

DEPARTMENT OF COMMERCE

BUREAU OF STANDARDS

George K. Burgess, Director

**ANNUAL REPORT OF DIRECTOR
OF THE BUREAU OF STANDARDS
FOR FISCAL YEAR ENDED JUNE 30, 1924**

MISCELLANEOUS PUBLICATIONS, BUREAU OF STANDARDS, No. 60

ANNUAL REPORT
OF THE
DIRECTOR OF THE BUREAU OF STANDARDS
TO THE
SECRETARY OF COMMERCE
FOR THE
FISCAL YEAR ENDED JUNE 30, 1924

(Miscellaneous Publication—No. 60)



WASHINGTON
GOVERNMENT PRINTING OFFICE
1924

Persons on a regular mailing list of the Department of Commerce should give prompt notice to the "Division of Publications, Department of Commerce, Washington, D. C.," of any change of address, stating specifically the form of address in which the publication has previously been received, as well as the new address. The Department should also be advised promptly when a publication is no longer desired.

REPORT OF THE DIRECTOR, BUREAU OF STANDARDS

CONTENTS

	Page
Functions and organization.....	3
Weights and measures.....	5
Orifice meters.....	5
Precision screw cutting.....	5
Testing of railroad track scales.....	5
National standard petroleum oil tables.....	6
Study of sieves and sieve cloth.....	6
Precision graduation of circles.....	6
Standardization of precision gauges.....	6
Density of denatured alcohol.....	6
Dental inlay materials.....	6
Seventeenth annual conference on weights and measures.....	6
General testing work.....	7
Electricity.....	7
Fundamental electrical standards.....	7
Frequency standards for radio.....	7
Radio beacons.....	7
Testing of electron tubes.....	7
Electrified insecticide dust.....	8
Magnetic testing of wire rope.....	8
Surveys of Government's telephone service.....	8
Government electric light and power requirements.....	8
Safety-code work.....	9
Standards for electric service.....	9
Corrosion of underground pipes.....	9
Study of impact stresses in highway bridges.....	9
Heat and power.....	9
International temperature scale.....	9
Properties of saturated steam.....	10
Fire resistance of theater curtains.....	10
Braking systems on motor vehicles.....	10
Utilization of heavier grades of gasoline.....	10
Routine testing of instruments.....	10
Explosion in dynamometer laboratory.....	10
Optics.....	11
Periodic characteristics of the chemical elements.....	11
Wave lengths of the solar spectrum.....	11
Determination of the color of sugar.....	11
Identification of the biose of amygdalin.....	12
Design of new colorimetric photometer.....	12
Aberrations of photographic lenses.....	12
Studies in thermal radiation.....	12
Germicidal effect of ultra-violet light.....	12
Increase in sensitiveness of photographic plates.....	13
Ruling of scales by light waves.....	13
Chemistry.....	13
General chemical testing.....	13
Reclamation of gasoline used in dry cleaning.....	13
New standard samples.....	13
New methods of analysis.....	13
Improvements in electroplating.....	13
Analytical separation of gases.....	14
Absorption of gases in liquids.....	14
Relations between densities, pressures, and temperatures of gases.....	14
Testing of gas appliances.....	14

	Page
Mechanics and sound.....	14
Elevator interlocking devices.....	14
Sound transmission through building materials.....	15
Location of ships by sound and radio waves.....	15
Aerodynamical characteristics of airfoils.....	15
Strength of masonry walls.....	16
Moving the large testing machines.....	16
Investigation of welded rail joints.....	16
Stress distribution in ship plate joints.....	16
Standardization of builders' hardware.....	16
Structural engineering and miscellaneous materials.....	17
Work on specifications.....	17
Quality of concrete.....	17
Workability of concrete mixtures, and tests of colorless water-proofing materials.....	18
General cement testing.....	18
Chrome and vegetable tanned sole leather.....	18
Synthetic tanning materials.....	18
Tests of automobile tires.....	19
Heat-retaining properties of fabrics.....	19
Wearing qualities of textiles.....	19
Foreign and domestic clays as paper fillers.....	19
Determining the whiteness of paper.....	20
Properties of gypsum.....	20
Investigation of plaster failures.....	20
Metallurgy.....	20
X-ray study of metals.....	20
Resistance of metals to corrosion.....	21
Properties of metals and alloys at high temperatures.....	21
High-speed steels.....	21
Gases in metals.....	21
Durability of gauges.....	21
Metal coatings.....	21
Preparation of pure platinum.....	21
Examination of failed metal parts.....	21
Ceramics.....	22
Researches carried on in private plants.....	22
Study of clays for specific purposes.....	22
Drying of ceramic wares.....	22
Strength of glazing glass.....	23
Specifications for refractories.....	23
Bond between hollow tile and concrete.....	23
Efficiency of tile and brick extrusion machines.....	23
Properties of enamel.....	24
Wet-process enamels.....	24
Federal specifications for ceramic materials.....	24
Simplified practice.....	24
Simplified practice recommendations accepted.....	24
Recommendations in process of acceptance and being considered.....	25
Field surveys in progress.....	25
American Marine Standards Committee.....	25
Utilization of waste in lumber industry.....	25
Building and housing.....	25
General work.....	25
Seasonal operation in construction industries.....	26
Reports prepared.....	26
Building-material prices.....	26
Cooperation with home owners.....	26
The office.....	27
Table 1. Disbursements, liability, etc., 1924 appropriation.....	27
Table 2. Disbursements, liability, etc., 1922 and 1923.....	28
Table 3. Comparison of number of tests completed and fees received during the fiscal years ended June 30, 1923 and 1924.....	30
Operation and construction.....	31

	Page.
Cooperative activities-----	32
Organizations with which bureau is cooperating-----	32
Talks on bureau's work-----	32
National Screw Thread Commission-----	33
Federal Specifications Board-----	33
Handbook of specifications-----	34
American Engineering Standards Committee-----	35
Pan American standardization-----	35
International cooperation-----	35
Research associates-----	35
General recommendations-----	36
Personnel-----	36
Additional land-----	36
Power plant-----	36
Care of buildings-----	37
Transfer of maintenance of the bureau's buildings-----	37
Needed support for test work-----	37

DEPARTMENT OF COMMERCE,
BUREAU OF STANDARDS,
Washington, July 1, 1924.

SIR: There is submitted herewith a brief report of the work of the Bureau of Standards for the fiscal year ended June 30, 1924.

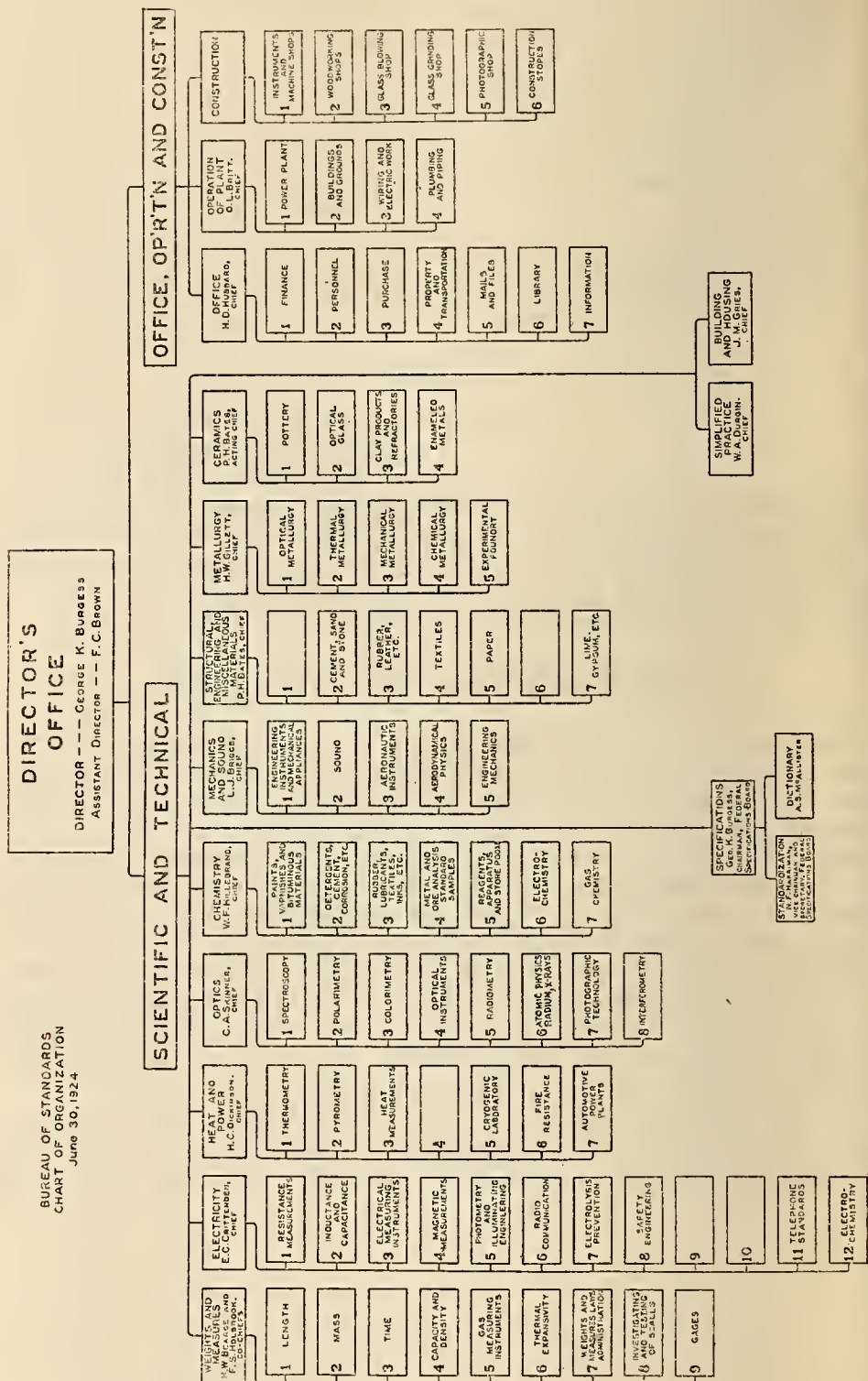
Before proceeding with a description of the bureau's work during the past year a few words concerning its functions and organization may be of interest.

FUNCTIONS AND ORGANIZATION

The general function of the bureau is the development, construction, custody, and maintenance of reference and working standards used in industry and commerce. Standards are divided into five classes, and the work necessarily covers a very wide field. As a matter of convenience the organization of the bureau is based not on classes of standards, but upon the nature of the work. Thus, experts in electricity are grouped in one division, while those dealing with optics form another major division.

There are 11 scientific and technical divisions besides the office, operation, and construction divisions. Each of these major divisions is made up of several sections, which deal with a definite class of problems. The scheme of organization of the bureau will be understood by reference to the accompanying diagram.

On the following pages will be found outlines of the functions of each of the major divisions, together with short accounts of some of their outstanding accomplishments during the past fiscal year.



WEIGHTS AND MEASURES

The division of weights and measures is charged with the custody of the national standards of the United States and with the task of spreading abroad their influence and of carrying them to as great an extent as is necessary into the scientific, industrial, and commercial life of the Nation. The division is thus concerned with research and measurements involving the fundamental units of length, mass, and time, and with derived or secondary units such as area, volume, density, and pressure. The activities of the division also include the enforcement of certain Federal weights and measures laws, the preparation of specifications and tolerances for use in connection with standardization of weighing and weighing apparatus, gauges, and screw threads; cooperation with States in the preparation and enforcement of weights and measures legislation, and in administration of weights and measures departments; the design, improvement, inspection, and method of test of weighing and measuring apparatus, both precise and commercial; the carrying out of researches designed to result in more accurate knowledge of physical constants; and improvements in engineering practice.

Orifice Meters.

The investigation of orifice meters for the measurement of large quantities of natural gas, mentioned in last year's report, has been continued and is nearing completion. All measurements will be finished within the next few months, and the calculations and preparations for publication will be completed within the present year. A closely related problem, namely, the test of large-volume gas meters, is also well under way. This work is being carried out in Chicago in cooperation with a joint committee of the American Gas Association and the Natural Gas Association of America.

Precision Screw Cutting.

In the work on precision screw cutting and the construction of a precision linear dividing engine for graduating short scales and gratings good progress has been made. A screw of the required accuracy has been completed, and the bed, carriage, and other parts of the dividing engine are well under way. It is hoped that when completed this machine will be capable of producing precision rulings over an interval of 20 centimeters (8 inches) with an accuracy of better than one-tenth of a micron. This may be regarded as the first step in the construction of a dividing engine of 1 meter capacity.

Testing of Railroad Track Scales.

In the work of testing railroad track scales and master scales a record year's work was done. Nineteen master scales and 1,019 commercial track scales, distributed over 37 States and the District of Columbia, were tested. Particular attention is directed to the number of tests completed, as it represents an increase of 13.9 per cent over the best previous year. This increase was accomplished without increase of funds, equipment, or personnel. It did, however, involve a practical discontinuance of certain other vitally important work; for example, the design and improvement of large-capacity weighing equipment, the development of specifications and tolerances, and the issuance of publications. While this concentration upon testing work to the practical exclusion of other activities was regarded as necessary by reason of the unusual demands, this policy can not properly be continued indefinitely.

Another point of special interest is that 56.9 per cent of the track scales tested passed the tolerance prescribed by the bureau for good performance. This represents a substantial improvement over the figures for the year previous, and is, in fact, the highest percentage of satisfactory performance since the work was begun in 1914. Since this work was first undertaken there has been a consistent improve-

ment from 38.2 for the first year to 56.9 per cent for the year just closed. This consistent improvement is most convincing proof of the value of the work.

National Standard Petroleum Oil Tables.

Circular No. 154 of the bureau, entitled "National Standard Petroleum Oil Tables," has been completed. These tables have been accepted by the Bureau of Mines, Bureau of Standards, and the American Petroleum Institute, and are recommended as the official tables of the petroleum industry. Their use will eliminate the confusion and uncertainty that have heretofore existed as a result of the use of two conflicting hydrometer scales.

Study of Sieves and Sieve Cloth.

A detailed study of sieves and sieve cloth, in cooperation with manufacturers of standard sieves, has resulted in a noticeable improvement in this product, which is widely used in the test of Portland cement, sand, and other finely divided materials of importance in engineering practice.

Precision Graduation of Circles.

New apparatus for the test of precision graduated circles has been ordered, and upon its receipt the bureau will be able to meet an acute and long-felt need of manufacturers and users of graduated instruments used in science and engineering.

Standardization of Precision Gauges.

Through the activities of the gauge section, the bureau has been unusually successful during the past year in establishing contacts with the manufacturing industries and in applying its facilities to the solution of problems of industrial importance. This has been accomplished through cooperation with the National Screw Thread Commission, the Sectional Committee on Plain Limit Gauges for General Engineering Work, and the Gauge Steel Committee.

Density of Denatured Alcohol.

A research on the density of denatured alcohol, carried out at the request of the Treasury Department, was completed during the year. This research furnished information necessary for the proper supervision and control of the preparation and distribution of denatured alcohol for industrial purposes.

Dental Inlay Materials.

Work on dental inlay materials, carried on under a research associate arrangement, is well under way and when completed will cover this field in the same thorough manner as the field of dental amalgams was covered four years ago.

Seventeenth Annual Conference on Weights and Measures.

The 1924 annual conference on weights and measures was probably the most successful one ever held. Bread weight legislation, both State and National, was discussed at length as a result of the recent decision of the United States Supreme Court on the Nebraska standard weight bread law; specifications and tolerances for fabric-measuring devices were adopted; existing codes of specifications and tolerances for weighing and measuring devices were modified in the

light of experience, and further action was taken in the development of specifications and tolerances for vehicle tanks and taximeters. Many interesting and instructive papers relative to weights and measures administration were presented and discussed.

General Testing Work.

The usual large amount of testing work was done by those sections in which this work naturally falls, namely, length, mass, and capacity and density. While this work has been kept as nearly up to date as our limited personnel would permit, an objectionable delay in some cases has been unavoidable. This unavoidable delay acts as a check upon the quantity of apparatus submitted for test, and tends to restrict a line of the bureau's work which could to advantage be allowed to increase to several times its present volume.

ELECTRICITY

The work of this division covers electrical units, standards, measuring instruments, and methods of measurement, including electromotive force, resistance, current, inductance, capacitance, conductivity, insulation, magnetic measurements and properties, radio and telephonic communication, and properties and performance of electrical equipment, such as lamps and batteries. As a result of cooperation with technical societies, public officials, and associations of manufacturers on safety and with public-service companies, public-utility commissions, and municipalities on public-utility problems, some of the work has been extended to cover more than strictly electrical matters.

Fundamental Electrical Standards.

An important part of the bureau's work in electricity is concerned with fundamental investigations of electrical standards from which the working standards used by manufacturers of electrical apparatus are derived, and several fundamental investigations are in progress. A new determination of the ohm in absolute units, a determination of the ratio of the international to the absolute henry, and the design and construction of an absolute electrometer for measurement of voltages up to 250,000 are well advanced.

Frequency Standards for Radio.

Progress in the reduction of radio interference depends on the maintaining of transmitting stations on their assigned frequencies. The accuracy of frequency standards and measurements was materially increased during the year, and the broadcasting and other stations were directly aided in holding their frequencies constant by the establishment of standard frequency stations, by measurements of station frequencies at the bureau laboratory, and by the transmission of standard frequency signals from the bureau station WWV.

Radio Beacons.

Two advances in radio beacons were made. One was the completion of the development of a directive system which enables a ship or aircraft to follow a specific course with the aid of ordinary receiving apparatus. The other was the construction of a low-power beacon apparatus which will be placed in service on buoys and may become an important new aid to navigation.

Testing of Electron Tubes.

In cooperation with Government and manufacturing interests the electron tubes used in radio, and methods for testing have been stand-

ardized. Applications of the tubes have been made in numerous practical radio receiving problems. In its radio standardization projects and technical investigations the bureau has cooperated with the various national engineering and scientific societies and with the other Government departments and boards having to do with radio. Direct service has been rendered to various branches of the Government on a large number of technical radio problems.

Electrified Insecticide Dust.

At the request of the Bureau of Entomology, Department of Agriculture, a cooperative investigation has been begun on the electric effects which are produced when insecticide dust is sprayed over a field. There seems to be considerable evidence that the electrified condition of such dust may increase its effectiveness and thus materially reduce the amount and cost of the poison which must be used per acre.

Magnetic Testing of Wire Rope.

The rope investigation, for which appropriation was made by Congress, has been actively prosecuted. An advisory committee composed of representatives of national technical societies, Government departments, and large users and manufacturers of wire rope was organized and has been of great assistance in outlining the investigation. The method which appeared to be most promising is the method of magnetic analysis. This method has received a great deal of study as a nondestructive method for testing iron and steel products, but it was at once recognized that no magnetic method has yet been developed, which gives results that are unambiguous and capable of definite interpretation. It was therefore necessary to make investigations of a basic and fundamental nature to establish the relations between magnetic properties of wires used in wire rope and the effect of the various causes of deterioration in wire rope arising from service conditions. A study of the effect of mechanical stress on the magnetic properties of steel wire has been completed and is nearly ready for publication. An investigation of the effect of wear is nearly completed, and work is in progress on the effects of fatigue and corrosion. The design and construction of apparatus for field tests have been begun.

Surveys of Government's Telephone Service.

The surveys of the Government's telephone service in the District of Columbia and in the field, under the auspices of the Bureau of the Budget and under direct supervision of the chief coordinator, have been continued. An additional annual economy of \$6,777 was effected over the \$62,000 reported last year, thus bringing the total annual economy as a result of the survey work up to nearly \$69,000. In addition, there was a single saving of \$2,831.50, which added to previous single savings makes a total of \$7,590.74. There are in sight additional economies of nearly \$26,000 per annum. In no case has the quality of telephone service been impaired as a result of the bureau's work.

Government Electric Light and Power Requirements.

At the request of the Bureau of the Budget a survey was carried out of electric light and power requirements of such of the Govern-

ment's buildings as could be supplied readily from a central plant. A report was rendered to the above bureau covering the matter.

Safety-Code Work.

Important progress has been made in the revision of the National Electrical Safety Code and the preparation of the Aeronautical Safety Code, the Safety Code for Elevators, the code for protection against lightning, and the code for colors of traffic signals. The National Safety Code for Logging and Sawmill Operations was published during the year as No. 5 in the bureau's handbook series, and is approved as an American standard by the American Engineering Standards Committee.

Standards for Electric Service.

The second edition of Circular No. 56, "Standards for Electric Service," was published early in the year, and a survey of street-lighting practice in municipalities of 10,000 population and over is nearing completion. The second annual conference of engineers of public-utility and railroad commissions was held in March and attended by engineers representing 16 States.

Corrosion of Underground Pipes.

In 1922 an extended and continuing investigation to determine the causes and mechanism of the corrosive action of various kinds of soil on underground pipes was started. About 13,000 specimens have been buried in 46 typical soils throughout the United States selected by the Bureau of Soils, Department of Agriculture. During the year about 900 specimens have been uncovered and returned to Washington for examination and study. Results so far obtained indicate that in certain soils in the South and Southwest initial corrosion of iron and steel is rapid. It has also been found that lead is seriously corroded in a few localities.

Study of Impact Stresses in Highway Bridges.

A cooperative investigation with a special committee of the American Society of Civil Engineers on impact in highway bridges has been carried on for some time. A 12-element electric-strain gauge has been constructed under the bureau's supervision, and field tests are now in progress at Ames, Iowa.

HEAT AND POWER

The field of the division includes measurement of heat, temperatures, and the thermal properties of matter; the specific effects of temperature on materials of construction; the transmission of heat; the production of power by means of heat engines; and the properties of fuels, lubricants, and accessories essential to the production of power by this means. Some of the projects are: Establishment of the standard scales of temperature throughout the range of measurable temperatures; testing and standardization of thermometers, pyrometers, and other temperature-measuring instruments; determination of specific and latent heats, heats of reaction, melting and freezing points, and other properties of materials, in the determination of which precise heat measurements are the principal requirements; standardization of calorimeters; production and distribution of standard heat and temperature samples; industrial application of heat and temperature measurements; determination of fundamental engineering data involving thermal constants; determination of the fire-resistive properties of structural materials; measurements of power characteristics of aircraft and other automotive engines; efficiency of power transmission in vehicles; characteristics of cooling radiators, brake-lining material, and minor accessories; properties of liquid fuels as regards power production and economy; laws of lubrication and behavior of lubricants; and performance characteristics of automotive vehicles.

International Temperature Scale.

Uniformity in basic standards is a prime essential to international commerce. A conference with the standardizing laboratories of

England, Germany, and the Netherlands followed by correspondence through the International Bureau of Weights and Measures has led to substantial agreement as to a uniform international temperature scale. This agreement probably will be formally ratified in the near future.

Properties of Saturated Steam.

A research on the properties of saturated steam and water, undertaken with the cooperation of the American Society of Mechanical Engineers, and now well under way, is designed to yield data of high accuracy on fundamental physical constants, while at the same time the data will find immediate application in the solution of modern problems of steam engineering.

Fire Resistance of Theater Curtains.

A complete research on the fire resistance and general effectiveness of curtains used in theaters to close the opening between the stage and the auditorium in case of fire on the stage has developed conclusive information as to the types of curtains necessary to afford adequate protection to the audience.

Braking Systems on Motor Vehicles.

There has been a national awakening of interest in the importance of adequate braking systems on motor vehicles. A recording and an inspection decelerometer were developed at the bureau to permit measurements of the braking ability of automobiles. Representatives of the bureau have been invited to explain and use these decelerometers at demonstrations carried out in several of the larger cities. The result has been increased information among city officials and the public, which will promote greater safety of traffic.

Utilization of Heavier Grades of Gasoline.

A research has shown that heavier grades of gasoline could be used in average service with resulting economy in the operation of motor vehicles throughout the country, except for certain limiting factors, such as crank-case oil dilution and starting difficulties. These are being studied with a view to an increase in economy of motor transportation.

Routine Testing of Instruments.

Routine testing of instruments and materials makes basic standardization work available to the industries and the public. Work of this nature has outgrown the facilities provided for it with the resulting necessity of refusing work urgently needed by the industries and of holding tests on hand for long periods. This had led to very severe criticism from the industries involved. It is of utmost importance that more adequate facilities shall be provided.

Explosion in Dynamometer Laboratory.

The disastrous explosion which occurred in one of the altitude test chambers in September, 1923, emphasized the need and suggested possibilities of modifications in the design of these units which would further reduce the chance of a repetition of such an accident. A special appropriation of \$72,000 has made it possible to remodel the equipment embodying the important added safety features. When this work is completed the operating staffs of the

three altitude test units will be safeguarded so far as can be foreseen from the danger of explosions occurring within the chambers.

OPTICS

The work of the optics division includes: Radiation and absorption spectra, along with certain phases of qualitative and quantitative chemical analysis for which these are especially applicable, and the development of infra-red photography for astronomical observations and aviation purposes, investigations and tests involving measurements of polarized light and its application, especially in the testing, standardization, and technology of sugar, including the supervision of the sugar laboratories of the customs service; measurement of the factors which determine color, the spectral transmissive and reflective properties of materials, and the color grading of light sources and materials; performance and development of optical instruments and materials; including refractive indices and dispersion measurements; the more general field of radiation, determination of the fundamental constants of radiation, the development of radiometric methods and instruments, and the determination of the emissive, reflective, and absorptive properties of materials for thermal radiation; investigation of atomic and molecular structure by measurements of the energy required for the formation of ions, and the radiation consequent upon their recombination; determination of the physical constants and tests of radioactive substances; investigation and application of X-rays, and study of means for avoiding their harmful effects; testing of photographic materials and devices and general photographic investigations; application of the light wave as a standard unit for high precision length measurements and development of interference methods.

Periodic Characteristics of the Chemical Elements.

Certain physical and chemical properties, such as valency, atomic volumes, expansion coefficients, boiling points, etc., exhibit periodicities in the system of chemical elements. Very recently emission arc and spark spectra have been shown to possess similar periodic characteristics throughout the eight groups of elements. Last year, the bureau announced for arc spectra, the verification of the so-called alternation law which states that even and odd groups of spectral lines alternate across the periodic table. This year, we have announced the verification of the so-called displacement law which states that the spark spectrum of any element resembles in structure the arc spectrum of the element just preceding it in the column to the left.

Wave Lengths of the Solar Spectrum.

Rowland's epoch-making table of solar spectrum wave lengths, which has been standard for more than 30 years, was recognized as inaccurate at least 20 years ago. In cooperation with the Allegheny observatory, the bureau has undertaken a complete standardization of the solar spectrum, based on the international system of units. A portion of the spectrum in the blue and violet was measured this past year—with a precision of about 1 part in 5,000,000. This program is planned to cover a period of 11 years so as to reveal any variation which may arise during a sun-spot cycle.

Determination of the Color of Sugar.

For many years one of the most important needs in the manufacture of sugar has been an accurate and a practicable method for the determination of the amount and character of color in the various stages of the processes utilized. The problem has recently become more acute because of the development and introduction of new decolorizing carbons. Intensive study of the subject has been made, beginning with the fundamentals of color measurement and their application to the sugar industry, and involving the combined physical and chemical characteristics of the materials used in the factory. The reason for the failure of the methods of color estimation now in use has finally been determined. The spectral character of the

color of the actual sugar liquors obtained during factory operation has been accurately determined, with the result that heretofore inexplicable difficulties encountered in factory processes have been explained. From the facts developed, what appears to be a practicable and relatively simple method of color measurement in the sugar factory has been worked out. The results obtained promise to be of unusual value to the carbohydrate industries.

Identification of the Biose of Amygdalin.

The identification of the biose of amygdalin is a problem of much importance and long standing in the history of efforts to determine the structure of the sugars. From a theoretical study of the problem, the use of polarimetric data on optical rotations, and Van't Hoff's hypothesis of additive optical superposition, the biose of amygdalin has been identified as gentiobiose, a disaccharide which has never been found free in nature.

Design of New Colorimetric Photometer.

It is believed that the long-existing troublesome uncertainties of heterochromatic photometry have been finally conveniently eliminated by the design of a rotatory dispersion colorimetric photometer. This instrument, now in constant use, was shown at the annual convention of the Illuminating Engineering Society. It measures the relative intensities of two different light sources under conditions of an exact color match, and also serves for the color grading of light sources.

Aberrations of Photographic Lenses.

The most complete and accurate investigation so far made of the aberrations of photographic lenses, covering the spherical aberration, departure from the sine condition, astigmatism, curvature of field, distortion, axial and lateral chromatism of 41 different high-grade objectives, was completed during the year and sent to press. From the results conclusions can be drawn regarding the uniformity of product of photographic lenses as commercially produced and the types of correction which are characteristic of the different objectives.

Studies in Thermal Radiation.

The application of the principles of thermal radiation to roofs and canopies on the one hand and to heaters on the other (issued as a technologic paper during the year) has aroused much interest, as indicated by the volume of correspondence on that subject.

Germicidal Effect of Ultra-Violet Light.

A quantitative investigation of the germicidal effect of ultra-violet radiant energy has been made which deals with the amount of killing as affected by wave length and intensity of the radiation, and also time of exposure. One of the important results of this investigation is the conclusion that waves longer than heretofore reported are found to be germicidal if the time of exposure given is sufficient. For example, radiant energy of wave length up to 365 millimicrons is found to have a germicidal effect if sufficient time be allowed, while heretofore 297 millimicrons has been given as the long wave limit for such action. Visible radiation ranges from about 380 to 720 millimicrons.

Increase in Sensitiveness of Photographic Plates.

It is gratifying to note the increase in sensitiveness and quality of some of the photographic plates and films during the last two years. We believe this is due in part to the publication of the characteristics of domestic plates and films (Scientific Paper No. 439). Many of them have been more than doubled in speed.

Ruling of Scales by Light Waves.

About two years ago this bureau ruled for a leading company, by interference methods, some 6-inch master scales sufficiently accurate to eliminate the use of correction charts. This company reports the release from the necessity of applying corrections to be highly gratifying and urges the bureau to expedite its plans for ruling larger scales with similar precision.

CHEMISTRY

The work of this division includes the investigation of the chemical composition and purity of materials, studies of chemical properties and constants, researches in connection with methods of analysis, the preparation of specifications for technical materials for other departments of the Government and for industrial and scientific laboratories. The chemistry division has general supervision of all chemical work at the bureau. In practically all questions of standardization or research the purity of the materials involved is an important factor. Much of the work of this nature supervised by the chemistry division is described under the appropriate headings elsewhere in this report.

General Chemical Testing.

The work of the chemistry division has included the usual great variety of tests and investigations. A large number of specifications have been prepared, covering bituminous roofing materials, rubber, inks, and typewriter ribbons. Thousands of tests have been carried out on bid samples and deliveries of Government purchases, resulting in the saving of large amounts of money to the various departments.

Reclamation of Gasoline Used in Dry Cleaning.

A process has been developed for the rapid and economical reclamation of gasoline used in dry-cleaning establishments, and the process is now in successful operation in several plants. The success of this undertaking was largely due to the close cooperation of the industry with the bureau and illustrates the value of the bureau's research associate plan.

New Standard Samples.

Nine new standard samples were prepared, standardized, and distributed, and four exhausted samples were renewed during the year. This is an unusually large number and involved a great deal of work on the part of the bureau and the cooperating analysts.

New Methods of Analysis.

Several new refined and routine methods for inorganic analysis were developed, and a number of methods for the analysis of the alloys of the platinum metals were worked out.

Improvements in Electroplating.

In the field of electrodeposition work on the general principles of "throwing power" (the ability of an electroplating solution to deposit in recesses) has been continued. The general distribution and

throwing power of various typical nickel-plating solutions have been determined. This research has also afforded valuable information upon cathode potentials and current efficiencies in nickel solutions.

Analytical Separation of Gases.

An apparatus for the analytical separation of gases into their constituents by fractional distillation has been developed and has proved of great value in the study of a standard method for the determination of gasoline in natural gas, which has been carried out in cooperation with the Natural Gas Association.

Absorption of Gases in Liquids.

This division has also developed apparatus for the absorption of gases in liquids. This is capable of showing definitely the course of a reaction lasting not more than one-tenth of a second.

Relations Between Densities, Pressures, and Temperatures of Gases.

A critical review of the literature dealing with the relations between densities, pressures, and temperature of gases has been prepared. This publication is especially designed to be useful to the general public without sacrificing scientific accuracy or completeness.

Testing of Gas Appliances.

Several methods of testing gas appliances have been developed to meet the need for better protection of the public against poisoning by carbon monoxide. The application of these methods to the study of appliances already has been of great assistance to many manufacturers.

MECHANICS AND SOUND

Investigations relating to mechanics, sound, and the properties of matter, including engineering mechanics, hydrodynamics, aerodynamics, and aeronautic instrument and engineering instrument research are included in the field of this division. This work embraces the standardization of mechanical appliances, the testing of structural and fabricated materials, the investigation of the sound-proofing qualities of building materials, the analysis and correction of acoustical defects in auditoriums, the development of radioacoustic ranging methods, time-signaling apparatus, the study of elastic fatigue and the elastic properties of diaphragms and springs, the development and testing of aircraft and engineering instruments, ballistics, wind-tunnel tests and research, orifice-meter investigations, walkway research, and the development and standardization of plumbing systems, builders' hardware, and elevator safety interlocks.

Elevator Interlocking Devices.

An investigation of elevator-interlocking devices, requested by the city of Baltimore, which was in progress during the previous year, was continued through the past fiscal year. Effective elevator hoistway door interlocks would, according to the best available statistical information, eliminate about three-fourths of the elevator accidents fatal to the public. While most modern elevator codes make use of such devices mandatory, at least for passenger elevators, the approval of the particular devices used has been based principally on a visual inspection. The purpose of this investigation is to develop test methods for determining the fitness of such devices by actual reliability-performance tests in place of visual inspection, and to apply such tests to the interlocking devices now commercially available. The formulation of test requirements for each of several operating conditions has been further developed, and a number of additional devices have been tested during the past fiscal year. The results of the tests made have shown very definitely the inadequacy of a visual inspection for such devices.

A second result has been an increase in the number of interlocking devices which may be considered as acceptable in the present state of the art. The manufacturers have been quick to apply the information developed, by the testing of their devices, to practical account, and to redesign their apparatus where this has been shown necessary.

The performance requirements developed for interlocking devices have been included in specifications for such devices used by the Supervising Architect of the Treasury Department.

Sound Transmission Through Building Materials.

Types of wall and floor construction which will prevent sound from being transmitted appreciably from one room to another would increase the comfort and efficiency of millions of our people. A comprehensive investigation of the subject is now under way, the experiments being conducted in a sound chamber especially constructed for the purpose. Measurements are made through panels $7\frac{1}{2}$ by 6 feet in dimensions which are sealed into a corresponding opening in the large sound chamber. The first measurements have been made with panels simulating present-day wall construction, both lime and gypsum plaster being used. The work is being carried on in cooperation with the National Lime Association and the National Gypsum Association.

Location of Ships by Sound and Radio Waves.

In cooperation with the Coast and Geodetic Survey a method has been developed for locating accurately the position of a surveying ship when the visibility is so poor that the coast can not be seen. The method employed involves the combined use of acoustic and radio signals. A small bomb is exploded near the ship, the instant of the explosion being recorded on a chronograph on board. The sound wave produced by the bomb is picked up by under-water microphones located at two or more known positions along the shore. When the sound signal reaches the microphone it is automatically sent back to the ship by radio, where the instant of its arrival is recorded on the chronograph. The time required for the signal to travel from the ship to each shore station can then be found by multiplying the time by the speed of sound in sea water. With this information the position of the ship can be quickly determined. The method is now in daily use by the Coast and Geodetic Survey in connection with sounding operations off the Pacific coast. Formerly surveying operations were often limited to five or six days in each month, due to the visibility being so poor that the shore stations could not be seen.

Aerodynamical Characteristics of Airfoils.

In cooperation with the National Advisory Committee for Aeronautics measurements have been made on the aerodynamical characteristics of airfoils at high speeds for the purpose of obtaining data for use in designing airplane propellers. The investigation was made at the Lynn works of the General Electric Co., where large centrifugal compressors were available for supplying a high-speed air stream. Measurements were made on six airfoils at varying wind speeds, which in some cases approached the speed of sound. The aerodynamical characteristics of the airfoils at high speeds were

found to be radically different from those obtained at low speeds, and it is believed the results will be of marked value in propeller design.

Strength of Masonry Walls.

An extended investigation on the strength of masonry walls is in progress, covering 8 and 12 inch walls, constructed from common and medium brick, sand-lime brick, and building tile. Three kinds of mortar are also being tested, including lime mortar, cement mortar, and a mixture of lime and cement in equal parts. Test walls 9 feet high and 6 feet long are constructed, allowed to age 60 days, and then loaded to failure in the 10,000,000-pound testing machine. The results will provide definite information regarding loads which may safely be carried by different types of wall construction and will be of great value to architects and builders.

Moving the Large Testing Machines.

During the year the 10,000,000-pound vertical testing machine (the largest testing machine in the world), which had been moved from the old branch laboratory at Pittsburgh, was set up in the Industrial Building. The large Emery high-precision machine was moved from the basement of the West Building to the Industrial Building, this being a particularly difficult job because of the relative situation of the two structures and the great weight and size of some of the parts.

The 600,000-pound machine from Pittsburgh and the small Emery machine were also set up in their new locations in the Industrial Building.

All this work was carried out by the bureau's staff and the results have been highly satisfactory.

Investigation of Welded Rail Joints.

Progress has been made in connection with the investigation of welded rail joints. Tensile tests have been made in the large Emery machine, and the anvil and other equipment for the repeated impact tests have been installed. The circular test track, however, has not been built as yet, because of the high cost of construction.

Stress Distribution in Ship-Plate Joints.

In cooperation with the Bureau of Construction and Repair of the Navy Department a study of stress distribution and elastic action in riveted ship-plate joints has been started. The large Emery machine is being used for this work.

Standardization of Builders' Hardware.

Work is in progress on the standardization of builders' hardware for Government as well as private use, and such laboratory tests as may be necessary to insure the adoption of articles having the requisite characteristics regarding durability and performance are being carried out. Surveys are being made to insure the adoption as standard of those items found in general commercial production. The Advisory Committee on the Standardization of Builders' Hardware, consisting of representatives of the prominent manufacturers in this field, in cooperation with the Bureau of Standards, has completed the first stage of standardization work by preparing and

adopting a comprehensive report on builders' hardware which, on a conservative basis, eliminates 26 per cent of the items manufactured in 1922. One of the outstanding accomplishments of this work is the setting up and adoption of 29 standard finishes in place of 100 nonstandard finishes formerly used. Standard-finish samples are held at the Bureau of Standards for reference.

STRUCTURAL ENGINEERING AND MISCELLANEOUS MATERIALS

This division is concerned with the investigation of the properties, uscs, design, and fabrication of certain types of structural, engineering, and miscellaneous materials. The materials included are: Cement, concrete, lime, gypsum, sand, stone, sand-lime brick, leather, rubber, and composition materials used in place of these, textiles, and paper. To make the study of these products complete, it is desirable to take into consideration the processes by which they are manufactured. Hence, the equipment includes an experimental rubber mill, textile mill, paper machine, cement plant, etc. The division is also concerned in the improvement of the present and the development of new methods of testing and the establishment of standards covering the manufacture and the use of the materials concerned.

Work on Specifications.

The past year has been a notable one on account of the number of specifications which have been prepared for the Federal Specifications Board. This is particularly true in respect to rubber and leather products, and in a less degree to textile materials. There are already indications of the increased amount of testing which the use of these specifications by the various Government departments will bring about. These specifications are based upon the delivery of commodities with definite specified qualities. In the case of cement, concrete, lime, gypsum, textiles, and rubber, and to a lesser degree in the case of paper and leather, the only testing equipment available in the Government departments is at the bureau.

Quality of Concrete.

In cooperation with the Portland Cement Association, the Joint Committee on Concrete and Reinforced Concrete, and a committee of concrete contractors, a very thorough field test was carried out on two major building operations to establish a means of introducing into practice some of the improvements in the technique of concrete making which recent researches have indicated to be desirable. The investigation also gave very interesting results as to the quality of the concrete which was being made on these jobs from hour to hour. Furthermore, the tests were carried out in such a way that the procedure originally adopted and usually followed out in such types of work was in no way interfered with, or changes suggested as a result of the testing work. In addition to the field work carried out, a comparative set of specimens was made in the laboratory from the same aggregate and cement, and these studies were supplemented by ones dealing with the effect of curing, time of mixing, method of sampling, etc. In general, the results showed that a very high quality of concrete was obtained. In the one case the average strength of the 1:6 concrete was 2,200 pounds per square inch in 28 days, and in the other job, the concrete of the same proportions but of different materials, gave 3,150 pounds per square inch. The maximum variations of the daily averages of strength were 23 per cent below and 34 above the grand average in the one case, and from 47 per cent below to 30 above in the second case. While these variations may

seem large, yet, in general, they were less than had been predicted for work carried on under these conditions.

Workability of Concrete Mixtures and Tests of Colorless Waterproofing Materials.

Two other notable pieces of work in the cement section were those dealing with the workability of concrete mixtures, and with colorless waterproofing materials, for stone in particular. The data obtained in the latter have been issued as Technologic Paper No. 248. The results indicate that those materials which utilize paraffin, aluminum stearate, or mixtures of paraffin with china-wood oil give good waterproofing values when properly applied. A special feature of the work in connection with the study of the workability of concrete mixtures consisted of incorporating various admixtures into the concrete mixtures and noting the effect of these. This was suggested by the extensive use of certain admixtures at the present time. The results show that the workability of a concrete mixture is about equally benefited by 1 part of celite, 2 parts of kaolin, or 3 parts of hydrated lime such as used in these tests, if the consistency as measured by the flow table is kept constant. These mixtures in the proportions used did not seriously affect the strength of the 1:2:4 or leaner mixtures.

General Cement Testing.

Due to the bureau's testing of all the cement for the Muscle Shoals Dam the total quantity tested by the bureau in its several branch laboratories was considerably more than that handled during the last year. The total amount tested was 1,293,158 barrels. In addition to this testing of cement, a very large amount of testing of concreting materials was carried on for the other Government bureaus.

Chrome and Vegetable Tanned Sole Leather.

The final results from the investigation to determine the comparative durability of chrome and vegetable tanned sole leather indicate that it would be economically advantageous to utilize the superior wearing qualities afforded by the chrome method of tanning, and that this might be accomplished by developing methods of rapidly retanning chrome leather with vegetable tanning materials in order to secure the desirable properties other than relative wear which the chrome-tanned leather does not possess. There is no question, however, that the chrome-tanned leather gives decidedly better wearing qualities than vegetable tanned.

Synthetic Tanning Materials.

The interest shown in synthetic tanning materials led the bureau to conduct quite an investigation into what these materials are, how they might readily be produced in this country, and the quality of the leather which might be obtained with their use. It was possible to obtain some excellent leathers, possessing good color, firmness, flexibility, and great strength, but lacking in that fullness and weight required of certain heavy leathers. It is believed that further work would result in obtaining this desired fullness through developing the correct method of applying these newer tanning agents.

Tests of Automobile Tires.

During the year Technologic Paper No. 240, Dynamometer Tests of Automobile Tires, was issued. This is the second paper published in connection with the study of power losses in automobile tires. These losses have been determined on a large number of tires, and the comparative results are given for the 3½, 4, and 5 inch sizes, both cord and fabric. The analysis of the results showed that the carcass is responsible for the greater part of the loss. Tests have been made also on about 20 of the new balloon types of tires. The results show that the rolling resistance of this type is greater than for high-pressure tires when each is operated at its recommended pressure.

Heat-Retaining Properties of Fabrics.

The results of a long series of tests on the heat-retaining properties of fabrics have been collated and are about ready for publication. In addition to the study of the actual transmission of heat in this problem, the permeability of the fabrics to air and water vapor was determined at the same time. This was done in view of the effect which the permeability of the fabric to air and moisture might have upon the passage of heat through it. As a consequence three different sets of apparatus were designed and sufficiently perfected to be considered finished pieces of laboratory apparatus. However, not enough types of fabrics have been studied to permit drawing general conclusions, but it has been shown that the apparatus would be satisfactory for this purpose.

Wearing Qualities of Textiles.

The apparatus designed for testing the wearing qualities of textiles has been modified in such a way that it is now possible to use it for testing a wide variety of textiles on the market. It has been used during the past year for a study of the effect of changing the number of plies in serges, with the yarn size and weight of fabric remaining the same. This particular investigation showed that there was a material difference in the abrasion of a 2-ply yarn over single yarns, and also that the effect of repeated stress was materially changed when the number of plies in the yarn differed. Some overcoatings and carpets, which had been specially treated were compared on this apparatus with the untreated samples, and showed the superiority of the former over the latter. A short study of the effect of reworked wool in wool fabrics was made, and showed that it was possible to use reworked wool in fabrics and secure a fabric superior in wearing qualities to one containing all virgin wool.

Foreign and Domestic Clays as Paper Fillers.

A technologic paper dealing with a comparison of foreign and domestic clays as paper fillers is now in press. This study was made in the experimental paper plant of the bureau and included the determination of the amount of clay retained in the paper, the quality of the paper produced, and a study of the physical properties of the clays that might influence the paper-making process of the finished product. The results show that with the proper manipulation of the paper-making machinery the amount of the domestic clay retained in the paper, and the quality of the paper containing

the domestic clay, are, in general, the same as the foreign clay. The color and the amount of grit favor the foreign clay, however.

Determining the Whiteness of Paper.

The need of being able to differentiate between the tints of so-called white papers led to a study of the application of the Pfund colorimeter for determining the departure of various white papers from a true white. This work has been published as Technologic Paper No. 244.

Properties of Gypsum.

The rapid increase in the use of gypsum products in the structural industries formed the incentive for an investigation of gypsum, its manufacture into the large variety of commodities in which it now appears on the market, and the service obtained from these. The effect of the composition of the original gypsum on the properties of the plaster, and studies of gypsum hollow tile, with particular reference to the relation of absorption, expansion, compressive, and transverse strength, were two of the major problems investigated.

Investigation of Plaster Failures.

A number of kinds of failures of plaster which were brought to the attention of the bureau have also been the subject of investigation. As is usual in the case of failure of materials of this type the cause is generally found not in the material itself, but in the attempt to use it without a proper knowledge of its qualities and of the variation in the material which may be present from time to time. In this particular type of materials there is marked evidence that the industries concerned could confer a great benefit upon the using public through their service departments by a system of education of the workmen as to how to use the commodity they are placing on the market. Certain industries have realized the necessity for doing this, and through field engineers are accomplishing very valuable results.

METALLURGY

The metallurgical division concerns itself with research, investigation, and testing as related to metals and alloys. The study of built-up metal structures and the processes of extraction of metals from their ores does not fall within the scope of the division. Its functions include the production of metals and alloys, both of the highest attainable purity and of commercial grades; the preparation and study of auxiliary metallurgical products, such as slags, "deoxidizers," molding sands, refractories, and "gases in metals"; the design and development of apparatus, instruments, and manufacturing appliances for metallurgical processes, research, and testing; the formulation and maintenance of standards and specifications of interest to metallurgists; the determination of metallurgical constants and properties; the investigation of the performance of manufacturing units; the determination of the causes of failure of metals, together with the study of the improvement of metal products; and the development of economical metal substitutes. The division has equipment for metallographic examinations of metals, such as microscopic analyses, including determinations of constitution, structure, and causes of failure; for thermal analyses, including determination of heating and cooling curves for location of critical points; for the various heat treatments, such as annealing, quenching, cementation, tempering; for various operations for the hot and cold working of metals, such as forging, rolling, drawing, and welding, and for miscellaneous mechanical tests; for the usual foundry operations of molding and casting ferrous and nonferrous metals; and for other metallurgical processes, such as production of pure metals by electrodeposition and other means, and determination of gases in metals.

X-ray Study of Metals.

One new major project of fundamental importance, the study of the atomic structure of metals by the X-ray spectrograph, has been instituted. All other major projects are continuations of investigations previously begun.

Resistance of Metals to Corrosion.

Of the above-mentioned investigations, the work on the standardization of methods for testing the resistance to corrosion of metals and alloys and the collection of experimental data on the subject, is of prime importance. This work has been carried on in cooperation with the American Society for Testing Materials.

Properties of Metals and Alloys at High Temperatures.

Next in industrial importance is the study of the properties of metals and alloys at high temperatures. Engineering calls for increased use of metallic materials at high temperature and pressures, and the data necessary are rapidly being collected. This laboratory is probably the best equipped in the country for this work, which is being done in cooperation with the American Society of Mechanical Engineers and the American Society for Testing Materials.

High-Speed Steels.

Gratifying progress has been made, in cooperation with the Naval Gun Factory, on the work with high-speed steels and on the machineability of steel.

Gases in Metals.

The fundamental problem of gases in metals, has, as in the past, received much attention. The laboratory equipment for this problem is second to none. Real progress has been made and it appears that this problem is well in hand. Very interesting results have been obtained in the work for the Joint Committee on Sulphur and Phosphorus in Steel. Much other work has also been done for this committee.

Durability of Gauges.

Progress has been made in the work on the durability and permanence of gauges. This work is in cooperation with the Gauge Steel Committee and Army and Navy.

Metal Coatings.

The work on coating materials of all sorts with metallic coatings by spraying, primarily for the Army and Navy, has had marked success. A special portable truck carrying a self-contained metal-spray outfit has been rigged up for the Army Air Service. Several spray guns have been built and delivered to different branches of the Navy and several very useful applications of metal spray to Navy problems have been worked out. No activity of the division has aroused more interest among the industries, although, on account of the confidential nature of much of the work, publicity has been avoided rather than courted.

Preparation of Pure Platinum.

The work on the preparation of pure platinum and of special refractories for the melting of platinum has continued with steady success.

Examination of Failed Metal Parts.

One important activity of the division is the carrying out for other branches of the Government examinations of metallic material which has failed in service or in connection with which questions arise which can only be answered by metallurgical study. The

Naval Gun Factory, the Panama Canal, the Veterans' Bureau, the Post Office Department, the National Advisory Committee for Aeronautics, the Fleet Corporation, many branches of the Army and Navy and of the Department of Agriculture, and others have brought in a large number of such problems. For example, a method for the restoration of obliterated identification marks on revolvers used by criminals has been worked out and has been a real aid to justice. On some of these problems too little information is available about the conditions of use of the material to allow a definite answer to the question brought up, but in the great majority of the cases the bureau has been able to solve the problem and thus be of material service.

CERAMICS

The work in connection with ceramics deals with standards of quality, methods of test, and specifications for ceramic materials and products; the study of problems relating to the preparation and utilization of ceramic materials, and to the manufacture of ceramic products; the elimination of waste by supplying definite guides to purchasers, governmental and private, and by obtaining and disseminating to manufacturers scientific information of assistance in the improvement of products and in increasing the efficiency of methods. The products embraced in this work include building materials, such as brick, hollow tile, wall tile, and architectural terra cotta; drainage materials, such as sewer pipe and draintile; paving materials, such as paving brick and floor tiles; refractory materials required for the lining of metallurgical and other furnaces; pottery and chemical porcelain; glass products, including window glass, glass containers, and optical glass; and products made by the enameling of sheet iron or sheet steel, cast iron, and other metals.

Researches Carried on in Private Plants.

The tendency of the ceramic industries to carry on certain phases of plant development and service requirement researches has relieved the bureau of many demands made upon it in this respect in the past. As a consequence it has been able to reorganize its personnel and work along the lines of paying more attention to the fundamentals required by the industry and in which more properly the efforts of the bureau should be directed.

Study of Clays for Specific Purposes.

There was inaugurated during the year a research to obtain physical-chemical constants for the study of clays for specific purposes, and also applicable in processes of their purification, and constants for the regulation of clay bodies for forming the various ceramic wares. The first phase of the work related to the degree of acidity or alkalinity of the water phase of the clay-water system, as determined by the hydrogen electrode. These data were published in Technologic Paper No. 234. At the present time the problem is being attacked from a slightly different viewpoint, namely, that of removing the contained soluble electrolytes from the clay and studying the qualities of the resultant purified clay.

Drying of Ceramic Wares.

All ceramic wares must in some part of the process of manufacture have removed the water used in working up the clay or the bodies by some drying treatment. The resistance of different clays and bodies to giving up this water varies very markedly, and the effect of giving up this water upon the mechanical properties of the body also varies to a very large degree. As a consequence, one of the most interesting phases in the manufacture of ceramic materials is the drying process. This has never been studied systematically. The work along this line during the past year has been very largely in the direction of determining the effect of the drying

treatment on the strength and other physical properties of the ware. Data have been obtained on the rate of moisture diffusion through clay, the rate of removal from the surface, and the rate of temperature rise within a body while being dried under different humidity conditions. Interesting data have been obtained but at the present time do not permit of the drawing of general conclusions. However, it was noted that, in general, the removal of the last per cent of water increased the dry strength from 50 to 100 per cent.

Strength of Glazing Glass.

Approximately 5,000 samples of glazing glass (2 by 18 inches) of various types were tested for strength by transverse loading and impact. The modulus of rupture varied from 5,000 to 13,000 pounds per square inch, and the Young's modulus from 550,000 to 16,670,000 pounds per square inch, depending upon the type of glass. Tests were also made on 12 by 12 inch pieces of glass mounted in frames and loaded at the center. The results show that the strengths of these sheets approximate very closely that which may be concluded from the strengths obtained by testing transversely strips 2 by 18 inches when tested as a beam supported at two ends.

Specifications for Refractories.

There has been prepared for publication a progress report on specifications for refractories, with special reference to refractories for stoker-fired boiler settings. The data were obtained in testing 42 brands of representative refractories, which were furnished through the cooperation of Stone & Webster from various power plant installations. The results indicated that a refractory which would successfully withstand 15 quenches from 850° C. to running water, also had a softening point equivalent to at least that of cone 32; that the per cent linear change in the endurance test would not exceed 2 per cent and the deflection in the same test, when transversely loaded, would not exceed 0.3 of an inch; that the per cent absorption after the constant volume test would lie between 6 and 10 per cent; and that the refractory should contain not more than 4 per cent flux and 20 per cent uncombined quartz. A short investigation was also carried out with some refractories for rotary cement kilns. This was primarily a study of the relative value of clay and high alumina refractories. The work permitted of the indication of requirements of specifications for this type of refractory, and also indicated the value of the high alumina refractories for cement kiln lining.

Bond Between Hollow Tile and Concrete.

The results of a series of tests on slabs of hollow tile with reinforced concrete ribs indicated that the bond between the concrete and the tiles was sufficient to cause the tiles to assist materially in taking both bonding and shearing stresses. When medium or hard tile are used, it appears that the shells of the tiles which are in contact with the concrete are as effective as an equal width of concrete.

Efficiency of Tile and Brick Extrusion Machines.

At the suggestion of the Hollow Building Tile Association the bureau has undertaken a study of the efficiency of hollow tile and brick extrusion machines. This rather complex problem is now under way, and the apparatus and equipment necessary for a study

of the various types of auger machines is being developed. The preliminary study of the problem has indicated that one of the principal difficulties will be the development of the apparatus which will be necessary for studying the efficiency of these machines. This is due very largely to the crudeness of the latter and to the difficulty in obtaining a constant maximum load torque for a sufficient length of time to make observations.

Properties of Enamel.

The relation between enamel composition and such properties of the enamel as strength and acid resistance, as well as the effect of the relative coefficients of expansion of the ground and cover coats on resistance of the enameled ware to impact and thermal shock, has been studied. The results were published under the title of "The relations between composition and properties of enamels for sheet steel" in the October, 1923, Journal of the American Ceramic Society.

Wet-Process Enamels.

There is an increasing use of the wet process of enameling in the industry. However, the technique and the compositions required for this type of enamel are not well known. As a consequence, the bureau, in connection with a commercial plant, carried on an extended piece of work which has been published in Technologic Paper No. 246. A number of very satisfactory compositions were worked out which have given very satisfactory results in the factory on such pieces as oven and broiler fire doors, oven-burner plates, flue doors, brackets, and other types of cast-iron ware.

Federal Specifications for Ceramic Materials.

There have been prepared for the Federal Specifications Board, and adopted by the latter, specifications for glass tableware, glass shades and chimneys, and sheet glass for glazing purposes. There have also been submitted to the Federal Specifications Board for promulgation specifications for tableware.

SIMPLIFIED PRACTICE

The division of simplified practice serves as a centralizing agency in bringing producers, distributors, and users together, in cooperation with American industries, to reduce industrial waste through the elimination of unnecessary diversity in sizes, types, styles, and other varieties of manufactured products.

Simplified Practice Recommendations Accepted.

Up to the present time the following simplified practice recommendations have been accepted by the representatives of the industries concerned and have been printed:

1. Paving brick.
2. Bedsteads, springs, and mattresses.
3. Metal lath.
4. Asphalt.
5. Hotel chinaware.
6. Files and rasps.
7. Face and common brick (clay).
8. Range boilers and expansion tanks.
9. Woven-wire fencing.
10. Milk bottles and caps.
11. Bed blankets.
12. Hollow building tile.
13. Paints, varnishes, and containers.

Recommendations in Process of Acceptance and Being Considered.

The following recommendations are now in process of acceptance: Paper, lumber, brass lavatory and sink traps, steel barrels and drums, forged tools, blackboard slate, roofing slate, structural slate, bolts and nuts for farm equipment, hot-water storage tanks, asbestos paper and millboard, builders' hardware, and hospital beds.

Simplified practice recommendations are being considered for concrete blocks, cafeteria and lunchroom chinaware, refractories, steel lockers, steel reinforcing bars, warehouse forms, oil-storage tanks, sheet steel, terneplate, eaves' troughs and conductor pipe, shovels, furnace parts (registers for warm-air furnaces), window sash, and doors.

Field Surveys in Progress.

Surveys of existing varieties are in process for the following industries: Automotive parts; gas water heaters (side arm and flueless types); copper boilers; hydropneumatic tanks; house tanks for cold-water storage; hacksaw blades; copper and brass products; screw drivers; pocket knives; refrigerator hardware; collapsible tubes; loaded shells; dental supplies; cotton-fabric colors; wood handles for tools; lock washers and nut locks; rubber heels; drills and reamers; milling cutters; clay products; taps and dies; grocery bags; boxes (colors and sizes) for gloves; underwear, hosiery, etc.; oil burners; elevated steel tanks and towers; manhole frames and covers.

American Marine Standards Committee.

A publication has been issued on the Organization of the American Marine Standards Committee and its Constitution and Rules. This publication describes the field, objects, organization, and mode of procedure of this committee, which has been making steady progress in the work undertaken in 1923. A general conference of this committee was called on May 5, 1924, to consider existing specifications for condenser tubes and ferrule stock and to adopt recommendations for a common standard for marine use.

Utilization of Waste in Lumber Industry.

A member of the division's staff has just completed the preparation of two reports on utilization of waste in the lumber industry, one of which covers a survey made in the Pacific Northwest, while the other deals with the situation in the Southern States.

BUILDING AND HOUSING

The work of this division includes gathering and distributing scientific, practical, statistical, and other information tending to encourage, cheapen, and improve construction and housing. It covers investigations for use in framing local building and plumbing codes and a study of problems connected with city planning and zoning. Information on the prices, production, consumption, and stocks of building materials, and on building activity is collected, analyzed, and distributed. Special attention is paid to factors bearing on the housing problem. The work includes studies of building practice and cooperation with efforts to reduce seasonal operation and otherwise eliminate waste in the construction industries.

General Work.

A survey of seasonal operation in the construction industries was the principal new activity of the division of building and housing during the year. The work on building codes, plumbing codes, city zoning, statistics, and service for the home owner continued logi-

cally from the work of the preceding year. The cooperation of trade associations, professional, scientific, and civic societies, and other bodies of citizens interested in construction, housing, and civic improvement, has helped to make the results of the division's work of maximum benefit throughout the entire country.

Seasonal Operation in Construction Industries.

The study of seasonal construction was initiated about the beginning of the fiscal year at the instance of a committee of the President's Conference on Unemployment. With the assistance of the committee and of experienced men whose services were contributed by trade associations an extensive report was prepared and served as a basis for recommendations by the committee. It was found that seasonal irregularity in building activity was due more to custom than to climate. The average building-trades worker customarily loses from a fourth to a third of his available working time during the year, and contractors' organizations, material manufacturers, and others connected with the industry suffer similarly. Constructive remedies based mainly on what has been accomplished in various communities were evolved, and the suggestions are being carried out in many communities.

Reports Prepared.

The building code committee prepared for publication its reports on "Masonry walls" and "Floor load requirements" and made substantial progress on other reports. The plumbing code committee issued its Recommended Minimum Requirements for Plumbing in Dwellings and Similar Buildings, and indications are that its provisions will be utilized in many States and local plumbing codes. In most localities where there are already plumbing codes its adoption will permit savings of from \$50 to \$200 per house over present practice, at the same time giving better assurance of safe and sanitary systems. The advisory committee on zoning published its Standard State Zoning Enabling Act, on which acts adopted in at least 13 States have been wholly or largely based. It is expected that the general use of this will simplify the legal status of zoning in the United States.

Building-Material Prices.

Increasing use has been made by the construction industry of the building-material prices and other current statistics which have been collected and published. Members of the division prepared the articles on "Construction" and "Construction materials other than lumber" for the Commerce Yearbook.

Cooperation With Home Owners.

How to Own Your Home, a 28-page pamphlet for the guidance of home seekers, was published in September, and has had a sale approaching 300,000 copies; in addition, sections of it have been very widely reprinted in newspapers and periodicals. At the close of the year a study of home financing was commenced. With the incorporation of Better Homes in America as an independent organization for public service, and the transfer of its headquarters to Wash-

ington, cooperation with it became closer. In May "demonstration homes" were conducted in several hundred cities and rural communities.

THE OFFICE

The work of the office comprises the supervision of the units of the administrative routine; of the editorial work of the bureau and of the technical library; planning and supervision of the bureau's clerical routine (finance, personnel, property and stores, transportation, mail and files, purchase, and information); and special problems connected with these functions, as well as special projects assigned.

During the year the office expended and accounted for funds aggregating \$1,804,930.34, including \$136,705 by transfer from other departments.

The following table shows the amount and object of each appropriation provided for the bureau for the fiscal year 1924, the disbursements during the year, the amount of unpaid orders at the close of the year, and the unexpended balance remaining at the close of business June 30, 1924:

TABLE 1.—*Disbursements, liability, etc., 1924 appropriation*

Appropriation	Total appropriation	Disbursements	Liability	Balance
Salaries.....	¹ \$396,500.00	\$371,415.11	\$15,008.33	\$10,076.56
Equipment.....	² 74,000.00	50,231.51	23,338.27	430.22
General expenses.....	³ 47,374.58	30,658.83	14,244.91	2,470.84
Improvement and care of grounds.....	10,000.00	8,766.59	1,001.47	231.94
Testing structural materials.....	⁴ 216,981.59	184,838.61	24,602.23	7,540.75
Testing machines.....	35,000.00	31,930.11	2,808.48	261.41
Metallurgical research.....	⁵ 40,831.28	36,553.98	4,181.56	95.74
Investigation of optical glass.....	25,000.00	23,920.50	957.06	122.44
Standard materials.....	10,000.00	8,130.65	1,213.04	656.31
Investigation of textiles, etc.....	25,000.00	21,039.39	1,675.32	2,285.29
Sugar standardization.....	⁶ 41,350.00	36,875.07	4,257.60	217.33
Gauge standardization.....	40,000.00	33,904.81	2,614.73	3,480.46
High-temperature investigation.....	10,000.00	8,586.36	879.22	534.42
Testing railroad scales.....	40,000.00	35,095.11	4,519.32	385.57
Investigation of fire-resisting properties.....	25,000.00	23,679.96	1,204.55	115.49
Testing miscellaneous materials.....	40,000.00	37,605.08	2,259.73	135.19
Investigation of public-utility standards.....	95,000.00	82,790.14	11,382.42	827.44
Radio research.....	⁷ 40,300.00	36,780.45	3,422.16	97.39
Industrial research.....	⁸ 153,038.64	138,171.45	11,601.38	3,265.81
Sound investigation.....	⁹ 5,430.00	5,035.44	266.67	127.89
Investigation of clay products.....	30,000.00	26,296.58	2,149.32	1,554.10
Color standardization.....	10,000.00	8,914.69	977.22	108.09
Radioactive substances.....	10,000.00	8,149.56	1,752.59	97.85
Standardizing mechanical appliances.....	¹⁰ 30,125.00	26,499.39	3,183.01	442.60
Investigation of mine scales and cars.....	15,000.00	8,671.92	3,490.52	2,837.56
Rope investigation.....	20,000.00	14,392.45	5,285.18	322.37
Standardization of equipment.....	100,000.00	91,794.74	7,380.51	824.75
Replacement of altitude chambers.....	72,000.00	11,144.88	60,243.14	611.98
Automotive power plant.....	10,000.00	7,674.91	2,131.16	193.93
Claim for damages.....	294.25	294.25		

¹ Excludes transfer of \$35,860 to the office of the Superintendent, State, War, and Navy Department Buildings

² Excludes transfer of \$20,000 to the office of the Superintendent, State, War, and Navy Department Buildings, and \$1,000 to contingent expenses, Department of Commerce.

³ Excludes transfer of \$27,000 to the office of the Superintendent, State, War, and Navy Department Buildings, and \$1,000 to contingent expenses, Department of Commerce, and includes reimbursement of \$374.58 received from other departments.

⁴ Includes reimbursement of \$21,981.59 received from other departments.

⁵ Includes reimbursement of \$831.28 received from other departments.

⁶ Includes reimbursement of \$1,350 received from other departments.

⁷ Includes reimbursement of \$300 received from other departments.

⁸ Includes transfer of \$2,500 and reimbursement of \$538.64 received from other departments.

⁹ Includes reimbursement of \$430 received from other departments.

¹⁰ Includes reimbursement of \$125 received from other departments.

TABLE 1.—*Disbursements, liability, etc., 1924 appropriation—Continued*

Appropriation	Total appropriation	Disbursements	Liability	Balance
Appropriations transferred from other departments which are available for the current year:				
Air Service, Army.....	\$12,840.00	\$11,008.76	\$1,557.53	\$273.71
Engineering, Bureau of Engineering.....	525.00	515.84	4.66	4.50
Ordnance stores ammunition.....	4,000.00	3,711.72	164.84	123.44
Signal Service, Army.....	525.00	448.77	46.77	29.46
Experiments, Bureau of Ordnance.....	5,000.00	4,880.38	70.47	49.15
Advisory Committee for Aeronautics.....	28,600.00	26,631.50	959.48	409.02
Aviation, Navy.....	5,125.00	3,694.94	1,354.37	75.69
Party expenses, Coast and Geodetic Survey.....	2,000.00	1,266.66	695.64	37.70
Ordnance and ordnance stores.....	2,625.00	1,385.86	1,207.10	32.04
Appropriations transferred from other departments which are available for a period of two years:				
Air Service, Army.....	7,725.00	5,652.23	-----	2,072.77
Aviation, Navy.....	50,000.00	31,589.49	1,822.50	16,588.01
Ordnance and ordnance stores.....	10,000.00	8,178.81	550.79	1,270.40
Tanks (1923-24).....	3,000.00	1,593.10	500.00	906.90
Field artillery armament.....	1,840.00	923.75	89.37	826.88
Party expenses, Coast and Geodetic Survey.....	2,900.00	59.15	-----	2,840.85
Ordnance stores ammunition (1923-24).....	600.00	-----	-----	600.00
Total.....	1,804,930.34	1,511,383.48	227,054.62	¹¹ 66,492.24

¹¹ \$5,000 of this amount represents budget savings.

The second table shows the condition of the appropriations for the two preceding fiscal years at the close of business June 30, 1924:

TABLE 2.—*Disbursements, liability, etc., 1922 and 1923 appropriations*

Appropriation	Total appropriation	Disbursements	Liability	Balance
FISCAL YEAR 1922				
Salaries.....	\$432,360.00	\$421,194.83	-----	\$11,165.17
Equipment.....	¹ 94,000.00	76,264.93	\$9.19	17,725.88
General expenses.....	¹ 74,000.00	63,621.32	317.46	10,061.22
Improvement and care of grounds.....	10,000.00	9,690.24	-----	309.76
Testing structural materials.....	² 178,035.50	157,749.10	242.99	20,043.41
Testing machines.....	30,000.00	28,129.75	-----	1,870.25
Metallurgical research.....	³ 40,154.07	37,641.98	25.58	2,486.51
Investigation of optical glass.....	⁴ 28,000.00	26,628.94	82.01	1,289.05
Investigation of textiles, etc.....	15,000.00	13,959.70	-----	1,040.30
Sugar standardization.....	⁵ 31,800.00	29,904.76	2.00	1,893.24
Gauge standardization.....	40,000.00	37,960.85	-----	2,039.15
High-temperature investigation.....	10,000.00	9,451.75	-----	548.25
Testing railroad scales.....	40,000.00	37,091.04	.42	2,908.54
Investigation of fire-resisting properties.....	25,000.00	23,082.50	-----	1,917.50
Testing miscellaneous materials.....	30,000.00	28,409.82	-----	1,590.18
Investigation of public-utility standards.....	70,000.00	69,294.36	16.54	689.10
Investigation of public-utility standards (1921-22).....	15,000.00	14,795.07	-----	204.93
Radio research.....	30,000.00	28,211.85	-----	1,788.15
Industrial research.....	⁶ 468,257.00	437,400.17	14,849.64	16,007.19
Sound investigation.....	5,000.00	4,829.31	-----	170.69
Investigation of clay products.....	25,000.00	23,432.38	-----	1,567.62
Color standardization.....	10,000.00	9,148.48	-----	851.52
Standardizing mechanical appliances.....	15,000.00	13,737.07	-----	1,262.93
Investigation of mine scales and cars.....	15,000.00	13,383.30	-----	1,616.70
Standardization of equipment.....	100,000.00	88,574.11	51.35	11,374.54
Appropriations transferred from other departments which were available for a period of 2 years:				
Gauge standardization, war transfer.....	3,000.00	2,738.94	220.00	41.06
Total.....	1,834,606.57	1,706,326.55	15,817.18	⁷ 112,462.84

¹ Excludes \$1,000 transferred to "contingent expenses," Department of Commerce.

² Includes reimbursement of \$3,035.50 received from other departments.

³ Includes reimbursement of \$154.07 received from other departments.

⁴ Includes transfer of \$3,000 received from other departments, which was available for a period of two years.

⁵ Includes reimbursement of \$1,800 received from other departments.

⁶ Includes transfer of \$316,673.66, a large portion of which was available for a period of two years, and reimbursement of \$1,583.34 received from other departments.

⁷ \$55,500 of this amount represents budget savings.

TABLE 2.—Disbursements, liability, etc., 1922 and 1923 appropriations—Con.

Appropriation	Total appropriation	Disbursements	Liability	Balance
FISCAL YEAR 1923				
Salaries.....	\$432,360.00	\$414,529.33	\$2,725.00	\$15,105.67
Equipment.....	¹ 94,000.00	86,849.49	1,352.36	5,798.15
General expenses.....	¹ 74,000.00	69,673.83	508.62	3,817.55
Improvement and care of grounds.....	10,000.00	8,304.41	45.00	1,650.59
Testing structural materials.....	⁸ 182,563.88	169,921.32	2,487.01	10,155.55
Testing machines.....	30,000.00	27,016.83	669.58	2,313.59
Metallurgical research.....	⁹ 40,133.04	39,738.06	180.00	214.98
Investigation of optical glass.....	25,000.00	22,694.40	966.28	1,339.32
Standard materials.....	10,000.00	9,346.18	30.00	623.82
Investigation of textiles, etc.....	25,000.00	21,972.36	187.83	2,839.81
Sugar standardization.....	⁶ 41,800.00	40,616.31	274.09	909.60
Gauge standardization.....	40,000.00	36,223.53	234.55	3,536.92
High-temperature investigation.....	10,000.00	9,418.35	50.00	531.65
Testing railroad scales.....	40,000.00	37,401.65	456.89	2,141.46
Investigation of fire-resisting properties.....	25,000.00	24,183.00	597.02	219.98
Testing miscellaneous materials.....	30,000.00	27,862.77	346.24	1,790.99
Investigation of public-utility standards.....	85,000.00	83,605.54	817.68	576.78
Radio research.....	30,000.00	29,440.62	248.75	310.63
Industrial research.....	¹⁰ 249,294.00	234,813.06	3,739.20	10,741.74
Sound investigation.....	¹¹ 5,200.00	5,077.27	3.75	118.98
Investigation of clay products.....	25,000.00	23,959.29	122.00	918.71
Color standardization.....	10,000.00	9,693.38	85.00	221.62
Radioactive substances.....	10,000.00	9,449.25	-----	550.75
Standardizing mechanical appliances.....	15,000.00	13,980.50	122.00	897.50
Investigation of mine scales and cars.....	15,000.00	9,800.29	8.36	5,191.35
Standardization of equipment.....	100,000.00	88,422.38	3,814.15	7,763.47
Investigating sources of crude rubber (1923-24).....	¹² 38,300.00	33,221.06	3,830.23	1,148.71
Appropriations transferred from other departments which are available for a period of two years:				
Aviation, Navy.....	3,300.00	2,404.83	-----	895.17
Party expenses, Coast and Geodetic Survey.....	11,300.00	9,747.37	141.93	1,410.70
Construction and repair, Bureau of Construction and Repair.....	1,650.00	1,134.87	-----	515.13
Engineering, Bureau of Engineering.....	550.00	414.75	-----	135.25
Ordnance and ordnance stores.....	550.00	522.80	-----	27.20
Experiments, Bureau of Ordnance.....	1,100.00	1,087.63	-----	12.37
Automatic rifles (1923-24).....	4,920.00	3,836.84	68.25	1,014.91
Incidental expenses of the Army.....	25,000.00	10,990.06	494.44	13,515.50
Subsistence of the Army.....	10,000.00	5,129.39	-----	4,870.61
Clothing and equipage.....	2,500.00	-----	-----	2,500.00
Total.....	1,753,520.92	1,622,588.00	24,606.21	¹³ 106,326.71

¹ Excludes \$1,000 transferred to "contingent expenses," Department of Commerce.² Includes reimbursement of \$1,800 received from other departments.⁸ Includes reimbursement of \$7,563.88 received from other departments.⁹ Includes reimbursement of \$133.04 received from other departments.¹⁰ Includes transfer of \$99,150, a large portion of which is available for a period of two years, and reimbursement of \$144 received from other departments.¹¹ Includes transfer of \$200 received from other departments.¹² This fund was allotted to the bureau by the Department of Commerce.¹³ \$24,300 of this amount represents budget savings.

Personnel actions involving 1,616 staff changes were handled for the 836 bureau employees, the staff status records being maintained up to date. The turnover by separation amounted to 33 per cent for the scientific, 37 per cent for the clerical, and 25 per cent for the construction employees, respectively. The bureau editorial committee received and considered 298 manuscripts prepared by members of the bureau staff for publication; 69 publications on bureau researches were actually published, including 14 scientific papers, 20 technologic papers, 20 circulars, and 15 miscellaneous publications. A complete list of these papers will be found in Circular No. 24 of the Bureau of Standards and its supplements. In addition, 26 technical letter circulars and 12 technical news bulletins were prepared and distributed. For each manuscript submitted the author now pre-

pare a popular abstract for the daily press and a more technical abstract for the technical press. From these and other sources 130 publicity items were prepared in the office for the newspapers. A new system of announcements of new publications, a revision of the bureau's mailing list, and a new policy with respect to document distribution received careful attention during the year. The resulting system has been found practical and effective in service. All bureau publications will be placed upon sale by the Superintendent of Documents and sales stock maintained as long as the demand continues.

With the new accessions of the year just ended the bureau's scientific library now contains 27,000 volumes, and received 646 technical and scientific periodicals from all parts of the world. Its book circulation has increased 20 per cent. The bureau's library is especially rich in primary sources in physics and the special technologies within its field. For the procurement of the special equipment and supplies, much of which is of a unique or highly specialized character, a technical catalogue library of 16,000 scientific, engineering, and industrial catalogues is maintained under the care of an experienced procurement clerk. During the year 5,275 special orders were placed, in addition to requisitions for restock of staple supplies; 6,500 vouchers were audited and prepared for payment; 2,580 pieces of scientific apparatus and other equipment were accessioned and placed in service. A total of 15,964 shipments were prepared and dispatched, consisting largely of scientific instruments tested by the bureau. The maximum freight movement was 69 tons in one day. The daily mail received at the bureau amounts to more than 1,000 pieces of all kinds. During the year the bureau made 135,852 tests, an increase of more than 20,000. For these the necessary routine and records are cared for in the central office.

A comparison of the number of tests completed and fees received during the fiscal years ended June 30, 1923, and 1924, is given in the following table:

TABLE 3.—Comparison of number of tests completed and fees received during the fiscal years ended June 30, 1923 and 1924

Nature of test	For public				For Gov- ernment		Bureau tests in connection with re- search and standard- ization		Total	
	Number		Receipts		Number		Number		Number	
	1923	1924	1923	1924	1923	1924	1923	1924	1923	1924
Length:										
Tapes.....	131	103	\$598.35	\$245.75	170	90	15		301	208
Sieves and sieve cloth.....		294		616.25		100		91		485
Gauges and gauge materials.....	1,193	1,216	1,771.50	473.25	439	297	3,150	3,578	4,782	5,091
Miscellaneous.....		958		1,259.30		138		87		1,183
Mass:										
Weights.....	4,085	3,811	1,779.60	1,717.00	892	841	1,723	1,046	6,700	5,698
Balances.....	1	1	1.00	1.00	3	8	29	12	33	21
Scales.....		1		4.00	847	1,188	28	122	875	1,311
Miscellaneous.....							2,613		2,613	
Time (clocks, watches, etc.).....	268	457	405.00	740.00	202	15	109	61	579	533
Capacity:										
Volumetric glassware.....		5,221		2,966.05		2,018		576		7,815
Miscellaneous.....	7,152	58	3,928.50	202.45	2,409	98	3,656	238	13,217	394

TABLE 3.—Comparison of number of tests completed and fees received during fiscal years ended June 30, 1923 and 1924—Continued

Nature of test	For public				For Gov- ernment		Bureau tests in connection with re- search and standard- ization		Total	
	Number		Receipts		Number		Number		Number	
	1923	1924	1923	1924	1923	1924	1923	1924	1923	1924
Density:										
Hydrometers and thermohy-										
drometers.....	469	770	\$833.10	\$1,345.95	439	313	17	-----	925	1,083
Miscellaneous.....		59		88.75			375	211	375	270
Electrical tests.....	565	670	3,209.20	4,458.98	461	410	864	1,450	1,890	2,530
Photometry.....	263	207	786.75	573.00	2,157	3,152	-----	60 ¹	2,420	1 ³ ,419
Temperature:										
Clinical thermometers.....	16,120	14,026	1,333.24	1,174.18	1,141	3,631	-----	-----	² 17,261	² 17,657
Other thermometers.....	2,058	¹ 1,939	-----	⁴ 4,534.10	-----	⁷ 762	97	⁶⁹ 69	³ 2,776	³ 2,770
Miscellaneous.....		341	5,796.82	1,953.24	810	102	5,941	5,154	6,130	5,597
Optical:										
Sugar polarimetry.....	27	26	87.50	90.50	1,864	1,888	30	65	1,921	1,979
Miscellaneous sugar tests.....							739	819	739	819
Miscellaneous.....	215	239	1,330.00	1,846.80	35	74	1,757	3,032	2,007	3,345
Radioactivity:										
Radium.....	2,151	1,110	17,284.80	9,614.00	-----	-----	-----	-----	2,151	1,111
Miscellaneous.....		70	-----	355.60	1,000	1	3	296	1,296	73
Chemical analyses:										
Cement.....					1,471	2,361	-----	-----	1,471	2,361
Other materials.....	11	7	278.00	207.50	4,886	5,070	2,108	1,518	7,005	6,595
Standard samples.....	4,077	4,446	8,786.35	9,187.75	302	477	-----	-----	4,379	4,923
Mechanical instruments and appliances.....	73	61	502.50	361.50	755	575	-----	6	828	642
Aeronautical instrument tests.....	7	5	20.75	17.50	58	52	19	73	84	130
Physical tests of materials:										
Cement.....	1	5	1.50	11.00	5,239	9,070	-----	-----	5,240	9,075
Concrete, aggregates, and mis- cellaneous materials.....							1,143	1,473	1,823	2,966
Other structural materials.....	127	90	340.00	238.20	1,140	2,946	50	2,940	1,317	5,976
Leather, rubber, etc.....				3.00		1,318	-----	65	-----	1,387
Textiles.....		79		373.50		4,595	-----	-----	-----	4,674
Paper.....	440	339	1,259.50	1,043.00	6,669	1,477	1,286	164	8,395	1,980
Lime, gypsum, etc.....		6		30.00		10	-----	154	-----	170
Metallurgical tests:										
Castings.....					524	913	1,463	1,480	1,987	2,393
Fusible plugs.....					456	571	-----	-----	456	571
Miscellaneous.....	21	19	346.00	358.00	280	117	1,437	984	1,738	1,120
Ceramic tests.....		6		30.00		166	12,283	27,263	12,283	27,435
Miscellaneous tests.....	36	4	265.50	35.00	46	58	-----	-----	82	62
Totals.....	39,491	36,648	50,945.46	46,156.10	34,695	46,048	41,543	53,156	115,729	135,852

¹ In addition, during the fiscal year, 1923 the bureau inspected 1,660,485 and during the fiscal year, 1924, 1,619,798 incandescent lamps at various factories for other departments of the Government.

² In addition, during the fiscal year, 1923, 11,599, and during the fiscal year, 1924, 6,717 clinical thermometers were submitted, all of which were rejected.

³ In addition, during the fiscal year, 1923, 288, and during the fiscal year, 1924, 210 other thermometers were submitted, all of which were rejected.

Communication between the 17 buildings in the bureau group is maintained by messenger service and telephone system. The latter includes a central switchboard with 10 trunk lines, one tie line, and 300 active telephone stations in the various buildings.

OPERATION AND CONSTRUCTION

The operation and construction divisions operate and maintain the power, heating, and refrigerating plants; install and repair electrical and plumbing equipment for laboratory use; care for the bureau's grounds, and construct special instruments and apparatus for laboratory use.

As has been pointed out in the past, the bureau's mechanical plant is unusually intricate because of the variety of services which must

be furnished to the various laboratories. Its operation is likewise complicated by the decentralized location of the equipment, brought about by the rapid growth of the bureau. This condition would be remedied by the construction of a modern, central power plant.

During the year some new equipment, such as carbon-dioxide recorders for the boiler flue-gases, two transformers for electric furnaces, and a new vacuum pump, was installed.

New electric wiring was supplied in some of the laboratories and the necessary repairs were made to plumbing and fixtures.

Work is well advanced on a new concrete stairway to connect the group of buildings on the hill with the industrial building, and a concrete road back of the east building was completed. Several smaller construction jobs were also carried out, and the usual work was done on improving the bureau's grounds.

The regular construction work in connection with scientific instruments and apparatus was carried out in the bureau's shops. Lenses and glass laboratory equipment and photographic services were likewise furnished.

COOPERATIVE ACTIVITIES

Organizations With Which Bureau is Cooperating.

The bureau has official responsibilities in connection with many branches of the Federal Government as well as with certain national organizations. Thus, the director is ex officio chairman of the Federal Specifications Board and of the National Screw Thread Commission, and a member of the National Advisory Committee for Aeronautics and of the National Research Council. He is serving this year as president of the American Society for Steel Treating and of the annual conference on weights and measures, and on the executive committee as past president of the American Society for Testing Materials. The assistant director is a member of the President's Committee on Patent Policy. On the American Engineering Standards Committee the Department of Commerce is represented by the director, assistant director, and chief of the division of mechanics and sound of this bureau. In the field of technology and science the director is chairman of several joint committees, such as the joint committee on sulphur and phosphorus in steel and the committee on welded rail joints, and is a member of others, including the joint committee on molding sand research. The bureau is carrying out experimental work in cooperation with these and other national organizations, and members of the staff are serving on numerous committees of such organizations, representing many engineering, technical, and scientific activities of the country.

Talks on Bureau's Work.

The director and senior members of the staff have been frequently invited to speak before representative bodies and contribute papers describing the bureau's activities. As illustrations the following may be cited: Address upon the scientific work which our Government is carrying on and its influence upon the Nation, delivered at the commencement exercises of the Case School of Applied Science; the advantages of a technical research laboratory for the boot and shoe industry, an address given before the National Boot and Shoe

Manufacturers' Association; an address on the simplification of the Government's purchases given before the Chamber of Commerce of the United States; a talk on the Bureau of Standards as an educational institution given before the Educational Press Association; and addresses on the general work of the Bureau of Standards before the American Institute of Architects, and the chamber of commerce and buyers' club, of Grand Rapids, Mich.

National Screw Thread Commission.

This commission was authorized by Congress in 1918 to ascertain and establish standards for screw threads. The magnitude of the task assigned to the commission was such that the inadequacy of the time contemplated by the original act was soon apparent, and the life of the commission has been extended by subsequent acts of Congress in order that its important work might be completed.

During the past year eight meetings have been held, and a second report, to be known as the 1924 Report of the National Screw Thread Commission, is nearly ready for submission to the Secretaries of War, Navy, and Commerce, for their acceptance and approval in accordance with the provisions of law.

The screw-thread standards established by the commission have already been widely accepted by the manufacturing industry, have been approved by the American Engineering Standards Committee as an American standard, and their general acceptance and use constitute the greatest single step recently taken in standardization as applied to interchangeable manufacture.

Federal Specifications Board.

This board is composed of one representative from each executive department and independent establishment which purchases supplies under specifications.

The board now has 65 technical committees at work on groups of related items of specifications, the several technical committees being composed of experts officially designated from the interested activities of the Government. The Bureau of Standards has taken a prominent part in the work of nearly all of the technical committees, and the chairmanships of 24 of the committees are held by Bureau of Standards experts. In connection with the development and formulation of the master specifications, a great deal of research work has been done by the bureau. One hundred and sixty-two master specifications have been promulgated as official Government standards.

Among technical problems of administration few are of greater importance or complexity than those involved in standardization of purchase requirements. Such standards put bids on an easily comparable basis, promote fairness in trade competition, and insure the proper grade of materials for a given use. The specification is the common meeting ground for manufacturers, dealers, and users, and it is at once a technical statement of what the purchaser desires and what the manufacturer is required to supply.

The writing of specifications is not a task that can be performed at any one time and be considered complete. A specification that reflects the best practice for one year may be found to be deficient or inadequate from the standpoint of succeeding years. The changes

in the requirements of the user, or developments in the arts of manufacture, make necessary revisions in the specifications. The Federal Specifications Board is revising the Government specifications as rapidly as the desirability of such changes is indicated.

The specifications promulgated by the board are being widely adopted by States, cities, and industrial establishments and in many cases are improving the product of entire industries.

Handbook of Specifications.

On May 25, 1923, there was held in Washington a conference of the official representatives of the State governors to discuss methods of decreasing the cost of supplies purchased out of taxes. As a result of this conference, work is now in progress at the Bureau of Standards with the active cooperation of the Bureau of Foreign and Domestic Commerce, in bringing together the satisfactory commodity specifications in preparation for the publication of a dictionary, handbook, or encyclopedia of specifications for such commodities as are purchased by the Federal, State, and municipal governments and public institutions.

In initiating this work contacts were established with organizations representing consumers, and with organizations which speak for all of the major branches of industry, and in several lines similar contacts were made with the lesser branches of industry, both organized and unorganized. All trade associations and technical societies having national recognition known to be interested directly or indirectly in specifications have been communicated with, as have also more than 500 public purchasing agencies, as well as the Federal departments and independent establishments. More than 1,000 of these organizations have been requested to supply copies of their specifications for consideration in connection with the compilation of material for the dictionary or handbook of specifications.

More than 30,000 cards have been prepared for a preliminary classified index of the existing specifications now on file at the bureau. Work thus far has been concentrated on making as complete as possible the collection of existing specifications issued by the public purchasers and the nationally recognized trade associations, technical societies, and public utilities, and on making the classified index thereto as accurate as can be. The next step will be the selection of one or more thoroughly satisfactory well-recognized specifications for each of the important commodities.

How to determine the most satisfactory specifications and how to issue them in the most convenient manner for the use of the public purchasers are among the problems being given consideration by a representative advisory board organized on June 11, 1923, at a meeting of official representatives of various national organizations interested in the preparation and unification of specifications. At its initial meeting on October 24, 1923, this board voted for the creation by the Secretary of Commerce, as chairman of the board, of three committees on the subjects of (1) classification of commodity specifications, (2) form and size of the publication, and (3) scope of the proposed handbook or encyclopedia of specifications.

On the advisory board there are represented 14 organizations, as follows: American Electric Railway Association, American Engineering Standards Committee, American Hospital Association,

American Hotel Association, American Society for Testing Materials, Associated Business Papers (Inc.), Associates for Government Service, Chamber of Commerce of the United States, National Association of Manufacturers, National Association of Purchasing Agents, National Conference of Business Paper Editors, National Conference of Governmental Purchasing Agents, National Electric Light Association, and Society of Automotive Engineers.

American Engineering Standards Committee.

Three members of the Bureau of Standards have continued to represent the department on this important committee, supported by the engineering organizations of the country. Under its procedure the bureau is "sponsor" or joint sponsor for 14 engineering standardization projects and is represented on 66 others.

Pan American Standardization.

The projects on Pan American standardization of commodities of industrial and engineering interests, which the department is fostering through a representative committee whose chairman is a member of the Bureau of Standards staff, have been outlined, and a tentative program drawn up for consideration at the forthcoming scientific congress in Lima, Peru, in December. Emphasis is being laid on standards and grades for raw materials, the products of the Pan American countries.

International Cooperation.

Dr. S. W. Stratton, formerly director of the Bureau of Standards, attended a meeting of the international conference on weights and measures in Paris. To the International Bureau has been delegated the task of a more complete correlation of standards of measurement among the signatory countries. The Bureau of Standards has also been in communication with the International Bureau and other national bureaus looking to international agreements on (1) the temperature scale, (2) the ratio of the yard to the meter, (3) photometric units, (4) electrical standards, (5) radio standards, (6) X-ray standards and technique, and (7) sugar standards. The bureau was represented at the world power conference and the meeting of the International Electro-Technical Commission in London, and at the meeting of the International Commission on Illumination at Geneva, Switzerland, as well as at the meetings of the French and English physical societies, and at a wool-standardization conference in England.

Research Associates.

In line with the policy which has been referred to in previous annual reports of closer cooperation with American industries, the system of research associates worked out a few years ago has been continued during the past year. In nearly every case these research associates are supported not by a single manufacturer but by a group through their trade association, and the results which are published by the bureau are available to the public at large. In this way the facilities of the bureau's laboratories and the experience of its scientific staff are made of benefit to the maximum number of people throughout the country, and incidentally men are trained for the industries in research methods. As an example, the

Portland Cement Association has shown its appreciation of the value of fundamental research by employing a corps of investigators stationed at the bureau to find out what Portland cement really is. At the present time there are at the bureau 29 associates representing 23 firms and industrial organizations.

GENERAL RECOMMENDATIONS

Since my last annual report some change has taken place in the character of the problems confronting the bureau, although in the main they are the same as before.

Personnel.

The new reclassification schedule became effective on July 1, 1924. This undoubtedly will be of considerable benefit to a portion of our personnel. On the other hand, since the total appropriations for the bureau remain at almost the same figure as for the year just closed there will be some reduction in the staff. It is to be expected that this will be reflected in the total amount of work turned out during the coming year, although it is also probable that the increased salaries, especially of the scientific and technical staff, will make for greater stability and contentment, and thus result in a correspondingly greater output per individual.

It is hoped that next year the Congress will feel able to provide sufficient funds to make up at least the deficit in personnel brought about by the inadequacy of funds to provide completely for reclassification.

During the year most of the important vacancies in the scientific staff were filled, including the position of chief of the division of metallurgy, but a number of resignations have taken place which have seriously affected the work.

Additional Land.

As pointed out in previous reports, the main entrance to the bureau's property is through privately owned land. The land between the present site and Connecticut Avenue should be acquired in order to give a proper entrance and to make provision for future development. Since this land is rapidly increasing in value, it is in the interest of economy to purchase it at the earliest possible moment, and particularly before it is built upon.

Power Plant.

The urgent need for a new central power plant to supply the bureau still exists. The Bureau of Standards is the place above all others where one would naturally look for the most efficient plant for supplying heat, light, and power. Instead, the bureau has been forced for several years to get along with a very inefficient and decentralized mechanical plant, consisting of the original power plant designed to supply two buildings, two additional boiler plants for heating, and numerous pieces of electrical machinery scattered through the various buildings for converting energy brought from the power company's plant to energy suitable for use in the laboratories.

The efficiency of such an installation is necessarily very low; more coal is consumed, and more men are required to operate and care

for the machinery than would be the case in a modern central power plant.

In addition, there are certain disadvantages brought about through the peculiar nature of the bureau's work. For supplying the needs of a scientific laboratory power supply must above all things be continuous. This is never the case when power is bought from a commercial concern and transmitted over a long distance. Often valuable results are lost through failure of the power, and the fact that this has to be taken into consideration in designing a large part of our laboratory apparatus greatly complicates the work.

Care of Buildings.

The number of janitors, laborers, and watchmen necessary properly to care for the buildings and grounds is entirely inadequate. There is actual danger in this situation and it should be remedied at once. The safety of the valuable buildings and equipment of the bureau is often dependent on this service, which is now very much below the standard set for ordinary office buildings belonging to the Government, in which no unusual risks are housed.

Transfer of Maintenance of the Bureau's Buildings.

It is hoped that the transfer back to the bureau's jurisdiction of the maintenance, custodial, and operative services of the bureau's plant may be consummated this year. The Superintendent of the State, War, and Navy Department Buildings, after a survey of conditions at the bureau made at the suggestion of the Director of the Bureau of the Budget, agrees that this should be done. As pointed out last year, the operation of the bureau's plant is so complex and so intimately interwoven with the laboratory services that a division of control and operation is a practical impossibility. *according to the annual report of*

Needed Support for Test Work.

An increase of more than one hundred and twenty-five times its initial volume has taken place in the testing work of the Bureau of Standards during the 23 years of its existence. During the first fiscal year—that is, up to June 30, 1902—there were completed 1,055 tests of all kinds. During the year just closed 135,852 tests were conducted by all divisions of the bureau, as compared with 115,729 in 1923.

Most of these tests were executed for other branches of the Government, practically every branch making use of the facilities provided. The bureau acts as the principal testing laboratory of the Government in the fields of physical science and engineering, and expenditures amounting to many millions of dollars are dependent on its findings. Its tests, which cover a large part of the supplies purchased by the Government, serve to insure that these supplies are of the right degree of excellence and in conformity with the specifications.

Much testing is also done for commercial firms and for individuals, over 40,000 test folders covering over 600,000 such tests, for which a charge is made, having been issued since the founding of the bureau. The Government work is given precedence, however, and in some cases all testing except that for the Government has had to be refused because the demand exceeds the facilities for doing the work.

The inability to meet this demand is unfortunate. It is very desirable for the bureau to carry out certain tests for outside parties, not only as a means of assisting American industries and American citizens but because the information so gained is of value to the bureau. The Bureau of Standards has no idea of entering into competition with commercial testing laboratories, but there are certain classes of work which it is considered desirable for it to undertake because the results would be of public benefit.

In certain lines American manufacturers have been compelled to adopt unsatisfactory substitutes for adequate tests, and in some cases they have even had to send instruments abroad and to Canada for test.

The Bureau of Standards itself was established as the result of an insistent demand that our manufacturers be made independent of other countries for precise measurements, and it is highly desirable that the testing service of the bureau keep pace with the scientific and industrial development of the country. This testing service is not a severe charge on the Treasury, as fees are charged which practically cover the cost of such tests. The fees, however, are required by law to be turned into the Treasury, while an appropriation must be secured to pay for the work.

I therefore recommend that more adequate funds be made available for this important service.

Respectfully,

GEORGE K. BURGESS,
Director.

To Hon. HERBERT HOOVER,
Secretary of Commerce.

○



