Annual Report

of the

Director of the Bureau of Standards

to the

Secretary of Commerce and Labor

for the

Fiscal Year Ended June 30, 1908

Washington
Government Printing Office
1909

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DIRECTOR OF THE BUREAU OF STANDARDS.

DEPARTMENT OF COMMERCE AND LABOR,
BUREAU OF STANDARDS,
Washington, July 1, 1908.

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, 1908:

DIVISION I.—ELECTRICITY.

The work of the electrical division of the Bureau comprises photometry as well as electricity and magnetism. Each subject involves scientific investigation and the practical application of the results of such investigations to the improvement of electrical standards and the testing and verification of instruments and materials.

The work of this division has been of three kinds—(*a*) pure research; (*b*) the investigation of methods of measurement and of testing, the design and construction of instruments for use in testing, the purchase, testing, and installation of equipment; and (*c*) the testing of instruments and materials for the public and the departments of the Government. It has been the policy of the Bureau from the outset to establish each line of work upon a rigorous scientific basis before undertaking actual testing for the public. A single test frequently involves extended research. Many of the tests are difficult and involve considerable theoretical knowledge as well as instrumental equipment. The electrical tests made during the year, 337 in all, include a wide variety of electrical standards, instruments, and materials. The research work done by the Bureau, the results of which have been published from time to time, has given it a high standing in the electrical world. The classical researches of Lord Rayleigh and others of a generation ago laid the foundation and set a high standard for work of this kind. But the order of accuracy now demanded in absolute measurements is at least ten times as great as then. This not only requires better instruments and facilities, but also refinements of theory and extended investigations of possible sources of error, which vastly increase the labor and time required.

ELECTRICAL RESISTANCE AND ELECTROMOTIVE FORCE.

The increased application of electrical methods to many classes of physical investigations and the more rigorous specifications for certain classes of commercial electrical apparatus has materially increased the testing work of the section. In order to reduce the time required for some of these tests and to facilitate the intercomparison of standards belonging to the Bureau, some new shunt-compensated resistance apparatus has been designed and is now under construction. The apparatus consists of a number of 1:1 and 10:1 ratio coils, and a multiple ratio box furnishing all the ratios met with in practice.

The investigation of standards of electromotive force referred to in previous reports has been continued and extended and further comparisons have been made between the Weston standard cells of the Bureau and those of the English National Physical Laboratory. The results have fully substantiated the accuracy of reproduction of several parts in one hundred thousand previously claimed. In addition, the cooperation of a number of American physicists, chemists, and physical chemists has been enlisted, with the object of testing the preliminary specifications proposed by the Bureau for the construction of Clark and Weston cells.

On the basis of the results attained at the Bureau and elsewhere, the Bureau of Standards has been convinced of the superiority of the standard cell over the coulometer as a fundamental electrical standard. This position, which has been indorsed by a joint committee of the American Physical Society, the American Institute of Electrical Engineers, and the American Electrochemical Society, will therefore be advocated at the forthcoming International Electrical Conference.

During the year a redetermination of the temperature formula of the Weston cell has been completed. The results show that the formula heretofore accepted does not correctly represent the changes in electromotive force with temperature below 10° and above 30°. The difference within the above range between the two formulæ are smaller, but must be taken into account when the highest precision is sought. A large amount of further work has been outlined and will receive attention as soon as time permits.

INDUCTANCE AND CAPACITY AND ABSOLUTE MEASUREMENTS.

In inductance and capacity measurements great progress has been made and a considerable program of work has been laid out for the next few years. The investigation of the ratio of electrical units in progress for three years was brought to a successful conclusion during the year and has been published in the Bulletin. This ratio is of fun-

damental importance in electrical measurements, and this investigation has fixed its value much more exactly than heretofore known. The current balance work is making good progress; much has been learned about the problem, and an improved form of the balance is under construction. Such work is so exacting and the difficulties so great that satisfactory progress can not be rapid. In the work on the new sealed standards of resistance enough has been done to demonstrate the great advance which has been made by their development in precision resistance work.

The practical units in terms of which all electric current and power are measured in this country are fixed by act of Congress, but in order that the units shall be the same throughout the world international conferences or congresses have been held from time to time to agree upon the values of these units. The units now in use were agreed upon at the International Electrical Congress held in Chicago in 1893, and they were enacted into law by act of Congress approved July 12, 1894. Subsequent investigation has shown the necessity for slight changes in some of the units and a revision of the law. For this reason and in view of the meeting of the International Conference on Electrical Units and Standards, to be held in London, October 12–21, 1908, considerable work has been done during the year on the improvement of the standards of electromotive force and standards of resistance, and on the determination of electric current in absolute measure. These researches are just now of special importance. The results of the above investigation will be presented to the conference and will no doubt form an important factor in the conclusions.

ELECTRICAL MEASURING INSTRUMENTS.

The number of electrical measuring instruments tested during the past year is nearly double that for the preceding year; instruments of various types and widely differing ranges being tested for the public. Other work done in this section included the study of new commercial instruments under varying service conditions; the testing of insulated wire and insulating joints for breakdown voltage; tests of inclosed fuses, dry cells, and the electrical properties of materials. A special electric heating device, submitted by one of the branches of the government service, was tested, and experiments were made with a view to improving this device and lowering its cost. Such an improved apparatus was constructed in the instrument shop of this Bureau and given a thorough test. A new instrument has been designed for the rapid measurement of current and voltage, which will materially reduce the time required for many electrical instrument tests.

MAGNETISM.

Problems have been studied involving the measurement of the magnetic properties of iron and steel, including soft iron in thin sheets, so extensively used by manufacturers of electrical machinery. The Bureau is now in a position to do this important work for the public. There is a greater difference in the quality of iron employed by manufacturers of electrical machinery than is generally appreciated, and this is mainly due to the difficulty of testing samples. Now that the Bureau is in a position to test such samples, it is possible to determine whether iron supplied for such purposes conforms with specifications. The Bureau standardizes the test bars and instruments used in magnetic testing and has done considerable work in improving the instruments and methods employed in magnetic measurements.

PHOTOMETRY.

The photometric work of the Bureau includes the study of problems arising in the accurate measurement of light sources and standards of candlepower, the testing and certification of such standards, and the inspection and testing of electric lamps purchased by the Government. The work in the photometric section during the past few years has been of great importance, and the high standard that has been set should be maintained. The Bureau maintains the standard of candlepower for the electrical industries of the country, thereby insuring uniformity in the measurement of illumination and in the rating of electric lamps. An effort is being made to secure uniformity in the value of the standard candle in England, France, and America, by a very slight modification of the units at present employed, and also to induce the gas industry of this country to adopt the modified unit, so that a candlepower will mean the same thing in gas and electric lighting. The present difference is small, and such a uniformity in the value of the unit would be advantageous, and would probably result in greater uniformity in the measurements of the illuminating value of gas in the different cities of the country. The Bureau has been of service to the electric-lighting industry by bringing the various manufacturers of lamps into agreement as to the candlepower unit, and the same ought now to be done for the gas industry. The use of flame standards will probably be continued for some time at least by the gas companies. A careful photometric investigation of flame standards and gas flames should be made.

DIVISION II.—WEIGHTS AND MEASURES.

The Bureau has cooperated with the state governments in establishing efficient inspection services, and during the year new evidences of interest and improvement have developed. The Territory of New Mexico procured and submitted to the Bureau for verifica-

tion a set of state standards and six sets of secondary standards for the use of as many local sealers, thus setting a worthy example to States in the protection of honest merchants and the public. Data was furnished the chief officials of weights and measures in the States of New Jersey, Ohio, Tennessee, and Virginia as to proper laws, and in the first-mentioned State a new law, based upon the model law adopted by the Convention of State Sealers, was enacted. Many inquiries for information and appeals for assistance were received from individuals in localities where inspection is inefficient or entirely lacking.

While the inspection of commercial weights and measures may be left to the state and local authorities, the weights and sizes of packages, barrels, crates, etc., should be defined by national laws, since commodities sold in such containers are invariably packed in one State and sold in others. In addition to answering numerous inquiries as to the standards used in selling certain commodities in different States, much information has been furnished to commercial and industrial bodies concerning the laws and practices of foreign countries. The demand for information of this character necessitates the establishment of some efficient means for systematically obtaining such data.

The demands upon the division from all sources are growing rapidly, the largest increase from any single source being from the Bureau of Chemistry of the Department of Agriculture. The enactment of the pure-food law necessitated the purchase of large amounts of volumetric apparatus and weights, all of which is purchased according to the specifications prepared by this Bureau and is examined as to its compliance with them.

Altogether about 3,000 pieces of glass volumetric apparatus have been tested, most of which conformed to specifications. The larger part of this testing has been for government departments. New forms of standard pipettes, for simplifying and reducing the work of testing flasks, pipettes, and burettes, have been developed. These pipettes for testing pipettes and burettes operate by direct volumetric measurements and thus obviate weighing each volume of water delivered. In flask testing these pipettes are automatic in operation, not requiring to be read, and are used in conjunction with a burette.

The testing of smaller metal-capacity measures by means of glass pipettes has been used successfully, along with the weighing method, to shorten the time of the complete test of a measure. A larger number of gas cubic-foot standards and other capacity measures have been tested than heretofore.

The improvement in the quality and accuracy of volumetric apparatus now supplied by manufacturers to departments letting contracts on Bureau of Standards specifications has been such as to prove the

necessity of this work. The specifications for volumetric apparatus have been revised and such changes and additions made as four years' experience indicated were desirable.

Two hundred and eighty-two standard engineer's tapes were tested during the year. Advance has been made in the standardization of the new bench for steel tape measurements, the calibration having been partly made, approximate coefficients of the two bars determined, and some work done toward establishing the total length. Approximate determinations of the coefficients of expansion of several nickel-steel tapes were made for the Coast and Geodetic Survey, for the Geological Survey, and for other institutions; a number of meter bars and shorter standards have been tested, as well as manufacturers' disk gauges and end standards. A comparator has been fitted up south of the Physical Laboratory for use in approximate determinations of the coefficient of expansion of 50-meter tapes. Information has been obtained regarding nickel steel as a material for meter bars, but more work is necessary before arriving at any conclusions.

The problem of establishing standard scales for hydrometers was given attention and important results accomplished. Before the question was taken up by the Bureau a variety of scales were in use, all purporting to give the same data, causing endless confusion among manufacturers and the industries in which such instruments are used. A new form of hydrometer comparator has been developed having as its essential feature the production, by simple manipulation, of a clean surface of liquid in which to compare hydrometers, thus obviating the use of special liquids not affected by surface contamination. A preliminary design has been constructed and put into operation for testing commercial instruments and for precise calibration of the primary standards of this Bureau, with very satisfactory results.

There was an unexpected increase in the demand made on the Bureau for the testing of standards of mass for the States, corporations, and individuals, the number of weights tested being 1,391. Data are being gathered as to the constancy of weights of different materials, but while striking changes have been noted definite results can be obtained only from observations extended over several years. Tables are being prepared to assist in correcting weighings for moisture in the air. The testing of weights has nearly doubled during the year, without extra assistance being provided. The extra work was provided for by developing rapid methods and apparatus and by deferring important investigations, much to the detriment of the Bureau's general efficiency.

Although the Bureau acquired a set of platinum-iridium standards, from 500 grams to 1 milligram, over five years ago, no opportunity has presented itself to calibrate them, notwithstanding the fact that

the weights are urgently needed. It is hoped that an opportunity to complete this long-deferred investigation will present itself during the coming year. Manufacturers are beginning to realize the necessity of a higher standard in the construction of precision weights. The Bureau cooperates by furnishing expert advice, specifications, models, and calibrating the maker's standards. A decided improvement is already noted in this important line of measuring apparatus.

In connection with the work of time measurements the determination of the rates of a number of watches loaned to the Bureau for this purpose was taken up. Data was obtained for use in drafting regulations for testing the best grades of stock watches, especially as to the criteria for granting certificates. The first test ran four months, the series of runs in different positions being repeated to determine the accuracy with which a watch will repeat its performance under fixed conditions. A clock room for the Riefler standard clock is now being fitted up in the basement of the Physical Laboratory. A chronograph for the testing of time-measuring instruments is also under construction in the shop.

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

Many urgent requests are being received for the determination of heat constants and the distribution of standardized materials. These include the calorific values of pure substances for the standardization of calorimeters used by engineers and chemists, the preparation and distribution of such substances, the determination of the calorific values of industrially important gases, the standardization of calorimeters on which are based purchases of coal and other combustibles. An intercomparison of the various forms of calorimeters used in industrial work is very desirable. Requests for work in this field come not alone from individuals and corporations, but also from public-utility commissions, who need such data in connection with the preparation of specifications and regulations.

The application of scientific methods to industrial processes at high temperatures is of growing importance, and the demands on the Bureau for data and experimental determinations include the testing of instruments used for measuring high temperatures, on whose indications are dependent the product of many industries, the determination of melting points, specific heats, conductivities, and emissivities of various substances, the properties of refractory materials, and the critical points of steels and other alloys.

The clinical thermometers submitted remain about constant in number, and appear to be the best grades of the several manufacturers. The Bureau has continued the practice of loaning standard thermometers to the manufacturers of clinical thermometers with most

satisfactory results, the accuracy of practically all the product of American manufacturers being controlled by standards loaned them by this Bureau.

The manufacturers of high-grade thermometers, including especially those for use at high temperatures, have very generally adopted the methods of annealing recommended by this Bureau as a result of a long series of experiments; hence it is no longer necessary to send abroad for satisfactory instruments of this class. Several manufacturers have installed annealing furnaces and testing plants from plans furnished by this Bureau. An increasing percentage of the thermometers submitted for test require calibration of the highest accuracy, such as calorimetric thermometers and certain grades used in chemical and high-temperature measurements.

Many of the pyrometers tested are the standards used by manufacturers of such instruments. Nearly all American manufacturers and agents of these instruments now have their product controlled by standards furnished by this Bureau. There is beginning to be a satisfactory uniformity in the indications of high-temperature measuring instruments in this country, whereas previously there was a most chaotic condition in this important field.

The Bureau has rendered assistance to manufacturers in the designing and testing of new types of high-temperature instruments and in the development of new methods of measurement. The assistance which the Bureau has been able to render in this way has apparently encouraged several firms to undertake the manufacture and introduction of pyrometers into industrial use.

The establishment and maintenance of correct standards is of fundamental importance. From the nature of the problem no concrete standards can be constructed for temperature measurement and the scale must constantly be reestablished and checked, which involves a large amount of work and time. It is only within the limited range of temperatures of 0° to 100° C. that the Bureau has yet been enabled to maintain a standard temperature scale with adequate accuracy. No work has yet been attempted on the low-temperature scale, and only a start has been made on the high-temperature scale. Preliminary work has been done toward the establishment of the high-temperature scale to 2,000° C., by means of the laws of radiation; and for the intercomparison of the high-temperature scales as given by electrical-resistance, thermo-electric, optical, and total-radiation methods.

The work in heat measurements has been mostly investigational, or in connection with cases of disagreement between litigants involving unusually extended experimental work. Such heat measurements include tests of inflammatory materials, melting points of metals,

behavior at high temperatures of metals, bricks, and other materials, and cooling curves of steel.

In collaboration with the American Society for Testing Materials, exhaustive tests of samples of lubricating oils from various sources, by different methods, have been begun by this division.

Work on the thermal properties of the materials used in the new filament lamps has been undertaken, but is not completed. It was hoped to be able to determine the melting points of some of the very refractory metals both in the form of filaments and in the form of minute particles by a new radiation method; but this work has thus far been limited to the determination of the melting points of tungsten and tantalum in the form of filaments.

The introduction in the industries of radiation methods of measuring high temperatures requires the determination of the errors of such instruments when examining incandescent substances, such as iron, copper, fire brick, etc. A few preliminary measurements have been made on the radiation from iron. Some experiments have been made on the constancy of melting of certain refractory metals in order to define and construct a new standard of light based on the intensity of light emitted from an inclosure immersed in a metal at its freezing point. A study has been made of the available methods of obtaining cooling curves for the thermal analysis of steels, alloys, and chemical compounds, the results of which have been published in the Bulletin.

The determination of the specific heats of brine solutions, data of great value for the refrigerating industries, has been nearly completed and a preliminary report published. A new type of vacuum jacket calorimeter suitable for the determination of specific heats at low temperatures has been developed, and several very sensitive resistance thermometers have been designed and constructed for calorimetric work. It is hoped that the work in calorimetry may be greatly extended, and certain gas calorimeters have been acquired with a view to an examination of their behavior.

The apparatus is being assembled for repeating and extending the work of Joule and Thomson on the free expansion of gases, a problem fundamental to the conception and measurement of temperature.

There were tested during the year 9,193 thermometers, including 202 high-temperature thermometers, 536 laboratory and special thermometers, 60 low-precision industrial thermometers, and 8,395 clinical thermometers; 9 optical pyrometers, 41 thermo-electric pyrometers, 12 resistance pyrometers; 99 viscosity and flash-point tests of oils; and 17 other tests involving heat measurements; in all about 9,351 separate tests. There was a considerable increase over the preceding year in the testing of high-grade mercurial thermometers and in oil tests for the United States Government.

DIVISION IV.—OPTICS.

SPECTROSCOPY.

Important investigations have been conducted in this section of the Bureau during the year. Work on the helium tube as a possible primary light standard has been continued. Age tests and the effect of varying the glass of the stem remain to be carried out. The purity of spectral light sources has been investigated further, recent work being devoted to the structure of composite lines. The intensity of any spectrum line was shown to be probably expressible in terms of but a single variable and two constants whatever the form of excitation of luminescence. The relation of light to radiation and visual sensibility has been examined in more detail, and practical deductions drawn.

The structure and properties of compound lenses have been studied, particularly the effect of the position of the transverse axis on astigmatism and distortion. Preliminary specifications suitable for defining lens "speed" were drawn up and applied to a photographic lens with a Martin's photometer.

A number of photographic lenses were tested as to fidelity of reproduction. The transparency for visible and ultra-violet radiation of a special absorption cell and of several samples of glass have been examined. The refractive indices of two samples of glass and a fluid were determined through the visible and ultra-violet portions of the spectrum. A special design of spectrophotometer was constructed and tested. A Lummer-Gehrcke plate and special camera for the echelon have been added to the spectroscopic equipment, and a precision optical bench for lens testing is being designed and constructed.

RADIOMETRY.

The measurement of radiant energy is still in a primitive state of development, in particular its measurement in absolute units. This is chiefly due to the fact that the radiation to be measured is generally from a surface, the temperature of which is practically indeterminate, as is also the energy expended within the radiating substance. The measurement of the energy radiated is exceedingly difficult, but progress is being made in the development of apparatus and methods for these measurements.

The recent development of processes which require an accurate knowledge of temperatures necessitates a study of the laws of radiation of various materials with variation in temperature. This is notably true of metals used in incandescent lamps to ascertain the cause of their luminous efficiency. Three investigations of such materials have just been completed. An investigation of the Nernst

glower radiation shows that its emission spectrum is discontinuous at low temperatures, gradually becoming continuous at high temperatures. No "radiation constant" was found, so that the results of previous experimenters are unreliable. An investigation of the radiation of solids in the form of electrically heated rods, and fine powder brought to incandescence on a heater, show the spectral partition of energy which occurs in sharp emission bands, superposed upon a weak continuous spectrum. The maximum emission moves toward the short wave lengths with temperature rise; but the bands remain fixed in position, simply increasing in intensity—a result entirely unexpected from previous observations in the visible spectrum.

The most important constant which occurs in the spectral radiation formula of metals, such as platinum, osmium, tungsten, tantalum, etc., in the form of filaments in incandescent lamps, has been investigated. This particular radiation "constant" also occurs in Stefan's law of total radiation, where it is given as 4 for a complete radiator. This important so-called constant was, however, found to decrease with rise in temperature, with a value higher than platinum at any given temperature. This accounts for the high luminous efficiency of metal filament lamps, and incidentally verifies the theory which requires the optical constants of the metals to be a function of the temperature and the wave length. This seems to have escaped the attention of previous experimenters.

Numerous inquiries concerning radiometers, the transparency of gases for heat waves, and of absorption screens for infra-red work have been received and appropriate information given.

POLARIMETRY.

Polarized light is utilized in testing all sugars bought and sold or imported. The polariscope and its accessories are therefore the indispensible adjuncts of the sugar refiner, the beet and cane sugar planter, and sugar laboratories, but such apparatus has remained unstandardized. Hence it is futile to expect tests by various interests to agree when not only apparatus but methods of testing differ so greatly. After extended investigation of the theory and practice of polarimetry, the basis of standardization of polarimetric apparatus is now rigidly defined by this Bureau. During the year a number of quartz plates and 1,270 samples of sugar for the Treasury Department were tested by this section.

The most important piece of work of the year was the successful development of a quartz compensating polariscope with adjustable sensibility. The theory and construction of this instrument are described in the Bulletin, and it has been adopted by the Secretary of the Treasury for use in the customs service.

The disturbing effect of atmospheric conditions on raw sugar tests is appreciable, as an investigation begun over a year ago clearly shows. This work will be continued until satisfactory correction has been obtained.

Large quantities of pure sugar are indispensable for research work in polarimetry, and numerous requests from various sources have been received during the past year for such sugar for calorimetric and other purposes. To meet these demands apparatus for preparing pure sugar by recrystallization has been developed. The Bureau will soon be able to produce standard sucrose in large quantities under controlled conditions which guarantee a high degree of purity.

A new optical system giving monochromatic light when used with intense sources has been developed for use in polariscopic work, and a compact form of apparatus is being designed.

DIVISION V.—CHEMISTRY.

The chemical division has been actively assisting government departments as well as the Printing Investigation Commission of Congress. The investigations commenced or continued on behalf of the departments and the Government Printing Office, and in which more or less progress has been made, relate to the testing of materials in connection with contracts and purchases. The work is of importance, not only to ascertain whether supplies furnished by contractors conform to specifications, but also as a preliminary to the formulation of specifications for future use where none is now insisted on. There is a wide field of chemical usefulness open to the Bureau in lines of research relating to the purchase of government supplies. The researches aiming at improvement in the quality of and methods of testing these materials have hardly more than begun, and will consume much time if results of real value are to be expected. In order to expedite this work and permit such routine testing as will be called for, a considerable addition to the working force and laboratory space is imperative.

The classes of problems planned and under investigation for the Government are numerous, and in all about 1,766 tests and analyses have been reported in the following classes during the year:

(1) Testing of writing, printing, copying, and carbon papers; writing, copying, record, and typewriter inks; typewriter ribbons; mucilage and sealing wax, and researches bearing on the preparation of suitable specifications, with a view of improving the quality, reducing the cost, and rendering the Government more independent of manufacturers than at present. There have been reported by the Bureau about 1,595 tests and analyses of papers, inks and ink powders, printer's ink, and mucilage.

(2) Tests and analyses of lubricating oils, linseed oils and driers, paints and varnishes, of which 139 separate tests have been made during the year.

(3) Miscellaneous tests of soaps, rubbers, metals and alloys, and other materials, about 32 in number.

(4) Analyses of standard steels intended for distribution to all who wish to test the accuracy of their own chemical work and that of their employees. The increasing demand on the part of those engaged in the iron and steel industries, and of analysts and others, for the standard irons and steels, we have been preparing with the assistance of the American Foundrymen's Association and the Association of American Steel Manufacturers, and the continued expression of interest in the subject, shows the value of this line of work. Of the irons and steels thus far prepared 465 separate samples were supplied to applicants during the year.

Further expansion is needed to meet the demands for cooperation on the part of other divisions of the Bureau. Cooperative problems pressing for solution that can not be solved without the aid of chemistry are: (1) The preparation and testing of pure materials used in the construction of standards of electromotive work; (2) the preparation of many substances of the very highest degree of purity, and the determination of certain constants of these substances for use as standards in calorimetric work; (3) the determination of the physical properties of metals and alloys used in the arts demands a detailed knowledge of their chemical composition. The successful carrying out of these researches will be of very great value to the wide range of industries in which these problems are of vital importance.

ENGINEERING INSTRUMENTS.

The demand of government departments and the public for information regarding engineering tests has greatly increased, and many instruments have been submitted for test, including anemometers, speedometers, meter provers, water meters, paper testers, pressure gauges, steam valves, and the work was mainly for practicing engineers or municipalities. A small mercury manometer, with maximum capacity of 60 pounds per square inch, has been erected for the calibration of gauges of low range, and one of greater capacity will be installed in the new building.

A study has been made of the effects of air drag, surrounding walls, wind currents, and centrifugal forces upon the present method of testing anemometers. In this connection a new tripping and timing device has been developed so as to completely eliminate the personal element of the operator. The upper limit of available speed has

been increased to 3,300 feet per minute, and the lower decreased to about 200 feet per minute.

PROPERTIES OF MATERIALS.

The purpose of this branch of the Bureau's work is the determination of the physical and chemical properties of materials in cases where definite authoritative information is needed in connection with their purchase and sale or their use.

As far as possible, this work is confined to investigational tests. Commercial tests are not made except for the departments of the Government and for individuals where the facilities of private testing laboratories are not available.

A study of a number of samples of brick was made, to determine the best method of measuring the absorptive capacity and its influence upon the adhesion between bricks and mortar. Apparatus has been secured and an investigation is being made of lubricating oils, for the purpose of determining the relation between their physical and chemical properties and their value as lubricants. An investigation of twenty-two bookbinding cloths has been made for the Printing Investigation Commission, as a basis for the preparation of standard specifications for the binding used on public documents. Other investigations of like nature are under way or will be begun in the near future. This work will be greatly facilitated by the completion of the new laboratory recently authorized by Congress.

The commercial tests made for the departments of the Government and others include cements, plasters, concrete, steels, alloys, bricks; steam, air, and water hose; valves and other fittings, textiles, paper, inks, twine, etc. In many of these cases the tests were made not only to ascertain whether or not they complied with the specifications, but with a view to securing data for the purpose of improving such specifications generally and the methods of testing.

PERSONNEL.

The personnel of the Bureau, including the Director, as provided by Congress, consists of 118 persons, classified as follows:

Scientific force.—One physicist, 1 chemist, 6 associate physicists, 1 associate chemist, 21 assistant physicists, 3 assistant chemists, 21 laboratory assistants, 6 aids, and 7 laboratory apprentices; total, 67.

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 technical library of the Bureau contains 4,561 bound volumes, consisting of works on physics, chemistry, mathematics, engineering, and related fields. The library is classified by subjects and card indexed by author and subject. During the year 1,087 books were added. The Bureau regularly receives 169 technical periodicals. The circulation of the library has been about 5,500, including 600 loaned by other government libraries. Cooperation among the scientific libraries in Washington has greatly extended the reference resources for technical investigation.

PUBLICATIONS.

During the year 31 technical papers were published giving the results of researches and investigations conducted by the Bureau. Nineteen extra editions of earlier papers were required to meet the public demand for the publications of the Bureau. The standard specifications for the purchase of carbon-filament incandescent lamps were published in revised form in Circular 13, and separately as a blank form for use in contracts for government purchases.

SUMMARY OF TESTS.

The work of the Bureau involves, among other things, a large amount of testing of standards, measuring instruments, and materials. A certain amount of this work is already organized upon an accurate routine basis. Much of it, however, involves investigation of the scientific principles underlying the test, a study of existing methods, and the development of new standard tests of known accuracy. In such cases the research which must precede the actual testing is a most important function of the Bureau. For the test, a reasonable fee is charged, except when made for the National or State Governments. The corresponding amounts for government testing are of interest, however, and are added to the statement of tests which follows:

NUMBER AND VALUE OF TESTS COMPLETED, FISCAL YEAR ENDED JUNE 30, 1908.

Nature of test.	For Government.		For public.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.
Length	187	$267.55	95	$181.20	282	$448.75
Mass	902	438.75	489	269.00	1,391	707.75
Capacity	2,313	728.20	517	356.10	2,830	1,084.30
Temperature	1,359	603.46	8,830	1,788.55	10,189	2,392.01
Optical	1,286	1,309.00	5	11.00	1,291	1,320.00
Engineering	1,778	6,582.40	62	89.25	1,840	6,671.65
Electrical	129	496.85	248	765.60	377	1,262.45
Photometry	32	81.50	69	103.50	101	185.00
Chemical	1,844	7,181.02	431	706.84	2,275	7,887.86
Miscellaneous	58	49.35	60	63.25	118	112.60
Total	9,888	17,738.08	10,806	4,334.29	20,694	22,072.37

The receipts for tests were as follows:

Total receipts, 1907–8	$4,375.77	
Received prior to July 1, 1907, for tests completed in fiscal year 1907–8	58.30	
		$4,434.07
Received for tests in progress at close of fiscal year 1907–8		99.78
Fees for tests completed, 1907–8		4,334.29

FINANCIAL STATEMENT.

The following statement shows the amount and object of each appropriation provided for the Bureau for the fiscal year 1908, 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, 1908:

Appropriation.	Total appropriation.	Disbursement.	Liability.	Balance.
Salaries	$130,620.00	$123,874.24	.....	$6,745.76
Equipment	41,000.00	30,665.93	$9,699.75	634.32
General expenses	15,000.00	13,099.63	1,763.52	136.85
Grounds	3,000.00	2,982.86	.....	17.14
Total	189,620.00	170,622.66	11,463.27	7,534.07

The following statement shows the condition of the appropriations for the preceding two fiscal years at the close of business June 30, 1908:

Appropriation.	1906.				1907.			
	Total appropriation.	Disbursement.	Liability.	Balance.	Total appropriation.	Disbursement.	Liability.	Balance.
Salaries	$99,660.00	$95,727.45	.....	$3,932.55	$111,440.00	$108,399.59	.....	$3,040.41
Equipment	41,000.00	40,927.61	$69.48	2.91	41,000.00	40,415.03	$494.73	90.24
General expenses	12,500.00	11,893.51	.....	606.49	15,000.00	14,996.35	.....	3.65
Grounds	1,500.00	1,499.37	.....	.63	3,000.00	3,000.00	.....	.....
Outbuildings	12,484.10	12,472.09	.....	12.01	.....	.....	.....	.....
Total	167,144.10	162,520.03	69.48	4,554.59	170,440.00	166,810.97	494.73	3,134.30

BUILDINGS AND GROUNDS.

During the year Congress provided for a new building to furnish laboratory space urgently needed by the Bureau. Plans in harmony with the existing buildings will be completed as soon as possible and the contract will be let early in the autumn. The new building will materially relieve the congestion in several lines of work.

The grading of the grounds has been continued along the lines previously laid out. The steep slope south of the main building has been partly filled in up to grade and seeded with lawn grass. The

east portion of the grounds has also been graded and put in excellent condition.

INSTRUMENT SHOP.

The apparatus used by the Bureau is largely special in character, designed by the experts who are to use it in their work and constructed under their direct supervision. The quality and quantity of testing and research depend to a large degree upon the facilities available for constructing such apparatus. The instrument shop of the Bureau is well equipped with skilled mechanicians and modern machine tools, and has materially aided the Bureau in maintaining a high standard in its technical work.

Respectfully,

S. W. Stratton,
Director.

To Hon. Oscar S. Straus,
Secretary of Commerce and Labor.

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