,967	5,871,501
1885	3,624	8,985,412	6,335,753
1886	3,100	8,183,313	5,767,656
1887	3,137	8,430,043	5,903,024
1888	3,440	9,437,957	6,640,834
1889	3,425	9,605,745	6,783,187
1890	3,389	9,749,129	6,890,094
1891	4,207	12,217,986	8,698,777
1892	3,559	10,866,401	7,712,029
1893	3,341	10,756,798	7,659,068
1894	3,352	11,283,855	8,039,175
1895	3,434	11,833,637	8,448,383
1896	3,409	12,039,859	8,560,284
1897	2,986	11,123,403	7,899,374
1898	3,503	12,962,632	9,238,603
1899	3,607	13,815,992	9,895,630
1900	3,441	13,699,238	9,738,152

The growth in the tonnage using the Suez Canal is graphically shown by the following diagram:



The increase in the traffic of the Suez Canal is well shown by grouping the figures of the foregoing table into five-year periods and comparing the totals of these periods. This is done in the following table:

Increase in the number of vessels and tonnage of the Suez Canal by quinquennial periods.

Years.	Number of vessels.	Net tonnage.	Increase.	Percentage which the tonnage of each five-year period is of the tonnage of 1875–1879.
			Per cent.	
1870–1874	4,770	5,358,237	....	....
1875–1879	7,684	10,995,214	105	....
1880–1884	14,542	23,916,374	117	217
1885–1889	16,726	31,430,454	31	286
1890–1894	17,848	39,899,143	27	363
1895–1899	16,939	44,012,274	10	401

If the first five-year period were made the basis of comparison, the rate of increase would be so great as to exaggerate the progress which the traffic made during the subsequent quinquennial periods. The Suez Canal could be used advantageously only by steamers, and in 1870 the number of steamers available for the commerce between

Europe and the East Indies was limited. For some years the greater part of the commerce continued to go in sailing vessels around the Cape of Good Hope. After the canal had been in use a few years, however, steamers were to a large extent substituted for the sailing vessels, and the Suez route for the Cape route for the greater part of the business. It will be seen that the traffic of the five years 1880–1884 was 217 per cent that of the previous quinquennial period. The tonnage of 1885–1889 was 286 per cent of the period from 1875 to 1879; the tonnage of 1890 to 1894 was 363 per cent, and that of 1895 to 1899, 401 per cent of the traffic of the five years 1875 to 1879. During the last quinquennial period of the twenty-five years from 1875 to 1899 the traffic of the Suez Canal was four times what it was during the first five years. Had the traffic of the years 1870–1874 been made the basis of comparison the above percentages would have been very much larger.

Omitting the first two years, when the traffic was comparatively light because but few steamships were available for the trade between Europe and the East, and making 1872 the basis of comparison, it will be seen that the traffic grew from 1,160,743 net tons in 1872 to 5,074,-809 net tons in 1882, a gain of 337 per cent. The tonnage of 1875 had increased 215 per cent by 1885. The traffic of 1890 was 125 per cent greater than that of 1880. Since 1890 the absolute gain in the tonnage figures has been large, although the percentage of increase is less than it formerly was. The gain of 46 per cent from 1889 to 1899 represents an increase of 4,210,247 tons gross register and 3,112,443 tons net.

Should the rate of increase in the tonnage of the isthmian canal during the first ten years be half that of the Suez during the second decade of its use, the rate would be 62½ per cent. In view of the much larger rate shown by the Suez Canal, and in view of the conditions that will favor commercial progress at the time of and subsequent to the opening of the American canal, 62½ per cent is believed to be a conservative estimate.

THE ESTIMATE FOR 1924.

A decennial increase of 62½ per cent in the estimated traffic available for the canal in 1914, as determined by the figures obtained by using the tables prepared by the New Panama Canal Company, would give a tonnage of 11,372,941 net vessel tons in 1924. A 62½ per cent increase in the estimated vessel-tonnage total of 1914, reached by the Commission's study of entrances and clearances—6,843,805—would amount to 11,121,183. These two estimates for 1924 average about 11,250,000 tons.

For reasons stated above the entire amount of the available canal tonnage can hardly be expected to use the new route during the first year or two of the operation of the waterway, the period required for the readjustment of commercial arrangements. This adjustment will, however, not be delayed by a scarcity of steamers, and will be quickly made. After two years the full amount of the available canal tonnage—the available tonnage of 1916, not of 1914—will be passing the canal in all probability, and the 62½ per cent increase in the available tonnage of 1914 may fairly be expected to represent the actual tonnage at the close of the decade ending in 1924. In this calculation it is assumed that the canal will have been put in operation by the beginning of 1914.

Chapter XXII.—*The question of tolls.*

In levying tolls, three different purposes may control action. Such charges may be imposed as will cause the receipts to cover expenses only, or to cover the expenses and a fair rate of interest on the capital invested, or charges may be fixed for the purpose of securing the greatest possible income from the canal.

Should the principle of maximum revenue be adopted, the effect of tolls upon the volume of traffic will need to be carefully studied, because the receipts derived from the operation of the canal will be the product of two factors—the rate of toll and the volume of traffic. The tonnage of traffic being dependent upon the tolls charged, it would be necessary, in order to secure the maximum revenue, to ascertain what rate of toll could be paid by that volume of traffic which when multiplied by the rate would yield the maximum product. It is hardly necessary to say that there is no fixed rule by which the rate can be determined that would yield the greatest revenue. If there were such a rule, it ought not to be the one adopted in fixing the tolls of the Isthmian Canal.

The policy in regard to tolls should be adopted with reference to all the purposes which the canal is constructed to accomplish, and no argument need be advanced to enforce the truth that the revenue-producing function of the canal will be a minor one as compared with its function of promoting the industrial, commercial, and social progress of the United States and all countries whose trade will be affected by it. The exaction of charges that would largely restrict the volume of business done through the canal would permit the waterway to perform only in part the chief services it is designed to accomplish.

The canal is to be constructed and operated by the Government primarily for the promotion of the economic and political welfare of the people of the United States, and the tolls charged will doubtless be fixed so as not unnecessarily to interfere with the realization of this purpose. The principle of maximum charges would be inconsistent with the public welfare, and if tolls are levied the choice will lie between a rate that will cover only the expense of operation or a rate that will, in addition, yield an income on the capital invested.

Before beginning the discussion of tolls with reference to the American canal, it will be profitable to study the experience of the Suez Canal. That interoceanic waterway has now been in use over thirty years, and the main features and results of the financial policy maintained in its management may well be considered.

SUEZ CANAL TOLLS.

The charges for passing the Suez Canal are 9 francs per net vessel ton, the tonnage being determined by the so-called Danube measurement, a system adopted by the International Tonnage Commission of Constantinople. Vessels in ballast obtain a reduction of 2½ francs per ton from the regular toll charges. Each vessel carrying passengers is obliged to pay 10 francs for each passenger above 12 years of age and 5 francs for each passenger between the ages of 3 and 12 years. There are, in addition to these tolls, certain port and transit dues. A towage service is maintained for the use of such ships as may require towing, and for this service there is a fixed schedule of charges.

In applying the Danube rules to the measurement of a vessel the net tonnage resulting is considerably larger than the net tonnage of a vessel registered under the British or American flags. The following table shows the relation of gross to net tonnage as determined by the Danube and other measurements for three typical vessels. The toll paid by these three ships is given and the amount which this charge would have been per ton net register, British measurement, is stated for two of the vessels, and per net ton Norwegian measurement for the third ship:

Tolls charged for passing Suez Canal.

Name of ship.	Nationality.	Gross register.	Net register.	Net register tonnage, Danube measurement.	Percentage which Danube is of other measurements.	Tolls paid.	Charge per ton net, British and Norwegian measurements.
		Tons.	*Tons.*				
Sunderland	British	3,414.07	2,198.282	2,571.45	117	$4,466.61	$2.03
Queen Christiana	do	3,596.00	2,291	2,747.66	119.9	4,775.84	2.08
Bergenhus	Norwegian	3,628.00	2,361	2,986.72	126	5,376.09	2.19

The table shows that, according to the Danube rules, the net tonnage of a vessel will average fully one-fifth more than when measured according to British or Norwegian measurements. The toll charges paid were considerably over $2 per ton on the net register of the vessels, British or Norwegian measurement. The American measurements are made by practically the same rules as the British.

The total transit dues of the steamer *Bergenhus* were 27,887.95 francs, of which 26,880.45 francs were paid for tolls—the charges other than tolls amounting to 1,007.50 francs, or $194.45.

The traffic receipts of the Suez Canal from the first year of its operation to the close of 1900, the last year for which figures are obtainable, is shown by the following table. The receipts are given in francs and in dollars, a franc having been considered equal to $0.193. The number of vessels and their mean net tonnage is also given in the table:

SUEZ CANAL TRAFFIC.

Number and size of vessels, receipts from tolls.

Year.	Number of vessels.	Mean net tonnage per vessel.	Transit receipts.	Receipts.
			Francs.	
1870	486	898	5,159,327	$995,750
1871	765	995	8,993,733	1,735,790
1872	1,082	1,071	16,407,591	3,166,665
1873	1,173	1,166	22,897,319	4,419,182
1874	1,264	1,290	24,859,383	4,797,861
1875	1,494	1,345	28,886,302	5,575,056
1876	1,457	1,439	29,974,999	5,785,174
1877	1,663	1,416	32,774,344	6,325,448
1878	1,593	1,425	31,098,229	6,001,958
1879	1,477	1,532	29,686,061	5,629,410
1880	2,026	1,509	39,840,488	7,689,214
1881	2,727	1,517	51,274,353	9,895,950
1882	3,198	1,586	60,545,882	11,685,355
1883	3,307	1,746	65,847,812	12,708,627
1884	3,284	1,787	62,378,116	12,038,976
1885	2,624	1,748	62,207,439	12,006,035
1886	3,100	1,860	56,527,391	10,909,786
1887	3,137	1,881	57,862,371	11,167,437
1888	3,440	1,930	64,832,273	12,512,628
1889	3,425	1,951	66,167,579	12,770,343
1890	3,389	2,033	66,98[illegible],000	12,927,912
1891	4,207	2,067	83,422,101	16,100,465

Number and size of vessels, receipts from tolls—Continued.

Year.	Number of vessels.	Mean net tonnage per vessel.	Transit receipts.	Receipts.
			Francs.	
1892	3,559	2,167	74,452,436	$14,369,320
1893	3,341	2,292	70,667,361	13,638,800
1894	3,352	2,398	73,776,828	14,238,928
1895	3,434	2,460	78,103,718	15,074,008
1896	3,409	2,511	79,569,994	15,357,009
1897	2,986	2,645	72,830,545	14,056,295
1898	3,503	2,637	85,294,770	16,461,891
1899	3,607	2,743	91,318,772	17,624,553
1900	3,441	....	90,623,609	17,490,356

It is shown that there has been a fairly steady and a comparatively rapid growth in the traffic receipts of the canal almost from the time when it was opened for commerce. The traffic and the revenues were comparatively small the first two years, because there were not many steamers available for the commerce between Europe and the East. The transit receipts for the year 1899 amounted to $17,624,553. By grouping the canal receipts into five-year periods and comparing those periods with each other the rate of growth can be shown more accurately than by comparing one year with another. The annual variations are frequently large, but when quinquennial periods are compared the effects of these annual variations are minimized. In the following table the figures of the preceding table are grouped according to quinquennial periods. In comparing the periods the first five years are omitted, because if the figures of that period were made the basis of comparison the rate of increase would be so great as to give an exaggerated statement of the growth that has taken place since 1875:

Increase in number and size of vessels, and receipts of Suez Canal, by quinquennial periods, 1875–1899.

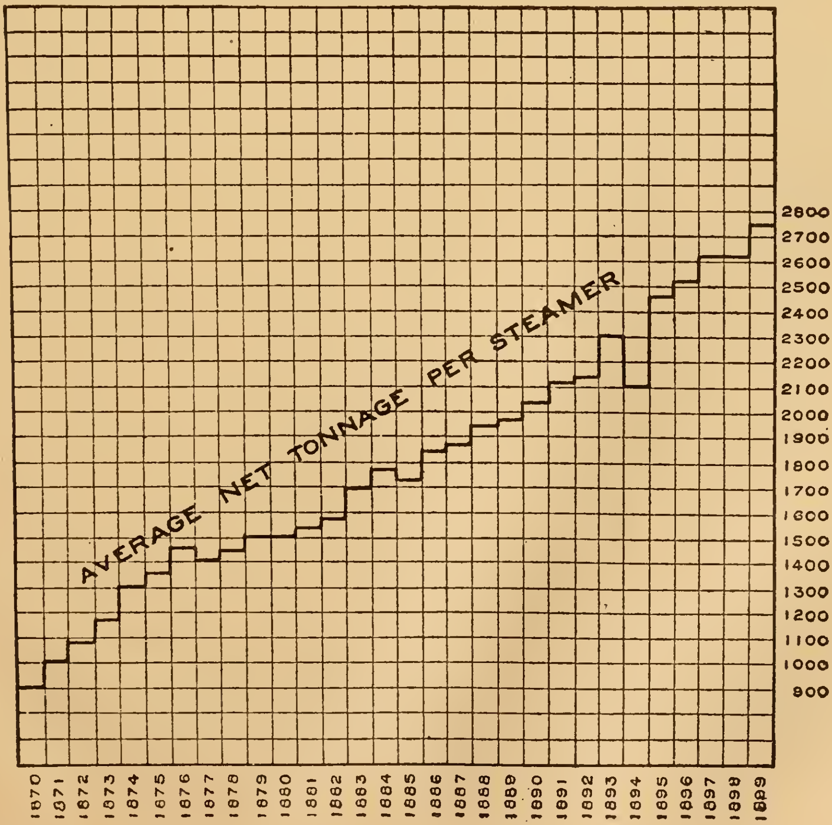
Year.	Number of vessels.	Mean net tonnage per vessel.	Receipts.	Percentage which receipts of 5-year periods are of receipts of 1875–1879.
1870–1874	4,770	1,123	$15,115,248	....
1875–1879	7,684	1,430	29,317,046	....
1880–1884	11,542	1,644	54,018,122	184
1885–1889	16,726	1,879	59,366,229	202
1890–1894	17,848	2,108	71,275,425	243
1895–1899	16,939	2,659	78,213,756	266

The receipts of the period 1880 to 1884, inclusive, were 184 per cent of those of the previous five years. The revenues from traffic during the five years 1885–1889 were 202 per cent of those obtained during the period 1875–1879, whereas the revenues for the five-year periods 1890–1894 and 1895–1899 were respectively 243 and 266 per cent of the receipts obtained in the years 1875 to 1879. The transit revenues of the last five years of the quarter century was two and two-thirds those of the first five years. The traffic of this latter period was fourfold that of the five years which are made the basis of comparison.

The Suez Canal has been a very profitable investment of capital. There are 400,000 shares of capital stock, with a par value of 500 francs each, and bonds which amounted to 177,340,000 francs in 1898. The dividends paid on the stock reached 5 per cent in 1874, were $5\frac{7}{10}$ per cent in 1876, and 6 per cent in 1879. They have been as high as 17 per cent. In 1898 the net balance for distribution, after paying costs of operation, interest on the bonds, and other expenses, amounted to 46,618,000 francs. In the distribution of this sum the shareholders received 71 per cent of the total, 33,098,780 francs, i. e., $16\frac{1}{2}$ per cent of the face value of their stock Of the remaining 29 per cent of the net earnings, 15 per cent went to the Egyptian Government, 10 per cent to the founders, 2 per cent to the directors, and 2 per cent to the employees.

An additional fact of much interest is shown by the preceding tables. It will be noted that the number of vessels passing the canal was no greater in 1899 than in 1885. During those fifteen years the tonnage has increased 56 per cent. The larger volume of traffic has been accommodated by increasing the size instead of the number of the ships. The mean net register of the vessels using the Suez Canal will very soon reach 3,000 tons. Should the present rate of increase continue until 1914, the vessels will then average 3,600 tons net, and it is probable that the larger dimensions about to be given the Suez Canal will result in more rapid increase in the size of vessels than is now taking place.

The growth in the size of ships using the Suez Canal is graphically shown by the following diagram:



The tendency to increase the size of ocean vessels is important in connection with the study of the traffic of the isthmian canal, because the cost of operating the canal will depend to some extent upon the number of lockages. The maximum traffic capacity of the canal will also be greater if vessels of large instead of small dimensions are used. A traffic of 10,000,000 tons net per year would require the passage of 5,000 vessels, with an average net register of 2,000 tons, or about 7 ships each way per day on an average. The same number of ships double the size would make the annual tonnage 20,000,000 tons without any increase in the number of lockages required.

In this connection attention may properly be called to the possible traffic capacity of a twin-lock canal such as the isthmian waterway will be. Not many years after the canal has been put into operation the vessels using it will in all probability average as much as 4,000 tons net register. If 50 such vessels were to pass through the canal daily, 25 each way on an average, the total annual net tonnage would be 73,000,000 tons. Inasmuch as the time ordinarily required for a ship to pass a lock will not exceed three-fourths of an hour, a canal with twin locks could readily handle an average of 25 vessels per day each way, and do so without delay to commerce, except, perhaps, at certain times when the rush of traffic might largely increase the average daily number of vessels making the passage.

EFFECT OF TOLLS UPON VOLUME OF TRAFFIC OF SUEZ CANAL.

In the case of the Suez Canal there is but a comparatively small percentage of the total available tonnage situated on the margin of advantage, and for that reason the Suez Canal Company has been able to derive large revenues from the maintenance of high tariffs. The trade of Europe with Australia is more liable than any other important category of available commerce to be kept away from the canal and sent around the Cape of Good Hope, but a part even of that trade is done by way of Suez. The passenger and mail steamers all use the canal, while most of the slow freight steamers take the Cape route.

A reduction in the Suez Canal charges would draw to that waterway some, but not a very large amount, of the European trade with the East. The change from steam to sail power is helping the Suez Company to get the business without reducing its charges. The high tolls of the Suez have a greater deflecting effect on the commerce of the eastern seaboard of the United States with the East than on the trade of Europe with the countries of that region, because the saving in distance accomplished by the canal is much less for the American than for the European commerce. From New York to Australia the Cape route is no longer than the canal route for full-powered steamers, and of course vessels go by the Cape. In going from New York to Singapore and points in China and Japan the course by way of Suez saves less than 2,000 miles, and the canal route is from seventh-eights to five-sixths as long as that around Good Hope.

Sailing vessels leaving New York for the Far East take the Cape route, but steamers always go through the canal. A large reduction in the Suez Canal tolls would doubtless hasten the substitution of steamers for sailers and secure for the canal a larger share of the total traffic, at least until the American isthmian waterway had become available.

The traffic of the Suez Canal could be increased by a reduction of 50 per cent in the transit charges, but the effect of tolls upon the tonnage of the Suez waterway is not so great as the influence of the isthmian canal charges will be on the volume of traffic using that waterway. The marginal traffic is much greater in the case of the American waterway, and high tolls will cause much trade to adhere to existing ocean routes. Moreover, the traffic between our two seaboards, which will constitute a large share of the total canal tonnage, will be competed for by rail as well as water routes, and the higher the canal tariffs are the larger will be the share of the total commerce between the eastern and western sections of our country that will move by rail.

The commerce whose routes will be most affected by the tolls of the isthmian canal will be that between Europe and Chile, that of the United States and Europe with Australia, and that of the United States with the Philippines, southern China, and a part of that with the Dutch East Indies.

ISTHMIAN CANAL TOLLS AND THE CHILEAN TRAFFIC.

Three-fourths of the Chilean tonnage consists of nitrate of soda, the deposits of which are located in the northern part of the country in the middle part of the west coast of South America. The route north from the nitrate beds of northern Chile by way of an isthmian canal will require the vessel to make a detour of some length to the west, and the average distances from Europe to the nitrate deposits will be shortened about 2,800 nautical miles by the canal. About 30 per cent of the present distances through the Straits of Magellan will be saved. A saving of 2,800 miles would shorten the time of the voyage for a 10-knot steamer eleven days and sixteen hours. In using the canal route for the purpose of saving this distance of 2,800 miles, something over a day would be required for passing the Nicaragua Canal, and somewhat more than a half day for the transit across Panama. In general, a 10-knot steamer could shorten the time of its voyage between Europe and the central part of western South America ten days by using a Nicaragua canal and eleven days by passing through a Panama waterway instead of going around by the Straits of Magellan. A vessel operated at a speed of 9 knots per hour, which is the present speed of the larger share of tramp steamers—the vessels in which the major portion of the world's ocean commerce is carried on—would shorten the time of its voyage thirteen days by avoiding 2,800 miles of sailing. Such a vessel could get from Europe to the middle part of the west coast of South America eleven and one-half days sooner by way of a Nicaragua canal and twelve and one-half days earlier via a Panama route.

Would the possibility of saving from ten to eleven and a half days cause a vessel running between Europe and Chile to pay tolls for the privilege of passing an isthmian canal, and what charges could the vessel afford to pay? This depends mainly upon the costs of operating the ship when at sea.

The information received from a firm operating several ships is:

> The cost of operating a modern freight steamer of, say, 2,500 tons net register (dead weight cargo capacity, say 6,000 tons), averages not exceeding, say $175 per day. This includes wages, provisions, coal, interest on capital invested, insurance, wear and tear.

Another authority states:

We find that the average cost of operating a steamer of, say, 8,000 gross tons dead weight capacity (about 3,500 tons net), which includes bunker coal as well as cargo, making an average speed of 9 knots per hour between New York and San Francisco, to be about $300 per day. This covers cost of bunker coal, victualing and manning, and insurance only. The cost of bunker coal is based upon the average cost of same to-day.

This latter statement of costs of operating ships does not include the expenses of interest on capital, nor is anything allowed for depreciation in the value of the ship. The addition of these items would somewhat increase the average daily expenses. It ought to be noted, however, that the present costs of coal are unusually high.

These two calculations as to the costs of operating vessels give results differing largely, doubtless for the reason that the first calculation is based on experience in the operation of ships under a foreign flag across the Atlantic, where coal is cheap, and for the reason that the costs are for normal times instead of the present, when prices are unusually high, while in the second estimate the experience drawn upon consisted in the management of vessels under the American flag at the present time of high prices and upon a route where the costs of coal are very much higher than in North Atlantic ports.

The present costs of chartering British steamers and operating them at a speed of 9 knots in the trade between the Atlantic and Pacific coasts of America are given by a firm having a large business.

The actual monthly and daily expenses incurred for two of these British ships by the American firm chartering them is as follows:

1.

Gross register .... tons..	3,048
Net register .... do..	1,954
Dead-weight capacity, including coal and stores .... do..	5,000
Freight, at 4s. 6d. per dead-weight ton per month (30 days), say, 1,125, at $4.86	$5,467.50
Coal, 20 tons per day, 30 days=600 tons, at $3	1,800.00
Total	7,267.50

$7,267.50÷30 days=$242.25 per day.

2.

Gross register .... tons..	3,244
Net register .... do..	2,104
Dead-weight capacity, including coal and stores .... do..	5,100
Freight at 5s. 6d. per dead-weight ton per month (30 days), say, 1,402-10, at $4.86	$6,816.15
Coal, 20 tons per day, 30 days=600 tons, at $3	1,800.00
Total	8,616.15

$8,616.15÷30 days=$287.20 per day.

In the case of both of these ships the charterer pays port charges, agency fees, stevedoring, and pilotage. The vessel owner pays for engine stores, wages of crew, insurance on vessel, and victualing, and in fixing his charges includes payment for wear and tear, and presumably a profit to owners.

The rates paid to the owner by the charterer—a certain amount per month per ton, dead-weight capacity—vary according to the supply of and demand for ships, and at the present time vessel rates are not especially high. It is probable, however, that the supply of vessels will so increase within a few years as to reduce existing charter rates very considerably.

A saving of $175 a day for ten days would amount to $1,750, and for eleven and one-half days to $2,022.50. A toll of $1 per net ton register on a ship of 2,500 tons would equal $2,500, or considerably more than such a vessel operated at a speed of 9 or 10 knots could save by shortening the voyage between Europe and Chile 2,800 miles. However, something should be added to these amounts saved by shortening the voyage, because the insurance would be less on the vessels that used the canal instead of passing through the Straits of Magellan, which are especially dangerous to navigate. Moreover, freight rates could be made somewhat higher by the vessel that could deliver its cargo in a shorter time. Time is money in most lines of trade. Furthermore, men operating vessels would for a like reason prefer to have the ships use the route that would enable them to do the greatest possible amount of business each year. It would be difficult to put these advantages of the isthmian over the Straits route into their exact money equivalent, but they would constitute a strong reason for using a canal and for paying something for the privilege. It is probable that a freight steamer of 2,500 tons net, even if operated at a total daily cost of no more than $175 while running between Chile and Europe, would prefer to pay $1 a ton net register for using an isthmian canal to taking the route through the Straits of Magellan.

If the daily expenses of the steamer of 3,500 tons net are $300 when run at 9 knots, it could save $3,750 by using a Nicaragua canal, and $4,050 by a Panama waterway, instead of going around through the Straits of Magellan. If the expenses were $300 when operated at a speed of 10 knots, it could save $3,050 by way of Nicaragua and $3,350 by way of Panama. A toll of $1 per net ton on the ship would amount to $3,500, and for the reasons just stated a charge of that sum for the use of the canal could profitably be paid.

The chartered steamers above referred to had a net registered tonnage of 1,954 and 2,104 tons, respectively. At the rate of $1 a ton their toll charges would amount to $1,954 and $2,104. A saving of ten days in making a voyage would reduce the expenses of the ship whose net register is 2,104 tons $2,872. It is evident that these vessels would pay $1 a ton for the use of an isthmian canal if they were being operated over a route that the canal could shorten ten days. They would, moreover, use the canal were the costs of chartering and operating them considerably lower than at present.

The commerce between the eastern coast of the United States and western South America would be so facilitated by an isthmian canal that a toll of more than $1 a ton could be paid for practically all this trade. The distance from New York to a point as far south as Valparaiso will be about 3,400 miles, or 40 per cent, less by way of Nicaragua—the longer canal route for this trade—than via the Straits of Magellan; and between ports on our coast south of New York and cities on the west coast of South America north of Valparaiso the absolute and percentage reduction in distance will be much greater.

ISTHMIAN-CANAL TOLLS AND THE AUSTRALIAN TRADE.

For the trade from New York to Australia the best route is that by way of the Cape of Good Hope, the distances by the Suez and Cape routes being practically the same; consequently, when the American canal has been opened the competition for the New York-Australian trade will be between the isthmian canal and the Good Hope routes. The distance from New York to Sydney via the Nicaragua Canal and Tahiti will be 9,676 nautical miles, and by way of St. Vincent, the Cape of Good Hope, Adelaide, and Melbourne 13,658, the difference in favor of the isthmian route being 3,982 miles. Adelaide is 1,816 miles nearer New York by the Nicaragua Canal, and Melbourne is 2,832 miles nearer.

A 10-knot vessel going out from New York to Sydney, Australia, would save between fourteen and fifteen days by taking the American canal route, and would certainly take that course if the toll were not over $1 a ton net register. Practically all vessels going to Australia, whether from the United States or Europe, call at Sydney, because it is the most important port and is a good place to obtain coal. A steamer from New York to Melbourne would save 2,832 miles and ten and one-half days by going by way of Brito, Tahiti, and Sydney instead of by the way of the Cape of Good Hope and Adelaide. A toll of $1 per ton could profitably be paid to accomplish this.

There is, then, no probability that steamers outbound from the eastern seaboard of the United States to Australia will take the Good Hope route in order to avoid American canal tolls of $1 a net ton. The route taken by the vessel on its return will be determined by the destination of the Australian exports. If the vessel should secure a full cargo in Australia for America, it would return by the Nicaragua Canal. The ability to secure a partial cargo for the United States and a partial cargo for Europe would probably cause the American canal to be used. Upon reaching the United States, the freight destined for the United States might be exchanged for European cargo with which the ship would proceed to Europe; or the steamer might discharge its entire cargo, that for Europe being transshipped to another vessel. The line steamer making the round trip from New York to Australia and return might come back by the Suez route at times; but the return voyage would usually be by way of the American isthmus. If the American tolls were much lower than those of the Suez, the route across the Pacific would certainly be taken.

Steamers securing a full cargo for Europe in Adelaide, Melbourne, or Sydney would probably return by the Cape of Good Hope, although cheaper coal in American stations might turn the scale in favor of the isthmian canal. The distance from Sydney to Liverpool via Melbourne, Adelaide, King Georges Sound, Colombo, and Aden is 12,234 miles, and via Tahiti and Brito the distance is 12,406, only 172 miles more by the American canal. A vessel starting from Melbourne for Liverpool would find the route via Sydney, Tahiti, and Brito 1,322 miles more than the one via Suez.

A ship obliged to leave Australia in ballast or with but little freight would seek cargo either in the East Indies, New Zealand, Chile, or elsewhere as the needs of commerce might determine. Those ships seeking freights west and north of Australia would naturally return by the Suez Canal.

THE PHILIPPINE TRADE.

The effect of the isthmian canal upon the routes followed by the trade between our eastern seaboard and the Philippines will be to divert a considerable share of the traffic from the Suez to the American canal. Steamers now use the Suez, and after the American canal has been opened the choice will lie between the two canal routes. The distance by the Cape of Good Hope is too great to permit that route to compete with the canals for the traffic handled by steamers. The distances from New York to Manila by the two canals are nearly equal—11,601 miles via Suez, 11,207 by way of Nicaragua, San Francisco, and Yokohama, and 11,274 via Honolulu and Guam. From our South Atlantic and Gulf ports the distances to Manila will be much less by the American canal than by way of Suez. As explained above in the chapter on the vessel tonnage of available canal traffic, chartered vessels outbound from New York will doubtless go sometimes by one route and sometimes by the other. The chief attractions of the American canal route will be the coasting trade of both seaboards of the United States—the shortest route from Central America to Manila being by the great circle which passes close to San Francisco—the large volume of exports from the United States to Asia, the Asiatic coasting trade of Japan, Shanghai, and Hongkong, and the cheap coal obtainable in the Caribbean and Japanese coaling stations. The inducements of the Suez route will be the large volume of exports from the United States to Europe, and the possibility of trading at numerous intermediate ports in the British, Dutch, and French East Indies. Likewise chartered vessels returning to the United States from Manila will sometimes come by way of Hongkong, Shanghai, Yokohama (or other Japanese ports), Puget Sound, San Francisco, Central America, etc., and sometimes by the East Indian ports, the Suez Canal, and Europe. Line steamers plying under the American flag between our eastern seaboard and the Philippines would probably be operated through the isthmian canal and would participate in the trade between the eastern and western coasts of the United States.

The Philippine Islands are so nearly antipodal to the eastern seaboard of the United States that the commerce between the two sections will be divided between the two opposite routes unless the tolls charged at one of the canals should be much higher than those levied at the other. A toll of $2 at Suez and $1 at the American canal would doubtless cause the latter route to secure much more than half of the total traffic. The certainty of competition between the Suez and American canal routes for the trade between our eastern seaboard and the Philippines and southern China suggests the desirability of making the isthmian canal tolls lower than those charged by the Suez Canal Company in order that as much as possible of the commerce of our Antipodes may be made tributary to the isthmian canal. In view of the fact that the larger part of the Suez traffic can afford to pay a high toll in preference to changing from the Suez to some other route, it is not probable that the Suez Canal Company will find it profitable to make radical reductions in its charges—a reduction of 50 per cent, for instance—in order to hold the commerce of the regions situated on the margin of advantage as regards the use of the easterly or westerly canal routes; consequently, it would seem that the adoption of moderate tolls not to exceed $1 per ton net register, American measurement, for the use of the American canal would enable that waterway to secure a large share of the commerce carried on between sections so situated that their trade with each other can and will choose between the Suez and American routes.

In general it may be said that there is but little of the available canal traffic that will be kept from using the waterway by a toll of $1 a ton, net register. The European trade with western South America and the commerce of our eastern seaboard with Australia will not be driven from the isthmian canal by a toll of that amount; but it seems probable that a higher charge than $1 a net ton would largely restrict the tonnage using the canal.

The tendency of traffic to follow round-the-world lines will be emphasized by moderate charges for the use of the American canal. The distance between Europe and the eastern shore of Asia is somewhat farther by way of Central America than by way of Suez, but there are commercial reasons why a portion of the trade between these two sections should pass by the eastern and western seaboards of the United States and through the American canal. A toll of $1 a net ton would probably not much restrict the operation of those commercial forces.

In the foregoing discussion a toll of $1 a net ton has been made the basis of reasoning because that represents a maximum beyond which the charge ought not to go. A tariff much higher than that would in all probability so restrict the tonnage passing the canal as to reduce the revenue derived from the tolls. Such a restriction would unfortunately limit the industrial and commercial value of the canal. The lower the tolls the greater the traffic of the canal and the larger the industrial and commercial benefits. It is believed that a toll of $1 a vessel ton net register would yield an income sufficient to pay the expenses of operation and maintenance and a moderate return on the capital invested. Should the United States prefer to levy tolls sufficient only to cover the cost of operation and maintenance, a tariff of 40 to 50 cents a ton would probably suffice.

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