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SENATE DOCUMENTS

VOL 10

10

TWENTY-SEVENTH ANNUAL REPORT
OF THE
NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

1941

ADMINISTRATIVE REPORT
WITHOUT TECHNICAL REPORTS



UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1941

LETTER OF TRANSMITTAL

TO THE CONGRESS OF THE UNITED STATES:

In compliance with the provisions of the act of March 3, 1915, establishing the National Advisory Committee for Aeronautics, I transmit herewith the Twenty-seventh Annual Report of the Committee covering the fiscal year ended June 30, 1941.

FRANKLIN D. ROOSEVELT.

THE WHITE HOUSE,
January 12, 1942.

LETTER OF SUBMITTAL

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS,
Washington, D. C., December 15, 1941.

MR. PRESIDENT:

In compliance with the provisions of the act of Congress approved March 3, 1915 (U. S. C. title 50, sec. 153) I have the honor to submit herewith the Twenty-seventh Annual Report of the National Advisory Committee for Aeronautics covering the fiscal year 1941.

The past year was one of great progress in aeronautics. Aircraft speed, range, capacity, altitude, fire power and other military characteristics were improved. Scientific research was the foundation for the advances made. Research facilities were notably increased by expansion at Langley Field, Va., and by bringing into operation, as constructed, various units of the new Ames Aeronautical Laboratory at Moffett Field, Calif. The engine research laboratory recently authorized is under construction at Cleveland, Ohio.

Vigorous research gives the only assurance that our construction program will yield aircraft unexcelled by those of any other nation. In this report the Committee describes its research organization and methods but, in the public interest, withholds the publication of details.

Respectfully submitted.

JEROME C. HUNSAKER, *Chairman.*

THE PRESIDENT,
The White House, Washington, D. C.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

HEADQUARTERS, 1500 NEW HAMPSHIRE AVENUE NW., WASHINGTON, D. C.

Created by act of Congress approved March 3, 1915, for the supervision and direction of the scientific study of the problems of flight (U. S. Code, title 50, sec. 151). Its membership was increased to 15 by act approved March 2, 1929. The members are appointed by the President, and serve as such without compensation.

JEROME C. HUNSAKER, Sc. D., *Chairman*,
Cambridge, Mass.

GEORGE J. MEAD, Sc. D., *Vice Chairman*,
Washington, D. C.

CHARLES G. ABBOT, Sc. D.,
Secretary, Smithsonian Institution.

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Deputy Chief of Staff for Air, Chief of the Air Forces,
War Department.

GEORGE H. BRETT, Major General, United States Army,
Chief of the Air Corps, War Department.

LYMAN J. BRIGGS, Ph. D.,
Director, National Bureau of Standards.

VANNEVAR BUSH, Sc. D.,
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WILLIAM F. DURAND, Ph. D.
Stanford University, Calif.

ROBERT H. HINCKLEY, A. B.,
Assistant Secretary of Commerce.

SYDNEY M. KRAUS, Captain, United States Navy.
Bureau of Aeronautics, Navy Department.

FRANCIS W. REICHELDERFER, Sc. D.,
Chief, United States Weather Bureau.

JOHN H. TOWERS, Rear Admiral, United States Navy.
Chief, Bureau of Aeronautics, Navy Department.

EDWARD WARNER, Sc. D.,
Washington, D. C.

ORVILLE WRIGHT, Sc. D.,
Dayton, Ohio.

GEORGE W. LEWIS, *Director of Aeronautical Research*

S. PAUL JOHNSTON, *Coordinator of Research*

JOHN F. VICTORY, *Secretary*

HENRY J. E. REID, *Engineer-in-Charge, Langley Memorial Aeronautical Laboratory, Langley Field, Va.*

SMITH J. DEFRANCE, *Engineer-in-Charge, Ames Aeronautical Laboratory Moffett Field, Calif.*

TECHNICAL COMMITTEES

AERODYNAMICS
POWER PLANTS FOR AIRCRAFT
AIRCRAFT MATERIALS

AIRCRAFT STRUCTURES
AIRCRAFT ACCIDENTS
INVENTIONS AND DESIGNS

Coordination of Research Needs of Military and Civil Aviation

Preparation of Research Programs

Allocation of Problems

Prevention of Duplication

Consideration of Inventions

LANGLEY MEMORIAL AERONAUTICAL LABORATORY

LANGLEY FIELD, VA.

AMES AERONAUTICAL LABORATORY

MOFFETT FIELD, CALIF.

Conduct, under unified control, for all agencies, of scientific research on the fundamental problems of flight

OFFICE OF AERONAUTICAL INTELLIGENCE

WASHINGTON, D. C.

Collection, classification, compilation, and dissemination of
scientific and technical information on aeronautics

TWENTY-SEVENTH ANNUAL REPORT

OF THE

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON, D. C., November 26, 1941.

To the Congress of the United States:

In accordance with the act of Congress approved March 3, 1915 (U. S. C., title 50, sec. 151), which established the National Advisory Committee for Aeronautics, the Committee submits herewith its Twenty-seventh Annual Report for the fiscal year 1941.

Against a background of fallen nations the airplane looms as the instrumentality that has changed previous concepts of military power and the course of history. In the emergency created by this situation, the United States is expending unprecedented sums for the production of aircraft, on the effectiveness of which the security of the Nation may largely depend.

Vast quantities of aircraft alone seem insufficient unless their performance is at least equal to those they may be called upon to oppose. This makes it essential to choose the most advanced designs for production, but allows little time to prove the new features incorporated. It falls to the aeronautical laboratories not only to provide the new ideas necessary to insure superior performance, but at the same time to prove in advance the soundness of the design as a whole. The Committee's work, therefore, falls into two principal categories: namely, research to furnish new ideas; and development, or the application of these ideas to current military designs. The present emergency has naturally revised the priorities in connection with the long-range research program, to the end that those things which give most immediate promise are emphasized. It has been possible, due to close collaboration with the Army, Navy, and aircraft industry, to incorporate the results of a great deal of the Committee's work in current production aircraft, thus making them more effective military weapons.

Only continued scientific research can give the Nation assurance that its aircraft will be kept at least the equal of those of any other nation. In order to develop aircraft to their full potentialities, both in peace and in war, scientific research must be prosecuted with vigor and imagination.

Survey of research needs.—As the threat of war grew grave, in 1938, and the pace of armament accelerated, the Committee surveyed its research needs in anticipa-

tion of greatly increased responsibilities. The Committee restudied the research facilities which would be needed to work effectively upon a great variety of problems of the airplane, its power plant, and its equipment; and proposed a program for the construction of additional and improved wind tunnels to investigate large airplane models at speeds in excess of current military requirements and for greatly increased facilities for power-plant research.

The Congress provided funds, first, to increase the research facilities at Langley Field, Va., and to provide an electric generating plant to permit operation of wind tunnels at all hours of the day; second, to establish a new aerodynamic research station, now known as the Ames Aeronautical Laboratory, at Moffett Field, Calif.; and third, to establish a separate station for fundamental research on aircraft engine problems. This station is now under construction at Cleveland, Ohio.

The Committee placed in operation during the past year at the Langley and Ames laboratories new wind tunnels, representing an expansion of more than 100 percent in the wind tunnels devoted to urgent defense problems, and is proceeding with construction of other wind tunnels, representing another 100 percent increase over those available a year ago. The regular and supplemental appropriations for the Committee for the fiscal year 1942 provide also for a substantial increase in personnel.

The Committee's ability to meet its growing responsibilities has thus been materially aided through the provision of a more adequate staff and better research facilities. At the same time it has had the effective support and cooperation of representatives of the Government agencies concerned with aeronautics and of a large number of experts from the industry and from private life. These experts have served on technical subcommittees charged with the planning of detailed research projects. Further reference will be made to the Committee's policy in securing such assistance.

Problems affecting the character and scope of aeronautical research.—The desired characteristics of the naval and military types of aircraft now included in the national defense program are such that both fundamental and specialized research are necessary to realize the performance required.

The outstanding fighters of 1940-41—the British Spitfire and Hurricane airplanes and the German Messerschmitt 109F—had maximum speeds of the order of 360 miles per hour. The American aircraft program must provide new fighters for 1941-42 of much higher speed. A speed of 400 miles per hour and as much more as is practicable is an obvious necessity. The factors involved include not only clean aerodynamic design, but the discovery of new principles and facts whose application in design leads to real improvements. It is not enough merely to increase the horsepower and to smooth the surfaces.

It was necessary to develop a new wing section of low-drag type, to obtain accurate data in a low-turbulence wind tunnel of its lift and drag, to determine the effect of various types of flaps for increasing lift, and the action of normal and other lateral control devices. It was also essential to reexamine the method of cowling and cooling both air-cooled and liquid-cooled engines at high air speeds. Special cowlings were required to handle the air needed to cool the engine, the oil radiator, the intercooler and, in the liquid-cooled type, the radiator. This work was based on theoretical analysis and proved in wind-tunnel and flight tests.

Propellers of usual design are inefficient at extreme speeds. New propeller blade sections and new plan forms for the blade have had to be developed to keep the losses under those conditions to a minimum. Again theoretical studies and wind-tunnel tests together were necessary to arrive at a practical solution.

At high speed the airplane is subject to compressibility effects. The wing, the fuselage, the propeller, and other parts must be designed to eliminate compression waves as far as possible. This requires testing in a high-speed wind tunnel.

Altitude requirements have been much increased. They demand better supercharging equipment and better cooling of the engine and the intercooler at high altitudes.

In planning the design of a new military airplane special model tests are necessary to determine its spinning characteristics. Where the design is of a radically new form tests are also made in the free-flight tunnel to be assured that the design will have adequate stability and control.

Research facilities.—The Committee initiated its present program of expansion of research facilities in 1938. Through the support of the President and the Congress since that time, the Committee has been able to place in operation during the past year seven wind tunnels of major significance, and a structures research laboratory, all now fully engaged on urgent problems relating to the defense program. The new wind tunnels at Langley Field are: A 20-foot free-spinning tunnel; a stability tunnel; a 2-dimensional

tunnel; and a 16-foot high-speed tunnel. At Moffett Field the new tunnels so far placed in operation include a 16-foot high-speed tunnel, and two 7- by 10-foot high-speed tunnels.

There are under way at Moffett Field a low-turbulence high-speed tunnel, a supersonic tunnel, and a full-scale tunnel.

An aircraft engine research laboratory is under construction at Cleveland, Ohio. This will include: special equipment for research on engines and accessories, propellers, fuels, and lubricants; an ice tunnel for the study of problems of ice formation in flight; and a novel, high-speed engine-research wind tunnel to operate under conditions of temperature and density existing at high altitudes.

There is also under construction at Langley Field a second seaplane towing tank, a seaplane impact basin, an electric power-generating plant, an additional shop building, and extensions to the Flight Research Laboratory and to the service and administration buildings.

In the present emergency the Committee, with the special approval of the Congress, has increased its use of available research facilities in educational and scientific institutions and in the National Bureau of Standards. The work so done supplements that of the Committee's own laboratories; and the Committee's research contracts enable scientists of special qualifications to work upon problems of national importance which they would otherwise lack the means to investigate.

Relation of research to civil aviation.—With the exception of dive-bombing problems and problems incident to armament installations, practically all of the research of the Committee is directly applicable to civil types of aircraft. Improvements in large two- and four-engine airplanes of the bombing type will undoubtedly be reflected in transport airplanes of tomorrow. New and improved engine installations, wing forms, and propeller designs developed for military types will be important factors in increasing the speed and efficiency of future civil aircraft.

Strengthening of subcommittees.—Under the law it is the duty of the National Advisory Committee for Aeronautics to "supervise and direct the scientific study of the problems of flight with a view to their practical solution" and also to "direct and conduct research and experiment in aeronautics."

To assist in the discharge of these duties and in the determination of present and future research needs of aeronautics, civil and military, the Committee has established standing technical subcommittees composed of specially qualified representatives of the governmental agencies concerned and of experts from private life. The members of the subcommittees, like the members of the main Committee, serve as such without compensation.

The subcommittees prepare and recommend research projects. Most of the projects recommended for investigation are assigned to the Committee's laboratories. Some projects are assigned to the National Bureau of Standards and others to universities and technical schools, depending on where the necessary research equipment exists and upon the availability of a qualified staff. This policy makes effective use of existing research facilities, stimulates aeronautical research, and also has the advantage of training research personnel.

The technical subcommittees, now increased in number and strengthened in personnel, have been meeting with greater frequency. This has led to stimulation and clarification of thinking and to greater coordination of effort. In all some 183 persons are serving on the various technical subcommittees.

In addition, frequent conferences devoted to special topics are held with engineers and designers from the industry who are responsible for parts of the defense program. These conferences bring members of the Committee's scientific staff in contact with those who apply the results of their research work.

PART I

TECHNICAL COMMITTEES

In order better to meet its responsibilities, the National Advisory Committee for Aeronautics has established a group of technical committees to recommend to the main Committee programs of research to be conducted in their respective fields. As a result of the nature of their organization, which includes representation from governmental agencies concerned with aeronautics, together with experts from civil life, the technical committees act as coordinating agencies, providing effectively for the interchange of information and ideas and for the prevention of duplication.

In addition to its standing committees, it is the policy of the National Advisory Committee for Aeronautics to establish from time to time special technical subcommittees for the study of particular problems as they arise.

The Committee has four principal technical committees: the Committee on Aerodynamics, the Committee on Power Plants for Aircraft, the Committee on Aircraft Materials, and the Committee on Aircraft Structures. Under these committees there are nine standing subcommittees and seven special technical subcommittees. The membership of these groups is listed in Part II.

THE COMMITTEE ON AERODYNAMICS

Marked increases in the speed of aircraft have emphasized the importance of aerodynamic refinement of the engine installation, as well as of external contours. Compressibility phenomena assume an ever-increasing role as the speed of the airplane and its components approaches the velocity of sound. The aircraft propeller is most affected because the blades are everywhere moving at a velocity greater than that of the airplane, and the tip speed in some cases may exceed the velocity of sound.

Increased wing loadings result in greater emphasis on the use of high-lift devices in order that the landing speed may be maintained at a reasonable value. The need for efficient airfoil sections is more apparent than ever. The effect of increased aerodynamic cleanliness and small wings is to impose much more severe loading on aircraft in the event a spin is encountered, and rapid recovery from the spin is important in order to keep the structural loads within safe limits. High speeds also impose severe loads on windshields and

pilot enclosures, and knowledge of these loads, as well as of efficient forms of windshields, is essential.

Special phases of the problems confronting the Committee on Aerodynamics are investigated under the cognizance of seven subcommittees, dealing respectively with meteorological problems, lightning hazards to aircraft, seaplanes, vibration and flutter, propellers, rotating-wing aircraft, and icing problems.

SUBCOMMITTEE ON METEOROLOGICAL PROBLEMS

The loads imposed on the aircraft structure by atmospheric turbulence have a direct bearing on the necessary factor of safety in the design of the structure. Statistical knowledge of gust loads has been accumulated for many types of aircraft over the continental United States and over ocean routes.

The Committee is engaged in the investigation of the structure of atmospheric turbulence, with particular reference to the gusts encountered on the fronts of moving air masses. An especially equipped airplane has made exploratory flights into the fronts of such masses at various altitudes and has obtained records of the turbulence encountered. The analysis of the data obtained from these flights is in progress, and a scale whereby the degree of turbulence of the atmosphere may be classified is under consideration.

The encountering of heavy rainfall is also of interest because of possible effects on engine operation and on air-speed indicators. The work on these and other meteorological problems which the subcommittee has taken up during the year has been carried on in close collaboration with representatives of the United States Weather Bureau.

SPECIAL SUBCOMMITTEE ON LIGHTNING HAZARDS TO AIRCRAFT

A careful study has been made of all recorded lightning strikes to aircraft. The data have been analyzed and a summary report has been issued. These studies have yielded certain criteria as to conditions favorable for lightning discharges, and have contributed to the understanding of atmospheric processes entering into the accumulation of electricity. Simulated lightning strikes to components of aircraft have also been studied in the special high-voltage laboratories of the Gen-

eral Electric and Westinghouse companies, and practical information has been obtained on the physical effects of such strikes.

An indicator has been developed by a commercial manufacturer which indicates when an airplane is entering a region in which lightning may be encountered. Thus forewarned, it is possible for the pilot to change course and so decrease the liability of being struck by lightning.

SUBCOMMITTEE ON SEAPLANES

The trend towards increased wing and beam loading has resulted in a need for data on the maximum loads likely to be encountered by a seaplane landing in a wide variety of seas. The dynamic stability of the hull is also an important problem on which considerable research efforts are being expended.

SUBCOMMITTEE ON VIBRATION AND FLUTTER

The use of wings of increased structural efficiency on high-speed long-range aircraft requires a thorough analysis of the flutter problem. Research on the various phases of flutter phenomena are being continued.

SUBCOMMITTEE ON PROPELLERS FOR AIRCRAFT

The subcommittee has given special attention to the problems of developing propellers which will maintain their efficiency when mounted on engines of very high power and aircraft of extremely high speed; and the committee's laboratories are conducting research on these problems.

SUBCOMMITTEE ON ROTATING-WING AIRCRAFT

The theoretical equations for the characteristics of a lifting rotor have been extended and simplified to facilitate determination of the effect of the various parameters on performance. The limitations of the theory have been reexamined and a method devised for determining the limit of application as affected by blade stalling.

SPECIAL SUBCOMMITTEE ON DE-ICING PROBLEMS

Extensive research has been conducted on the prevention of ice on aircraft, including investigations on an experimental airplane equipped to prevent the formation of ice on the windshield, wings, and tail surfaces through the use of heat. Various means of de-icing propellers are also being investigated.

THE COMMITTEE ON POWER PLANTS FOR AIRCRAFT

The trend towards increased size, wing loadings, range, and higher-altitude operation of aircraft has

resulted in greater emphasis in power-plant development upon increased take-off power and power at altitude, better cruising fuel economy, and the recovery of waste heat energy. Higher engine output has made the study of the stresses in the moving parts desirable so that design factors may be established to provide maximum durability and minimum weight.

Special phases of the problems confronting the Committee on Power Plants for Aircraft are investigated under the cognizance of four subcommittees dealing respectively with aircraft fuels and lubricants, supercharger compressors, exhaust-gas turbines and intercoolers, and induction-system de-icing.

SUBCOMMITTEE ON AIRCRAFT FUELS AND LUBRICANTS

The importance of superior fuels is evident both to insure the minimum consumption so essential to long-range operation and the maximum power for take-off and climb without detonation. Research on such fuels is in progress and a study is being made of the lubrication problem.

SPECIAL SUBCOMMITTEE ON SUPERCHARGER COMPRESSORS

The importance of obtaining good performance at extremely high altitudes is placing increasing emphasis on the aircraft-engine supercharger. Research has been conducted on the centrifugal type during the past year with the object of increasing its efficiency and output. A large amount of testing has also been conducted to improve the laboratory technique required for testing superchargers and to furnish a common basis for comparing the performance of different makes.

SPECIAL SUBCOMMITTEE ON EXHAUST-GAS TURBINES AND INTERCOOLERS

The long-range requirements of modern aircraft have made it essential to study waste-heat recovery methods in an effort to utilize a greater percentage of the available energy. Research is in progress on the use of exhaust gas in the most efficient manner, and also on intercoolers.

SPECIAL SUBCOMMITTEE ON INDUCTION-SYSTEM DE-ICING

The occurrence of ice in the induction system of an aircraft engine may cause a serious decrease in the power output of the engine. Research is in progress to determine the range of conditions under which ice occurs in the induction system of present day engines, and an investigation is also being made to obtain information on means of preventing its formation and removing it.

THE COMMITTEE ON AIRCRAFT MATERIALS

The search for aircraft materials with the highest possible ratio of strength to weight is never ending. In addition to aluminum alloys, magnesium alloys, stainless steel, plastic-impregnated and plastic-bonded plywoods show promise for use in aircraft structures. The work of the Committee on Aircraft Materials is handled in greater detail by three standing subcommittees dealing respectively with metals used in aircraft, miscellaneous materials and accessories, and welding problems. In addition, there has recently been organized a special subcommittee for study of metals for turbosupercharger wheels and buckets.

SUBCOMMITTEE ON METALS USED IN AIRCRAFT

In addition to the need for metals having a high strength-weight ratio, the need arises for a material which will maintain its strength at high temperature. The effect of change of temperature on strength presents a real problem for aircraft which attain extremely high altitudes. Research on the durability and strength of many metals is in progress.

SPECIAL SUBCOMMITTEE ON METALS FOR TURBO-SUPERCHARGER WHEELS AND BUCKETS

In view of the importance, mentioned above, of providing high-strength heat-resistant metals for turbosupercharger wheels and buckets, a special subcommittee was appointed to handle the problem.

SUBCOMMITTEE ON MISCELLANEOUS MATERIALS AND ACCESSORIES

The demand for substitute materials, and the development of improved synthetic resin glues and new plywood fabrication methods, have stimulated efforts to utilize plastics and plywood in aircraft construction.

The properties of these new materials are being investigated.

SPECIAL SUBCOMMITTEE ON WELDING PROBLEMS

The increase in aircraft production has placed emphasis on the development of improved fabrication methods. The Committee has been engaged in basic research on the welding problems of aluminum and magnesium alloys, and further work is now under way. Problems in the welding of aircraft steels and other materials are also receiving attention.

THE COMMITTEE ON AIRCRAFT STRUCTURES

Special problems are associated with the use of shell-like aircraft structures. Buckling, stress distribution around cut-outs, diagonal tension beams, and strength of various types of fastenings are problems on which knowledge is essential in order to design efficient structures.

Knowledge of the loads imposed on aircraft structures arising from atmospheric disturbances and maneuvers involve both structural theory and aerodynamic investigation. The existing body of information on the magnitude and nature of these loads is being constantly increased through the collection of records of the accelerations experienced by aircraft in both military and civil operation. A further field for structural research is the determination of water loads imposed upon seaplane hull structures within the range of possible landing conditions.

SPECIAL COMMITTEE ON JET PROPULSION

A Special Committee on Jet Propulsion was appointed in order to review the scientific aspects of the propulsion of aircraft using reaction jets.

PART II

ORGANIZATION AND GENERAL ACTIVITIES

The National Advisory Committee for Aeronautics was established by act of Congress approved March 3, 1915, and the membership increased from 12 to 15 by act approved March 2, 1929 (U. S. C., title 50, sec. 151). Its membership is appointed by the President and consists of two representatives each of the War and Navy Departments from the offices in charge of military and naval aeronautics, two representatives of the Civil Aeronautics Administration (Civil Aeronautics Act of 1938), one representative each of the Smithsonian Institution, the United States Weather Bureau and the National Bureau of Standards, together with six additional persons who are "acquainted with the needs of aeronautical science, either civil or military, or skilled in aeronautical engineering or its allied sciences." These latter six serve for terms of five years. All the members serve as such without compensation. During the past year the following changes occurred in the membership of the main Committee:

Dr. Robert E. Doherty, President of the Carnegie Institute of Technology, Pittsburgh, Pa., resigned July 3, 1941, because of his assumption of additional responsibilities as Chairman of the Production Planning Board of the Office of Production Management.

To succeed Dr. Doherty the President, on July 23, 1941, appointed Dr. William F. Durand, Professor Emeritus of Mechanical Engineering, Leland Stanford Junior University, Palo Alto, Calif., for the balance of Dr. Doherty's term, expiring December 1, 1944.

Dr. Durand had previously served as a member of the Committee from 1915 to 1933, having been one of the original members appointed by President Wilson and having served two terms as Chairman during the period of World War I.

The President, having by Executive order of June 28, 1941, established the Office of Scientific Research and Development and appointed Dr. Vannevar Bush director thereof, Dr. Bush, on July 1, 1941, tendered his resignation as Chairman of the National Advisory Committee for Aeronautics and as Chairman of its Executive Committee. The Committee, on July 24, accepted with sincere regret Dr. Bush's resignation, effective July 31, 1941, and adopted a resolution expressing appreciation to Dr. Bush "for the time, energy, and inspiring leadership he has given to the work of the Committee."

The Committee, on July 24, 1941, elected Dr. Jerome C. Hunsaker, head of the Departments of Mechanical

and Aeronautical Engineering at the Massachusetts Institute of Technology, Chairman and also Chairman of the Executive Committee, to serve from August 1, 1941, until the next annual meeting, October 23, 1941.

Under the rules and regulations governing the work of the Committee, as approved by the President, the Chairman and Vice Chairman are elected annually, as are also the Chairman and Vice Chairman of the Executive Committee. On October 23, 1941, Dr. Jerome C. Hunsaker was reelected Chairman and Dr. George J. Mead was reelected Vice Chairman of the main Committee for the year ending October 22, 1942. Dr. Hunsaker was also reelected Chairman of the Executive Committee and Dr. Charles G. Abbot was reelected Vice Chairman of the Executive Committee.

The executive offices of the Committee, including the Office of Aeronautical Intelligence and the Office of Aeronautical Inventions, which had been located in the Navy Building, Washington, D. C., for more than 21 years, were removed in October 1941, to rented quarters, 1500 New Hampshire Avenue NW. This was done in order to provide for necessary expansion of the Navy and of the Committee.

The Office of Aeronautical Intelligence was established in the early part of 1918 as an integral branch of the Committee's activities. It serves as the depository and distributing agency for the scientific and technical data on aeronautics comprising the results of Committee researches and also for similar information collected by the Committee from governmental and private agencies in this country and abroad. The data collected are classified, catalogued, and disseminated by this office.

RESEARCH FACILITIES

The Committee now has three major research stations: the Langley Memorial Aeronautical Laboratory, Langley Field, Va.; the Ames Aeronautical Laboratory, Moffett Field, Calif.; and the Aircraft Engine Research Laboratory, Cleveland, Ohio.

A description of research facilities added during the past year at the Langley and Ames laboratories is presented earlier in this report.

The Second Deficiency Appropriation Act, 1941, approved July 3, 1941, increased the limit of cost of the Aircraft Engine Research Laboratory at Cleveland, from \$8,400,000 to \$13,300,000 to meet increased construction and equipment costs and because of the need

of expanding the principal units of the laboratory to an extent that will permit research to be conducted under conditions more commensurate with expanding military requirements. The Cleveland laboratory is under construction and it is expected that actual research will start in some units during the summer of 1942.

The Second Supplemental National Defense Appropriation Act, 1942, approved October 28, 1941, increased the limit of cost of the Ames Aeronautical Laboratory from \$10,000,000 to \$16,207,500 to provide for the completion of the authorized construction program and for the addition of a high-speed low-turbulence wind tunnel. Seven units of the Ames Laboratory have been constructed and are busily engaged on urgent research projects with some units working on a two-shift basis.

Plans have been approved for the operation of the Langley Field laboratory generally on a two-shift basis and in some sections on a three-shift basis. This will require more than 100 percent increase in personnel, which increase has been authorized by the Congress.

COOPERATION WITH THE AVIATION INDUSTRY

The Committee's research program has always been shaped to give due consideration to the immediate problems of the industries designing, building, and operating aircraft. Through correspondence and through personal contacts, the Committee has obtained suggestions and recommendations from aircraft manufacturers and operators as to investigations that are considered by them to be especially important. This practice has been expanded and strengthened during the past year because of the urgency of problems that arise in connection with the National Defense Program. The research facilities of the laboratories, with the expectation of those devoted to longer-range fundamental projects, have been utilized for the conduct of applied research on specific airplane designs about to be built or actually under construction.

The number of technical representatives of the aircraft industry visiting the Committee's laboratories is so great and the investigations conducted for the improvement of strictly military designs are so numerous that the Army Air Corps maintains a liaison organization at the laboratories to facilitate the handling of problems presented by military contractors, and the Navy Bureau of Aeronautics also maintains a liaison officer. The Committee also arranges for staff specialists to confer with Government contractors in their own plants. Through these arrangements the Committee is able to render a maximum of service and to be better informed on developments that may influence its research program.

A cooperative action of special significance is the functioning during the past year of the "Power Plant Installation Group" at the Langley Field laboratory. This working group is composed of NACA staff members and designing engineers from virtually all of the makers of military aircraft and military engines. Its objective is the application of research findings to the practical requirements of power plant installations for military airplanes. Flight results from some of the arrangements that have been thus evolved indicate the work of this group to be highly effective in anticipating and solving engine-installation difficulties.

Still another evidence of healthy cooperation is the increasing number of visits of airplane designers to the Committee's laboratories for consultation regarding designs that are in the formative stage. With a tentative arrangement of the complete airplane to consider, the Committee's staff may suggest the use of research information that may be beneficial to performance or flying qualities, or may point out difficulties that can be anticipated as a result of laboratory experience.

Cooperation with the aircraft industry also benefits the members of the staffs of the Committee's laboratories through first-hand contacts with the men working on airplane design and development problems. Through such contacts, the technical staff obtains an appreciation of the points of view of the designers.

In view of the military significance of the Committee's research results and because of the pressure of work, it has again been found to be impractical to hold a general conference of representatives of all branches of aviation to review the work done during the year. Instead, smaller conferences have been arranged for representatives designated by the military services whenever a field of research has reached a stage where practical applications can be made, and where the information can be transmitted most advantageously by first hand means.

With the present rapid advance in the art research results should be made available at the earliest possible date to those units of the industry which have been designated by the Army or Navy to receive restricted or confidential information. When the results of an investigation appear at some stage of the program to be of special interest and value to designers, the Committee makes the information immediately available, usually by issuing the data in advance restricted or confidential form.

AERONAUTICAL INVENTIONS

By act of Congress approved July 2, 1926, an Aeronautical Patents and Design Board was established consisting of Assistant Secretaries of the Departments of War, Navy, and Commerce. In accordance with

that act as amended by the act approved March 3, 1927, the National Advisory Committee for Aeronautics passes upon the merits of aeronautical inventions and designs submitted to any aeronautical division of the Government, and submits reports thereon to the Aeronautical Patents and Design Board. That board is authorized, upon the favorable recommendation of the Committee, to "determine whether the use of the design by the Government is desirable or necessary and evaluate the design and fix its worth to the United States in an amount not to exceed \$75,000."

During the past year the inventions section considered approximately 2,600 inventions, suggestions, and designs pertaining to aeronautics. Careful consideration was given to these proposals and their merits were evaluated. The necessary correspondence was conducted to advise the submitters of the evaluations, and personal interviews were held with inventors who visited the Committee's offices.

In August 1940, the National Inventors Council was created by the Secretary of Commerce with the concurrence of the President to serve as a central Government clearing house to which can be submitted inventions and suggestions that might prove valuable to the national defense. The Committee's Director of Aeronautical Research, Dr. George W. Lewis, serves as chairman of the Council's Technical Committee on Aircraft and Aeronautics. During the past year the Council has referred to the Committee for comment many of the proposals dealing with aeronautics submitted to it for consideration.

COORDINATION OF AERONAUTICAL RESEARCH

The Office of the Coordinator of Research has been active in maintaining contact with the aircraft industry and with scientific and educational institutions. A comprehensive study has been made of research facilities adapted to investigations on aeronautical problems.

During the past year 385 visits were made to manufacturers and to scientific and educational institutions. Thirty-six contracts for scientific investigations and reports were made with 18 educational institutions.

MEMBERSHIP OF SUBCOMMITTEES

A discussion of the scope of activity of each of the standing and special technical committee's and subcommittees has been presented in part I. The organization of the subcommittees is as follows:

COMMITTEE ON AERODYNAMICS

Dr. Edward Warner, Chairman.
Dr. Hugh L. Dryden, National Bureau of Standards, Vice Chairman.
Edmund T. Allen, Boeing Aircraft Company.

Lt. Col. Howard Z. Bogert, Air Corps, United States Army. Matériel Division, Wright Field.

Lt. Col. Franklin O. Carroll, Air Corps, United States Army. Matériel Division, Wright Field.

Marion P. Crews, Civil Aeronautics Administration.

Commander Walter S. Diehl, United States Navy.

John Easton, Civil Aeronautics Administration.

Dr. Jerome C. Hunsaker.

Eastman N. Jacobs, National Advisory Committee for Aeronautics.

S. Paul Johnston, National Advisory Committee for Aeronautics (ex officio member).

Prof. Otto Koppen, Massachusetts Institute of Technology.

John G. Lee, United Aircraft Corporation.

Dr. George W. Lewis, National Advisory Committee for Aeronautics (ex officio member).

Dr. Clark B. Millikan, California Institute of Technology.

Robert R. Osborn, Bell Aircraft Corporation.

Commander John E. Ostrander, Jr., United States Navy.

H. J. E. Reid, National Advisory Committee for Aeronautics.

Fred E. Weick, Engineering and Research Corporation.

John B. Wheatley, The Glen L. Martin Company.

Theodore P. Wright, Office of Production Management.

SUBCOMMITTEE ON METEOROLOGICAL PROBLEMS

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Col. E. S. Gorrell, Air Transport Association of America.

Prof. H. G. Houghton, Massachusetts Institute of Technology.

Dr. W. J. Humphreys, United States Weather Bureau.

S. Paul Johnston, National Advisory Committee for Aeronautics (ex officio member).

R. W. Knight, Civil Aeronautics Administration.

Dr. George W. Lewis, National Advisory Committee for Aeronautics (ex officio member).

Delbert M. Little, United States Weather Bureau.

Dr. Charles F. Marvin, Washington, D. C.

Capt. Arthur F. Merewether, Air Corps, United States Army.

Lt. Comdr. Howard T. Orville, United States Navy.

Richard V. Rhode, National Advisory Committee for Aeronautics.

Dr. C. G. Rossby, United States Weather Bureau.

Prof. A. F. Spilhaus, New York University.

SPECIAL SUBCOMMITTEE ON LIGHTNING HAZARDS TO AIRCRAFT

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Dr. O. H. Gish, Carnegie Institution of Washington.

Lt. Comdr. M. P. Hanson, United States Naval Reserve.

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Maj. C. K. Moore, Air Corps, United States Army, Matériel Division, Wright Field.

Peter Sandretto, United Air Lines Transport Corporation.

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SUBCOMMITTEE ON SEAPLANES

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Prof. K. S. M. Davidson, Stevens Institute of Technology.
 Commander W. S. Diehl, United States Navy.
 Michael Gluhareff, Vought-Sikorsky Aircraft Division.
 Capt. H. E. Gray, Pan American Airways.
 S. Paul Johnston, National Advisory Committee for Aeronautics (ex officio member).
 Paul E. Hovgard, The Glenn L. Martin Company.
 B. V. Korvin-Kroukovsky, Edo Aircraft Corporation.
 Dr. George W. Lewis, National Advisory Committee for Aeronautics (ex officio member).
 Maj. C. K. Moore, Air Corps, United States Army, Matériel Division, Wright Field.
 A. L. Morse, Civil Aeronautics Administration.
 Capt. H. E. Saunders, United States Navy.
 H. A. Sutton, Consolidated Aircraft Corporation.
 Starr Truscott, National Advisory Committee for Aeronautics.

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 Capt. Frederick R. Dent, Jr., Air Corps, United States Army, Matériel Division, Wright Field.
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 Prof. C. S. Draper, Massachusetts Institute of Technology.
 Lt. Comdr. Robert S. Hatcher, United States Navy.
 Charles H. Helms, National Advisory Committee for Aeronautics.
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 S. Paul Johnston, National Advisory Committee for Aeronautics (ex officio member).
 Dr. George W. Lewis, National Advisory Committee for Aeronautics (ex officio member).
 Dr. Irving R. Metcalf, Civil Aeronautics Administration.
 Dr. Walter Ramberg, National Bureau of Standards.
 Lt. Albert B. Scoles, United States Navy.
 Benjamin Smilg, Matériel Division, Army Air Corps, Wright Field.
 Dr. Theodore Theodorsen, National Advisory Committee for Aeronautics.

SUBCOMMITTEE ON PROPELLERS FOR AIRCRAFT

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 S. Paul Johnston, National Advisory Committee for Aeronautics (ex officio member).
 Dr. George W. Lewis, National Advisory Committee for Aeronautics (ex officio member).
 Erle Martin, Hamilton Standard Propellers.
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 Commander W. S. Diehl, United States Navy.
 Capt. V. R. Haugen, Air Corps, United States Army, Matériel Division, Wright Field.

S. Paul Johnston, National Advisory Committee for Aeronautics (ex officio member).
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 John W. Crowley, National Advisory Committee for Aeronautics.
 Maj. Rudolph Fink, Air Corps, United States Army, Matériel Division, Wright Field.
 Dr. W. C. Geer, Ithaca, N. Y.
 Prof. H. G. Houghton, Massachusetts Institute of Technology.
 Willson Hunter, B. F. Goodrich Company.
 C. L. Johnson, Lockheed Aircraft Corporation.
 Ralph Johnson, United Air Lines.
 S. Paul Johnston, National Advisory Committee for Aeronautics (ex officio member).
 Karl Larson, Northwest Airlines.
 Dr. George W. Lewis, National Advisory Committee for Aeronautics (ex officio member).
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 G. H. B. Davis, Standard Oil Development Company.
 Lt. Comdr. Henry R. Dozier, United States Navy.
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Dr. George W. Lewis, National Advisory Committee for Aeronautics (ex officio member).

H. R. Lewis, Ohio Seamless Tubing Company.

Paul Merriman, Glenn L. Martin Company.

Alan L. Morse, Civil Aeronautics Administration.

H. G. Runde, Vought-Sikorsky Aircraft.

Lt. Comdr. J. E. Sullivan, United States Naval Reserve.

William H. Swanger, National Bureau of Standards.

A. J. Williamson, Summerill Tubing Company.

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SPECIAL SUBCOMMITTEE TO MAKE SURVEY OF TECHNIQUE AND EQUIPMENT FOR ELASTIC EXAMINATION OF LARGE AIRCRAFT STRUCTURES IN LIEU OF DESTRUCTION TESTS

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Dr. George W. Lewis, National Advisory Committee for Aeronautics (ex officio member).

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Eugene E. Lundquist, National Advisory Committee for Aeronautics.

Edward I. Ryder, Civil Aeronautics Administration.

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Lt. Comdr. William A. Evans, Jr., United States Navy.

Maj. Barney M. Giles, Air Corps, United States Army.

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J. W. Lankford, Civil Aeronautics Board.

Dr. George W. Lewis, National Advisory Committee for Aeronautics (ex officio member).

Maj. Charles W. Sullivan, Air Corps, United States Army.

Albert A. Vollmecke, Civil Aeronautics Administration.

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Prof. A. G. Christie, Johns Hopkins University.

Dr. Hugh L. Dryden, National Bureau of Standards.

Brig. Gen. O. P. Echols, Air Corps, United States Army.

Dr. Jerome C. Hunsaker.

Capt. S. M. Kraus, United States Navy.

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Dr. Jerome C. Hunsaker.

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John F. Victory, Secretary.

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Dr. Jerome C. Hunsaker, Chairman.

Dr. Charles G. Abbot.

Dr. Vannevar Bush.

Dr. George J. Mead.

John F. Victory, Secretary.

TECHNICAL PUBLICATIONS OF THE COMMITTEE

Because of the national emergency, and at the request of the Army and the Navy, the publications of the Committee presenting the results of its researches are classified as confidential or restricted, and as such are not available for general distribution.

To meet the needs of the Army, the Navy, and aircraft, engine, and accessories manufacturers who are contractors to the Army and the Navy, the Committee has inaugurated two new series of publications which are issued as advance reports. The distribution of these is limited for security.

The series known as technical memorandums contains translations and reproductions of important foreign aeronautical articles. This series is available to the public.

FINANCIAL REPORT

APPROPRIATIONS FOR FISCAL YEAR 1941

The general appropriation for the National Advisory Committee for Aeronautics for the fiscal year 1941, as contained in the Independent Offices Appropriation Act approved April 18, 1940, was \$2,775 000. The amount expended during 1941 was \$2,774,988, itemized as follows:

Personal services.....	\$1, 806, 535
Supplies and materials.....	223, 075
Communication service.....	10, 291
Travel expenses.....	40, 203
Transportation of things.....	18, 539
Furnishing of electricity.....	68, 171
Repairs and alterations.....	46, 580
Special and miscellaneous investigations.....	100, 000
Contracts for research.....	120, 000
Equipment.....	341, 594
Expended and obligated.....	2, 774, 988
Unexpended balance.....	12
Total, general appropriation.....	2, 775, 000

The appropriation for printing and binding was \$25,000, of which \$24,978 was expended.

The Independent Offices Appropriation Act, approved April 18, 1940, also provided \$1,000,000 for continuing the construction of additional facilities at Langley Field, Va., an initial sum of \$2,140,000 having been provided for this purpose in the Second Deficiency Appropriation Act, fiscal year 1939, approved May 2, 1939. Of this fund, the amount of \$1,220,741 was obligated during the fiscal year 1941.

The Independent Offices Appropriation Act, approved April 18, 1940, also provided \$4,200,000 for continuing the construction and equipment of an additional research laboratory at Moffett Field, Calif., an initial amount of \$1,890,980 having been provided for this purpose in the Third Deficiency Appropriation Act, fiscal year 1939, approved August 9, 1939, which act

also provided for entering into contracts not to exceed a total of \$10,000,000. Of this fund, the amount of \$2,276,791 was obligated during the fiscal year 1941.

The First Supplemental National Defense Appropriation Act, 1941, approved June 26, 1940, provided \$2,000,000 for beginning the construction and equipment of an aircraft engine research laboratory, on a site to be selected by the Committee, and authorized entering into contracts for construction and equipment of such buildings and facilities, including the purchase of land and rights-of-way, at a total cost of not to exceed \$8,400,000. Cleveland, Ohio, was selected as the site for this new laboratory, and the amount of \$1,165,869 was obligated during the fiscal year 1941.

The First Supplemental National Defense Appropriation Act, 1941, approved June 26, 1940, also provided \$1,200,000 for the construction and equipment at Langley Field, Va., of a power-generating plant. Of this amount \$1,151,326 was obligated during the fiscal year 1941.

The amount of \$1,460 was received during the fiscal year 1941 for two special deposit accounts to cover the cost of scientific investigations for manufacturers. This amount, with \$10,000 remaining from the previous fiscal year, made the amount of \$11,460 available for four tests. Two investigations were completed during 1941, resulting in a deposit of \$5,628.24 in the Treasury to the credit of Miscellaneous Receipts, as proceeds, and the return of \$1,571.76 to depositors.

APPROPRIATIONS FOR FISCAL YEAR 1942

The general appropriation for the fiscal year 1942, as contained in the Independent Offices Appropriation Act, 1942, approved April 5, 1941, was \$4,567,890, and the amount provided for printing and binding was \$25,000. This act also provided \$3,409,020 for continuing construction and equipment of the Ames Aeronautical Laboratory at Moffett Field, Calif., and \$5,600,000 for continuing construction and equipment of the aircraft engine research laboratory at Cleveland, Ohio. The total amount provided for the Committee in this act therefore was \$13,601,910.

The Second Deficiency Appropriation Act, 1941, approved July 3, 1941, provided an additional amount of \$465,000 for the general purposes contained in the Independent Offices Appropriation Act, 1942. An additional amount of \$875,000 was also provided for continuing the construction and equipment of additional laboratory buildings and research facilities at Langley Field, Va. This act also provided for an increase from \$8,400,000 to \$13,300,000 in the total cost of construction and equipment of the aircraft engine research laboratory at Cleveland, Ohio.

The Second Supplemental National Defense Appropriation Act, 1942, approved October 28, 1941, provided an additional amount of \$1,162,575 for the general pur-

poses contained in the Independent Offices Appropriation Act, 1942. An additional amount of \$261,425 was also included in this act for continuing the construction and equipment of additional laboratory facilities at Langley Field, Va. This act also provided for an increase from \$10,000,000 to \$16,207,500 in the total cost of construction and equipment of the Ames Aeronautical Laboratory at Moffett Field, Calif.

CONCLUSION

This country has embarked upon a tremendous aircraft production program. Its success, however, will depend not only on the number of airplanes produced but even more on their performance. Improvement in performance depends upon research. Adequate research requires modern and adequate facilities and trained personnel.

The recent establishment of additional research laboratories at Moffett Field, Calif., and at Cleveland, Ohio, and enlargement of facilities at Langley Field,

Va., will, when authorized construction is completed, mean an increase of about two hundred per cent in the Committee's research facilities. The staff to man the new facilities and to operate them on a two-shift and three-shift basis is being organized and trained.

It is essential that each new type of aircraft have performance superior to its predecessors. Through effective collaboration with the Army, the Navy, the Civil Aeronautics Administration, and the industry, improvement in performance has been materially accelerated by incorporating research results in new designs. Only from sustained and farsighted scientific research can the country have assurance that from its vast expenditures it will have aircraft at least equal to the best produced by others.

Respectfully submitted.

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS,
JEROME C. HUNSAKER, *Chairman*.

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