Annual Report

of the

Director of the Bureau of Standards

to the

Secretary of Commerce and Labor

for the-

Fiscal Year Ended June 30, 1905



Washington Government Printing Office 1905



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DEPARTMENT OF COMMERCE AND LABOR

Document No. 43

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BUREAU OF STANDARDS

REPORT

OF THE

DIRECTOR OF THE BUREAU OF STANDARDS.

DEPARTMENT OF COMMERCE AND LABOR, BUREAU OF STANDARDS, Washington, D. C., July 1, 1905.

SIR: I have the honor to submit the following report of the work of the Bureau of Standards for the fiscal year ended June 30, 1905:

BUILDINGS AND GROUNDS.

While the mechanical laboratory was practically completed during the preceding year, a large part of the work carried on in this building has been organized during the past year. The completion of the physical laboratory made it possible to transfer entirely the work of the Bureau from the temporary quarters to the new laboratories during November and December. There remained to be done considerable piping, wiring, plumbing, and special work incident to the occupation of the physical laboratory, which has since been partly accomplished, and the different sections of the Bureau are established in the quarters set aside for them in this building. The original plans and specifications of the buildings included a cement floor on the ground floor of the physical laboratory, and did not provide for the painting or decoration of the walls. During the year a substantial wood floor has been laid on the concrete and the walls have been painted. The buildings as completed are plain and dignified in character, yet substantial and well adapted to the purposes for which they were designed.

Designs, have been completed for the low-temperature laboratory provided for by Congress, and its construction is well under way. In this additional space will be placed the apparatus for the liquefaction of gases, including a liquid-hydrogen plant. These facilities will enable the Bureau to undertake investigations involving the lowest temperatures that have been produced and will enable it to test low-temperature measuring apparatus.

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The appropriations for the improvement of the grounds have only been sufficient to construct temporarily the most necessary roads and walks and to do a small amount of grading. The site of the Bureau of Standards is one of the most beautiful in the District of Columbia. Its location is such that it will not require any considerable amount of grading, and it is the desire of the Bureau to retain the grounds in a comparatively natural condition.

However, the ground in the immediate neighborhood of the buildings should be graded and covered with good soil and grass and the entire site cleaned from rubbish and undergrowth. It will be necessary to lay out and construct a permanent road from the street to the buildings and on the grounds where needed. The block in which the Bureau is situated is bounded on the north by Shepherd street, on the west by Idaho avenue, on the south by Quincy street, and on the east by Connecticut avenue extended. This block forms a natural hill, sloping to each of these streets. The Bureau site is located on the crest of the hill, but does not extend to the streets named. It is very desirable that the remaining portions of this block should be secured in the immediate future before any buildings have been placed on the property. The streets surrounding the site should be opened as soon as possible, especially Shepherd street, on the north. The Bureau is at present using Pierce Mill road as an entrance, which, owing to its steep grade and poor condition, does not serve as a proper entrance to the grounds.

WEIGHTS AND MEASURES.

WEIGHTS.

During the year the installation of the new balances was completed. Solid masonry piers independent of the floor were built for the precision balances, thus insuring a foundation which would be free from vibrations due to the movements of the observer. On one of these piers is mounted the new 25-kilogram balance, which is about 50 times as sensitive as the old balance used formerly by the office of weights and measures. The new kilogram vacuum balance has not been permanently installed, but is temporarily used in the balance room.

The very important work of reestablishing secondary standards of mass throughout the entire range from 50 pounds to fractions of a milligram was begun. The new balances have been found very satisfactory indeed for this work and will enable the working standards of the Bureau to be determined with considerably more accuracy than has heretofore been possible. This work will include the comparison of the secondary standard kilogram with the prototype by means of the vacuum balance. Preliminary work has been done looking toward the establishment of more complete regulations in regard to weights submitted for test, involving more rigid specifications than have been deemed advisable heretofore, requirements which it is hoped will lead to a decided improvement in the quality of weights submitted by manufacturers.

With the cooperation of the Customs Service, a classification of weights will probably be made and tolerance errors adopted for different classes of weights. Considerable work has been done during the year for the various departments of the Government, for universities, and for manufacturers of precision balances and weights. Many representatives of such firms have visited the Bureau and have taken great interest in its equipment and work.

MEASURES OF LENGTH.

During the year a small vertical Zeiss end comparator having a range of 1 decimeter was acquired. A comparator having a range of 4 decimeters was constructed in the instrument shop according to plans prepared by the Bureau. This comparator has but recently been completed. Preliminary results obtained, however, are extremely satisfactory, and it is believed that the comparator will permit the determination of the length of the end gages and standards with greater accuracy than has heretofore been obtained.

The 50-meter comparators in the tunnel connecting the mechanical and physical laboratories have not been completed but satisfactory progress has been made on them. One of these comparators is to be similar to the bench standard heretofore used, and will consist of a continuous steel bar 50 mm by 13 mm in cross-section. This bar will be mounted on rollers 1 meter apart, the rollers being in turn mounted on cast-iron brackets fastened to the wall of the tunnel. The graduations on the 50-meter bar will be made on small platinumiridium disks, which will be inserted in the surfaces of the bar. The 50-meter comparator for geodetic base bars and for tapes used in geodetic work is partly completed. The stone piers, 5 meters apart, on which are the microscopes used in observing the lines on the 5-meter standard, have been placed in position, and between one pair of piers four other piers have been placed 1 meter apart for the purpose of building up the 5-meter bar from the national prototype meter.

It is intended to investigate a number of nickel-steel tapes for the Coast Survey during the coming winter to determine whether nickelsteel tapes are suitable for the measurement of geodetic base lines.

The 1-meter precision comparator remains to be constructed. The stone piers have been secured and will be installed in one of the basement rooms. This comparator will be of the optical beam compass type; that is to say, the microscopes will be clamped on a beam which will rest on piers at each end instead of being mounted on piers directly. The advantages of this type are that the microscopes may be varied and the comparator used to compare either yards or meters or other lengths down to 1 decimeter. If the beam is made of nonexpanding nickel steel the microscopes of the comparator should be at least as stable as those mounted on independent piers.

During the year a meeting of State sealers of weights and measures was held at the Bureau. A collection of balances, weights, and measures, etc., suitable for their use was shown, some of which were designed at the Bureau of Standards. The results of the meeting were eminently satisfactory. Many of the delegates whose duties were merely nominal learned for the first time the importance of the work of testing the commercial weights and measures. In addition, the Bureau secured very much valuable information as to the condition of affairs throughout the country. A report of this meeting containing the statements of the various delegates as to the testing of commercial weights and measures has been prepared, and it is expected that it will be issued during the coming year. A compilation of the laws relating to weights and measures in the United States and Territories was published principally for the information of the State and city sealers of weights and measures. Considerable demand for this publication has come from manufacturers throughout the country.

On account of the increase in the amount of routine testing in this section, it is impossible with the present force to properly keep up with the work, much less to undertake investigations which suggest themselves and for which there is urgent need. It will be necessary to provide additional assistance in this work at the earliest possible moment. Assistance is also needed in the preparation of circulars of information, tables of equivalents and constants, a dictionary of weights and measures, values of foreign weights and measures, etc. At the present time many inquiries can be only imperfectly answered because of the great amount of time required to look up references.

MEASURES OF VOLUME.

The work in connection with the testing of volumetric glassware has been further developed during the past year. Regulations regarding the construction, marking, use, limits of error and fees for testing have been determined upon and published in Circular No. 9. Purchasers of volumetric apparatus are now specifying that it shall conform to the regulations of the Bureau of Standards, and frequently they submit it for test. The methods of testing this apparatus have been further perfected, and it may now be tested with great rapidity in large quantities. The methods of using and testing burettes have been investigated with reference to the correction of the errors met and to improvement in their manufacture. Considerable testing has been done for the Government and for private individuals, including several manufacturers who wish to construct apparatus in accord with the regulations of the Bureau.

A large amount of work has been done for the Hygienic Laboratory of the Public Health and Marine-Hospital Service. This laboratory has recently acquired an equipment for work in connection with diptheria antitoxins and the testing of the potency and purity of antitoxins supplied to the public. A large part of this equipment consists of volumetric apparatus which has been submitted to the Bureau for the most careful investigation. Much of this apparatus requiring the highest degree of precision in measuring small quantities of liquid has been adjusted by the Bureau. To do this there has been added to the equipment a balance embodying special features which make it possible to work with great rapidity and precision. The performance of this balance has been so satisfactory that it is proposed to obtain another of the same type, but larger, in order to extend the range of this class of work to apparatus of two liters capacity.

MEASUREMENT OF TIME.

Preparations for the work of testing time-measuring apparatus have been carried forward during the year, but it is not sufficiently far advanced to permit the investigation of time pieces for the public. The standard clock made by Riefler at Munich is at present temporarily mounted on the wall of a second-floor laboratory, but plans are being prepared for a permanent clock room in the basement, which will be much better adapted for this purpose. Through the courtesy of the Bureau of Equipment of the Navy Department the noon signals are received from the Washington Navy-Yard by wireless telegraphy, the connection between the navy-yard and the Naval Observatory being by telegraph. The correction to the noon signal as sent out by the Naval Observatory is furnished to the Bureau, so that the only errors are those due to the transmission of the signals from the navy-yard to the Bureau.

Notwithstanding the unfavorable position of the clock, the rate has been very satisfactory, the daily variations not usually exceeding one-tenth of a second—an accuracy more than sufficient for all ordinary purposes. In addition to the double-pen chronograph ordered last year, a cabinet for the position test of watches was designed and purchased. This cabinet is constructed to maintain the watches at a nearly uniform temperature, and it will be fitted with adjustable holders making it possible to vary the position of the watches. With the transfer of the clock to the vault mentioned and the building of a small room where the temperature can be raised and lowered for the temperature tests of watches, for which plans are being drafted, the preparations for watch testing will be practically completed and the work may be inaugurated.

THERMOMETRY, PYROMETRY, AND HEAT MEASUREMENTS.

The work carried on by this section during the year includes the testing of thermometers of all kinds and of the various forms of pyrometers for the measurement of high temperatures, the determination of calorific values of fuels, and investigations bearing on the establishment and control of the temperature standards of the Bureau. Information has been furnished, upon request, to several departments of the Government, and to cities, manufacturing interests, technical schools, and individuals, as to methods of measurement, thermal constants, specifications for thermometers. etc.

The intercomparison of the primary standard mercurial thermometers of the Bureau in the interval $0^{\circ}-100^{\circ}$ C., in a specially designed comparator, has been carried on from time to time during the year, and is now nearing completion. A number of platinum resistance thermometers, together with the necessary apparatus for their use, have been designed and constructed, to be used in connection with the establishment of the standard scale of temperature, which work, owing to the rapidly increasing demands for testing, has not progressed in accordance with its importance.

An electrically heated fused salt bath has been constructed in the instrument shop for the intercomparison of the standards of the Bureau and the testing of high-temperature thermometers in the interval 300°-525° C.

During the year the first part of the investigation as to the methods of measurement of high temperature by means of the light and heat emitted by incandescent bodies, with a view to their application in the laboratory and in the industries, has been completed, and an account of it was published in Bulletin No. 2, pages 189–254.

The demands of electrochemical processes make it necessary to control and measure temperatures far beyond the range of any pyrometer requiring contact with the heated substance. With the establishment of a satisfactory scale of extreme temperatures in view, an investigation has been carried out during the year in which the several methods of estimating such temperatures by optical and radiation pyrometers were compared at the extreme temperature of the electric arc. The results of this investigation, which showed the several methods to be in satisfactory agreement, were published in Bulletin No. 1, pages 109–124.

The construction and study of a standard gas thermometer, which is the ultimate standard in all thermometric work, is of fundamental importance in its bearing on the standards of the Bureau. Some progress has been made in assembling the apparatus necessary for this investigation.

In view of the great amount of work incident to the establishment and study of the Bureau's standards of temperature and the large amount of testing to be done in this section, a considerable increase in its working force will be necessary.

The low-temperature liquid air and hydrogen plant recently acquired by the Bureau makes available the equipment necessary for the extension of the scale and the study of the standards at the lowest attainable temperatures.

THERMOMETRY.

During the year over 13,000 thermometers of various kinds have been tested, including precision standards, clinical standards, hightemperature, maxima and minima, and clinical thermometers. These include many thermometers that will be used as standards by manufacturers. The tests were based upon the international hydrogen scale of temperature, thus leading to the general adoption of that scale. The tests have shown that a large percentage of the hightemperature and industrial thermometers were subject to very considerable changes with use, due to improper methods of treatment during the process of construction. The attention of thermometer manufacturers was directed to this matter by correspondence, with the result that the more recent product submitted shows a marked improvement in this respect. Investigations bearing upon this question have been completed during the year, and the results are ready for publication. The tests include over 12,000 clinical thermometers submitted by manufacturers, dealers, hospitals, physicians, and the several medical departments of the Government.

During the preceding year 11.6 per cent of the clinical thermometers submitted failed to pass the test requirements, in comparison with 8.4 per cent in the past year, which indicates an improvement in the quality of the product submitted. The details of the apparatus used and the methods of testing have been described in Bulletin No. 2, pages 275-289. This information has been furnished to a number of manufacturers, and clinical standards have been loaned to them for short periods with a view to facilitating the general use of a uniform scale of temperature and an improvement in the product. The apparatus, which has been especially designed for this work, and which has been constructed in the instrument shops of the Bureau, has now been subjected to exhaustive trials, and leaves little to be desired in accuracy of results and speed of working. Nevertheless, the demands for this work have increased so rapidly during the past year that the facilities of the Bureau in this line have been overtaxed.

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PYROMETER AND HEAT MEASUREMENTS.

Under this head the following instruments have been tested: Thermocouples for measuring high temperature, pyrometer galvanometers, expansion pyrometers, platinum resistance thermometers, optical pyrometers, and a combustion calorimeter, and several tests have been made of the calorific value of fuels. Several of the pyrometers tested will be used as standards by manufacturers, and will thus serve to control a large number of pyrometers used in industrial processes and will facilitate the introduction of a uniform scale of temperature. The instruments tested cover a wide variety of applications, viz: the control of temperatures in hardening and annealing, and in glassware and chemical furnaces, engineering tests, and investigations involving high temperatures.

The great importance in many industrial processes of an accurate knowledge and control of the temperatures at which the operations are carried out is just beginning to be realized in this country. The representatives of many manufacturing plants have visited the Bureau during the year, with a view to studying the pyrometers in use in its laboratories and consulting its experts concerning the methods of temperature measurement, and no inconsiderable part of the work of this section has been the furnishing of information of this kind to the public.

OPTICS.

The organization of the optical work was begun to a small extent in the temporary quarters. The completion of the physical laboratory during the year has made it possible to take up several important problems. While the work of this section is chiefly related to the determination of physical laws and constants, considerable testing has been done, especially in connection with polariscopic apparatus and standards. This section, and in fact the entire Burean, is very much in need of the services of a mechanic skilled in the grinding and polishing of glass and a glass blower.

SPECTROSCOPY.

The spectroscopic work has been confined chiefly to the determination of the laws and conditions governing the production of pure spectra, with a view to their application in spectroscopic methods, the determination of standard wave lengths and their use in optical methods of measurement. It has involved investigations in connection with the spectra of mixed gases and multiple spectra. The spark and arc spectra of twenty-one different metals were photographed under different conditions. An examination was also made of the spark and arc spectra of alloys. It is proposed to further examine the individual lines by means of the echelon spectroscope. For this purpose a 30-step echelon grating has been purchased and a special mounting constructed.

POLARIMETRY.

The work in polarimetry has been confined almost entirely to the examination of methods and apparatus used in polariscopic analysis of sugar. During the past year polarizing apparatus for especially accurate measurements and a thermostat for use in connection with this apparatus have been designed and built in the Bureau shops. An accurate quartz compensation polariscope has been assembled, and a number of quartz control plates to be used as primary standards have been obtained. One of the greatest obstacles to accurate polariscopic measurements is the lack of sources of monochromatic light of sufficient intensity. Sodium light, the accepted standard, is far from monochromatic. One of the spectral lines emitted by a guartz mercury lamp seems to answer every requirement. Accordingly a determination of the rotation of quartz for light of this particular wave length has been undertaken. The measurement of the absolute rotation of quartz control plates for primary standards is well under way.

Owing to the lack of reliable data on the effect of the reagents commonly used in sugar testing, it has been found necessary to determine their rotary dispersion curves. These measurements, as well as those on quartz, for the mercury line referred to above will soon be published.

During the past year the Bureau has been requested by the Treasury Department to test the exchange samples of sugar from the four principal sugar ports. These ports send samples daily to each other and to the Bureau. The results of these tests are forwarded to the Secretary of the Treasury, the work of the Bureau thus giving him a check on the accuracy of each day's work at the ports referred to. Active cooperation has also been carried on with the Treasury Department toward establishing uniform and improved methods for polariscopic sugar analysis.

A considerable amount of testing was done during the latter portion of the fiscal year, including tests of a number of quartz control plates and polariscopes. The Bureau is prepared to test control plates to a high degree of accuracy.

ENGINEERING INSTRUMENTS AND MATERIALS.

It has been impossible to assign to this section laboratory space and assistance commensurate with the importance of the work and the demand for testing. The Bureau is in a position to study and test water meters not larger than 2 inches, gas meters, speed indicators,

and pressure gauges. Designs have been completed for an anemometer testing machine, which is now in process of construction in the shops of the Bureau. The tests made during the year include among others two different kinds of water meters, several sizes of a new form of speed indicator, and a paper tester—the latter to be used in one of the Departments of the Government. The investigation in connection with fire-hose couplings has been continued with a view to the selection of a national standard. Important progress has been made in this direction. The more important tests of materials include the test of the tensile strength of the new cable for the elevator in the Washington Monument, the cement used in the construction of the new office building for the House of Representatives, and the adhesive power of a large number of mucilages, with a view to determining the proper specification to be used in Government purchases of this article.

INSTRUMENT SHOP.

During the year a large amount of special apparatus has been constructed in the instrument shop. Every test or new problem taken up requires a certain amount of mechanical assistance. Special apparatus which can not be bought in the market is much more cheaply constructed under the personal supervision of the experts who have planned it and who will superintend its use than elsewhere. The mechanics employed in the instrument shop are all instrument makers of experience and skill. The equipment of the shop is modern and efficient, but neither the number of instrument makers nor the equipment is sufficient to meet the needs of the Bureau.

ELECTRICAL WORK.

The electrical work of the Bureau is divided into five principal sections. The first has to do with resistance and electromotive force, the second with magnetism, the third with inductance and capacity, the fourth with a wide range of electrical measuring instruments, and the fifth with photometry.

The work of the first, second, and third sections was transferred from the temporary quarters previously occupied to the new Physical Laboratory at its completion. The work of the fourth and fifth sections was partially installed during the previous year in the Mechanical Laboratory. The establishment of the electrical work in new quarters has enabled the Bureau to begin several investigations relating to fundamental electrical units and standards. This is especially important in view of the coming International Electrical Congress, at which the Bureau will be expected to contribute the results of its work.

At the request of the authorities of the Louisiana Purchase Exposition, an electrical testing laboratory was equipped and maintained in the Electricity Building of the exposition. The object of this installation was to exhibit a working electrical laboratory and to test instruments and standards for the jury of awards, for the railway test commission, for the Government, and for other electrical interests at the exposition. Notwithstanding the fact that the laboratory was in a temporary structure, it possessed many of the appointments of a permanent installation, and a considerable amount of testing was done in it during the latter half of the exposition period. 'The exhibit proved to be of great value to the electrical interests of the country. It was especially appreciated by visitors from abroad familiar with the equipment of European institutions doing similar work, and was awarded a grand prize by the exposition authorities.

ELECTRICAL RESISTANCE AND ELECTROMOTIVE FORCE.

The work of this section involves the construction and verification of resistance standards and standards of electromotive force, the calibration of resistance boxes. Wheatstone bridges, potentiometers, precision rheostats, and resistances for current measurements, and the determination of the electrical conductivity of materials. The permanent installation of the work of this section in the rooms set aside for it has involved the expenditure of considerable time and labor. This has been done with a view to facilitating as much as possible the routine work of testing and the undertaking of several important investigations relating to fundamental electrical standards. The new pieces of apparatus purchased or constructed during the year include a direct-reading shunt compensation ratio set, by which two resistance standards may be quickly and accurately compared; a special Carey-Foster bridge, a mercury contact Wheatstone bridge, and a D'Arsonval galvanometer of the highest sensibility. A direct-reading method has been devised and apparatus designed for the rapid calibration of resistance boxes, with satisfactory results. Further work has been done on the construction of some primary and secondary mercurial resistance standards, and it is hoped that they will be completed during the coming year. Investigations pertaining to the standard cell have been interrupted by the work incident to the installation of the new laboratories and by routine testing. These investigations will be taken up again during the coming year.

MAGNETISM AND ABSOLUTE MEASUREMENT OF CURRENT.

Several different pieces of apparatus for testing the magnetic properties of iron and steel have been calibrated by comparison, by the double-yoke method. The Burean is prepared to determine the

magnetization and static hysteresis curves of suitable specimens of iron, and a few such tests have been made. During the present year apparatus will be added for testing sheet iron by the wattmeter method.under widely varying conditions. In connection with the work of current measurement, the study of the silver coulometer has been continued. An absolute electrical dynamometer is in process of construction, the cylindrical frames of which have been completed and carefully measured. An examination of the elastic properties of suspensions for use in this instrument has been made. The electrodynamometer will probably be completed during the coming year.

INDUCTANCE AND CAPACITY.

This work includes the investigation of methods of inductance and capacity measurement. the construction and testing of standards of inductance and capacity for the Bureau, the testing of such standards for the public, and the measurement of the inductance and capacity of instruments. As a result of the year's work, several important improvements have been made in these measurements, and the accuracy attainable has been appreciably increased. An extended study of the standards of inductance of the Bureau has been made and their values fixed with satisfactory precision. An investigation has been carried on to determine with greater accuracy than has as yet been done the ration of the electromagnetic to the electrostatic units of electrical measure. Excellent progress has been made and the work will be continued during the next year.

ELECTRICAL MEASURING INSTRUMENTS.

In this section is carried on the investigation, and construction when necessary, of instruments of precision for measuring electrical current, electromotive force and power, and the phase, wave form. and frequency of alternating electrical currents: also the testing of laboratory and commercial ammeters, voltmeters, wattmeters, anad watt-hour meters for both direct and alternating current, and frequency meters, phase meters, curve tracers, and other instruments used in connection with alternating currents. Several investigations have been made in connection with electrical measuring instruments and a considerable amount of testing has been done. During the past six months a large amount of work has been done in perfecting the installation and equipment necessary for this wide and important field of electrical testing. The facilities required for handling and measuring alternating currents of 1.000 amperes and direct currents of several thousand amperes are much more difficult to provide than for smaller currents. An effort is being made to equip this laboratory with the instruments necessary for measuring all of the alternating currents involved in precision and commercial testing

and to provide it with the generating machinery, transformers, and other apparatus necessary to produce the range of frequency, wave form, and power factor necessarily employed in the testing of alternating-current instruments. A special harmonic alternator is now being built for the Bureau, which will add materially to the facilities for the testing and study of such apparatus.

PHOTOMETRY.

While the work in photometry is principally optical in character, its relation to the electrical work is such that it has been included in that branch of the Bureau's work for the present. In addition to the regular testing for the departments of the Government and for the general public, the photometric standards of the Bureau have been intercompared and their comparison with the standards of other countries has been taken up.

The integrating photometer for the measurement of mean spherical candlepower, designed at the Bureau and begun a year ago, has been completed, and after adjustment will be applied to the solution of several problems of commercial importance in addition to its use in the actual testing of electric lamps.

A rapid commercial photometer has been designed to meet the increased demands for commercial testing of incandescent electric lamps by the various departments of the Government, and it is nearing completion. For this work a photometer is required with which lamps may be rapidly tested. This photometer, together with adequate means for making life tests of lamps, will constitute a fairly complete equipment for the photometry of incandescent electric lamps. During the year a thorough study of the sectored disk, an essential adjunct to a photometric equipment, was begun, and it is expected that the results of this investigation will be published within the next year.

CHEMISTRY.

Since the rooms set aside as chemical laboratories are situated in the Physical Building, very little could be done toward their permanent equipment and the installation of the large amount of special fixtures and plumbing necessary until the completion of this building, thus delaying the chemical work in new quarters until March of the present fiscal year. Previous to this, work of the chemical section was carried on in the temporary quarters of the Bureau and in the chemical laboratory of the Bureau of Chemistry of the Department of Agriculture through the courtesy of the Secretary of that Department and the chief of the Bureau of Chemistry. In addition to the planning and installation of the permanent equipment and apparatus of the chemical laboratories, a number of investigations have been

undertaken which were considered important from a commercial or scientific standpoint, or have been necessary in connection with the work of this and other Government bureaus.

The Bureau has undertaken to standardize some of the more important chemical reagents, and considerable work has been done in this direction. Samples of a few important materials, including limestone and steel, have been carefully analyzed with a view to their distribution when necessary for the purpose of checking the accuracy of methods of analysis used in scientific work and the industries. Questions relating to the purity of reagents and analytical methods are of the greatest importance to scientific and commercial interests. It is hoped that the Bureau may considerably extend this work during the coming year. A number of substances have been examined physically and chemically for the Department of Commerce and Labor and other Departments of the Government with a view to determining standards and standard specifications to be employed in the purchase of Government supplies. The relation of the chemical work to that of other sections of the Bureau is exceedingly important. Scarcely a problem can be taken up concerning the construction of standards. or properties of materials, that does not involve chemical preparations, chemical analyses, or the cooperation and advice of expert chemists. The entire work of the Bureau has been greatly strengthened and its efficiency increased by the organization of the work in chemistry.

PERSONNEL.

The personnel of the Bureau 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.

In recommending persons for appointment to the staff of the Bureau every precaution is taken to insure that they possess the proper qualifications for the work in hand and the fundamental education or training necessary for advancement in the service.

The staff of the Bureau, including the Director, consists of 71 persons, distributed as follows:

Scientific force.—One physicist, 1 chemist, 4 associate physicists, 1 associate chemist, 7 assistant physicists, 1 assistant chemist, 15 laboratory assistants, 1 computer, 2 aids, and 3 laboratory apprentices; total, 36.

Office and clerical force.—One secretary, 1 librarian, 6 clerks, 1 storekeeper, 1 draftsman, 2 assistant messengers, 1 messenger boy; total, 13.

Engineer and mechanical force.—One engineer, 2 assistant engineers, 1 electrician, 5 mechanicians, 2 woodworkers, 2 shop apprentices, 2 firemen, 2 laborers, 2 watchmen, 1 janitor, 1 charwoman; total, 21.

LIBRARY.

The library has been increased by the addition of 235 volumes. It now contains 2,184 bound volumes and about 1,200 pamphlets, reprints, and miscellaneous reports. These books are all of a purely technical character, dealing with the work of the Bureau or with subjects closely related to it.

The library subscribes to or exchanges with 77 scientific periodicals, and receives gratis many reports, translations, and bulletins from similar scientific institutions, universities, and learned societies. During the year 101 volumes of this material have been entered and bound.

Acquisitions by purchase have been, in general, books that were not available in the other libraries of the city or were in such constant use as to require that copies be immediately at hand. The privileges of nearly all the other libraries of the city have been extended to the Bureau. Many books have been borrowed from them during the year, and much assistance has been rendered by the several librarians. A complete author and subject catalogue of the works on hand has been prepared. Through the card distribution of the Library of Congress the Bureau possesses a complete author and subject catalogue of the Library collection, so far as cards have been printed, in the subjects relating to the work of the Bureau. Titles are being continually added as they appear.

PUBLICATIONS.

The following publications have been issued during the year:

Circular No. 8, covering fees, regulations, and instructions relative to the testing and use of thermometers.

Circular No. 9, in connection with the testing and use of glass volumetric apparatus.

Circular No. 10, regarding legal weights, per bushel, of various commodities.

The results of the scientific work of the Bureau are published in the form of bulletins, two of which were issued during the year.

A new edition has been issued of a graphical chart illustrating the international metric system of weights and measures and its relations to the customary system.

The national and State laws concerning weights and measures have been compiled and published in a volume for the use of the Bureau and for State and city officials having in charge matters pertaining to weights and measures.

NUMBER AND VALUE OF TESTS COMPLETED.

The following table shows the number of tests made at the Bureau and the amount of the fees received therefor during the fiscal year ended June 30, 1905:

Nature of test.	For Government.		For public.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.
Length	• 111 260	\$170.50 269.50	133 321	\$177.70 209.70	244 581	\$348.20 479.20
Capacity Temperature Optical	$ \begin{array}{r} 756 \\ 1,417 \\ 539 \end{array} $	$243.20 \\ 266.13 \\ 430.25$	$\begin{array}{c} 42\\11,274\\1\end{array}$	$\begin{array}{r} 47.00 \\ 1,752.48 \\ 5.00 \end{array}$	$798 \\ 12,691 \\ 540$	$\begin{array}{r} 290.20\\ 2,018.61\\ 435.25\end{array}$
Eugineering Electrical Photometry	18 171 984	$ \begin{array}{r} 66.00 \\ 404.25 \\ 161.30 \end{array} $		$24.00 \\ 417.30 \\ 71.75$	$24 \\ 515 \\ 1,087$	90,00 821,55 233,05
Chemical Suudry	34 87	90.00 68.75	4 39	$50.00 \\ 31.50$	38 126	$\frac{140.00}{100.25}$
Total	4,377	2,169.88	12,267	2,786.43	16,644	4,956.31

The number of tests made for the Government in 1904–5 was 27 per cent greater than in the preceding fiscal year, and the number of tests for the public was 185 per cent greater, the increase in tests for both Government and public being 115 per cent.

The receipts for tests were as follows:

Total receipts 1904–5	\$2, 815. 38	
Previously received for tests in progress 1904-5 \$31.60		
Due for outstanding tests 33-25		
	64.85	\$2 880 23
Received for tests completed 1903-4	29.05	φ2, 000. 20
Received for tests in progress	64.75	
· · · · · · · · · · · · · · · · · · ·		93, 80
Fees for tests completed 1904-5		2, 786. 43

FINANCIAL STATEMENT.

The following statement shows the amount and object of each appropriation provided for the Bureau for the fiscal year 1904-5, the disbursements 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, 1905:

APPROP.	RIATIONS,	1904 - 5.
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Appropriation.	Disbursement.	Liability.	Balance.	Total.
Salaries. Equipment Geueral expenses Grounds. Outbuildings	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	\$8,176,55 882,93 12,000,00	$\frac{\$2,210,90}{111,71}\\148,06\\484,10$	\$85,780,00 78,500,00 13,430,00 1,000,00 12,500,00
Total	167, 195, 75	21,059,48	2,954.77	191, 210.00

The following statement shows the condition of the appropriations for the two preceding fiscal years at the close of business June 30, 1905:

Appropriation.	Disbursement.	Liability.	Balance.	Total.
Salaries Equipment General expenses	\$32, 559, 93 29, 350, 00 4, 939, 97		\$3,500.07 650.00 60.03	
Total	66,849.90		4,210.10	71,060,6
	<u> </u>			

APPROPRIATIONS, 1902-3.

APPROPRIATIONS, 1903-4.

Salaries Equipment General expenses Grounds	$\begin{array}{c} \$69,754.59\\ 109,172.15\\ 10,876.36\\ 500.00 \end{array}$	\$600.65	\$4,945.41 227.20 48.97	
Total	. 190, 303. 10	600.65	5, 221.58	196, 125, 33

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Respectfully,

S. W. STRATTON, Director.

The Secretary of Commerce and Labor, Washington, D. C.





