

U. S. DEPARTMENT OF COMMERCE

R. P. LAMONT, Secretary

BUREAU OF STANDARDS

LYMAN J. BRIGGS, Acting Director

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ANNUAL REPORT OF THE DIRECTOR OF THE BUREAU OF STANDARDS

TO THE

SECRETARY OF COMMERCE

FOR THE

FISCAL YEAR ENDED JUNE 30, 1932



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BUREAU OF STANDARDS

DEPARTMENT OF COMMERCE,
BUREAU OF STANDARDS,
Washington, July 20, 1932.

The honorable the SECRETARY OF COMMERCE.

DEAR MR. SECRETARY: From April 21, 1923, until July 2, 1932, the work of the Bureau of Standards was directed by Dr. George Kimball Burgess. While at his desk on the morning of July 2, Doctor Burgess was stricken with cerebral hemorrhage and died on his way to the hospital. He was a distinguished scientist and a wise and kindly administrator. His loss is keenly felt by every member of the staff and by his many friends in this country and abroad.

As acting director, I respectfully transmit the following report on the bureau's work during the fiscal year ended June 30, 1932:

GENERAL ACTIVITIES

Organization.—The regular staff at the close of the fiscal year numbered 1,035 employees. With miscellaneous assignments the grand total was 1,109 persons, a decrease of 62 as compared with last year. The turnover was very low, 2.7 per cent, against 5 per cent for 1931. There were no promotions.

Cooperation.—As of June 30, 66 research associates were stationed at the bureau representing 28 associations, as compared with 95 associates from 45 associations last year. The bureau has continued its close cooperation with all Government departments and with public and private organizations interested in its work.

Finances.—The congressional appropriations for the fiscal year 1932, exclusive of nonrecurring items, amounted to \$2,749,570. By curtailing certain activities, postponing new lines of work, and exercising special care to insure economical operation, approximately \$165,000 was turned back to the Treasury. Funds received from other governmental agencies for special investigations amounted to \$417,370.

Visiting committee.—The committee suffered a severe loss by the death on October 18, 1931, of its senior member, Dr. Samuel W. Stratton, who was Director of the Bureau of Standards from its organization in 1901 until 1923, when he resigned to accept the presidency of Massachusetts Institute of Technology. The present personnel of the committee is: Gano Dunn, Charles F. Kettering, Dr. Charles L. Reese, Morris E. Leeds, and Dr. Karl T. Compton. The committee held a formal meeting in June, 1932.

International relations.—In accordance with recommendations of the International Committee on Weights and Measures, the bureau,

jointly with the British and German national laboratories, made a new determination of the value for the international volt by means of silver voltameters. George W. Vinal represented the bureau in these measurements, which were carried out in Berlin during June and July, 1931. Mr. Vinal then went to Paris and London to compare our standard cells and resistances with the national standards of France and Great Britain.

E. C. Crittenden and Irwin G. Priest attended the International Illumination Congress in Great Britain and the sessions of the International Commission on Illumination held at Cambridge in September, Mr. Crittenden as the head of the American delegation and Mr. Priest as its technical adviser on problems of color measurement. The commission appointed an international technical committee of eight members, including one from the Bureau of Standards, to cooperate with the International Committee of Weights and Measures in establishing a uniform system of photometric units and standards. Representatives of the national laboratories decided upon a procedure for bringing their practical standards of candlepower into better agreement.

The bureau was represented by three members on the American committee of organization appointed to arrange for participation by this country in the International Electrical Congress in Paris in July, 1932; and on the invitation of the French committee in charge, special reports on problems of electrical measurement were prepared for the congress by H. B. Brooks, H. L. Curtis, N. E. Dorsey, R. L. Sanford, and G. W. Vinal. Doctor Curtis was designated as the bureau's representative at the congress.

L. S. Taylor attended the Third International Congress on Radiology in Paris as the representative of the United States on the International X-ray and Radium Protection Commission and of the Bureau of Standards on the X-ray units committee. Mr. Taylor carried one of the bureau's X-ray standards to the national laboratories of England, France, and Germany, where comparisons were made.

Comparisons of the temperature scales of the National Physical Laboratory, the Reichsanstalt, and the bureau, in the range in which the platinum, platinum-rhodium thermocouple is used to define the standard scale, were completed and a report on the work is in preparation.

The National Physical Laboratory, the Reichsanstalt, and the laboratory of the Rothschild Foundation are conducting experiments with the form of black body proposed by the Bureau of Standards for international adoption as the basis of a standard of light.

Weights and measures conference.—In the interests of economy the twenty-fifth meeting of the National Conference on Weights and Measures was postponed until next year.

Conference of State utility commission engineers.—The tenth annual conference of State utility commission engineers was held at the bureau on June 2 and 3. Committee reports and papers were presented on grounding of electrical circuits, protection of grade crossings, rural electrification, rules for bus operation, heating value of gas, liquefied petroleum gas, Diesel-engine operation, and on commission engineering activities.

Federal fire council.—A report was submitted on the fire-hazard survey of the portion of the Capitol group of buildings requested by a Senate resolution, and on water meter installations in lines serving Government buildings in the District of Columbia, the latter with particular relation to restriction of water flow for fire extinguishment. The inspection of Federal civil prisons, conducted under the auspices of this group by the National Fire Protective Association, was completed, reports being submitted on eight institutions. A form for use in inspecting properties for fire hazard and one for reporting of fires were developed and distributed to Government departments and establishments.

American Standards Association.—Close cooperation with this association has been continued. A member of the bureau's staff was detailed to the A. S. A. headquarters in New York as liaison officer for approximately 10 months. The bureau is sponsor for 17 standardization projects and is represented on 84 sectional and special committees.

National Screw Thread Commission.—The two meetings of the commission were devoted to consideration of necessary revisions of the latest report, special consideration being given to a proposed revision of the class 4 fit. The commission cooperated with the American Society of Mechanical Engineers, the Society of Automotive Engineers, and with manufacturers and users of screw-thread products in carrying out a survey of American screw-thread practice to learn the extent to which the standards set up by the commission are being followed by industry.

American Gage Design Committee.—This committee extended its work on the design of gage blanks for plain and thread plug and ring-limit gages by including size ranges not previously covered. A similar project on snap gages is nearing completion. The committee has had the fullest cooperation of manufacturers and users of limit gages in carrying on this work.

Federal Specifications Board.—This board, of which the Director of the Bureau of Standards is ex officio chairman, has promulgated 780 purchase specifications, including 305 during the past year. Many of these are based upon research work in the bureau's laboratories, and the chairmanships of many of the board's committees are held by members of the staff.

Publicity, bureau reports, etc.—The number of papers published in the Bureau of Standards Journal of Research was 124. In addition, the Technical News Bulletin and Commercial Standards Monthly were issued each month, and the sixth volume of the Standards Yearbook was released in May. Forty papers were published in the other series of the bureau. Approximately 250 papers were published in outside journals. Releases to the press totaled 276, including a few special illustrated articles on the general work of the bureau.

Testing.—Table 1 gives a summary of the bureau's test work during the past year. The total number of tests completed was 253,823, and the fee value \$944,302.83. The corresponding figures for 1931 are 212,717 and \$816,979.59.

TABLE 1.—*Numbers of test items, determinations, and fee value for tests completed during the fiscal year ended June 30, 1932*

Kind of instrument or material, class of test, or nature of service rendered	Number of test items for—			Total number of test items	Number of determinations	Fee value
	Public	Government departments and State institutions	Bureau of Standards			
Electrical standards, instruments and materials.....	587	961	591	2,139	3,325	\$14,799.77
Electric batteries.....		2,028	6	2,034	4,599	12,215.50
Electric lamps and lighting equipment.....	444	3,662	267	4,373	4,548	128,650.47
Length-measuring devices.....	129	148	9	286	2,127	2,610.00
Gages and gage steels.....	1,132	854	81	2,067	8,216	1,708.75
Hæmacytometers, sieves, thermal expansion, etc.....	1,785	1,824	92	3,701	12,251	9,152.90
Weights and balances.....	2,267	2,843	340	5,450	12,285	5,737.40
Scales.....	1	1,134	4	1,139	34,272	53,807.00
Timepieces.....	165	52	49	266	7,091	1,785.00
Volumetric apparatus.....	6,477	6,386	467	13,330	26,936	8,395.40
Hydrometers.....	382	437		819	2,269	1,017.00
Density determinations.....			167	167	219	247.00
Laboratory thermometers.....	2,023	340	401	2,764	12,216	7,286.50
Clinical thermometers.....	15,329	111,095		126,424	435,498	17,763.00
Pyrometers, calorimeters, etc.....	163	46	86	295	3,229	3,391.25
Insulating materials.....	49	32	2	83	122	1,295.00
Fire-resisting materials.....	6	56		62	118	7,330.00
Fuels and lubricants.....	132	2,060	189	2,381	9,881	33,947.50
Automotive equipment, etc.....	17	57	1	75	247	4,258.00
Airplane engines.....		28		28	185	43,700.00
Optical instruments and materials.....	387	725	432	1,544	5,604	6,390.15
Carbohydrates.....	1	1,874		1,875	2,838	3,086.00
Radioactive materials.....	1,486	37	4	1,527	913	6,115.50
Engineering instruments and appliances.....	149	1,251	28	1,428	1,570	21,313.15
Aeronautic instruments.....	33	395		428	2,017	6,315.50
Aerodynamic tests of models.....	1	29		30	113	710.00
Physical properties of engineering materials.....	68	3,275	82	3,425	6,218	22,625.01
Sound producing and measuring instruments.....	6	22		28	28	350.00
Making of special castings.....		66	123	189	593	1,177.22
Fusible boiler plugs.....		279		279	558	697.50
Metallographic examinations.....		388	82	470	4,181	6,588.12
Miscellaneous metallurgical tests.....		363	369	732	2,787	6,715.49
Pottery and chinaware.....		10		10	25	35.00
Glass.....		32	23	55	82	228.50
Refractories and heavy clay products.....		3,957	49	4,006	8,546	17,531.50
Cement, concreting materials, lime, etc.....	12	28,092	30	28,134	124,356	292,675.50
Stone and sand-lime brick.....		89	46	135	330	1,256.00
Miscellaneous ceramic materials.....	70	9,841	7,140	17,051	36,217	38,264.30
Rubber.....		2,251	8	2,259	12,878	44,781.50
Textiles.....	107	7,191	102	7,400	17,696	48,552.50
Paper.....	13	2,484	34	2,531	8,616	23,321.00
Leather.....	1	718		719	2,664	4,952.00
Paint, varnish, and bituminous materials.....	8	4,538	226	4,772	34,360	95,719.00
Chemical analysis of metals.....	5	447	273	725	3,291	12,672.95
Chemical tests of miscellaneous materials.....	5	911	57	973	4,156	11,436.00
Distribution of standard samples.....	4,955	256	4	5,215	73	11,696.00
Total.....	38,395	203,564	11,864	253,823	3,860,344	3,944,302.83

¹ Includes fee value of \$5,051.97 for inspecting 1,792,265 incandescent lamps at various factories for other branches of the Government.

² Includes fee value of \$55,719 for sampling 2,576,947 barrels Portland and 19,500 barrels masonry cement; testing 3,069,176 barrels Portland and 20,800 barrels masonry cement; and shipping 2,313,986 barrels Portland and 28,990 barrels masonry cement.

³ Of these totals 145,789 determinations were for the public, fee value \$56,158.44; 680,377 determinations were for the Government departments and State institutions, fee value \$844,162.08; 34,178 determinations were for the bureau, fee value \$43,982.31. The number of test items and determinations necessary in connection with the bureau's own work of research and standardization, with the resulting fee values, is not included in these totals.

SALARIES (\$732,740)

Under this appropriation are carried the general administrative functions of the bureau, the operation of the power plant, the maintenance force, and in a large measure the instrument, carpenter, and glass shops. A large part of the testing for the Government is conducted under this fund, as well as the care and comparison of the standards, and the determination of fundamental constants not otherwise provided for.

Maintenance of international electrical units.—For the fourth consecutive year comparisons of electrical units were made by taking standard cells and resistance coils to the principal European standardizing laboratories. By using the new type of resistance standards developed in the Bureau of Standards a considerably higher precision has been obtained. The recent comparisons show that the ohm of Great Britain and that of Germany now differ by less than 2 parts in 100,000, while the ohm of the United States is between the two. The French unit is larger than that of the United States by 7 parts in 100,000.

Known discrepancies in the values for the second basic unit, the volt, led to a special joint test, by means of silver voltameters, at the German national laboratory, by representatives of Germany, Great Britain, and the United States. The German value for standard cells was found in error. Correction brought the units of the three laboratories into agreement within 3 parts in 100,000, the volt of the bureau having the lowest value of the three. The French unit is smaller still by 3 parts in 100,000.

New basis for electrical units.—The plan of the various national laboratories to replace the present international electrical units (which are represented by arbitrary standards) by others not slightly different, but concordant with mechanical units, requires most precise determinations of the new units. As its part of the program, the bureau is establishing a value for the ohm by two methods, both of which involve the construction of inductance coils having dimensions which must be very accurately measured; and it is establishing the ampere by weighing the forces between coils carrying electric current. The work of the last year has been largely a study of the many small corrections necessary in order to assure the highest attainable accuracy in the final results.

Corrections to results previously obtained with the Rosa-Dorsey-Miller current balance indicate that the international ampere equals 0.99996 absolute ampere. The corrected value of the ohm (derived from a coil on porcelain) is 1 international ohm equals 1.000463 absolute ohms. An independent determination with a coil wound on quartz gives 1.000458, but corrections for variation in pitch of the windings are yet to be made.

Magnetic testing and research.—The results of two bureau investigations were utilized in a revision of the specifications of the American Society for Testing Materials for standard methods of magnetic testing. An investigation completed during the year on effect of mechanical strain on magnetic properties will aid materially in interpreting results of magnetic tests made for the purpose of determining the fitness of steel products for specific purposes. Thermo-

magnetic analysis of heat-treated steel wire gave conclusive evidence of aging effects.

Maintenance of the international candle.—International measurements on 10 carbon-filament lamps supplied by this bureau have shown that the standards of luminous intensity as maintained in France, Great Britain, and the United States are in close agreement while that of Germany (computed from the Hefner unit) is smaller by more than 1 per cent. This difference is in the basic unit; still larger discrepancies arise in measurements on lamps of commercial types because of difference in color of the light. The national laboratories of the four countries mentioned have agreed to bring their standards of light into accord through the use of the visibility factors established by measurements at the bureau some years ago and since accepted by the International Commission on Illumination. Colored filters to serve this purpose are being circulated for final measurement at the four laboratories.

Use of light waves for the production of end standards.—To compare the accuracy of end-standard calibration, 16 decimeter end standards of fused quartz are being constructed and measured and will be submitted to the principal national laboratories for their calibration. It is hoped to reduce all errors of plane-parallelism of the ends and of the length to less than one-millionth of an inch.

Ultra-violet window glass; sources of ultra-violet radiation for health purposes.—In cooperation with the Council on Physical Therapy of the American Medical Association data have been obtained and specifications prepared on the minimum permissible transparency of window glass designed to transmit ultra-violet solar radiation. A minimum permissible intensity has also been established for artificial sources of ultra-violet radiation. Various methods of measuring the ultra-violet output of sources of radiation were investigated, and a balanced thermocouple and filter radiometer developed which satisfies the requirements of a standard laboratory ultra-violet dosage-intensity meter.

International temperature standards.—Seven precision platinum resistance thermometers from the national laboratories of England, Germany, and the United States were intercompared for the establishment of international uniformity in temperature measurements.

Comparison of line standards of length.—A recomparison of the bureau's secondary standards of length was completed during the year. The secondary and working standard meter bars have not changed in length by more than 0.2 micron since the last previous comparison. Two invar meter bars measured in 1924 and again in 1929 have shortened several microns during the past eight years. This result was unexpected, as invar bars usually lengthen with time.

Platinum-iridium meter bar No. 21 is now at the International Bureau of Weights and Measures for recomparison with the international standard.

Horological Institute.—Cooperation with the Horological Institute has continued, and during the year certificates have been issued by the institute to 56 junior watchmakers and 32 certified watchmakers.

Preparation of ethyl-alcohol tables.—At the request of the Treasury Department certain tables of the Gauger's Manual on the density

and thermal expansion of ethyl alcohol and its mixtures with water have been recalculated on the basis of results obtained at this bureau.

Extension of the temperature scale to -259° C.—The increased industrial application of low temperatures has stimulated research in this field. In response to urgent requests the bureau has undertaken the extension of the scale of temperatures from -190° C. to -259° C. A temporary scale covering this range has been established.

Low-temperature calibration of thermometers.—To assist in the exact control of low temperatures, necessary in commercial manufacturing processes, many liquid-in-glass and electrical thermometers, thermocouples, and resistance thermometers have been calibrated, at low temperatures.

Development of seismometers.—The basic theory underlying galvanometer design has been successfully extended to include the development of improved seismometers and other instruments for studying the effects of earthquakes. In recognition of this work the Franklin Institute awarded the Wetherill medal to Dr. Frank Wenner.

Elastic hysteresis research.—An experimental investigation has been completed of the method of determining the relation between statical hysteresis and flexural stress by measuring the decrement of a freely vibrating U bar. The results of the investigation, which have been published in the Journal of Research, show this method to be especially suitable for low stresses.

Instruments for measuring tilt of earth's strata.—In response to requests for some instrumental means of predicting imminent earthquakes, two types of tiltmeter, based on optical interference, have been designed and constructed and are being subjected to test in different localities. These instruments are theoretically capable of revealing tilts as small as one-tenth second of angle, and the laboratory tests corroborate this. If these instruments prove practicable, they should find application in other fields where small tilts under load are important.

Photographic sensitometry.—In connection with the international standardization of sensitometric methods, a study is being made of developing agents and of the effect of variations in the composition of the developing solutions.

The Eighth International Congress of Photography formally adopted one of the Davis-Gibson light filters, which were developed at the bureau, as an international standard filter for use in the sensitometry of negative materials. The International Commission on Illumination has also adopted three of these filters for use in colorimetry.

Test of airplane photographic objectives.—Determinations of the focal length and distortion have been made for the Air Corps of the War Department on 79 airplane-camera lenses, employing methods developed at this bureau. Such tests are necessary for any lens which is to be used for airplane mapping. A new lens-testing apparatus, which reduces the necessary time to about two work days per lens, has been designed and is in use.

Refractive index of distilled water.—The refractive properties of water have been determined for several wave lengths of the visible

spectrum at 5° intervals in the temperature range 0° to 60° C. The results are referred to dry air at standard pressure and at the temperature of the water. These data are considered accurate within ± 0.000003 in index.

Concentration of the new isotope of hydrogen in water.—By fractional electrolysis, the concentration of hydrogen isotope of mass 2 in water has been raised from 1 part in 30,000 to 2 parts in 1,000. The water containing the higher concentration of this isotope has a density greater than that of ordinary water by 16 parts in 100,000.

Hydrocarbons from petroleum.—With the cooperation and financial support of the American Petroleum Institute, the following new hydrocarbons have been isolated from petroleum: 2-methylhexane, *p*-xylene, *o*-xylene, *m*-xylene, ethylbenzene, 2-methylheptane, *n*-decane.

Methods of analysis.—New or improved methods have been developed for the determination of tin in ferrous materials, cobalt in irons and steels, silicon in ferrous materials, and molybdenum in ores and metallurgical materials. Critical study of methods for determining impurities in reagent chemicals was continued in cooperation with the American Chemical Society. Seventeen new specifications were published, making a total of 121 which are recognized by all American producers of reagents.

Volume change at an electrode during electrolysis.—An electrode pycnometer, suitable for determining volume changes at the electrode during electrochemical reactions, has been developed and applied to certain electrodes in the determination of transference numbers by the moving-boundary method.

Platinum metals.—An accurate method for the analytical separation of rhodium and iridium has been developed, together with methods for the determination of the two metals. A beginning was made on a complete procedure for the analysis of materials containing all of the platinum metals. Spectrographically pure iridium and rhodium were prepared for use in the bureau's work on primary standards of light.

Crystal structure of metals.—The presence of unstable phases in metallic alloys often limits their practical usefulness, as in certain die castings. Zinc-aluminum alloys are being studied to show the underlying changes in crystal structure and possible means of stabilizing such alloys by inhibiting these changes.

Preparation and properties of pure iron.—The critical review of the literature on pure iron, in preparation for a monograph in cooperation with Engineering Foundation, is nearing completion. Pure iron, the basis of all steels, is practically unknown. A method has been developed for preparing iron oxide of unusual purity and the conversion of the oxide without contamination to metallic iron is now in progress.

Carbon-oxygen equilibrium in molten iron.—This reaction is the basis of all steel-making processes. Experimental determination of the carbon-oxygen equilibrium in liquid steel at three different temperatures has been completed and the determination of the hydrogen-oxygen equilibrium is in progress.

"Body" of carbon tool steel.—It is well known that steels of the same apparent composition may differ decidedly in properties, and

this is of considerable practical importance in tool steels. Work has been undertaken to define more precisely the cause of the so-called body or timbre or tool steels.

Test for galvanized coatings.—In specifying the quality of zinc coating of many galvanized-steel products an old simple test of immersion in copper sulphate solution has been relied upon, in spite of its limitations and the misleading results often obtained. The bureau proposes a modification which will yield dependable results.

Thermal conductivity of metals.—The thermal conductivity of 21 metals and alloys was determined over the range 100° to 550° C. A study of the relations between thermal conductivity and constitutional changes of certain commercial alloys is in progress.

Information circular on zinc.—This is an addition to the bureau's series of circulars on the technology, properties, and uses of commercial metals, and embodies results of a critical survey of the technical literature on zinc supplemented by results obtained in past investigations at the bureau.

Chemical nature of rubber.—The crystallinity of rubber hydrocarbon has been established, refractive indices and melting point (10° C.) determined, and accurate analyses made, all for the first time.

Cooperation with American Society for Testing Materials.—The bureau has cooperated with the American Society for Testing Materials in the preparation of specifications and methods of test of a number of paint, varnish, lacquer, and bituminous roofing and waterproofing materials and also methods for the chemical analysis of ferrous and nonferrous materials.

Miscellaneous investigations.—Experimental work on a recording gas calorimeter was completed and the results prepared for publication; a twin-bomb method was developed for the measurement of the pressure-volume-temperature data for gases; the coefficient of thermal expansion of benzoic acid was determined between 15° and 30° C.; a satisfactory method was developed for determining the insoluble matter in shellac; and a more rugged modification of the glass electrode was constructed which is useful in measuring the pH (acidity) of various solutions.

EQUIPMENT (\$213,000)

This appropriation provides for the purchase of equipment and supplies for the general testing and operating expenses of the bureau. Additional funds were provided this year for (1) carbon-dioxide refrigerating system, (2) renovation of buildings, and (3) addition to the dynamometer laboratory.

Shop consolidation.—The instrument, machine, woodworking, glass-grinding and glass-blowing shops have been moved to the north building. This necessitated extensive realignment of power and other lines, but the consolidation will effect economies in operation and increase efficiency.

Mechanical plant upkeep.—The replacement of worn-out piping, fittings, electrical installations, etc., has been made as required, and, in addition, two boiler-water deconcentrators and a number of electrical panel boards and motors have been installed. The new carbon-

dioxide refrigerating plant will soon be placed in service, and through an elaborate piping system will make refrigeration available in all of the major buildings.

Repairs and alterations.—The necessary repairs and alterations have been made to the buildings, and with the extra amount appropriated for renovating the buildings extensive repairs, consisting of roofing and stonework, interior and exterior painting, plastering, etc., have been made on the principal buildings.

Dynamometer laboratory addition.—The addition to the dynamometer laboratory provided for under this appropriation will soon be ready for occupancy. This permits the centralization of scattered units of testing and research work in the automotive group, and will result in a more efficient and satisfactory working condition, at lower cost to the Government.

Laboratory equipment.—The equipment for life-testing of electric lamps was much improved by the purchase and installation of a 100-kilowatt motor-generator set, with the necessary regulating equipment, and a 100-kilovolt-ampere transformer. Other items purchased were a clock system, spectrograph and prism, potentiometers, recorders, variable induction coils, high-frequency convertor, etc.

GENERAL EXPENSES (\$64,000)

Power plant.—The major expenditures under this appropriation are for coal for heating and power and electric current for power and lighting. There is a steady increase in the demands for this service.

Miscellaneous supplies.—Stationery, other office expenses, cleaning and toilet supplies, special gloves, goggles, etc., as well as the repair and maintenance of passenger cars and motor trucks, are provided as needed. The requirements are reduced to the minimum.

Library.—The total number of accessioned volumes is now 37,671. Scientific and technical periodicals received now number 1,211.

Travel.—The traveling expenses of the visiting committee, the annual traveling expenses of the bureau lamp inspector, and travel of the staff on the general business of the bureau is provided for from this fund.

IMPROVEMENT AND CARE OF GROUNDS (\$14,400)

Improvement of grounds.—In addition to maintenance work on the grounds, additional areas have been seeded and placed in reasonably good condition. A new entrance road on the west side of the property has been rough graded and the foundation for a road to the hydraulics building completed.

TESTING STRUCTURAL MATERIALS (\$333,200)

Building stone.—Seventy-five samples of stone were tested for Government departments and 37 samples for the public. This included investigations of the cause of decay in the interior marble of a post office building, determination of the physical characteristics of 14 samples of stone from Montana for the United States En-

gineer Office, study of stone preservative treatments at the request of Public Buildings and Public Parks and the National Park Service, and study of a peculiar type of discoloration on limestone.

An investigation of the physical properties and weathering characteristics of the commercial granites of this country has been started. Fifty samples have been collected from Maine, Vermont, New Hampshire, Massachusetts, Connecticut, North Carolina, South Carolina, Georgia, Wisconsin, Minnesota, and Texas.

Slate.—An investigation of slate has been completed and used by the Federal Specifications Board in formulating a quality specification for roofing slate. Forty-seven samples of roofing slate have been tested for Government buildings.

Brick masonry.—Shear tests of reinforced beams indicate that resistance to failure by diagonal tension depends largely on the arrangement of the brick and the tensile and shearing bond strength of mortar to brick. The investigation of the physical properties of mortars and bricks and of the durability of the bond of mortar to brick has been continued.

Cinder concrete building units.—Data have been obtained on the weight, hardness, particle-size distribution, ignition loss, and soundness of cinder aggregates from 57 different sources. Equipment has been designed and built for making and testing concrete specimens from most of these aggregates.

Plastic (calking) cements.—The test procedure developed at the bureau is now being used for testing practically all plastic cements used in Government construction, 345 samples having been tested this year. Some of the large manufacturers are using this test procedure to control their processes.

Chemical properties of cement.—The Portland Cement Association Fellowship has continued its study of the basic chemical problems of the cement industry with a view to extending the usefulness and improving the durability of concrete structures. One paper has been published on the compounds formed by soda in a part of the chemical system of Portland cement. The influence of composition on the qualities of the resulting cements is receiving attention, particularly the heat liberated during hardening and the volume changes of specimens stored under various conditions of exposure.

High early strength cements.—Strength and volume changes have been determined for different water-cement ratios, initial temperatures, and curing conditions for 13 brands of high early strength cements. Concrete specimens are being subjected to alternations of drying, soaking, and freezing, and compared with specimens stored under normal conditions.

Masonry cements.—Workability, water-retaining capacity, volume change in the wet and dry condition, compressive strength, transverse strength, and modulus of elasticity, rate of water absorption, and resistance to freezing and thawing have been determined for 40 brands of masonry cements now on the market. Compressive strengths ranged from 10 to 3,000 pounds per square inch at the end of seven days. Resistance to freezing and thawing varied from failure in 2 cycles to no signs of failure in 30 cycles.

Properties of cements.—Investigations in progress dealing with the properties of cement include: Volume changes of mortars during

and subsequent to setting, temperature studies of cement during setting, effect of fineness of cement on the strength, reaction of calcium chloride on cement, reaction of water on calcium aluminates, and phase equilibrium studies of the systems $\text{CaO-B}_2\text{O}_3$ and $\text{CaO-SiO}_2\text{-H}_2\text{O}$.

Cement reference laboratory.—The cement reference laboratory, a cooperative project of the Bureau of Standards and the American Society for Testing Materials, devoted the greater part of its activities to field work, inspecting 175 cement laboratories. The Bureau of Public Roads has required this inspection at all laboratories which test cement for Federal-aid projects.

Branch laboratories and inspection of cement.—The bureau's branch laboratories in Pennsylvania, Colorado, and California, together with the laboratory in Washington, tested 3,089,976 barrels of cement during the year for Government purchasing agencies; 2,342,976 barrels of the tested cement were shipped under bureau supervision, an increase of 26 per cent over last year.

Gypsum.—Methods have been devised for preparing calcium sulphate and its hydrates of high degree of purity, and their heats of solution in 2 *N* hydrochloric acid have been determined at 30° C. Rapid methods have been devised for determining the purity of gypsum plaster and the sand content of set gypsum plaster, using a solution of ammonium acetate as a solvent. Determination of the chemical and physical properties of nine samples of commercial Keene's cement led to a proposed Federal specification for this material.

Vitreous enamels.—The thermal expansion at temperatures approaching those at which the enamel is formed has been studied, as well as the effect of composition on the expansion and the modulus of elasticity.

Miscellaneous structural materials.—Papers have been published or are in preparation based on the following investigations: Durability of concrete aggregates, determination of the particle size of hydrated lime, study of commercial waterproofing compounds for concrete, properties of cast stone, tests of one of the arches of the Arlington Memorial Bridge, the properties of common brick from 36 States, and the effect of clay admixtures on concrete.

Building codes.—Nearly 300 cities reported the use of the recommended minimum requirements of the building code committee. Assistance was given numerous local and State code committees and building officials. Progress was made on building exits and precautions during erection of buildings. Revised requirements were prepared for small dwellings to afford owners the maximum use of latest developments consistent with safety.

Plumbing codes.—Continued study was given the performance of plumbing systems with particular reference to possible reductions in required pipe sizes.

Cooperation on building and housing problems.—The President's Conference on Home Building and Home Ownership in December afforded unusual opportunity for advancement of projects in cooperation with representatives from all sections of the country. The committees especially concerned included those on fundamental equipment (heating, plumbing, lighting, refrigeration, etc.), utilities

for houses, subdivision layout, business and housing, industrial decentralization and housing, blighted areas and slums, reconditioning, remodeling and modernizing, construction, city planning and zoning, finance, home ownership and leasing, home information centers, relationship of income and the home, legislation and administration, and technological developments. These subjects were taken up with special reference to low-cost housing for families of small income, through reduced costs and improved methods and quality in construction materials and equipment.

Joint studies, made with committees of the national conference on construction, aim to help stabilize construction activity and enable the industry better to serve the public.

City planning and zoning.—Periodic reports and study of local subdivision regulations were continued.

Home financing.—Investigations of the home financing situation were made for the President's conference, and for the congressional committees which considered the Federal home loan bank bill.

TESTING MACHINES (\$54,700)

Calibration of proving rings.—Forty-two proving rings have been calibrated and certified for industrial and other laboratories during the past year for use in calibrating their testing machines. The continually increasing use of proving rings shows that the development of this device by the bureau has materially furthered the standardizing of testing machines. Special tests showed that even with the largest (300,000 pounds) rings all thermal effects became negligible in less than 50 seconds, which is about the minimum time required to take a reading during calibration. The thermal time lag in some other elastic calibrating devices was found to be four or five times as great.

Steel columns incased in brickwork.—At the request of the municipal architect, District of Columbia, 6-inch rolled-steel columns, 22½ feet long, were tested in compression, some incased in brick walls, and some bare. The columns incased in brickwork did not buckle sidewise as did the bare columns, but were much stronger, behaving like very short bare columns. The results of these tests are now being applied in the design of some District buildings and will effect a saving in cost.

Reinforcing bars for concrete.—There is no general agreement on the method which should be used to determine the cross-sectional area of deformed bars when samples are tested for yield point and ultimate strength. An investigation was made of the four methods which have been widely used in this country. The results showed definitely that if the area is computed from the length and weight of the bar more consistent results are obtained at less cost than if any of the other methods are used.

Reinforced brick masonry.—Steel bars are extensively used in other parts of the world, especially India, to reinforce brick masonry (such as beams) subjected to bending moments. There is considerable interest in this subject in this country because in some cases it appears more economical to use brick than to use concrete. A preliminary investigation was therefore made of the strength of brick beams rein-

forced by steel bars near the lower surface. The results showed that, in general, the methods used for the design of reinforced concrete could be followed in designing reinforced brickwork.

Impact resistance of screw threads.—An investigation is in progress covering the impact resistance of bolts with different forms of threads—American national coarse, American national fine, and Dardelet. Five different metals and four sizes of bolts were used for each thread. Through the cooperation of the War Department the specimens were tested in the large Charpy-type impact machine at Watertown Arsenal. The results show that for the materials tested the impact resistance of bolts with American national fine threads and Dardelet threads is considerably greater than that of bolts with American national coarse threads. The last-named thread is used in most machines and engineering structures at present.

Formed sheet-steel floor.—In cooperation with the American Institute of Steel Construction an investigation has been made of the strength and other properties of a floor made from two sheets of steel which are bent and then fastened together by electric spot welds to form a panel having longitudinal cells. The tests showed that these panels were light and strong.

Wire rope.—In cooperation with the American Society of Mechanical Engineers an investigation has been started to determine the tensile strength of wire rope after it has been removed from service and to obtain reliable methods which can be used by the inspector to determine when a rope having worn or broken wires becomes unsafe. Over 100 samples of worn wire rope accompanied by complete data sheets have been obtained by the wire rope research committee of the A. S. M. E. Users of wire rope are showing a great deal of interest in this investigation which may result in replacing ropes less frequently and thereby effect appreciable savings.

INVESTIGATION OF FIRE-RESISTING PROPERTIES (\$34,820)

General scope.—Results of this work help to safeguard buildings, contents, and personnel, within and outside the Government service, from the dangers of fire. Many fire tests of materials and equipment mainly for Government services were made during the year.

Protection of records.—Four reports were published on record classification and protection. The revision of Federal specifications for insulated safes was completed, and three safes were tested to determine conformity with specification requirements. A survey made of the property of bureaus of the Department of Commerce showed that for a total value of buildings and contents of approximately \$225,000,000, over 80 per cent consists of records and similar uninventoried values.

Fire tests of welded-steel floors.—A special furnace was constructed in 1931 for the testing of this new type of construction which consists of a steel floor plate welded to beams spaced 2 feet apart. Six tests were made with fire above the floor and five with fire below, with various types of protection.

Automatic fire detection.—A new oven for conducting sensitivity tests of thermosensitive elements was constructed and work done on standardizing the test and instruments used to measure temperature rise.

Other research projects.—These included fire tests of partitions, gypsum column protection, theater proscenium curtains, motion-picture projectors and booths, fire-retardant treated wood, roofing materials, compression tests of steel and cast iron at high temperatures, investigation of fire causes, susceptibility of materials to spontaneous heating and ignition, and standardization of the fire-testing procedure.

INVESTIGATION OF PUBLIC-UTILITY STANDARDS (\$106,570)

Electrical codes.—A 1932 edition of the Electrical Code, combining accident-prevention and fire-prevention features, was issued, and work was carried on almost continuously on the revision and interpretation of the National Electrical Code. A revision of the Code for Protection Against Lightning has been completed. Definitions of electrical terms have been standardized through the activities of a national committee.

Engineering studies of Government telephone service.—On request of, and in cooperation with, the Chief Coordinator, Supervising Architect, Bureau of Prisons, Post Office Department, Public Health Service, and other agencies, studies were made to determine the most economical method of meeting the telephone-service requirements in a large number of Federal buildings in and outside of Washington. Substantial savings have been effected without restricting the amount or quality of service.

Standards for gas service.—The standards of service voluntarily maintained by 370 of the largest gas companies were compared and tabulated. A revised set of rules for recommendation to State regulatory bodies and (with modifications) to municipalities was prepared. Two States and two municipalities were advised on standards of service, and conferences on the same subject were held in Washington with official representatives of six States.

Effect of altitude on the use of gas.—In cities at high altitudes trouble has developed with gas appliances found to be satisfactory for use at sea level. A study has been undertaken of the causes of the trouble and their remedy.

Design of gas appliances.—A thorough investigation was made of the factors which determine the best design for an appliance to use natural gas. The studies included the effect of variable conditions of service and adjustment in relation to design, a knowledge of which is essential in the consideration of standards of service rendered by a public utility supplying fuel gas.

Elimination of hazards in the use of gas.—The bureau has cooperated with the American Standards Association, the American Gas Association, the National Fire Protection Association, the District of Columbia, the Washington Gas Light Co., and the President's conference on home ownership, in eliminating the hazard from carbon-monoxide poisoning.

Soil-corrosion studies.—The investigation of the relation of soils to underground corrosion, begun in 1922, has now reached a stage where some definite conclusions can be drawn, although the last of the specimens originally buried will not be removed until 1934. Soils containing considerable quantities of soluble salts or acids are nearly

always corrosive, as are heavy clays which shrink badly on drying. Ferrous pipe materials have been found to behave similarly under similar soil conditions, but the corrosion products of cast materials differ somewhat from those of wrought materials. Two methods for identifying corrosive soils in the field have been developed.

TESTING MISCELLANEOUS MATERIALS (\$46,160)

Tests for Government departments.—One of the primary functions of the bureau is the testing of supplies purchased by the National Government. During the year an unusually large number of paints, varnishes, bituminous roofing and waterproofing materials, cements, detergents, boiler plugs, dental alloys, reagent chemicals, and other materials were tested.

RADIO RESEARCH (\$85,280)

Primary frequency standard.—The accuracy of this standard was further increased to 1 part in 10,000,000. Precise studies were made of the functioning of the various elements of the standard. An auxiliary unit was constructed to guard against stoppage of the four original oscillators, and special equipment was installed to protect against failure of the power supply.

Secondary frequency standards.—New piezooscillators were designed and constructed and were found to be remarkably constant in frequency. They are of wide application as standards and as control units for radio transmitters.

Standard frequency dissemination.—The standard frequency service was extended and improved. Regular transmissions were provided on a frequency of 5,000 kilocycles per second for four hours every Tuesday. The accuracy was better than 1 cycle per second (1 part in 5,000,000). Some of the transmissions were controlled, by wire-line transmission of a frequency from the national primary standard.

Measurement of radio field intensity.—Methods and apparatus developed for the automatic recording of field intensities of distant radio stations were applied to a study of effects produced by the synchronization of two pairs of broadcasting stations. Research on the accuracy of measurement of field intensity and on short-distance absorption of radio waves was completed.

Measurement of height of ionized layer.—The ionized layer in the atmosphere, more than 70 miles above the ground, has been determined to be the major determining factor in the long-distance transmission of radio waves. The measurement of the height of this layer is of primary importance in interpreting transmission conditions and increasing our knowledge of radio-wave propagation. Such measurements were made on one day each week, using improved equipment. This included an automatic recorder, which will allow continuous measurement of the height in the future.

Radio research facilities.—Two experimental radio stations were established in the suburbs of Washington. One is a transmitting station located on the animal husbandry farm of the Department of Agriculture near Beltsville, Md. The other is a receiving station; for this 200 acres of land were purchased near Meadows, Md. Six

small frame buildings were erected. Facilities are thus provided for an improved standard frequency transmission service and for researches on radio-wave transmission.

COLOR STANDARDIZATION (\$15,680)

Calibration of Lovibond glasses.—These color standards—the complete set numbering upwards of 400 different colors—are used extensively by the vegetable-oil and other industries as a basis for the fulfillment of contract. Their extended use made it advisable for the bureau to investigate their colorimetric accuracy individually and in combination, and steps have been taken to bring about international standardization of these glasses. The statistical investigation of the uniformity of red glasses has been continued, and a new fundamental standardization of the red, yellow, and blue series has been undertaken.

Standard glass filters.—These are intended for checking spectrophotometric transmission as determined by various instruments and different laboratories. Filters of five different kinds of glass have been selected, and measurements of the spectral transmission of four have been made. In accordance with a plan agreed upon by the national laboratories of Great Britain, Germany, and the United States, one set of these glasses, measured with great care, is to be sent in turn to the National Physical Laboratory of Great Britain and the Reichsanstalt of Germany to serve in an international comparison of measurements of spectral transmission.

Color grading of illuminants.—The color of illuminants is expressed by their “color temperature”; that is, by the temperature of a closed cavity which most nearly matches the illuminant in question. Preliminary work has been done toward using the radiation from freezing iridium and other metals as standards of color temperature.

INVESTIGATION OF CLAY PRODUCTS (\$48,760)

Special low-fire white-ware bodies.—Ceramic bodies comparable in transverse breaking strength to earthenware and resistant to crazing and mechanical abrasion, nearly white in color, and varying in absorption from 1 to 5 per cent, were made of commercially available materials by the dry-press process and matured below 1,000° C.

Factors affecting the crazing of earthenware.—The data obtained indicate that the fused feldspar of earthenware bodies is the most susceptible ingredient to moisture expansion. When absorption has been reduced to about 10 per cent during firing, the increased content of fused feldspar produces structures of least resistance to crazing.

Study of refractories.—The transverse strength and modulus of elasticity obtained at 1,250° C. of 17 different brands of fire-clay brick were increased from 100 to 400 per cent by first reheating the brick for 5 hours at 1,400° C. The plastic deflection under load, on the other hand, was decreased as much as 60 per cent. Progressively increasing the firing temperature of 5 representative kaolins affected

the thermal expansion of those containing the greater amount of foreign material to a less extent than those of higher purity.

Thermal dilatation of fire clay and special refractories.—Linear expansion measurements were made on 18 different materials, including chrome ores, ball clays, fire-clay bricks, kaolins, fire clays, magnesite, and high-alumina brick, at various temperatures up to 1,800° C. The thermal expansion was materially changed in practically all cases when the same specimen was put through the same temperature cycle a second time.

Ceramic materials of low thermal expansion.—An investigation was made of several ceramic materials which were believed to have very low coefficients of thermal expansion. This was found to be true of cordierite, zinc orthosilicate, celsian, and beryl. A body approximating cordierite is used commercially.

Extrusion machines for clay.—Data have been obtained regarding the performance of auger machines as determined by the type of auger tip, the length of the collective spacer, and the length and taper of both die and cores. The design of the auger and taper of the die affect both the rate of extrusion and the power consumption. The length of the collective spacer affects power consumption and (within certain limits) the rate of extrusion while the length of die, within practicable limits, influences only the power requirements.

Resistance of materials to abrasive action of plastic clay.—Tests were continued on dies made from 19 metals and alloys using the "standard" abrasive mixture of 60 clay and 40 glass sand and a plastic porcelain composition for comparison with the "standard." Abrasion tests of dies made from sillimanite porcelain gave a high abrasive resistance at first, the resistance decreasing with depth.

Columbus laboratory.—To determine the nature of the glassy bond formed in fired ceramic materials, the tensile strength, elasticity, and fusing point of five eutectic glasses and a number of blends were determined. The effect of mica, a common impurity of clays and feldspars, was noted. Five and ten per cent additions of the mica were readily absorbed. A comparative study of the properties of English and American china clays has been made as a basis for the substitution of the latter for the former in white-ware bodies. The data on English clays were completed and a final report is under way; in addition, considerable data have been gathered on leading American china clays. The properties of 27 Ohio clays used in heavy clay manufacture have been determined. In cooperation with the special boiler refractories committee of the American Society of Mechanical Engineers, the study of the multiple-component system involved in the interaction of the clay refractories with the slag has been continued and about 60 new points determined.

STANDARDIZING MECHANICAL APPLIANCES (\$51,020)

Testing of engineering instruments.—Approximately 1,300 engineering instruments were calibrated in the past fiscal year. An extended study of water-current meters was made in connection with the development of the stream-meter method of determining the efficiency of large hydraulic-power installations.

Fire-extinguishing appliances and equipment.—The bureau has continued to act in the capacity of a technical laboratory in the in-

vestigation and testing of the various types of fire-extinguishing equipment, submitted to the Steamboat Inspection Service for its approval for use on vessels under its jurisdiction. A large number of such devices, including both portable extinguishers and installed systems, has been examined and tested in the past fiscal year.

Elevator safety interlocking devices.—The recent inclusion in the American Standard Safety Code for Elevators of performance standards and performance tests of elevator safety interlocks, previously developed, has resulted in an extension of their application. Type tests of additional devices have been made for the information of the Government departments, certain State governments, and other inspectional and regulatory bodies.

Postage-metering and stamp-vending devices.—At the request of the Post Office Department, the investigation and testing of different types of postage-metering and similar devices, particularly from the standpoint of reliability and accuracy, prior to their approval for use, has been continued. There has recently been great activity in the development by manufacturers of automatic machines of this type and this work has grown correspondingly in importance and volume.

INVESTIGATION OF OPTICAL AND OTHER TYPES OF GLASS (\$27,180)

Production.—Thirty-two pots of optical glass, embracing five different kinds, were melted. From a part of these melts 36,787 blanks for optical elements, weighing 3,627 pounds, were made for the Navy Department. The time required for melting borosilicate crown glass has been reduced about 45 per cent, or from 24 to 13 hours.

Composition and physical properties of glass.—The tensile strength of six types of glasses was determined. It has been found that borosilicate, medium-flint, barium-flint, and dense-flint glasses have approximately the same maximum tensile strength, namely, 11 kilograms per square millimeter, and the strength of light barium crown and light crown (ordinary plate) glass is approximately 15 kilograms per square millimeter.

The thermal expansion of a number of soda-lime-silica glasses has been determined from room temperature to the initial softening point, and equations derived for computing the expansion of any glass in the range of compositions studied.

In attempting to determine definitely why some glasses transmit only a few per cent of the therapeutic rays (ultra-violet) in sunlight while others may transmit as much as 60 per cent, small samples of soda-lime glasses were made which would transmit as much as 85 per cent, which is only exceeded by fused quartz. Apparently iron in the glass has a very large effect on the ultra-violet transmission.

A method for the direct determination of soda in commercial glasses was developed, and is now being used by glass chemists with very satisfactory results.

INVESTIGATION OF TEXTILES, ETC. (\$60,600)

Durability of carpets.—Using the carpet wear-testing machine, designed and built by the bureau, accelerated wear tests were made

of rugs and carpets furnished by the manufacturers, and the results were correlated with wear in service. The Federal Specifications Board's technical committee on floor coverings cooperated in this work by conducting service tests on 32 specimens representative of the important grades. Although the practical tests have not been completed, the machine tests are in excellent agreement with the serviceability of the specimens so far as known. The machine was also applied to studies of rug constructions, such as height of pile, density of pile, and grade of wool in the pile. The results should be of assistance to manufacturers in producing the most serviceable rug for a given price.

Manila rope.—A method for evaluating the color of manila rope fiber was developed at the request of the Cordage Institute and the cordage committee of the Federal Specifications Board for inclusion in Federal specifications and for the control of production of commercial rope.

Cotton textiles for aeronautics.—At the request of the Bureau of Aeronautics, Navy Department, and the National Advisory Committee for Aeronautics, gas-cell fabric and outer cover cloth for airships have been produced in the bureau's cotton mill, each having ten times the tear resistance of fabrics now used. Large-scale tests are now in progress at the plant of the Goodyear Zeppelin Corporation.

A study of the mercerization of cotton for aeronautical uses demonstrated that the optimum conditions of mercerization for increasing the strength of yarns are different from those of ordinary commercial mercerization. An increase of 50 per cent in strength was found to be possible.

Dry-cleaning solvents.—A study was made at the request of the National Association of Dyers and Cleaners and several machine manufacturers to determine the cleaning efficiency of carbon tetrachloride, trichloroethylene, and Stoddard solvent, and their effect on clothing fabrics and equipment. Work on the toxicity of the solvents was started in cooperation with the Public Health Service.

Serviceability of bed sheets.—The Cotton Textile Institute and Associates for Government Service have been conducting service tests of 24 brands of sheets in New York State public institutions to find what types give the most service. Physical tests of the original sheets and of sheets taken from service after 35 and 65 launderings were made by the bureau.

Wool processing.—In cooperation with the American Association of Textile Chemists and Colorists and the Textile Foundation, the electrophoresis cell was found to be a new and valuable tool in the study of wool processing. With it the isoelectric point of wool, a fundamental characteristic of practical importance in scouring, carbonizing, dyeing, and finishing, was determined accurately. The cell is being applied to several wool-processing problems.

Preservation of records.—In cooperation with the Carnegie Foundation and the Brown Co. additional data have been obtained regarding the permanence qualities inherent in different grades of fibers used in the manufacture of record papers, as well as for the best manufacturing procedure for conservation of initial quality. The bureau's recommendations for purification of air and protec-

tion of records from sunlight are being applied in libraries, and were followed in the plans for the National Archives Building.

Based on the results of this research, a classification of record papers, relative to the life requirements of the various classes of records, has been formulated. Application of this by Government departments and many outside organizations has improved the quality of their permanent record papers, and has also effected economies through better selection of the other classes of papers.

Printing quality of lithographic papers.—Misregister is responsible for very great waste in the lithographic printing industry, and constitutes the most serious printing difficulty in which paper is a factor. The bureau is studying this question, and laboratory analyses and tests have been made of lithographic papers. Printing-plant studies of factors affecting closeness of register and the response of a series of specially prepared papers of known history to those factors have also been carried on. Seventeen factors affecting register have been detected and the influence of each is being studied in its relation to difficulties encountered in commercial practice. Information on the effect of moisture variables has been obtained, and improved procedure in handling and conditioning papers in the printing plant has been developed. The work is being done in cooperation with the Lithographic Technical Foundation.

Government papers.—In cooperation with the Bureau of Efficiency and Bureau of Engraving and Printing, paper-making experiments and trial printings were conducted on additional grades of rag and wood fibers for currency paper. Further study was made of protective coatings for improving the wear quality of paper currency. The cooperative study with the Bureau of Engraving and Printing of materials and processes for manufacturing postage stamps was continued.

SUGAR STANDARDIZATION (\$94,520)

Crystalline gluconic delta lactone.—A new method for the separation and purification of the delta lactone of gluconic acid, heretofore unavailable for use in the arts, was developed. It is potentially a weak acid which will prove of value for many purposes, as in dyeing, tanning, baking powders, etc. Crystalline gluconic delta lactone may be prepared by the new process in quantity at a fairly reasonable cost.

Crystalline xylonic lactone.—A quantity of crystalline xylonic lactone was prepared by a simplified method from the product obtained by the electrolytic oxidation of xylose. Previously xylonic lactone had been prepared only in small quantity by a very expensive method.

Oxidation of the sugars.—It has been shown that the first step in the oxidation of a sugar with bromine water is not the sugar acid, as formerly believed, but the delta lactone; that the beta form of glucone is oxidized about forty times as fast as the alpha form; and that the oxidation of a sugar solution proceeds rapidly until the beta form of the sugar in solution is used up and then more slowly as the alpha form continues to be oxidized.

New compounds of mannose.—A full series of well-defined crystalline halogen acetyl derivatives of mannose have been prepared and

their properties determined, yielding data of a permanent value for general application.

Properties of levulose.—The investigation of the fundamental properties of levulose and the selective reduction method of analysis have been completed, and the data applied to the analyses of crude materials which contain levulose. Particular attention has been given to the juices of the Jerusalem artichoke and the products derived from it during levulose manufacture. The methods have also been applied to honey and fruits. In most fruits levulose has been found to be the predominating sugar.

Commercial production of levulose.—The extracting and precipitating end of the semicommercial plant was operated on a 24-hour day basis during two major periods, studying methods of juice extraction and the operation of the conversion process. The methods of extracting the juice from fresh artichokes by pressing and from dried chips by diffusion have been compared. The gums and proteids which appear in the solution when the macerating process is used have given trouble. Small-scale experiments with a diffusion battery have shown that the gums and proteids in the solution can probably be greatly reduced by the use of a diffusion process for extracting the polysaccharides. A large diffusion battery capable of handling approximately 10 tons of artichokes in 24 hours' continuous operation will be installed to handle this year's crop. Special attention will be given during the coming year to the study of the yields and losses in the diffusion battery.

Color in the sugar industry.—Comparatively inexpensive and simple methods have been developed for measuring the color of sugar products, and the results obtained are entirely satisfactory.

GAGE STANDARDIZATION (\$49,700)

Certification of master gages.—The retest and certification of the American Petroleum Institute's grand-master and regional-master cable tool-joint gages were completed after lead errors in some of the ring gages had been corrected by the manufacturer.

Several helicoidal transmission gears were submitted for determination of helix angle. A considerable number of the current models of automobiles employ constant-mesh helicoidal-transmission gears, and in order to obtain quiet operation and minimum wear it is necessary that the helix angle of mating gears be held to very close limits. Commercial apparatus for measuring helix angle apparently is not sufficiently accurate for the purpose. Hence the bureau is called upon to assist industry in these important and difficult measurements.

Cooperation with the National Physical Laboratory and the Physikalisch-Technische Reichsanstalt.—Information has been exchanged with the national laboratories of Great Britain and Germany on methods of testing A. P. I. gages, and on the interpretation of A. P. I. specifications. The Physikalisch-Technische Reichsanstalt has adopted several of the inspection methods developed at the bureau.

Screw-thread survey.—Nearly 8,000 samples of bolts, nuts, and threaded studs collected from 128 manufacturers and users of screw threads were measured and the detailed measurements tabulated and

analyzed to determine how closely they conform to the standards of the National Screw Thread Commission.

Cooperation with Bureau of Fisheries.—*Measurement of gill nets.*—The bureau has cooperated with the Bureau of Fisheries in the measurement of mesh size of gill netting used in important inland waters, such as the Great Lakes. Standard measuring equipment and standard methods of use, acceptable to the various jurisdictions involved, are being developed.

Gage testing.—A large number of plain cylindrical gages, screw-thread gages, snap gages, precision-gage blocks, penetration needles, polariscope tubes, etc., have been tested for various industries.

INVESTIGATION OF RAILROAD AND MINE SCALES AND CARS (\$62,060)

Master scale calibrations.—Each of the 19 master track scales was calibrated and 2 received supplementary calibration following completion of modifications recommended by the bureau. The grade of weighing accuracy of each master scale on final calibration was within the tolerance applied (approximately 0.01 per cent). A new master-scale installation, on the Norfolk & Western Railway, was placed in service following formal calibration.

Tests of railroad track scales.—A total of 959 railroad track scales was tested. Of these, 768 scales or 80.1 per cent were correct within the allowable tolerance of 0.20 per cent. For the entire group, the average indicated weighing error was 0.17 per cent, representing a somewhat higher standard of performance than has heretofore been displayed.

Track scales in grain-weighing service.—Seventy-two track scales, subject to the special tolerance of 0.10 per cent fixed by the Interstate Commerce Commission for scales in grain-weighing service, were tested. Sixty-four per cent were within the required tolerance and the average error for the group was 0.13 per cent.

Test-car calibrations.—Sixty calibrations of track-scale test-weight cars were made on the master scale at Clearing. In addition, 41 track-scale test cars were verified in the field, but the accuracy of the results obtained is by no means comparable to that obtainable on a master scale.

Track-scale testing equipment.—The new test equipment purchased last year completed its first schedule and proved satisfactory. A new power plant is being installed to replace the outworn and obsolete plant in No. 2 car. No. 3 car was equipped with new roller bearings.

Tests of mine scales.—The mine-scale testing equipment made 145 tests in the coal-mining regions of Indiana, Ohio, Kentucky, and West Virginia. Fifty-four scales—37.2 per cent—were within the tolerance of 8 pounds per ton of applied load; 91 scales—62.8 per cent—were not within the tolerance. Faulty installation and poor maintenance were generally responsible for these inaccuracies.

Paints for test weights.—As the result of an investigation begun two years ago, paints of light body vehicle, such as varnish (pigmented or unpigmented), have been found to give the best surface protection for large weights.

Cooperation with technical groups.—The members of the staff cooperated with committees of the National Scale Men's Association

and the American Railway Engineering Association in initiating a formal definition of standard practice for testing railroad track scales, and rules for the maintenance and transportation of track-scale test-weight cars.

Cooperation with Government departments.—Assistance has been rendered Government departments, especially the Post Office and Treasury, in cases involving weighing scales and measuring devices. Purchase specifications have been prepared, proposals examined and checked, and a number of tests made.

Cooperation with the States.—Formal State conferences were attended in Illinois, Massachusetts, Michigan, New Jersey, New York, Ohio, and Pennsylvania (two), and informal conferences were held with State officers in Connecticut, Indiana, and Wisconsin. A large amount of information was furnished by letter.

METALLURGICAL RESEARCH (\$60,640)

Atmospheric corrosion of nonferrous metals.—The character of the surface film formed on a metal under atmospheric exposure is generally believed to be intimately associated with the degree of corrosion resistance. The American Society for Testing Materials is conducting exposure tests of commercial nonferrous metals in different parts of the country. The bureau is studying the films formed on these metals under various climatic conditions. Methods for removing the films intact have been developed and some work on the character of the corrosion film on copper has been completed.

Aeration and submerged corrosion.—The marked differences in corrosion of iron due to degree of aeration and pH of water in closed systems have been found to be less pronounced as the corrosion period is lengthened. Initial corrosion is greatly affected by these factors, which also control the character of the rust scale, which may serve to protect the underlying metal.

Copper roofing materials.—A report was issued on seam corrosion as a summary of the cooperative work with the Copper and Brass Research Association. Heating incidental to soldering is an important factor in determining the degree and extent of corrosion.

Machinability of metals.—Speed and quantity of metal removed are greatly emphasized in all present-day machining methods. A study has been made of the influence of lathe-cutting conditions on the properties and structure of the machined surfaces of carbon and alloy steels to determine whether quality is being sacrificed for speed, as shown by the magnitude and depth of the work hardening of the metal at the machined surface.

Rail steel.—To determine whether "secondary brittleness" shown in most rail steels by tensile tests at elevated temperatures is an inherent property of the steels or a function of the rate of loading, Charpy impact tests, impact-tensile tests, and torsion tests on the same steels have been made. No indications that "secondary brittleness" is not a property of the steel itself have been found.

Bridge wire.—Numerous tensile, torsion, and fatigue tests, and "long-time" tensile tests on galvanized and ungalvanized wires, supplemented by microexamination, have shown that the presence of a galvanized coating, the rate of loading, and the imperfections in the

surface of the wire have a more pronounced effect on the resistance to fracture of heat-treated carbon-steel bridge wire than on a cold-drawn steel wire of similar composition.

Metallurgical factors affecting endurance of steels.—Fatigue tests have shown that in some cases a hot-dipped galvanized coating lowers the endurance limit of steel by as much as 40 per cent. Electroplated zinc coatings did not have this effect. A pulsating tensile test for wires, to duplicate service conditions, was developed.

Nonferrous ingot metals.—A report was issued on the properties of red brass (Cu 85, Pb 5, Zn 5, Sn 5) poured at different temperatures and in test bars of various shapes. The effect of remelting and of impurities, such as sulphur, has also been studied. The results will serve in establishing a "base line" for the Nonferrous Ingot Metals Institute in classifying the numerous commercial variations of this alloy.

Fluidity of metals.—Success in foundry casting operations is greatly affected by the running properties of the molten metal. Based on the work of the past two years, a report has been issued on a practical method to be used by the foundry worker in determining the running properties of metal under conditions identical with those of casting.

HIGH-TEMPERATURE INVESTIGATION (\$10,080)

Establishment of a color-temperature scale.—Experiments are under way to establish a set of reproducible working standards of color temperature based on the radiation from hollow inclosures or "black bodies" immersed in freezing metals.

Freezing point of iridium.—This fixed point, which is of importance in photometry and color-temperature measurements, has been found to be 2,450° C.

Standardization of thermocouple materials.—All the principal base metals used for thermocouples have been studied. Reference curves for chromel-alumel, chromel-constantan, copper-constantan, and iron-constantan have been worked out and those for platinum-platinum-rhodium couples have been revised. This standardization is a matter of immediate practical importance in numerous industrial operations in which high temperatures must be measured.

Intercomparison of temperature scales.—The international comparison of temperature scales in the range 660° to 1,063° C. has been completed, and work begun on the other portions of the scale.

SOUND INVESTIGATION (\$11,140)

Absorption coefficients of acoustic materials.—Sound absorption measurements have been made on 97 different samples of material submitted by manufacturers. It is worthy of note that this work is associated with the development of a new business in the country, and that fully three-quarters of this development has taken place in the last three years. In this the bureau has taken an active part. The materials are used in the interior finish of auditoriums to produce good acoustic qualities.

Sound-proof partitions.—Thirteen panels of various constructions submitted by different manufacturers were measured for sound trans-

mission, and improved methods and instruments were developed for this work. The public demand for soundproof walls and floors in apartment and 2-family houses is steadily increasing.

Ultrasonic waves.—An investigation of the speed of travel of ultrasonic waves in various organic liquids has been completed and published. This work supplements investigations in other sections of the bureau on the mechanical and electrical properties of electrical insulating materials.

General acoustic laboratory work.—This includes such routine testing as the bureau is called upon to make, chiefly the rating of tuning forks, oscillograph records of vocal and instrumental sounds, and their subsequent harmonic analysis.

INDUSTRIAL RESEARCH (\$248,860)

Wind pressure on structures.—Measurements have been made of the wind pressure on a model of the Empire State Building for comparison with measurements on the actual building in a natural wind to be made by the American Institute of Steel Construction. Further measurements have been made on the bureau's power-plant chimney in natural winds.

Storage batteries.—The resistance of wood and porous-rubber separators was compared, and the resistivity of sulphuric acid determined for service conditions at low temperatures. Corrosion of plates and detrimental effect of antimony were found closely related. New alloys were tried in battery construction, and nonspill devices for airplane batteries were studied.

Protective coatings for pipe lines.—With the cooperation of the American Gas Association and the American Petroleum Institute, laboratory and field tests of commercial pipe coatings are in progress. It is now possible to determine where coatings should be used, and those types of coatings which give enough protection to be worth their cost.

Insulating properties of rubber.—To determine the properties of pure rubber, about 10 kilograms of rubber hydrocarbon have been prepared by digestion of latex at high temperatures, while a smaller sample has been purified by treatment with the enzyme trypsin at room temperature. Specimens of these materials have been prepared to check determinations already made of dielectric constant, power factor, and compressibility of rubber compounds.

Protective value of electroplated coatings.—In cooperation with the American Electroplaters' Society and the American Society for Testing Materials, over 8,000 steel specimens, plated under definite conditions, are now exposed in six localities to determine their resistance to atmospheric exposure.

Decomposition of cyanide plating baths.—Factors affecting the decomposition of cyanide solutions have been studied, and methods of reducing it suggested.

Orifice meter research.—The analysis of recent experimental data has continued. A paper on the expansion factor to be used in metering gases will be found in the Journal of Research for July, 1932, and a paper on the water coefficients is in preparation.

Gas analysis.—Study of methods of gas analysis included: Rapid separation of gases by fractional distillation, improvement of gas

analysis apparatus for laboratory use, separation of "illuminants" from each other, effect of oxidation of nitrogen, mercury, and iridium on analyses by combustion, removal of vapors of reagents from gases under analysis, and interference by sulphur dioxide in analyses made by the use of iodine pentoxide. Assistance was given to nine manufacturers of laboratory apparatus who undertook commercial production of apparatus developed by the bureau for gas analysis.

Phase-equilibrium diagram for the system $\text{SiO}_2\text{-ZnO-Al}_2\text{O}_3$.—The complete phase-equilibrium diagram was determined for this system, which is the important system in zinc retorts.

Heat content of gases as a function of pressure.—A new calorimetric method was developed for accurate determination of this quantity and the method applied to oxygen and mixtures of oxygen with carbon dioxide.

Thermal properties of water and steam.—This work has been continued with the cooperation and support of the American Society of Mechanical Engineers' special research committee on thermal properties of steam. A calorimeter was completed and used in measurements of heat capacity, latent heat of vaporization, and vapor pressure. For the range 100° to 370° C. the vapor pressure for a given temperature is now reliably known to within a few parts in 10,000.

Thermal conductivity of insulating and refractory materials at high temperatures.—The conservation of heat in industrial processes is an outstanding problem. Apparatus and technique have been developed for measuring thermal conductivity at high temperatures and tests made on various refractory materials up to temperatures of $1,700^\circ$ F.

Heat transfer by convection.—This work has been done under the McMillan Fellowship of the Johns-Manville Corporation. Measurements by optical means of the temperature distribution in air adjacent to heated surfaces, both plane and cylindrical, have made it possible to compute heat transfers with considerable accuracy. This method is the only one thus far devised for measuring heat transfer between fluids and solids over definite small portions of the solid surface and promises important practical applications.

Thermal conductivity of metals.—Measurements were made on the thermal conductivity of 21 metallic alloys over the temperature range 100° to 500° C. The work is being continued to correlate changes in conductivity with structural changes in the metal, particularly in the case of nonferrous alloys.

Isotope of hydrogen.—The bureau, in cooperation with the staff of Columbia University, discovered an isotope of hydrogen twice as dense as the ordinary gas, thus filling a gap in the series of primitive elements and contributing to our knowledge of the constitution of matter.

Specific heats at low temperatures.—Measurements of the specific heats of certain nitrogen compounds at low temperatures have been made on a number of compounds in cooperation with the fixed nitrogen laboratory in connection with the synthesis of such compounds for use as fertilizers.

Similar measurements on rubber compounds have been made to develop information on the processes occurring in the vulcanization of rubber.

Spectrochemical analysis.—This is the most rapid and accurate method yet developed for determining extremely small amounts of impurities. One sample of "proof gold" prepared by and tested for the United States Mint showed total base metal impurities amounting to only 23 parts in 1,000,000. To improve the spectroscopic data used in such chemical identification, new spectroscopic measurements have been made for several elements. The method has been used to identify impurities having a deleterious effect on industrial materials.

Photographic emulsions.—In the bureau's studies to improve photographic emulsions, it has been found that gelatin forms a nonionized compound with the silver, in appreciable quantity, under emulsion conditions; that sensitivity of emulsions, free of dyes, is little affected by large changes in silver-ion concentrations; that the desensitizing action of soluble bromides increases with the acidity of the emulsion; and that bathing with ammonia leaves the emulsion with an excess of silver over halogen.

Atomic structure investigations.—A study of the efficiency of production of radiation in the positive column of a caesium discharge shows that most of the radiant energy is in two spectrum lines in the near infra-red. With low pressures and currents nearly the total power input is radiated. With increasing currents and pressures an increasing fraction of the power is expended in heating the tube walls. The results have a direct bearing on the practicability of a columnar discharge as a source of illumination.

Acid in leather.—Additional evidence was obtained that the life of leather in the presence of sulphuric acid is influenced by the tanning material used. Tests on leather tanned with mangrove bark extract showed it to be more resistant to deterioration by sulphuric acid than leather tanned with chestnut-wood extract and less resistant than leather tanned with quebracho-wood extract. Quebracho leather subjected to high temperature and humidity deteriorated faster than when stored under ordinary room conditions. Studies of the effect of temperature on the deterioration of chestnut leather treated with sulphuric acid, the effect of oxalic acid on the deterioration of both chestnut and quebracho leathers, and the effect of sulphuric acid on leather tanned with sumac were initiated. All leather for this work was prepared in the bureau's experimental tannery.

Effect of humidity on leather.—Tests show that the moisture content, strength, stretch, and area of chrome and vegetable-tanned calf leathers increase with increase in atmospheric moisture. The results emphasized the necessity of establishing standard test conditions for leather, of controlling humidity in establishments making leather goods where accuracy of dimensions is required, and of studying the treatment of leather to minimize these changes. Chrome leather showed greater changes than vegetable-tanned leather.

Fur-seal skins.—A study of natural defects in fur-seal skins which interfere with manufacturing processes was made for the Bureau of Fisheries to enhance the value of this Government-controlled commodity.

Rubber balloons.—A study of sounding, pilot, and ceiling balloons used by the Weather Bureau resulted in improved life and quality and provided data for calculating the performance of the balloons in the upper atmosphere.

Service failures of metals in aircraft.—Changes recommended as a result of metallurgical examinations of aircraft structures or engine parts that had failed in service or during “type testing” of the engine eliminated further trouble in a number of cases.

High-temperature properties of metals.—In cooperation with the American Society for Testing Materials and the American Society of Mechanical Engineers a study of the embrittlement of “18 and 8” stainless steels by carbide precipitation at certain tempering temperatures has been completed. Fundamental aspects of the mechanism of “creep” of metals at elevated temperatures and the influence of grain size are being studied with single-crystal test specimens of several pure metals.

Wear resistance of metals.—The metal-to-metal wear of carbon steels in oxygen-free atmospheres has been studied, and the importance of surface oxide films in determining the rate of wear has been clearly shown.

High-strength cast iron.—Work is in progress on the effect of controlled superheating prior to casting as a means of modifying the structure and improving the mechanical properties of cast iron.

Safety code for foundries.—The bureau cooperated in the preparation of the safety code for industrial workers in foundries sponsored by the American Foundrymen’s Association and the National Founders Association. This code has been approved by the American Standards Association.

Device for turning spherical surfaces.—An attachment for use on an ordinary lathe has been designed and constructed. It can be adjusted to produce a surface with any desired radius of curvature greater than 20 inches. Although designed for the production of lens-grinding tools, it promises to have other applications, as it performs work not possible with any other machine tool available on the American market.

Thermal expansion.—Forty-one series of determinations were made on structural alloys and materials used in the arts, and nine firms were assisted in installing equipment for measuring thermal expansion. Automatic autographic-expansion equipment has been designed and built for use in industrial laboratories where detailed records of thermal expansion are needed.

Precision dividing engine.—The precision dividing engine, designed and built at the bureau, performed excellently on a preliminary test.

Research associates.—The following table gives the names of associations and manufacturers cooperating with the bureau under the research associate plan, together with the number of associates and the problems on which they are engaged:

TABLE 2.—*Research associates at the Bureau of Standards*

Assigned by—	Num- ber	Specific project
American Association of Textile Chemists and Colorists, Lowell, Mass.	2	Action of light on silk; tests of waterproofed fabrics; fastness to light of dyed fabrics; determination of iso-electric point of wool, etc.
American Dental Association, Chicago, Ill.	2	Study of dental materials; tests.
American Electroplaters Society, Chicago, Ill.	1	Electroplating methods; protective coatings.
American Gas Association, New York, N. Y.	2	Research on gas; corrosion of pipe lines; gas burner design, etc.
American Petroleum Institute, New York, N. Y.	14	{ Properties and chemical constituents of petroleum products; protective coatings for pipe lines; cooperative fuel research, etc.
National Automobile Chamber of Commerce, New York, N. Y.		
Society of Automotive Engineers, New York, N. Y.	5	Steam table research and high temperature measurements; lubrication; screwthreads.
American Society of Mechanical Engineers, New York, N. Y.	3	Research in cement; testing; fatigue of springs.
American Society for Testing Materials, Philadelphia, Pa.	2	Development and testing of elevator safeties and buffers.
American Standards Association, New York, N. Y.	1	Durability of felt fibers.
Asphalt Shingle & Roofing Institute, New York, N. Y.	1	Investigation of plastic materials for floor covering and writing specifications therefor.
Asphalt Tile & Mastic Association, New York, N. Y.	1	Research in cement; testing, etc.
Atlas Lumnite Cement Co., New York, N. Y.	1	Quality of purified wood fiber.
Brown Co., Berlin, N. H.	2	Improvement of paper currency.
Bureau of Efficiency, Washington, D. C.	1	Use of calcium chloride in cement.
Calcium Chloride Association, Washington, D. C.	1	Corrosion of cast iron.
Cast Iron Pipe Research Association, Chicago, Ill.	1	Determination of absolute viscosity of water.
Chemical Foundation, New York, N. Y.	1	Measurement of manila rope.
Cordage Institute, New York, N. Y.	1	Specific heats at low temperatures.
Fixed Nitrogen Research Laboratory, Department of Agriculture, Washington, D. C.	1	Study of physical properties of Bedford limestones.
Indiana Limestone Association, Bedford, Ind.	2	Masonry mortars.
Masonry Mortar Research Fellowship, Pittsburgh, Pa.	2	Methods of manufacture of hosiery and knitted goods; specifications.
National Association of Hosiery & Underwear Manufacturers, New York, N. Y.	1	Concrete building units.
National Building Units Corporation, Philadelphia, Pa.	12	Radio; insulating materials; paper; mechanics; petroleum; insulating liquids; motor fuels, etc.
National Research Council, Washington, D. C.	1	Non-ferrous ingot metals.
Non-Ferrous Ingot Metal Institute, Chicago, Ill.	5	Constitution and hardening of Portland cement.
Portland Cement Association, Chicago, Ill.	1	X-ray research.
Radiological Research Institute, St. Louis, Mo.		

STANDARDIZATION OF EQUIPMENT (\$258,620)

National Directory of Commodity Specifications.—In April, 1932, there was issued the second revised edition of the National Directory of Commodity Specifications, the first edition of which was issued in August, 1925. All nationally recognized standards and methods of test for commodities regularly produced in this country are briefly summarized as to technical characteristics, scope, and special applications. The book covers commodity specifications adopted by national technical and trade associations and those agencies which speak with the authority of the Federal Government as a whole.

Encyclopedia of specifications.—The third volume of the encyclopedia series, Standards and Specifications for Metals and Metal Products, is now being printed. This is a companion volume to Standards and Specifications in the Wood-Using Industries and Standards and Specifications for Nonmetallic Minerals and Their Products issued in October, 1927, and April, 1930.

Facilitating the use of specifications.—Lists of sources of supply of commodities guaranteed to comply with the requirements of 349

Federal specifications and 32 commercial standards were compiled and distributed to 8,500 agencies making purchases out of tax moneys—Federal, State, county, and municipal. These lists represent 17,960 requests from 7,878 firms, as compared with 13,956 requests from 5,789 firms in 1931.

Simplified practice recommendations.—Twelve new simplified practice recommendations were developed by general conferences, increasing the total to 161, exclusive of one regional and one limitation of variety recommendation. Both the latter, and 135 of the 161 simplified practice recommendations, have been approved and accepted by the industries affected. Seventeen recommendations are in process of acceptance, and 127 have been issued in printed form.

Preliminary conferences.—Sixteen preliminary conferences were held to discuss the simplification of 10 commodities. Surveys of existing diversification of product have been conducted by five of these industries, and plans were started for similar activity by the other five groups.

Revision and reaffirmation conferences.—Twenty-nine existing simplified practice recommendations were reviewed by their respective standing committees. Of these, 16 were reaffirmed without change, and 13 were revised. During the previous year 32 of the 38 recommendations reviewed, or 84.2 per cent, were reaffirmed.

Identification of simplified lines in trade literature.—Organized consumers have been urgently requesting the adequate identification of simplified lines in trade literature. Since transmitting these requests to the producing element, several hundred manufacturers have inserted items in trade literature identifying the simplified commodities, thus facilitating their selection and purchase. This movement indicates a trend toward greater adherence to the various simplified-practice recommendations by the manufacturers, distributors, consumers, and other interested parties.

Commercial standards.—At the close of the fiscal year there were 75 active projects for the establishment of commercial standards. Cooperation with the respective industries at their request resulted in the acceptance and promulgation of 10 commercial standards for steel bone plates and screws; Fourdrinier wire cloth; plywood (hardwood and eastern red cedar); bag, case, and strap leather; hospital rubber sheeting; wool and part-wool blankets; diamond core drill fittings; surgeons' latex gloves; surgeons' rubber gloves; and clinical thermometers (first revision). Fourteen preliminary and nine general conferences were held covering hosiery lengths, binders' board, wool and part-wool blankets, men's shirts (exclusive of work shirts), fiber insulating board, paper apple wraps, oil-storage tanks, surgeons' rubber gloves, cast stone, pure-dye rayon fabrics, and sulphonated oils. Printed editions of 11 established commercial standards were issued.

Safety codes.—Members of the staff have participated in the work of the National Safety Code Correlating Committee and other committees which have prepared safety codes. Codes for walk-way surfaces; cranes, derricks, and hoists; and accident reports and statistics are in preparation. Codes on school lighting; mechanical refrigeration; brakes and brake testing; elevators, dumb-waiters, and escalators are being revised. An elevator inspector's handbook is practi-

cally completed. A new edition of the bureau's circular, Safety for the Household, was issued. Assistance was given State officials in preparing regulations.

Batteries.—Results of periodic "qualification" tests of dry batteries from principal manufacturers assisted Government purchasing officers and served as a basis for a Federal specification. Tests for industrial flash-light batteries have been developed, and specifications for storage-battery electrolyte are in preparation.

Specifications for shipping containers.—To assist the shipping container committee of the Federal Specifications Board in preparing specifications for metal drums, an extensive study was made of the methods of constructing the chine, flanges, plugs, closures, etc. The specification has been submitted to the board for promulgation. In the past the drums which have been purchased have only met the minimum requirements of the Interstate Commerce Commission and ordinary commercial standards. It is believed that drums complying with the proposed specification will have a much longer life.

STANDARD MATERIALS (\$10,540)

This fund is used for the preparation and precise analysis of standard samples of ores, ferrous and nonferrous alloys, pure metals, cement, and pure chemicals.

These samples are sold to industrial laboratories accompanied by certificates giving the true composition of each sample and are used extensively to check the methods employed in analyzing similar samples of unknown composition. This plan has contributed greatly to the precision of the analytical work in industrial laboratories, and the project is self-supporting. During the past year 5,215 standard samples were distributed, and samples of five new materials were analyzed and added to the list of standard materials.

INVESTIGATION OF RADIOACTIVE SUBSTANCES AND X RAYS (\$31,320)

Corpuscular radiations.—An investigation of the rate of emission of alpha particles from very weak radioactive preparations using a double Geiger counter has revealed that there is no appreciable deviation from a probability distribution for large solid angles. A continuation of the study of the deviability of cosmic rays in a magnetic field shows that a deviation definitely exists, and it seems probable that at least an estimate can be made of the energy distribution of the cosmic-ray spectrum.

Grading high-voltage X-ray emission.—By means of a new voltmeter operating up to 250,000 volts, the energy output of an X-ray tube has been related to the effective voltage. By this new method, all X-ray generator outputs may be expressed in terms of a single standard, thus bringing to the medical profession a much-needed control in the application of X rays. This work was carried out in cooperation with the Radiological Research Institute.

X-ray investigations.—An investigation of the X rays generated in very thin metal foils has clarified the fundamental laws of X-ray emission. Two new instruments, an electrostatic voltmeter and a

sensitive manometer, were designed and an investigation describing volume color changes and surface chemical changes due to the bombardment of metal with cathode rays was published.

Radium tests.—One thousand five hundred radium preparations were tested, having a radium content of over 17 grams and a market value of about \$1,200,000.

UTILIZATION OF WASTE PRODUCTS FROM THE LAND (\$52,400)

Insulating board from cornstalks.—The processes and board-forming machine devised and tested semicommercially in cooperation with Iowa State College at Ames, Iowa, are now in industrial use. Boards from mixtures of cornstalks and straw are being made and tested in the bureau's semicommercial plant.

Pressed boards from cornstalks.—By new processes the pressure required has been lowered from 500 to 70 pounds per square inch, and cornstalk bookbinder's board having over three times the standard strength has been manufactured and satisfactorily used as book covers. An electrical resistance method for measuring dryness has been developed. Mixed cornstalk-straw pressed boards are being made and tested. A machine is being built to add to the bureau's insulating board machine to make pressed boards continuously in semicommercial operations.

Paper from cereal straws.—In attempts to use the 50,000,000 tons of straws grown and wasted on American farms annually, strong light-colored kraft pulp and paper in over 40 per cent yields have been made from wheat, oat, and rye straws. The economics of the processes and commercial applications will be next undertaken.

Xylose from cottonseed hull bran and cornstalks.—Studies in medical laboratories of the effect of xylose on the human system are being continued, and the possibilities of its industrial utilization are receiving attention. A simplified process with cornstalks gave about 15 per cent yields of xylose and also 36 per cent of high-grade alpha cellulose, the usefulness of which in the rayon industry will be investigated.

Textile sizing from sweetpotato starch.—Textile sizing made from sweetpotato starch, and the physical properties of the sized yarns, are under test in cooperation with the Alabama Polytechnic Institute and local textile factories.

Elimination of obnoxious odors formed in the kraft-paper processes.—The odoriferous mercaptans generated in the kraft pulp processes of paper manufacture are a public nuisance. Experiments to eliminate odors while producing good pulp are under way in cooperation with the University of Alabama.

Optical studies.—Optical methods are being developed to study the "hydration" of cellulose, the pentose content of farm wastes, and the acidity of paper.

Adsorption-desorption studies.—The adsorption and desorption of water by cellulose products are being studied to determine the fundamental laws governing such phenomena; to develop standard tests for the absolute moisture content of paper, textiles, etc.; and to solve many practical problems arising from the interaction of water with such materials.

INVESTIGATION OF AUTOMOTIVE ENGINES (\$49,760)

This fund provides assistance to Government departments and others on basic problems relating to power production for motor vehicles and aircraft. It is supplemented to the extent of more than 200 per cent by transfers from other departments and by personnel assigned by the automotive and petroleum industries. A few of the 40 projects now under investigation are as follows:

Vapor lock.—Measurements on practically all 1931 cars showed that excessive fuel-line temperatures occurred in many of them, which may cause boiling of the gasoline and hence engine stoppage from vapor lock. Modifications in the fuel-system design have been made in many 1932 cars resulting in lower fuel temperatures. Road tests on these and older models are under way.

Antiknock characteristics of fuels.—The equipment and procedure for rating motor fuels, developed by the cooperative fuel-research steering committee, have been proposed to the American Society for Testing Materials as a tentative standard. Further tests are in progress to determine whether any of the test conditions should be altered to improve the correlation between laboratory ratings and knock in automobiles. To insure purity of the primary reference fuels, heptane and octane, samples of each batch are tested by this bureau. Test conditions for determining the detonation characteristics of aviation fuels are being studied.

Combustion in an engine cylinder.—Various cylinder heads equipped with windows of quartz and fluorite have been used in obtaining visual and photographic observations of flame movement and measurements of the cyclic variations in pressure and infra-red radiation during the explosive period in an engine. Preliminary work has been done on the use of absorption spectra to detect molecular changes in the explosive charge ahead of the flame.

Phenomena of combustion.—From photographic records of improved precision, data have been obtained on explosive temperatures and dissociation at these temperatures for the explosive reaction of carbon monoxide and oxygen at constant pressure.

Heat-distribution data.—The altitude laboratory has completed an analysis of the heat distribution in a 12-cylinder V-type, water-cooled engine, supercharged and unsupercharged, for a variety of operating conditions and at various altitudes.

Automobile headlighting.—A motion-picture camera, mounted on an automobile, was so equipped as to show graphically the effect of curves, grades, and road irregularities on the field of view under night-driving conditions. These pictures illustrate important facts about safe headlighting which have been determined at the bureau but are not generally understood.

INVESTIGATION OF DENTAL MATERIALS (\$9,940)

Investigation of dental materials.—Specifications now available for alloys, investments, wax and impression compound, prepared on the basis of researches carried out under this appropriation, have resulted in a 50 per cent improvement in some of these materials, with no increase in price; in fact, in some cases, prices have been reduced. The American Dental Association spent approximately \$10,000 assist-

ing in the work on specifications and standard test methods. Educational work has continued, and groups of dentists, under the direction of a special committee of the American Dental Association, have cooperated by giving the bureau's research data a thorough trial and application in dental practice.

HYDRAULIC LABORATORY RESEARCH (\$36,830)

National Hydraulic Laboratory.—The hydraulic laboratory building has been turned over to the bureau by the contractor, and is being equipped for hydraulic research.

The equipment now under installation includes 5 centrifugal pumps having a total capacity of 58,000 gallons per minute, 7 sluice gates, 2 cranes, 1 hoist, one 20-ton and two 9-ton scales for weighing water, a constant-level tank, a volumetric tank, the piping for the pumps, the switchboard, transformers, and various pieces of instrumental equipment. The first research problem will be a study of the flow of water around pipe bends, undertaken at the request of the Bureau of Reclamation.

Plumbing investigations.—The permanent experimental equipment of the 100-foot tower, erected for an investigation of requirements for plumbing drains for tall buildings, has been completed. Experiments have been made to determine the capacities of sloping drains and measurements of flow in new cast-iron soil pipe from 2 to 5 inches in diameter with slopes varying from one-sixteenth to 2 inches fall per foot, together with similar measurements on old cast-iron soil pipe, 12 years in service. A paper covering this phase of the investigation is in preparation.

A study of surging flow in sloping drains, produced by the intermittent discharge of plumbing fixtures, distributed from the second to the tenth stories of the tower, has been made to obtain an estimate of the relation of capacities under these conditions to the capacities of the same drains with steady flow. These studies have been practically completed on 4, 5, and 6 inch drains with slopes of $\frac{1}{8}$, $\frac{1}{4}$, and $\frac{1}{2}$ inch fall per foot.

TRANSFERRED FUNDS (\$417,370)

Organizations and projects.—During the year funds were transferred from the following departments and independent establishments of the Federal Government, covering the projects listed:

Bureau of Engraving and Printing: Electrodeposition of metals on printing plates; studies of currency paper and postage stamps.

Department of Commerce: Promotion of use of specifications, development of accelerometer; aids to air navigation; type testing of commercial airplane engines; general engineering research on airplane engines; making of special castings.

National Advisory Committee for Aeronautics: Fundamental research in aerodynamics; aeronautic power plants; cotton cloth for parachutes; causes of embrittlement of light alloys.

Navy Department: Submarine storage batteries; strength of welded seams; strength of airship girders; development of aeronautic instruments; fabrics for gas cells of airships; development of special textiles; corrosion of duralumin; investigation of ignition systems for engines; general work on batteries and aluminum alloys.

Post Office Department: Investigation of motor trucks.

Treasury Department: Use of radio by the Coast Guard.

War Department: Making of experimental gages; corrosion of duralumin; ignition systems for automotive engines; substitutes for tin and sole leather; studies of bearing metals; development of machine guns; general work in heat measurements and miscellaneous materials.

Many of these projects were supported partly by bureau and partly by transferred funds. Some of these have already been described under the appropriate bureau funds. Important investigations supported wholly by transferred funds include the following:

Air navigation facilities—radio (research division, Aeronautics Branch).—A new antenna system for radio range beacons was developed, which greatly reduces the fluctuations of the indicated course at night. In cooperation with the airways division, Department of Commerce, service tests were made of the visual type of radio beacon on the midcontinent airway from Texas to California. Assistance was given air transport companies in installing the visual indicators on their airplanes. Specifications were prepared and issued on airplane receiving equipment for the visual type of beacon, for the combined phone and beacon, and for the bureau's system of radio aids to blind landing. Automatic volume-control devices for use with commercial receiving sets were developed, and the pointer type of visual indicator for the beacon system was improved. A direction finder was developed for use on airplanes which gives a visual indication of the direction of arrival of radio waves.

Air navigation facilities—lights (research division, Aeronautics Branch).—The development and service testing of an air-traffic-control projector have been completed. A series of candlepower measurements has been carried out on the 36-inch airway beacon. Tentative specifications for the certification of position lights have been prepared, and progress made on the standardization of aviation red and green signal colors, and in a study of flash characteristics of code lights.

Aircraft instrument developments.—Four electric resistance thermometers for airship use, one bimetallic strip strut thermometer, an experimental accelerometer, one stern weighing-off device for the airship *Akron*, and two suspended-head commutator-condenser air-speed indicators were designed and constructed for the Bureau of Aeronautics. Suitable apparatus for testing aircraft oxygen-control instruments was developed. The temperature coefficients of the two elastic moduli of many diaphragm and spring materials were measured. A monograph was completed on aircraft speed instruments for the National Advisory Committee for Aeronautics.

Control surfaces of airplanes.—A wind-tunnel study of the yawing moments of rudders at large angles of attack was completed with the cooperation of the Aeronautics Branch of the Department of Commerce and the National Advisory Committee for Aeronautics. Aeronautics Bulletin 15, describing the work on ailerons, was published by the Aeronautics Branch.

Jet propulsion.—A report has been prepared on work conducted in cooperation with the National Advisory Committee for Aeronautics on jet propulsion with special reference to thrust augmentors.

Reduction of noise in airplanes.—In cooperation with the Aeronautics Branch of the Department of Commerce, measurements have been made of the reduction in engine noise effected by various

mufflers, some submitted by commercial firms or inventors, the others designed by members of the staff.

Crash resistant tanks.—In cooperation with the Aeronautics Branch of the Department of Commerce, many tests have been made on aircraft fuel tanks designed to be more resistant to failure in accidents.

Flat plates under normal pressure.—The impact of seaplanes on the water tends to cause "washboarding" or wrinkling of the thin sheet metal which covers the hull. An investigation has been completed for the Navy Department which provides design data to meet the severest service conditions. The results show that resistance to washboarding would be increased if the plates used at present were made thinner, with the added advantages of a saving in weight.

Strength of riveted joints for aircraft.—Thin sheet metal is rapidly replacing wood for the structural members in aircraft. Although welding is widely used for fabricating the joints there are advantages in riveting some members. To provide fundamental engineering data which will allow designers to obtain the greatest strength with the least weight, an investigation is now being made on the strength of joints in relation to the dimensions of the rivets and the method of driving the rivets in thin sheet metal.

Torsional strength of tubing.—At the request of the Navy Department a large number of chrome-molybdenum steel tubes have been tested in torsion, and curves have been calculated which show a direct relation between the torque at which buckling begins and the diameter-over-thickness ratio for this type of tubing.

High-frequency fatigue testing.—Fatigue tests of a series of aluminum and magnesium alloys have been made in cooperation with the National Advisory Committee for Aeronautics. Frequencies of 200 cycles per second were employed, and the measurements were carried to 200,000,000 cycles of stress.

Ignition systems.—At the request of the Bureau of Aeronautics, Navy Department, laboratory tests were conducted on available commercial types of harnesses for shielding engine ignition systems.

Effect of air humidity on engine performance.—As a result of bureau work, the National Advisory Committee for Aeronautics has recognized humidity as a major factor influencing engine-power output and recommended allowances for it in Army, Navy, and Commerce Department tests.

Type testing of commercial airplane engines.—Twenty-seven type tests and 4 calibration tests, involving 18 engine types submitted by 11 manufacturers, were undertaken for the Aeronautics Branch of the Department of Commerce. Of the 9 engines which successfully passed the 50-hour endurance test only 4 had not suffered at least one previous failure.

Automotive vehicles for postal service.—Assistance was given the Post Office Department in preparing improved purchase specifications for mail-truck chassis. Since 1929, 7,845 chassis have been procured on the basis of performance tests by the bureau, resulting in large savings in motor vehicle maintenance costs.

Bearing alloys.—The cooperative study with the War Department of bearing alloys containing little or no tin was concluded with the

development of a copper-lead mixture which is decidedly superior to other "alloys" in commercial use. A report on the properties of the common tin-base and lead-base "babbitts" at different temperatures has been published.

Prevention of embrittlement of sheet duralumin by atmospheric corrosion.—The 5-year program of exposure tests in cooperation with the National Advisory Committee for Aeronautics, the Army Air Corps, and the Bureau of Aeronautics, Navy Department has been completed. The degree of embrittlement of heat-treated high-strength aluminum-alloy sheet under different climatic conditions has been determined, together with the protective effect of heat treatment. The relative merits of coating materials, together with the proper means of application, are well established. A new series of tests on materials recently developed has been started.

Chromium plating.—For the Bureau of Engraving and Printing a consistent theory of chromium plating was developed for the first time. It clarifies the subject and should lead to improvements in existing methods.

Substitute for sole leather.—In cooperation with the War Department, a substitute soling material made from domestic raw products (heavy cotton duck and a synthetic resin) was developed. Laboratory tests indicated satisfactory wearing quality, and service tests are in progress on 100 pairs of soles at Fort Benning, Ga., to determine suitability of the material for military use.

Substitute for shellac in Army hats.—A domestic synthetic resin was applied as a stiffener for felt hats used by the Army as a substitute for shellac, and service tests showed satisfactory performance.

Accelerometers for the study of earthquakes.—A new seismometer which measures and records one vertical and two horizontal components of acceleration, was designed for the Coast and Geodetic Survey. This instrument is suitable for measuring disturbances that might lead to the injury or destruction of buildings.

GENERAL FINANCIAL STATEMENT

During the fiscal year 1932 the bureau expended and accounted for funds aggregating \$3,295,245.37, including \$420,675.37 received by transfer and reimbursement from other departments for special researches. The amounts and objects of each appropriation for the past fiscal year, together with disbursements, liabilities, and balance for each appropriation, are shown in the following table:

TABLE 3.—*Appropriations, disbursements, liabilities, etc., 1932*

Appropriation	Total appropriation ¹	Disbursements	Liabilities	Balance
Salaries.....	\$732,740.00	\$727,024.72		\$5,715.28
Equipment.....	213,000.00	151,986.26	\$53,998.03	7,015.71
General expenses.....	² 64,551.37	49,670.43	7,293.62	7,587.32
Improvement and care of grounds.....	14,400.00	14,232.09	164.97	2.94
Testing structural materials.....	333,200.00	294,852.95	5,542.44	32,804.61
Testing machines.....	54,700.00	43,263.26	8,453.60	2,983.14
Metallurgical research.....	³ 60,654.00	57,209.65	1,449.80	1,994.55
Investigation of optical glass.....	27,180.00	23,431.28	157.06	3,591.66
Standard materials.....	10,540.00	10,505.05	16.28	18.67
Investigation of textiles.....	60,600.00	54,209.00	2,797.95	3,593.05
Sugar standardization.....	⁴ 97,020.00	87,054.97	8,640.67	1,324.36
Gage standardization.....	49,700.00	47,883.57	109.56	1,706.87
High-temperature investigation.....	10,080.00	9,696.05	236.10	147.85
Testing railroad-track, mine, and other scales.....	62,060.00	58,151.78	120.09	3,788.13
Investigation of fire-resisting properties.....	34,820.00	31,542.83	1,354.05	1,923.12
Testing miscellaneous materials.....	46,160.00	44,822.09	355.59	982.32
Investigation of public-utility standards.....	106,570.00	100,750.18	379.61	5,440.21
Radio research.....	85,280.00	78,766.02	2,427.45	4,086.53
Industrial research.....	248,860.00	215,170.09	5,775.90	27,914.01
Sound investigation.....	11,140.00	11,078.52		61.48
Investigation of clay products.....	48,760.00	44,351.89	1,941.38	2,466.73
Color standardization.....	15,680.00	14,942.88		737.12
Investigation of radioactive substances and X rays.....	31,320.00	29,719.89	279.05	1,321.06
Standardizing mechanical appliances.....	51,020.00	45,185.80	3,447.64	2,386.56
Standardization of equipment.....	⁵ 258,660.00	210,750.01	4,877.23	43,032.76
Investigation of automotive engines.....	⁶ 59,760.00	50,445.11	5,564.64	3,750.25
Utilization of waste products from the land.....	52,400.00	47,271.56	335.02	4,793.42
Investigation of dental materials.....	9,940.00	9,489.17	102.00	348.83
Hydraulic laboratory research.....	36,880.00	24,726.38	10,925.68	1,227.94
Appropriations transferred from other departments which are available for the current year:				
Aircraft in commerce.....	92,000.00	82,724.71	9,049.68	225.61
Air navigation facilities.....	⁷ 96,075.00	91,818.29	3,268.31	988.40
Incidental expenses of Army.....	28,500.00	27,178.04	1,062.47	259.49
National Advisory Committee for Aeronautics.....	49,500.00	45,281.70	3,549.44	668.86
Salaries and expenses, Bureau of Engraving and Printing.....	15,000.00	13,527.31	1,081.65	391.04
Air Corps, Army.....	2,500.00	1,750.06	453.67	296.27
Aviation, Navy.....	82,000.00	72,142.53	8,452.30	1,405.17
Export industries, Bureau of Foreign and Domestic Commerce.....	2,640.00	2,632.50		7.50
Gages, dies, and jigs, for manufacture.....	3,100.00	2,822.46	62.72	214.82
Ordnance service and supplies, Army.....	2,755.00	2,559.57	140.43	55.00
General expenses, Coast and Geodetic Survey.....	450.00	264.27	157.79	27.94
Engineering, Bureau of Engineering.....	4,000.00	3,355.24	567.36	77.40
Contingent expenses, Coast Guard.....	3,000.00	2,466.67	463.44	69.89
Construction and repair, Navy.....	1,300.00	322.22	902.51	75.27
Party expenses, Coast and Geodetic Survey.....	1,000.00	793.17	111.62	95.21
Appropriations transferred from other departments which are available for a period of 2 years:				
Ordnance and ordnance stores.....	21,000.00	16,891.81		4,108.19
Repairs to Coast Guard vessels.....	400.00		28.80	371.20
Outfits, Coast Guard.....	1,600.00			1,600.00
Party expenses, Coast and Geodetic Survey.....	750.00			750.00
Total, 1932.....	3,295,245.37	2,954,714.03	156,097.60	184,433.74
Total, 1931.....	4,123,487.39	3,941,870.22	62,835.26	118,781.91
Total, 1930.....	2,938,670.50	2,933,952.22	12.33	4,705.95

¹ Includes reimbursements and transfers received from other departments as shown under the following footnotes:

² \$551.37.

⁴ \$2,500.

⁶ \$10,000.

³ \$14.

⁵ \$40.

⁷ \$200.

RECOMMENDATIONS

Patent policy.—It is highly desirable that a uniform patent policy should be established by the Government with respect to patents developed in the service. The patent policy of this bureau has always been that patentable devices developed by employees paid out of public funds belong to the public; and if not so dedicated directly, the vested rights should be held by the Government. The procedure followed by the various departments at present is far from uniform.

Increasing demands.—The volume of tests of instruments and materials requested by the various branches of the Government continues to increase rapidly. The fee value of the tests conducted for the Government and the public during the past fiscal year amounted to over \$944,000, representing an increase of over \$127,000, compared with the preceding year. There has also been a striking increase in the number of requests from various industries for technical information, indicating a wide interest in new lines of industrial activity.

Building program.—An administration building is urgently needed. This would release about 40,000 square feet of space in laboratory buildings which is much in demand for experimental and testing work, and would bring together the nonlaboratory functions of the bureau, now scattered through various buildings.

A high-voltage laboratory designed to provide the large clearances which are necessary in such work is also urgently needed. The problems arising from the use of higher voltages and extended networks emphasize the necessity of standardization and research in this field.

Other building needs which have been presented in a 5-year program include an enlarged low-temperature laboratory, an applied-mechanics building, a suitable building for the precision testing of weights and measures, and a fire-resistance laboratory.

Very truly yours,

LYMAN J. BRIGGS,
Acting Director, Bureau of Standards.





