Annual Report

of the

Director of the Bureau of Standards

to the

Secretary of Commerce and Labor

for the

Fiscal Year Ended June 30, 1907



Washington Government Printing Office 1908



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IRSL. PUBLICATION, NO. 2

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DEPARTMENT OF COMMERCE AND LABOR

Document No. 88

BUREAU OF STANDARDS

REPORT

OF THE

DIRECTOR OF THE BUREAU OF STANDARDS.

DEPARTMENT OF COMMERCE AND LABOR, BUREAU OF STANDARDS.

Washington, July 1, 1907.

Sin: I have the honor to submit the following report of the work of the Bureau of Standards for the fiscal year ended June 30, 1907:

DIVISION I.-ELECTRICITY.

ELECTRICAL RESISTANCE AND ELECTROMOTIVE FORCE.

The work of this section includes the construction and verification of standards of resistance and electromotive force, the verification of resistance boxes, Wheatstone bridges, potentiometers, and other resistance apparatus, and the determination of the electrical conductivity, temperature coefficient, and thermoelectric properties of materials.

The investigation of standards of electromotive force, begun during the fiscal year in conjunction with the chemical division, has been continued. The necessary materials were subjected to various methods of purification, and, in addition, a special study was made of the methods of preparation of the mercurous sulphate, to which most of the irregularities previously observed are to be attributed. A large number of Clark and Weston cells, set up from time to time, have been under continuous observation, and the results obtained establish the high accuracy with which cells of both types can be reproduced. This is further shown by the close agreement of cells obtained by exchange from American investigators, and also from the English National Physical Laboratory and the Laboratoire Central d'Electricité of France, thus establishing the suitability of the standard cell as a primary electrical standard. In connection with this investigation a study has been made of the electrode equilibrium of the Clark and Weston standard cells. These investigations will be continued and extended and a redetermination of the temperature coefficients will be made.

A considerable amount of precision testing has been done by the section. This is necessitated by the extensive application of electrical methods to many classes of physical investigation.

INDUCTANCE AND CAPACITY AND ABSOLUTE MEASUREMENTS.

The extended investigation on the ratio of the electrical units, which occupied more than two years, was completed during the past year and the results have recently been published. This ratio is of fundamental importance in electrical measurements, and this investigation has fixed its value much more exactly than before.

Investigations on the absolute measurement of current by means of current balances and on the silver coulometer were begun during the year and will be continued during the present fiscal year. These have to do with fixing more accurately the fundamental unit for the measurement of current.

An investigation into the absolute measurement of resistance by the inductance method has been undertaken, and a thorough study of the theory of the calculation of inductance from the dimensions of the coils has been made. The results of this study have been published in the Bulletin from time to time.

Further experimental investigations on the accurate measurement of inductance and capacity have been made, and important improvements in the construction of condensers as standards of electrical capacity have resulted from this work.

A very thorough study of resistance standards and of precision resistance apparatus with respect to changes in resistance due to atmospheric humidity was made during the year and methods devised for preventing these changes. This has resulted also in devising a new form of resistance standard which has proven to be very superior to the form now generally used. An extended study is now being made of a number of these new standards.

Condensers and inductances have been tested during the year for manufacturers, educational institutions, and the Government and advice and assistance given to manufacturers and others relative to the design of certain kinds of instruments and apparatus.

ELECTRICAL MEASURING INSTRUMENTS.

The testing of electrical measuring instruments during the year shows an increase over last year. More watt-hour meters were tested than any other class of instruments. Next in order were voltmeters and ammeters. Most of the watt-hour meters were tested in position in the District of Columbia, usually in cases of disagreement between supply company and consumer. Some were sent in by lighting companies to be tested for use as standard meters. A number of indicating watt-meters, single and polyphase; current shunts up to 5,000 amperes; current transformers, and potential transformers up to 11,000 volts were tested and certified. The determination of breakdown pressure for samples of rubber-covered and other insulated wires and of insulating paper and varnish was made, and other miscellaneous work was done.

A new instrument has been designed for the rapid and accurate calibration of voltmeters and has been put into service.

An investigation has been made with a view to the development of an electric heating device for special duty in an important branch of the Government service.

MAGNETISM.

The magnetic work of the year has included a thorough investigation of various methods of measuring the magnetic induction and permeability of iron and steel in its many forms, with reference both to the accuracy and reproducibility of the measurements and the rapidity and convenience of the testing. This work led to an extended study of the methods of demagnetizing the specimens under test so as to bring them to a standard neutral condition magnetically, as it was found that comparatively small variations in the process of demagnetization made a considerable difference in the results obtained for the permeability. The results of this work will shortly be published.

A thorough study is also being made of the measurement of the hysteresis of iron and steel, particularly in the form of sheets as used in dynamos and transformers, and the development of accurate and convenier't methods of testing specimens submitted by manufacturers. Two papers on this work will shortly be published.

PHOTOMETRY.

During the past year the cooperation of the Bureau was sought in an informal conference between Government engineers and manufacturers of electric incandescent lamps for the purpose of deciding upon suitable uniform specifications for the purchase of incandescent lamps by the Government. The specifications used previously by the various Departments were not uniform. As a result of the conference specifications were drawn up which have been adopted by most of the Departments, and a large number of copies, published in the form of a Bureau circular, have been distributed, upon request, to municipal officers and private companies.

The services of the Bureau were also extended to the committee on standardization of the American Gas Institute in conducting experiments on the suitability of the pentane lamp as a standard in the photometry of gas. In this connection a movement has been started by the Bureau looking toward the establishment of a single unit of candlepower throughout the United States in the photometry of all kinds of illuminants. Heretofore the candlepowers of gas and electric lamps have been expressed in terms of different " candles."

A great many tests have been conducted during the past year, including a large number of lamps for the Government Departments. An investigation of the relative properties of plain and frosted bulb lamps yield the explanations of the comparatively short life of frosted lamps—a fact which has been recognized for many years. A study of the possible errors incident to the various methods used in measuring incandescent lamps commercially suggested an improved method which has been found satisfactory.

Improvements and additions to the photometric equipment have been made during the year, including several new instruments which have been designed at the Bureau.

DIVISION II .- WEIGHTS AND MEASURES.

The third conference on weights and measures, held April last at the Bureau, was the most successful one thus far, both in point of attendance and in the amount and importance of the business transacted. Seventeen States were represented, and the delegates without exception manifested the greatest interest in the movement to bring about improvements in the methods of inspecting weights and measures. The question of honest weights and measures in all business transactions is of practically the same importance as money and can only be guaranteed by proper governmental inspection. At present large sections of the country are without any inspection service whatever, and consequently the purchasing public, as well as honest merchants, are at the mercy of those unscrupulous enough to take advantage of the existing conditions. The conference ontlined and recommended a model law for adoption by the States and also recommended that additional powers be given to the Bureau of Standards in order to make the State laws effective.

A platinum-iridium meter bar was purchased from the French Government and sent to Geneva, Switzerland, for graduation into millimeters. When this work is completed the bar will be sent to the International Bureau of Weights and Measures for investigation. This bar will complete the equipment of the Bureau for length standards of precision and render it possible to refer all length measurements to the national prototype meter without loss of accuracy on account of inferior secondary standards.

Considerable progress has been made in the construction of a comparator for standards of length with thermostatic regulation of temperature. Nickel-steel (Invar) for the microscope supports was obtained from France after many disappointing delays, due to the difficulty encountered by the manufacturers in rolling bars of the desired size. It is expected that the comparator will be completed during the coming year and that recomparison of the primary standards will be made, as well as a redetermination of their coefficients of expansion.

The calibration of the primary hydrometer standards was begun, and on account of the importance of the surface tension of the liquids in which such instruments are ordinarily used an investigation of a number of these liquids was undertaken. A method was developed for measuring the surface tension of the liquid at the moment a hydrometer is used. In this connection a special spring balance was devised and constructed at the Bureau for rapidly and accurately determining the density of the liquid in which the standard hydrometers are immersed. With this balance the variation of the surface tension with temperature of mineral oils of different densities was studied; also the surface tension of different mixtures of sulphuric acid and alcohol and of varying concentrations of sulphuric acid and water. Preliminary investigations of the surface tension of varying concentrations of sugar and water were also begun. In connection with the work an overflow cylinder was devised for readily securing fresh or noncontaminated surfaces on the liquids used. As contamination of the liquid surfaces is a fruitful source of error in the graduation and testing of hydrometers, it is proposed to recommend to manufacturers and users of hydrometers the use of such overflow cylinders.

An investigation of the effect of varying humidity in air on the apparent mass of standard weights is now being carried on, but the work has not progressed sufficiently to draw any reliable deductions from the results obtained to date.

In connection with the design of a standard mercury barometer experimental determinations of high precision were made of the capillary depression of mercury in tubes of from 11 to 40 millimeters diameter for a certain definite surface tension, the result of the investigation showing that above 40 millimeters diameter the depression is so small as to be incapable of detection except by optical means. Preliminary measurements of the surface tension of soiled mercury surfaces were also made, with a view to determining the effect upon the capillary depression of such surfaces as are usually found in barometers. It appears from these investigations that the corrections usually employed for tubes of 20 millimeters and less are appreciably in error, because the maximum surface tension of mercury has been employed in calculating them. It is proposed to continue the investigation of the surface tension of mercury under conditions similar to those usually found in the mercury barometers and calculate from the results obtained the depression corresponding to a wide range of surface tensions and of tube diameters.

The routine work of the division has steadily increased, rendering it extremely difficult to give the necessary attention to a number of new problems of importance. A résumé of the tests made during the year is as follows: Length measures tested, 185; weights, 782; capacity measures, 2,177; barometers, hydrometers, and miscellaneous, 737; in all, 3,881.

The quality of the weights, measures, and measuring apparatus submitted for inspection and test shows a marked improvement over that of previous years.

DIVISION III.—THERMOMETRY, PYROMETRY, AND HEAT MEASUREMENTS.

The work carried out in this division during the year consisted in the testing of some 9,021 thermometers of various kinds, such as calorimetric and Beckman thermometers used in the determination of the calorific value of fuels, laboratory thermometers used for the precise measurement of temperatures up to 500° C. (930° F.), clinical thermometers used by the medical profession, maxima and minima thermometers, industrial thermometers for controlling the temperatures of technical processes, clinical standard thermometers used by manufacturers to control their product; 8 optical pyrometers, 35 thermocouples, 7 pyrometer galvanometers, and 5 platinum resistance thermometers, used for the measurement and control of high temperatures in metallurgical and other industrial operations and for special investigations in engineering laboratories. Other tests that have been made include the determination of the specific heat of amorphous silica, the freezing points of solutions, the fire-resisting properties of concrete, the calorific value of coal, the physical properties of oils, including the determination of flash points, viscosities, and setting points, and the calibration of a number of thermocouples for measurement of very low temperatures (- 300° F.).

The 8.444 clinical thermometers tested were submitted by manufacturers, dealers, hospitals, physicians, and the several medical departments of the Government. About 5 per cent of the clinical thermometers tested failed to pass the test requirements, in comparison with 7.5 per cent for the year preceding. The Bureau has loaned to the manufacturers for brief periods certified working standards, which has resulted in a continued improvement in the quality of the product submitted for test.

The results of the investigation carried out on the proper methods of annealing high temperature mercurial thermometers used in industrial operations are evident in the continued improvement in the product submitted for test. The plans and specifications for the electric annealing furnace designed and constructed at the Bureau for the annealing of thermometers has been furnished to a number of manufacturers, several of whom have already installed a number of these furnaces, so that it is confidently expected that the average of the American product will at an early date be in every respect equal to the product that has hitherto been imported to meet the requirements of industrial work.

The investigations carried out on the measurement of high temperatures by means of the radiation emitted by incandescent bodies has directed attention to the availability of these methods in many industrial operations and has already led to the extensive use of optical and radiation pyrometers. A very considerable number of consulting engineers, representatives of industrial plants and of engineering laboratories, have visited the Bureau during the year for the purpose of studying methods of high temperature measurement and observing the operation of the various types of pyrometers in use in its laboratories. The information the Bureau has been able to place at the disposal of American manufacturers and engineers is an important feature of the work of this section.

The investigation on which is based the standard scale of temperature in the interval 0° to 100° C. has been completed during the year. As a result of this work the Bureau is now in possession of a number of carefully studied standards which will serve to reproduce the international hydrogen scale of, temperature with the highest attainable precision. These standards were then applied to the calibration of several specially designed platinum resistance thermometers which were used to determine the transition temperature of sodium sulphate (32°.3840). As this point is now one of the most accurately known fixed points in thermometry, it will be of great service as a control point and for the standardization of resistance and calorimetric thermometers.

The great demands made on this division in testing has retarded progress on the important work incident to the establishment of the standard scale of temperature in the interval 100° to 500° C. Most of the apparatus has been designed and constructed, and considerable work has been done on the calibration of the standard thermometers to be used in this work.

The necessary apparatus for the determination of the specific heat of calcium chloride solutions (brine) has been constructed and assembled and some preliminary measurements have been made. The determination of this constant was undertaken at the request of the refrigeration industries, and as a result of the numerous inquiries addressed to the Bureau for information relating to this constant.

A low temperature thermometer comparator has been designed and constructed for the intercomparison of thermometers at temperatures down to -100° C.

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A theoretical investigation on the establishment of the thermodynamic scale of temperature by means of the gas thermometer has been made. The facilities now available in the way of liquid air, liquid hydrogen, compressed gases, electrical energy, and apparatus especially designed for the measurement of small temperature differences with the highest attainable accuracy impose upon the Bureau the imperative duty of repeating and extending the classical experiments of Thomson and Joule on the free expansion of gases—work which is fundamental to the whole conception of temperature.

The first portion of the work on the melting points of palladium and platinum was completed during the year. These constants are of great importance, since they serve as standard points of reference for the high temperature scale. Recent work here and abroad has called into question the entire high temperature scale, and it is of the utmost importance that further work be done on its establishment. It is also necessary to redetermine the fixed points of the lower range of the high temperature scale by means of a standard gas thermometer and to extend this scale to the highest attainable temperatures by the several radiation laws.

The introduction of metal filament lamps having a very greatly increased efficiency over the carbon filament lamps now in use has led to numerous investigations as to the cause of the great gain in efficiency, i. e., whether it is to be attributed to selective radiation or a higher working temperature of the metal filaments. An investigation on the temperature and selective radiation of carbon, tantalum, tungsten, and osmium lamps has shown that to a great extent the marked gain in efficiency over the carbon filament lamps is due to a higher working temperature at which the metal filaments can be used.

A new radiation method of measuring the melting points of the elements, especially applicable where only minute quantities are available, has been applied to the metals of the iron group and the results will be published in a forthcoming Bulletin.

The demands on the limited working force of this division in the matter of routine testing has grown to such an extent as to seriously interfere with important lines of work relating to the establishment of our standards with that precision which is rightfully demanded of us by the scientific and technical world.

DIVISION IV.—OPTICS.

SPECTROSCOP.Y.

The preliminary investigation of pure light sources has been concluded, and sources suitable for use in polarimetry, interferometry, reference standards of wave length, and for absolute length standards have been selected and recommended. In this work nearly all of the

available spectrum lines, numbering several hundred, were examined. The theory of spectral homogeneity was developed mathematically and the requirements of light sources for different purposes briefly outlined.

The luminous equivalent of radiation, or the specific relation of light to radiant energy, has been carefully examined theoretically in the light of the best data on visual sensibility of physical instruments, with a view to applications to commercial photometry, pyrometry, polarimetry, spectroscopy, and other similar work.

The luminous properties of conducting helium gas have been investigated experimentally with a view to the determination of its value as a primary standard of light intensity. The light from conducting helium was found to be very constant and free from external influences, but of a color not the most desirable for photometric precision.

Such tests of materials and measuring instruments as depend upon spectroscopic measurements have been made by this section.

RADIOMETRY.

Radiometry interests itself mainly with various problems in emission, absorption, and reflection spectra, particularly in the infra-red. The most recent completed work in this line is (1) a study of the radiation from a thermopile at room temperature to a complete radiator which is at the temperature of liquid air, (2) an examination of the infra-red reflection spectra of two groups of minerals (oxides and sulphides) not heretofore studied, and (3) a search for bands of selective reflection, "residual rays," in the extreme infra-red. The discovery of substances having such bands of selective reflection is of importance in extending the researches of Rubens and Kurlbaum on the radiation laws of a complete radiator at various temperatures.

While these subsidiary investigations have been in progress apparatus has been assembled for studying the radiation laws of a complete radiator (so-called "black body"), which must be done with improved apparatus and with more attention given to the measurement of the temperature of the radiator and to the adjustments of the apparatus than has been done in the past. Preliminary measurements of the uniformity of the temperature distribution of the radiator are now in progress, and it is a matter of but a short time when regular observations will be made on the "constants" in the radiation laws established by Wien and by Planck.

A study of the efficiencies of several radiation meters, including the bolometer, the radiometer, the radiomicrometer, and the thermopile, has been completed. The subject is treated historically as well as experimentally, and an attempt is made to rate each instru-

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ment as to its reliability and adaptability for particular kinds of work.

POLARIMETRY.

At the request of the Secretary of the Treasury the Bureau has made many recommendations relative to changes in the scientific methods employed in the customs laboratories, and a large amount of work preliminary to the introduction of these changes has been done.

An accurate determination of the effect of basic lead acetate, the clarifying reagent, on sucrose has been completed. The results show an unexpected lowering of the test of the sugar when there is a slight excess of the reagent and an increase when a considerable excess of the reagent is present. An effort is being made to discover a reagent free from this defect.

It is of the utmost importance that the methods of testing raw sugar at the different ports of entry be uniform. In view of this fact it was found necessary to make a careful investigation of the effects of the widely varying atmospheric conditions on such tests. 'This investigation is now being carried on and has resulted in correcting several obscure sources of error.

The determination of the 100° (sugar) point on the saccharimeter scale involves the preparation of chemically pure sugar, and it has accordingly been found necessary to defer that determination until an exhaustive study can be made of sucrose prepared by different methods. This investigation is well under way and promises to develop a method whereby chemically pure sugar may be prepared at the Bureau in quantities sufficient for purposes of testing and investigation.

Ordinary polariscopes for sugar testing do not permit of variable sensibility, i. e., they can not be adjusted to give the best results on widely varying sugars. A polariscope has been devised which overcomes this and other defects, and is now being constructed by the makers of such apparatus.

During the year certificates were issued for eleven quartz plates, submitted by the general public, and 1,202 samples of sugar were tested.

DIVISION V.-CHEMISTRY.

During the year determinations of the combining ratios of hydrogen and oxygen and of hydrogen and chlorine have been practically completed. In conjunction with the latter a new method of preparing chloroplatinic acid was devised.

In the preceding year the Bureau undertook, in cooperation with the American Chemical Society, to investigate and revise the methods of testing for and determining small amounts of impurities in the more important analytical chemicals and to work out appropriate

specifications. During the year an accurate method for determining minute traces of iron in chemicals was worked out, and work on a colorimetric method of determining traces of bromine, iodine, and sulphuric acid was begun, but had to be interrupted when well under way, owing to the increasing demands on the force of the division in other directions. The importance of work of this nature is very considerable, for not only does the accuracy of chemical analysis depend largely on the purity of the reagents employed, but determinations of the physical constants of matter, as electrical conductivity, melting points, atomic weights, etc., require material of exceptional purity, a condition which can in general be secured or determined only by chemical means. This work has therefore an important bearing on other problems of the Bureau and should be resumed as soon as possible.

An investigation of the methods of analysis of adhesive gums has been begun in connection with the testing of Government supplies.

The Bureau is constantly called on to furnish samples of materials of accurately known composition, among them irons and steels of various grades, alloys, iron ores, copper slags, etc. These afford to the chemist a valuable means of checking results and eliminating errors in his work. In response to this demand the division undertook the preparation of a series of seventeen accurately analyzed standard steel samples, from material furnished by the Association of American Steel Manufacturers, and of these three were completed and their distribution begun during the year. The demand for these, as well as the standard cast irons, has shown a gratifying increase. Inquiries have also begun looking toward supplying similar standard alloy steels, the industrial importance of which is rapidly increasing. The preparation of further standard analyzed materials is very desirable.

In cooperation with the committee on technical analysis of the American Chemical Society a sample of phosphate rock was carefully analyzed, with the object of throwing light on the accuracy of the analytical methods employed and of supplying a standard analyzed material.

Further work has been done in the way of experimenting with different methods of preparing materials used in the construction of standards of electromotive force, with the result that a much higher degree of uniformity has been reached:

Beginning with March, there has been an unusual increase in the testing work of the division, due largely to the demand for testing paper in connection with Government contracts and purchases. Several hundred samples of paper have been analyzed chemically, in conjunction with physical and microscopic tests, and this work has absorbed much of the time of the force. It has been the effort of the division to report tests with the greatest possible promptness, in order not to delay pending contracts or the use of the material in question. With the limited force of the division this could only be done by interrupting or even indefinitely postponing other important work.

Samples of paints, oils, ink, mucilage, and silk have also been analyzed for this and other Government Departments, in connection with the purchase of materials. The value of this work is shown by the fact that the materials examined frequently deviate widely from the specifications, or are of inferior quality, a fact which could only have been determined by testing.

While the increasing recognition of the importance of carefully examining supplies purchased by the Government is very gratifying and will lead to the use of better materials and the saving of money, other investigations which have an immediate bearing on practical questions connected with the manufacture and use of materials should be continued. Specifications are frequently very imperfect, and the methods of testing are often far from satisfactory. These can not be improved except through chemical and other scientific and practical investigations. The time and cost required to make these is usually trivial when compared with the continuous saving which would result to the Government and others, yet to carry them out is possible only with the aid of increased facilities sufficient to handle the required testing with promptness.

ENGINEERING INSTRUMENTS.

The tests and investigations in connection with engineering instruments have included water meters, gas meters and gas-meter provers, pressure and vacuum gauges, and anemometers. An open mercury manometer has been installed for the careful study of gauges of low range, especially those used on paper-testing apparatus. The range will be extended within a short time to include gauges up to 500 pounds per square inch.

An improvement has been made in the apparatus for testing anemometers and the range increased to 2,300 feet per minute. A careful study has also been made of the effects of air drag and the adjacent walls of the room upon the accuracy of the method of testing anemometers.

Work upon the comparison and development of standard methods and instruments for the calibration of gas meters, water meters, and other engineering instruments and a comparative study of the various types now on the market has been delayed on account of the great amount of testing to be done.

The rapidly increasing demands for the careful study and calibration of engineering instruments warrants a considerable extension of

this work. The requests for accurate data and tests have far exceeded the facilities and assistance available, and it has been necessary to limit the work to what has appeared to be the most urgent and important cases.

PROPERTIES OF MATERIALS.

During the year the Bureau has met with an unprecedented demand for information concerning and the testing of the properties of materials, which includes engineering, construction, and other materials ordinarily purchased according to specifications. These requests have been made principally by the various bureaus of the Government service and are due to the rapidly increasing desire on the part of the purchasing agents and other officials to purchase all such materials according to proper specifications and to insure conformity with such specifications by suitable tests of the articles delivered. For many materials no satisfactory methods of testing or measuring instruments are available, and these must be developed by the Bureau before the required information can be furnished. Furthermore, the development of instruments and methods for the testing of all such materials and the experience that is gained in testing them in connection with the Government purchases are sources of valuable information for the manufacturer and user of these materials. The materials tested thus far include the usual tests of steel, iron, concrete, cement, cement mortar, brick, paper, and textile fabrics.

Repeated requests have been received from a number of the Government Departments for assistance in the analysis of and specifications for their paper supply. These requests became so urgent that the subject was taken up, and the Bureau is now rendering them assistance daily, especially in connection with the purchase of paper by the Government Printing Office and the Post-Office Department.

For several years the textile industries have urged the Bureau to take up important questions pertaining to the textile industry. It has been impossible to respond to these requests on account of the lack of facilities. However, the testing of textiles in connection with Government purchases will necessitate the solution of many of these problems, the results of which may be placed at the disposal of the manufacturer as well. The equipment for determining the physical properties of textile materials is being developed. Tests have been made on silk, cotton, and linen fabrics, and twine.

The relation of the physical and chemical properties of lubricating oils to their value as lubricants is a problem which must be solved before suitable specifications and tests can be made. The Bureau has made considerable progress in this direction and contemplates an investigation of the physical and chemical methods that are now in use for the purpose of testing lubricating oils. A large number of miscellaneous materials have been examined, principally in connection with Government purchases, to ascertain their composition and whether or not they were in accordance with specifications. In many of these cases methods of testing must be perfected, and information regarding these materials is acquired which will prove of great value to the producer and the consumer, thus bringing about better conditions under which such materials are bought and sold.

PERSONNEL.

The personnel of the Biureau may be classed in three groups. The first has to do with the scientific work of the Bureau, the second with the office and clerical work, and the third with the operation of the mechanical plant, the construction of apparatus, and the care of the buildings and grounds. The plan of organization in each of these groups involves a regular gradation of salaries, in order that faithful and efficient service may be rewarded by promotion when vacancies occur.

The staff of the Bureau, including the Director, consists of 110 persons, distributed as follows:

Scientific force.—One physicist, 1 chemist, 6 associate physicists, 1 associate chemist, 16 assistant physicists, 3 assistant chemists, 19 laboratory assistants, 5 aids, and 7 laboratory apprentices; total, 59.

Office and clerical force.—One secretary, 1 librarian, 9 clerks, 1 storekeeper, 1 draftsman, 2 assistant messengers, 4 messenger boys; total, 19.

Engineer and mechanical force.—One engineer, 4 assistant engineers, 1 electrician, 7 mechanicians, 1 woodworker, 3 skilled laborers, 3 firemen, 1 elevator boy, 4 laborers, 2 watchmen, 2 janitors, 2 charwomen; total, 31.

LIBRARY.

The library contains 3,474 bound volumes, in good condition, carefully classified, and catalogued. The increase during the past year was 1,041, nearly all of which were acquired by purchase. The library has also a considerable number of reprints, pamphlets, and unbound reports, the total number of which is probably 1,500. These pamphlets contain some very valuable material; the work of classifying and cataloguing them is now in progress.

The circulation of the library during the year was about 4,500, and in addition about 900 books were drawn from other Government libraries. Through the courtesy of the Coast and Geodetic Survey the Bureau has had the use of sets of Wiedmann's Annalen and the Philosophical Magazine. The privileges of the other scientific libraries of Washington have greatly added to the resources of the technical literature at the disposal of the Bureau.

PUBLICATIONS.

The following publications were issued by the Bureau during the year:

Circular No. 12, concerning the verification of polariscopic apparatus and auxiliary instruments.

Circular No. 13, in regard to the adoption of standard specifications for the purchase of carbon-filament incandescent lamps. The specifications adopted were also separately printed as a blank form for the use of Government Departments and the general public.

A report of the proceedings of the second annual conference on the weights and measures of the United States.

The results of the scientific work of the Bureau were published in 31 technical papers.

SUMMARY OF TESTS.

In connection with the work of the Bureau a certain amount of testing of standards and standard measuring instruments is done. The tests completed during the fiscal year are shown in the following table. In case the testing is done for parties other than the Government, fees are charged as provided for by law. For comparison, the corresponding amounts are also indicated for Government tests.

NUMBER AND VALUE OF TESTS COMPLETED DURING FISCAL YEAR ENDED JUNE 30, 1907.

Nature of test.	For Government.		For public.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.
Length	82	\$243.40	103	\$224.25	185	\$467.65
Mass	275	140.50	507	294.05	782	434.55
Capacity	1,630	661.45	547	288.65	2,177	950.10
Temperature	740	382.92	8,459	1,523.52	9,199	1,906.44
Optical	1,197	1,203.00	17	35.50	1,214	1,238.50
Engineering	425	1,596,40	47	95.00	472	1,691,40
Electrical	131	386.70	175	541.85	306	928.55
Photometry	2,016	1,019.20	72	37.80	2,088	1,057.00
Chemical	362	1.247.86	447	748.29	809	1,996.15
Miscellaneous	728	583.75	9	6.50	737	590.25
Total	7,586	7,465.18	10,383	3,795.41	17,969	11,260.59

The receipts for tests were as follows:		•	
Total receipts, 1906–7		3,609.11	
Returned for canceled test, submitted and paid in previous year	\$5.00		
Received prior to July 1, 1906, for tests com- pleted in fiscal year 1906–7	276.18		
Due for outstanding tests	5.65	286.83	\$3, 895, 94
Received for tests completed in fiscal year 1905–6		38.23	,
Received for tests in progress at close of fiscal year	1906–7 -	<u>62. 30</u>	100. 53
Fees for tests completed 1906–7			3, 795, 41

FINANCIAL STATEMENT.

The following statement shows the amount and object of each appropriation provided for the Bureau for the fiscal year 1907, the disbursement during the year, the amount of unfilled and unpaid orders at the close of the year, and the unexpended balance remaining at the close of business June 30, 1907:

Appropriation.	Total appro- priation.	Disburse- ment.	Liability.	B
Salaries	\$111,440.00	\$108,399.59 35,225,80	\$5 549 15	
General expenses	15,000.00	13,895.74	886.42	
Do. <i>a</i>	1,000.00	509.87	335,30	
Total	171,440.00	161,031.00	6,770.87	

FISCAL YEAR ENDED JUNE 30, 1907.

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\$3,040.41

225.05 217.84 154.83 3,638.13

^a Made immediately available.

The following statement shows the condition of the appropriations for the two preceding fiscal years at the close of business June 30, 1907:

FISCAL YEAR ENDED JUNE 30, 1905.

Appropriation.	Total appro- priation.	Disburse- ment.	Liability.	Balanee.
Salaries	\$85,780.00	\$83,932.44 78 500.00		\$1,847.56
General expenses Grounds	13,250.00 1,000.00	13,176.29 1,000.00		73.71
Outbuildings	15.90	15.90		
Total	178,545.90	176,624.63		1,921.27

FISCAL YEAR ENDED JUNE 30, 1906.

Salaries	\$99,660.00	\$95,727.45	\$70.08	\$3,932.55
Equipment	41,000.00	40,678.01		251.91
General expenses	12,500.00	11,889.61		610.39
Grounds	1,500,00	1,499.37		.63
Outbuildings	12,484.10	12,472.09		12.01
Total	167,144.10	162,266.53	70.08	4,807.49

BUILDINGS AND GROUNDS.

The improvement of the grounds and the construction of roads has progressed slowly, but satisfactorily. No attempt has been made to do more than put the grounds in a condition satisfactory to the needs of the Bureau.

The site of the Bureau should be extended to the streets on the north and south and two or three hundred feet farther east, before building is begun in the neighborhood. Furthermore, the lowering of the grade on Connecticut avenue at its junction with Pierce Mill road has made the grade of the latter street so steep that it will be necessary to provide another entrance to the Bureau's grounds as soon as possible. This will be accomplished by the extension of the site to the street on the north.

Additional laboratory space is urgently needed for the testing of materials. The extraordinary growth of this work has seriously interfered with that in connection with standards and measuring instruments. Nevertheless, its importance has been such as to warrant considerable sacrifice on the part of the Bureau in order to comply with some of the more important demands for assistance. Should Congress make provision for this additional space during the coming session, it will then be at least two years before it would be available. What to do with this work in the meantime is one of the most serious problems the Bureau has met with.

INSTRUMENT SHOP.

The character and quantity of the work done at the Bureau is influenced largely by the facilities possessed for the construction of the special apparatus involved in all investigations. In every branch of testing new and improved apparatus must be designed and constructed in order to increase the accuracy or reduce the cost. The instrument shop, while well equipped with machines and provided with several excellent workmen, can not meet the demands of the Bureau for its service. It'is hoped that additional space and equipment may be provided for it in the near future.

Respectfully,

S. W. STRATTON, Director.

To Hon. OSCAR S. STRAUS, Secretary of Commerce and Labor.

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