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DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
George K. Burgess, Director

RESEARCH ASSOCIATES
AT THE
BUREAU OF STANDARDS

CIRCULAR OF THE BUREAU OF STANDARDS, No. 296

Pres. H. C. Gray

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FOREWORD

This circular is issued to acquaint interested persons and organizations with the plan for cooperative research worked out at the National Bureau of Standards. This is designed to enable organizations to conduct specific researches on important problems affecting their industry or specialty.

The bureau thus supplements the facilities of organizations conducting research and affords facilities for those who have none. It makes research possible for any organization by loaning equipment, providing quarters, and affording facilities, data, and supervision, giving to qualified workers training and experience in research under bureau auspices and cooperation.

The postwar demand for trained research workers drew heavily on the bureau's personnel. The plan provides an agency to meet the growing demand for training in industrial research.

Nine hundred industrial and other experts aid the bureau by service on advisory committees, cooperating in the formulation of research programs by advice and discussion and reviewing the results. The bureau, on its part, is represented on hundreds of technical committees, cooperating on problems which concern the expert groups or technical societies. The research associate plan extends the cooperation from counsel to actual research, under certain simple rules and reasonable restrictions.

GEORGE K. BURGESS, *Director.*

RESEARCH ASSOCIATES AT THE BUREAU OF STANDARDS

ABSTRACT

This circular gives a brief story of the origin and present status of the research associate plan which has recently grown notably both in magnitude and variety of fields. Examples are given of actual cases with a brief account of the research problems. Some published results are listed by title and citation to place of publication. A list of associates with the names of sustaining organizations and the problems under investigation is given. The actions of Congress which authorized the opening up of the bureau's facilities for study and research are quoted in full. Research in progress ranges from fundamental science to the most practical applications in industry.

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I. ORIGIN

On April 12, 1892, Congress authorized ¹ the use of the scientific and technical research facilities of the Government by scientific investigators and students.

On March 3, 1901,² Congress extended the privilege to include certain specified and technical establishments of the Government, and "similar institutions hereafter established," and to include "duly qualified individuals," students, and graduates of institutions of learning. The privilege was made subject to such rules and restrictions as the heads of the bureaus and departments may prescribe.

The act of 1901 was in response to a resolution based upon that proposed by Dr. Alexander Graham Bell in the preceding year.

¹ Supplement to Revised Statutes of the United States, vol. 2, 1892-1901, pp. 71, 72, Apr. 12, 1892. 27 Stat. L. 395. See full text given on p. 20 of this circular.

² Par. 8 (8), deficiency appropriation act, approved Mar. 3, 1901, Revised Statutes, vol. 31, p. 1039. See full text given on p. 20 of this circular.

It was drafted by a committee of the Washington Academy of Sciences and, after passage, was approved by the President on the same day as he approved the act establishing the National Bureau of Standards, March 3, 1901.

Dr. C. D. Walcott, in an address³ reviewing the then existing facilities and opportunities for education and research in the National Government, referred to the act of 1901, as follows: "The action of Congress in the present year in opening the Government bureaus at Washington for study and research is a long stride forward, and, if carried out in good faith must result in another and higher standard for American endeavor." It was then (1901) estimated that perhaps 10 might apply in the field of physics under the new act. There are to-day 61 research associates in the Bureau of Standards, and the number is growing.

II. THE ASSOCIATE PLAN

New standards of quality and performance for devices and processes of industry call for experimental research on each factor, to eliminate waste and attain higher efficiency in the product or service. Outstanding problems arise in every industry in great numbers. Some are of such pressing importance that an industry or group of technicians concerned may apply to the bureau for cooperation. If facilities and other conditions are favorable, the bureau may authorize the appointment of a research associate. The industrial or technical group allot funds for the purpose.

A research worker is then sought either by the bureau or the employing organization. If mutually acceptable, he is appointed research associate by the Director of the Bureau of Standards. Usually the appointee is a technical or scientific graduate qualified to initiate and conduct research. The employing organization is usually an association of an entire industry or a specialized scientific or technical group.

When appointed, the research associate is subject to the same rules and regulations as the personnel of the bureau and enjoys most of the rights and privileges which the bureau staff enjoy. On reporting for duty at the bureau, the newly appointed associate registers at the personnel section office (Room 308, South Building), meets the director, and is assigned to a scientific or technical division and directed to the chief of the division under whom his work is to be done. He may attend the staff meetings and consult specialists in pertinent fields of work on technical aspects of his research program. Associates observe the standard schedule of service hours, annual

³ Science, 13, p. 1001; 1901.

and sick leave, and conform to other administrative practice. The bureau does not govern or handle the fund nor determine the salary paid, although it may be consulted as to personnel and other points.

In conformity with bureau practice, each proposed research is outlined on a special form and submitted to the chief of the division, who submits it to the director for approval. If the project meets the joint approval of the supporting group and the administration of the bureau a research authorization is approved, a copy being filed in the central office.

Each month a progress report is made to the supporting association through the director. This is transmitted for information, not for publication. Special reports may be made and transmitted in like manner. Original data and records are the property of the bureau and subject to its use and disposition.

Manuscripts prepared for publication are submitted through the chief of division to the bureau editorial committee and handled exactly as other bureau publications, except that the manuscript is also submitted to the supporting industry for comment. The research results are immediately available to the industry concerned, and are printed, usually in bureau publications or elsewhere. The bureau reserves the decision as to publication and may authorize its printing in the technical journal of an industry. Joint authorship is often called for and the bureau expert cooperating may be so associated in the preparation of the report and suitably included as coauthor on the title page.

Devices developed during the research are for the free use of the industry, the Government, and the public, and will not be patented unless the patents are dedicated free for such use. The work of a research associate is one of peculiar trust, often confidential, on problems of concern to an entire industry.

Professional activities of research associates are discussed with the chief of the division to which they are assigned. The work of such associates is directed exclusively to research projects approved by the Director of the Bureau of Standards.

The cooperation of other sections of the bureau is available by arrangement through the associate's immediate chief. Shop facilities are to a limited extent available, although jobs of major importance are carried on outside contracts at the expense of the sustaining organization. Correspondence relating to the work of the research associate goes through regular official bureau channels, like regular Government mail. Correspondence is not usually conducted directly with the supporting industry, except on purely personal matters.

III. PURPOSE

The research associate plan was established to link the Bureau of Standards more usefully with the industries it was founded to serve. At this writing 36 organizations, most of them national in scope, maintain 61 research associates at the bureau. The list rightly includes guest associates and trainees, to whom, under the act of Congress cited, the director of the bureau may extend the courtesy of the laboratories for study or research.

Specifically, the aims are: (a) To permit qualified workers to utilize the bureau's facilities and staff in conducting researches of mutual interest; (b) to afford training and experience in research in an institution where research is a most important part of its service to the nation; (c) to promote the close-knit cooperation between the industries and the bureau in accordance with its policy from its establishment; (d) to encourage the application of science to industry in order that industrial processes may be controlled by measurements ascertained by research to insure high quality of product or high efficiency in service; (e) to lend the prestige of the Government to research results, tending thus to expedite the acceptance and application of such results in the industries. The bureau is the agency of the Department of Commerce for research and testing for the industries.

In pursuance of these aims and the cordial mutual efforts in solving key problems of the technology of industry, the bureau has to offer a laboratory unsurpassed in the fields of physics, chemistry, and technology. For those organizations which have no research laboratory or facilities those of the bureau should prove most acceptable. For those already engaged in research the bureau's facilities supplement the equipment in highly specialized fields for which few laboratories are equipped so well. Much of the bureau equipment is specially designed, and without equal elsewhere. There is a distinct advantage in certain fundamental researches in having contact and access to the standards of measurement upon which applied science must depend.

IV. RESEARCH FACILITIES

The bureau *staff of experts* comprises scientists, technicians, artisans skilled in the laboratory arts, mechanics, and engineers—this unusual group of specialists being, perhaps, the most important asset to the research associate. The advice and information from such a group permit the associate to focus many sources of specialized knowledge and technique on his problem.

The *meetings* of the bureau staff give opportunity for keeping in touch with new discoveries in the sciences pertinent to the bureau's work, both in America and abroad. Visiting scientists, national conventions, meetings of scientific groups, industrial organizations, and the like afford unusual opportunities for contact with active workers in the industries and technical research specialists.

The *laboratory facilities* required in modern research are available. These comprise such services as refrigerating plants and liquid air and liquid hydrogen; precision time service, beating seconds signals through electric circuits for making precise time interval measurements; vacuum and compressed air piped to the laboratories; electricity of wide ranges of voltage and current; freezing brine circuits; live and exhaust steam; air conditioning for the control of air humidity, temperature, pressure; and the usual general facilities, such as gas, hot and cold water, special ventilation, provision for soundproofing, lightproofing, and freedom from vibration.

Equipment quite unusual, often unique, is available at the bureau for industrial research; for example, experimental mills for making textile yarns and fabric, paper pulp and papers of various materials and kinds, Portland cement, lime, gypsum, clay products of the widest range from brick to the finest porcelain, glazes and glass, enameled ware, sugars of all kinds, highly pure chemicals, special metals and alloys, rubber and rubber goods, and a tannery for tanning leathers. New processes may be tried out on a semi-industrial scale, varying each factor under measured control and studying the effect of each change.

The *technical shops* include an instrument shop, pipe shop, glass-blowing shop, precision glass-grinding shop for producing optical parts, gauge shop, photograph laboratory and shop, an experimental foundry, rolling mill, and draw bench. The foundry is useful for experimental casting of special metals and alloys. Facilities for melting the most refractory materials, such as thoria and other resistant substances are available.

More than a hundred highly *specialized laboratories* are equipped for the many kinds of measurements and research and testing. These cover such subjects as length, mass, density, capacity, time; expansivity, heat, temperature, and power; light, radioactivity, atomic physics; radio, electrical resistance, voltage, capacity, and magnetic permeability; the strength, elasticity, and yield of materials; and many others. Other specialized laboratories have to do with processes, such as the crystallization, thermal treatment of metals, annealing of glass, electrodeposition of metals, radiobroadcasting, the

functioning of automotive power plants, and fuels. Still others deal with industrial materials, such as metals, cement, stone, lime, gypsum, paper, textiles, rubber, leather, and others in great variety. All such laboratories have machines, apparatus, instruments, and devices suitable for work in their respective fields of experiment—conditioning ovens, vulcanizers for rubber and rubber products, constant humidity and constant temperature laboratories for textile, paper, and other researches and testing, variable air-pressure laboratories, and ovens for the thermal treatment of metals and for annealing glass and enamels.

The *library* of the Bureau of Standards is rich in texts on physics, chemistry, and the special technologies within its field. It contains 28,000 volumes available for reference to research associates, and it receives regularly 600 scientific and technical periodicals from all parts of the world. The bureau has access also to the Library of Congress with its 3,000,000 books and pamphlets, 200,000 charts and maps, and thousands of periodicals. A list of other scientific and technical libraries covering subjects within the bureau's field of work is given later in this section.

The great collection of *reference works* at the Library of Congress is unequalled for volume and accessibility. The classified reference files of patent drawings and specifications at the Patent Office with the files of correspondence relating thereto are open to associates and afford a unique fund of sources of information nowhere else available. The bureau's library has sets of journals in its field, some of which are the only complete sets in this country.

The scientific and technical bureaus and organizations in Washington have collections of reference works and specimens of the utmost importance. Many of these are of direct concern and interest to the Bureau of Standards on account of interlacing interests and applications of its work. These institutions include the National Museum, the Carnegie Institution for Scientific Research with its laboratories for the study of geophysics and terrestrial magnetism, the Weather Bureau, the scientific bureaus of the Department of Agriculture, and the technical bureaus of the military departments, and numerous others. A brief summary of technical and scientific library collections in Washington, classified by dominant subject, is given in Table 1. The number of volumes is the total reported in a recent survey, and is increasing.

TABLE 1.—*Technical and scientific libraries in Washington*

Subject	Library	Number of volumes
Architecture	Supervising Architect's	2,500
Astronomy	Astronomical	2,000
	Astrophysical	3,000
	Naval Observatory	36,000
Cartography	Coast and Geodetic Survey	25,000
Chemistry	Bureau of Chemistry	8,000
	Carnegie Institution (Geophysical Laboratory)	3,000
	Hygienic Laboratory	18,000
	Bureau of Mines	18,000
	Bureau of Standards	28,000
Climatology	Weather Bureau	42,000
	National Geographic Society	5,000
Commerce	Chamber of Commerce of the United States	10,000
	Department of Commerce	110,000
	Foreign Service School	1,500
	St. John's College of Commerce and Finance School	500
	United States Tariff Commission	7,500
Engineering	Bureau of Standards	
	Bureau of Public Roads	5,000
	Chief of Engineers	2,000
	Engineer School	63,000
	Federal Power Commission	2,000
	(See also special branches of engineering and technology.)	
Geography	National Geographic Society	5,000
Geology	Geological Survey	150,000
	Geophysical Laboratory	3,000
Hydraulics	Reclamation Service	3,500
Hydrography	Coast and Geodetic Survey	25,000
	Hydrographic Office	3,000
Manufacture	Quartermaster General	27,000
	(Catalogue library, Bureau of Standards)	16,000
Metallurgy	Bureau of Standards	
	Bureau of Mines	18,000
	Bureau of the Mint	1,500
Meteorology	Weather Bureau	42,000
	Astrophysical Laboratory	
Natural resources	National Conservation Association	500
Navigation	Hydrographic Office	3,000
Patents	American Patent Law Association	6,000
	Patent Office	6,000
Phonetics	Volta Bureau	15,000
Physics	Bureau of Standards	
Sciences	(See separate titles.)	
Scientific management	United States Bureau of Efficiency	2,500
Surveying	Coast and Geodetic Survey	25,000
	Hydrographic Office	3,000
	General Land Office	
	Geological Survey	150,000
Weights and measures	Bureau of Standards	

The Public Library of the District of Columbia contains 250,000 volumes, including a technology collection occupying a special room. The books are available for reference or circulation.

Educational advantages at the Bureau of Standards are provided by the bureau through an educational committee appointed by the director. The *courses of instruction* are conducted outside the regular service hours and are accepted as credits toward advanced degrees by leading universities. The subjects are changed each year. This plan enables associates to continue their education along scholastic lines pertinent to their chosen career. During the past year 46 were enrolled in four courses—advanced mathematics, electricity and magnetism, advanced organic chemistry, and the fundamental concepts of physics. On the last subject the *general*

lectures (under the auspices of the Physics Club) were attended by 150 persons.

Association with several hundred scientific bureau workers and technicians, and the occasional contact with similar workers in the many *scientific and technical organizations and bureaus* in Washington is most stimulating and informative. Organizations find it helpful to send their experts and their assistants to the bureau to study new methods and devices in operation within the field of the bureau's functions, and to obtain new points of view and new data of value in their respective specialties; in other words, to keep in touch with scientific and technical progress in the interest of their industry or specialty. The ensemble of equipment, facilities, staff, library, prestige, and locale make the bureau a uniquely useful place for national organizations to conduct research under sympathetic and stimulating auspices.

V. TYPICAL CASES

That industrial research pays extraordinary dividends is proved by many actual cases. It is credibly estimated that such research at the bureau returns to industry and the public a yearly dividend a hundred times the investment. Less direct gains of a high order promote safety and efficiency and help lay the foundations of the scientifically planned industries of to-morrow. Such research is part of the business enterprise program of many industries. The research associate plan is designed to make it possible for all on a basis which, as shown below, not only pays its own way but yields dividends of great magnitude as well.

Work by bureau personnel furnishes striking examples of the large gains resulting from experimental research. The Bureau Visiting Committee established by Congress cited in its recent report several recent cases of economic savings to industry from bureau work—\$15,000,000 annually saved to industry and the public from the bureau's brake-lining investigation, \$40,000,000 annually from its tire investigations, and \$100,000,000 annually from the motor-fuel investigations and standards. The establishment of a dextrose industry was a result of discoveries in the bureau's carbohydrate laboratory. In the pending establishment of a new national industry for the commercial production of levulose, the sweetest member of the sugar family, the bureau is devising the technique for crystallizing out this new sugar from the artichoke and dahlia.

An example of how incidental gains from a research may far more than pay for the research is seen in the bureau's researches on elevator interlocks, which are credibly estimated as saving \$500,000 annually to organizations owning and operating elevators through

voluntary reduction in insurance premiums by the insurance companies.

Examples of results obtained by research associates stationed at the Bureau of Standards are given in the list of representative publications containing research results obtained. (See p. 12 of this circular.) These include much fundamental scientific and technical work of the most varied kinds, as well as the perfecting of methods and devices notably affecting economy and efficiency. Below are given typical cases of research associates appointed by the bureau at the request of organizations of technicians or industrial groups.

The Portland Cement Association has placed at the bureau a group of seven specialists to study the fundamental problems concerned with the chemical constitution and internal structure of Portland cement. Exacting researches on phase equilibria, synthetic cements, pure cement compounds, influence of minor constituents, catalytic effects, hydrolysis, hydration, disintegration, thermal effects in the setting process, consistency, solution equilibria, petrographic mineral analysis, optical constants of constituents, and the X-ray examination of clinker are among the more important studies at present being investigated.

The engineers in charge of the trackage of the electric railways of the country found that welded joints in the rails were failing within a year or two, while the rails themselves would last 15 or 20 years. Renewals involving tearing up and replacing of the paving were a large proportion of the expense of track maintenance. Experts enlisted the cooperation of the bureau, a research program was outlined, and the companies interested, through the American Electric Railways Association, contributed a specially designed impact-testing machine and staff to operate it, including welding outfits and welders. The machine was used because the failure of the rails was found to be due to impacts of the wheels in passing joints. The impact tests were made of all types of rail joints usually used and the results have been published in progress reports by the committee. The third progress report, recently made, gives test-data figures of broken rails. The seam-weld joints were found to fail at 35,000 to 265,000 impacts; the best butt-weld joints are withstanding a million and a half impacts of 400 pounds dropped 6 inches 70 times a minute for a month.

The manufacturers of walk-way surfaces and the walk-way safety group maintain a research associate on recommendation of the American Engineering Standards Committee. This associate has already devised a method and apparatus for measuring the slipperiness or coefficient of friction of walk-ways, and made actual measurements for the two classes of oak-tanned sole leather and rubber soles. The astonishingly large number of accidents from falls on walk ways makes the research one of human interest and economic importance.

The Copper and Brass Research Association maintains a research associate at the bureau to study metal roofing and the best methods of applying such roofing to structures to withstand the effects of temperature, humidity, and chemical action under the varied conditions in this country. This associate is obtaining data for perfecting the design and installation of such roofing. Measurements of the roof of the National Museum showed that under the direct rays of the sun the roof attains a temperature of 50° higher than that of the surrounding air. This and other conditions must be met in securing the maximum durability and effectiveness of metal roofing.

The national organization of the dyeing and cleaning industry maintains a research associate, with assistants, for research pertinent to the industry. The problem of the recovery of the gasoline used in cleaning has been solved, tried out, and the reports published for the benefit of the industry, thus saving large quantities of gasoline formerly thrown away as unrecoverable. The same associate has written a reference handbook of cleaning technology for his industry, and conducts schools in various cities for members of the national association covering scientific methods of cleaning. At present the group is investigating the cleaning of silk as affected by perspiration and the metal loading of the fibers.

A prominent steel company has stationed a research chemist as associate at the bureau to study and devise new methods of working and treating iron and steel. A large textile organization maintains an associate on problems of interest to the hosiery industry. The results are reported to have saved the industry \$28,000,000 already. One item, the standardization of hosiery boxes and packing cases, is estimated as having a potential saving of \$3,000,000 when the accepted results are applied. It is not unusual that a research pays dividends a hundred times its cost.

The face-brick industry arranged for a research associate now engaged in experimental study and research on the problem of effervescence of brick walls and the means for preventing it. The gas industry maintains a worker studying methods of testing the safety of gas appliances. The American Society of Mechanical Engineers, through two skilled experts appointed as research associates, is cooperating in determining with precision the numerical constants and the properties of steam as a basis for its more effective use.

The Federal Bureau of Efficiency has two research associates working at the Bureau of Standards on the durability factors of currency paper. A metal organization supports an associate experimentally studying the wear resistance of bronzes. The rise of the industrial uses of gypsum led the gypsum industries to establish a research as-

sociate to study the possible means of waterproofing gypsum. The Hollow Building Tile Association made provision for research on the fire-resistance properties of hollow clay tile. A limestone quarrymen's association supports research on the properties of this important building material, methods for waterproofing its products, and the prevention of objectionable discolorations.

Similar problems upon which research associates are working concern such subjects as the use and care of marble for interior installations, the moisture content of yarns, the use of glue for sizing paper, the development of a quick-setting lime plaster, research on architectural terra cotta, electrotyping refrigeration, experimental research on the physical properties of dental materials with special reference to their shrinkage and other dimensional changes as affecting their suitability for dental fillings.

The State of Alabama having passed a model weights and measures law, asked that its new superintendent of weights and measures might receive training in his duties and in the technical fields pertinent thereto. The bureau, as usual, extended its facilities and its experts gave intensive training in the technical details of weights and measures inspection, including experience in each of the specialized laboratories for length measurements, capacity measurements, and the verification of weights and balances, closing the short course with some active experience in the National Capital under the immediate auspices of an expert city inspector. The result was most gratifying as officially reported to the bureau.

The State of Virginia made a similar request for its superintendent of weights and measures. The city of Baltimore did the same, adding an arrangement for the active cooperation of the bureau to continue indefinitely by which the more technical questions might from time to time be brought to the bureau for discussion, investigation, experiment, and advice. Many sealers visit the bureau for short visits, during which they receive personal attention along lines in which they desire to become better posted. Congress recognized the importance of this phase of the bureau's work by including a specific item "cooperation with the States in securing uniformity in the weights and measures laws and in the methods of inspection."

Quite in line with these cases are special courses of demonstration and instruction ranging from informal meetings to set procedure. For example, the research associate engaged in cleaning research conducts schools for the industry, the ceramics division has offered courses for manufacturers, while military groups have been given special instruction in aeronautical instruments, radio, and other subjects. Two textbooks on radio were made basic reference and instruction texts for the use of the military officers studying radio.

In general, the system of research associates, ranging from the individual guest associates to the more formal and enduring research workers who may remain stationed for several years, offers a most flexible method of close-knit cooperation with the industries, the technical groups of experts, and scientific societies and organizations for the conduct of special study and research.

VI. SOME PUBLISHED RESEARCH RESULTS

Typical publications giving results of researches conducted by bureau research associates are listed below, classified by subject. An asterisk (*) indicates that the author is a research associate.

ADHESIVES

The use of glue for coated paper, by V. H. Gottschalk,* Paper Trade Jour.; November 13, 1924.

AUTOMOTIVE RESEARCH

Factors affecting the rate of crank-case oil dilution, by J. O. Eisinger,* Jour. Soc. of Automotive Engineers; July, 1924.

Progress report of cooperative fuel research, by S. W. Sparrow and J. O. Eisinger,* Jour. Soc. of Automotive Engineers; February, 1925.

Engine starting tests, by J. O. Eisinger,* Jour. Soc. of Automotive Engineers; July, 1925.

Measurement of crank-case dilution. Vacuum distillation transition method, by T. S. Sligh, jr.,* Bull. Am. Petroleum Inst.; December 31, 1924, 5, No. 75.

CERAMICS

Strength, absorption and freezing resistance of hollow building tile, by H. D. Foster,* Jour. Am. Cer. Soc.; March, 1924.

Portable equipment for transverse tests of brick, by H. D. Foster,* Clayworker; February, 1925.

Methods for making absorption determinations for hollow building tile, by H. D. Foster,* Jour. Am. Cer. Soc.; November, 1922.

Capping for compression specimens, by H. D. Foster,* Jour. Am. Cer. Soc.; May, 1923.

The weathering of glass containers, by K. L. Ford,* Jour. Am. Cer. Soc.; December, 1922.

DENTAL RESEARCH

Physical properties of dental materials **II** (wrought gold alloys), R. L. Coleman,* Jour. Am. Dental Assoc.; May, 1925.

FIRE RESISTANCE

Effect of grog addition on fire resistance of hollow building tile, H. D. Foster,* Jour. Am. Cer. Soc.; June, 1922.

METALLURGY

Experiments with sherardizing, L. H. Marshall,* Trans. A. I. M. M. E., 68, p. 764; 1923.

Prevention of columnar crystallization by rotation during solidification, H. M. Howe* and E. C. Groesbeck, Trans. A. I. M. M. E. 62, pp. 241-246; 1920.

- Preparation and reflective properties of some alloys of aluminum with magnesium and with zinc, R. G. Waltenberg* and W. W. Coblenz, B. S. Sci. Paper No. 363; 1920; B. S. Bull., 15.
- A study of the relation between the brinell hardness and the grain size of annealed carbon steels,* H. S. Rawdon and Emilio Jimeno-Gil,* B. S. Sci. Paper No. 397, 1920; B. S. Bull. 16.
- The magnetic susceptibility and iron content of cast-red-brass, L. H. Marshall* and R. L. Sanford, B. S. Tech. Paper No. 221; 1922.
- Embrittlement of malleable cast iron produced by heat treatment, as revealed by impact tests, L. H. Marshall,* B. S. Tech. Paper No. 245; 1923.
- New deoxidizers for steel manufacture, J. R. Cain,* Chem. and Met. Eng., 23, pp. 879-902; 1920.
- Influence of S, O, Cu, and Mn on red-shortness of iron, J. R. Cain,* B. S. Tech. Paper No. 261; 1925.
- Malleability and metallography of nickel, P. D. Merica* and R. G. Waltenberg,* B. S. Tech. Paper No. 281; 1925.
- Measuring metal's resistance to shock, R. G. Waltenberg,* Chem. and Met. Eng., 31, p. 657; 1924.
- The malleability of nickel, P. D. Merica* and R. G. Waltenberg,* A. I. M. M. E. preprint 1398-E; January, 1925.
- A laboratory high frequency vacuum furnace, J. R. Cain* and A. A. Peterson, Am. Elec. Soc. (advanced copy) not pub.

OPTICS

- Excitation of forbidden spectral lines, Paul D. Foote, T. Takamine,* and R. L. Chenault, Phys. Rev., 26, pp. 165-175; 1925; Nature, 115, p. 265; 1925.
- The molecular dimensions of celluloid, V. P. Barton* and F. L. Hunt, Nature; December 13, 1924.
- Effect of magnetic fields upon polarization of resonance radiation, A. Ellett,* Nature; December 27, 1924.
- Polarization of sodium resonance radiation in magnetic fields; larmor precession of excited atoms, A. Ellett,* Jour. Opt. Soc. Am., and R. S. I., 10, pp. 427-434; 1925.
- The depolarizing influence of a rapidly changing magnetic field on the resonance radiation, G. Breit and A. Ellett,* abstract in Phys. Rev., 25, p. 888; 1925. Complete paper in preparation.
- Polarization of radiation excited by electron impact, A. Ellett,* Paul D. Foote, and F. L. Mohler. To be submitted to Physical Review.
- Some of the by-products of hydrolyzed starch, H. Berlin.* Presented before the sugar division of the American Chemical Society, April, 1925.
- The occurrence of gentiobiose in the products of the commercial hydrolysis of starch, H. Berlin.* Presented before the sugar division of the American Chemical Society, August, 1925, at Los Angeles, Calif. Abstract published in Facts About Sugar, 20, p. 784; 1925; and The Planter and Sugar Manufacturer, 75, p. 131.
- Relations between rotary power and structure in the sugar group, Part X. The chloro-bromo- and iodo-acetyl derivatives of lactose, C. S. Hudson and Alfons Kunz,* Jour. Am. Chem. Soc., 47, p. 2052; 1925.
- Studies on salicin. Part I. Exceptional rotations of the halogenotetra-acetyl derivatives of salicin. A new synthesis of salicin, Alfons Kunz,* American Chemical Society.
- Variations in glass caused by heat treatment, A. Q. Tool and C. G. Eichlin,* Jour. Am. Cer. Soc., 8, No. 1; January, 1925.

- Gesetzmässigkeiten im Bogenspektrum des Wolframs, Otto Laporte,* *Die Naturwissenschaften*, **13**, p. 627; 1925.
- Regularities in the arc spectrum of ruthenium, W. F. Meggers and Otto Laporte,* *Science*, **61**, p. 635; 1925.
- Some rules of spectral structure, Otto Laporte* and W. F. Meggers, *Jour. Opt. Soc. Am.*, and *Rev. Sci. Insts.* (In press.)
- Some remarks on primed terms in the spectra of lighter elements, Otto Laporte,* *Jour. Wash. Acad. Sci.*; November 4, 1925.
- Progress on the determination of normal gray light, I. G. Priest,* *Proc. 7th An. Meeting O. S. A., Jour. Op. Soc. Am.*, **7**, p. 72; 1923.
- The colorimetry and photometry of daylight and incandescent illuminants by the method of rotatory dispersion, I. G. Priest,* *Proc. 7th An. Meeting O. S. A., Jour., Op. Soc. Am.*, **7**, p. 75; 1923.
- The effect of various conditions upon the determination of the normal stimulus of gray, I. G. Priest,* *Proc. 7th An. Meeting O. S. A., Jour. Op. Soc. Am.*, **7**, p. 73; 1923.
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- Relative merits of cotton and jute cement sacks, R. J. Manis,* B. S. Tech. Paper No. 292.
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- Report on standard hosiery length. Standard hosiery lengths as recommended for adoption by manufacturers of United States, E. M. Schenke,* Daily News Record; December 20, 1924.
- Suggested method of testing knitted fabrics—breaking strength test, Charles H. Hamlin,* Assoc. Knit Underwear Mfrs. of Am.
- Artificial silk, Charles H. Hamlin,* Assoc. Knit Underwear Mfrs. of Am. Standard Sizes for Knit Underwear, Charles H. Hamlin,* Assoc. Knit Underwear Mfrs. of Am.

VII. LIST OF ASSOCIATES AND SUSTAINING ORGANIZATIONS

The following organizations, classified by subject or fields of research, maintain research associates at the National Bureau of Standards:

WEIGHTS AND MEASURES:

Horological Institute of America.
Weinstein Research Laboratories.

ELECTRICITY:

Shaw, H. S.
United States Veterans' Bureau.

HEAT AND POWER:

American Society of Mechanical Engineers.
Common Brick Manufacturers Association of America.
Hollow Building Tile Association.
Icemaster Co.
Society of Automotive Engineers.
Standard Pyrometric Cone Co.

OPTICS:

Corn Products Refining Co.
Munsell Research Laboratory.
National Research Council.
Rockefeller Foundation of International Education Board.

CHEMISTRY:

American Gas Association.
Climax Molybdenum Co.
International Association of Electrotypers.

MECHANICAL AND SOUND:

Copper and Brass Research Association.
Elevator Safety Code Committee.
Gypsum Industries.
National Lime Association.
National Safe Walk Way Surfaces Code Committee.

STRUCTURAL, ENGINEERING, AND MISCELLANEOUS MATERIALS:

American Bureau of Welding.
American Society for Testing Materials.
Associated Knit Underwear Manufacturers of America.
Bureau of Efficiency.
Gypsum Industries.
Indiana Limestone Quarrymen's Association.
National Association of Dyers and Cleaners.
National Association of Hosiery and Underwear Manufacturers.
National Association of Marble Dealers.
National Glue Manufacturers Association.
National Lime Association.
Portland Cement Association.

METALLURGY:

Academy of Science Engineers.
American Rolling Mills Co.
Chicago Bearing Metal Co.

CERAMICS:

American Face Brick Association.
Golwynne, H. A.
National Terra Cotta Society.

TABLE 2.—*Research associates at the National Bureau of Standards*
 [Classified by sustaining organizations]

Organization accorded research associate privileges	General field of research	Specific project	Research associate
Academy of Science Engineers, Stockholm, Sweden. American Bureau of Welding, Committee on Welded Rail Joints, 292 Madison Avenue, New York, N. Y.	Metallurgy----- Railway materials-----	Gases in metals----- Research on welded rail joints-----	Kjerrman, Bengt. Olsson, E.
American Face Brick Association, 130 North Wells Street, Chicago, Ill. American Gas Association, 342 Madison Avenue, New York, N. Y.	Structural materials----- Gas engineering-----	Prevention of effervescence on brick walls. Methods of testing gas appli- cances to determine their safety. Corrosion of sheet steel-----	Palmer, L. A. Corsiglia, J.
American Rolling Mills Co., Middletown, Ohio----- American Society of Mechanical Engineers, United Engineering Building, New York, N. Y. American Society for Testing Materials, 1315 Spruce Street, Philadelphia, Pa. Association of Knit Underwear Manufacturers of America, Union Station, Utica, N. Y. Bureau of Efficiency, Washington, D. C.-----	Metallurgy----- High temperature meas- urements. Structure materials----- Textiles----- Paper----- Metallurgy----- Dyes----- Fire resistance-----	Properties of steam----- Correlation of data on cement tests. Standardization and simplifica- tion of underwear sizes. Durability of currency paper----- Wear resistance of bronzes----- Application of molybdenum in dye industry. Specifications for brick-----	Cain, J. R. Passano, R. F. Osborne, N. S. Stinson, H. F. Popkins, G. R. Thomas, A. D. Hamlin, C. H. Gofitschalk, V. H. Holt, W. L. Harbaugh, W. L. Stewart, J. R. Christenson, C. O.
Chicago Bearing Metal Co., Chicago, Ill.----- Climax Molybdenum Co., 61 Broadway, New York, N. Y. Common Brick Manufacturers Association of America, 2121 Guarantee Title Building, Cleve- land, Ohio. Copper and Brass Research Association, 25 Broad- way, New York, N. Y.	Structural materials----- Carbohydrates-----	Investigation of safe loading of corrugated copper roofing; etc. Hydrolysis of starch-----	Beij, K. H. Berlin, Henry.
Corn Products Refining Co., 17 Battery Place, New York, N. Y.			

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

Organization accorded research associate privileges	General field of research	Specific project	Research associate
Elevator Safety Code Committee, Subcommittee on Research, Approval, and Interpretation, American Engineering Standards committee, 29 West Thirty-ninth Street, New York, N. Y. Golwynne, H. A., 26 Cortland Street, New York, N. Y.	Safety engineering-----	Elevator safety equipment; development of instruments and methods; construction, maintenance, operation, etc. Investigation of application of rare minerals to manufacture of refractories.	Dickinson, J. A. Booth, N. D. Freed, M. L.
Gypsum Industries, 844 Rush Street, Chicago, Ill.	Sound-----	Investigation of acoustical properties of building materials.	Chrisler, V. L.
Hollow Building Tile Association, Conway Building, Chicago, Ill.	Structural materials-----	Waterproofing of gypsum, etc.	Peter, J. P. C.
Hortological Institute of America, Academy of Sciences Building, Washington, D. C. Icemaster Co., Haverhill, Mass.-----	Fire resistance----- Time measurements-----	Fire resistance of hollow clay tile. Certification of watchmakers	Campbell, A. J. Foster, H. D. Miller, M. M.
Indiana Limestone Quarrymen's Association, Bedford, Ind.	Refrigeration-----	Operating efficiency of "Ice-master", household refrigerating machine.	Meyers, C. H.
International Association of Electrotypers, H. G. Guiteras, field secretary, Cleveland, Ohio. Munsell Research Laboratory, 10 East Franklin Street, Baltimore, Md.	Structural materials-----	Properties of Indiana limestone, including waterproofing, discoloration, etc.	Dutton, H. H.
National Association of Dyers and Cleaners, 807 Mills Building, Washington, D. C.	Electrotyping-----	Nickel electrotyping-----	Winkler, J. H.
National Association of Hosiery and Underwear Manufacturers, 334 Fourth Avenue, New York, N. Y.	Colorimetry-----	Hue discrimination, saturation, and purity of colors.	Brickwedde, F. G. Munsell, A. E. O.
National Association of Marble Dealers, 648 Rockefeller Building, Cleveland, Ohio.	Cleaning and dyeing-----	Cleaning weighted silk as affected by cleaning solvents and perspiration, and general cleaning and dyeing problems. Moisture content of carded and combed yarns; standardization of twist with respect to dye application.	Faling, M. F. Goldman, M. H. Hubbard, C. C. (in charge) Schenke, E. M.
	Textiles-----	Use and care of marble for interior installations.	Kessler, D. W.
	Structural materials-----		

National Glue Manufacturers Association, J. R. Powell, secretary, Armour Glue Works, 1355 West Thirty-first Street, Chicago Ill.	Adhesives-----	Glue for use in paper sizing-----	Hammill, G. K.
National Lime Association, 918 G Street, Washington, D. C.	Sound-----	Investigation of acoustical properties of building materials.	Chr'sler, V. L.
National Research Council, Washington, D. C.	Structural materials-----	Development of quick-setting lime plaster.	Miller, E. A.
National Safe Walk Way Surfaces Code Committee, American Engineering Standards Committee, 29 West Thirty-ninth Street, New York, N. Y.	Optics-----	Ecta ray velocities-----	Curt'ss, L. F.
National Terra Cotta Society, 19 West Forty-fourth Street, New York, N. Y.	Safety engineering-----	Coefficients of friction of walk way surfaces.	Hunter, R. B.
Portland Cement Association, 111 West Washington Street, Chicago, Ill.	Structural materials-----	Investigation of architectural terra cotta.	Fuller, D. H.
Rockefeller Foundation of International Education Board, 61 Broadway, New York, N. Y.	do-----	Research on Portland cement.	Schurecht, H. G. Ashton, F. W. Bogue, R. H. (in charge). Brownmiller, L. T. Dillon, M. M. Hansen, W. C. Harrington, E. A. Lereb, W. Kunz, A.
Shaw, H. S., 78 Cypress Street, Newton Center, Mass.	Carbohydrates-----	Derivatives of milk sugar, salicin and amygdalin.	Laportic, O.
Society of Automotive Engineers, 29 West Thirty-ninth Street, New York, N. Y.	Spectroscopy-----	Structure of complex spectra and their relation to atomic physics.	Parkinson, T.
Standard Pyrometric Cone Co., Columbus, Ohio	Radio-----	Radio wave phenomena-----	Eisinger, J. O. Ritchie, Don C. Sligh, jr., T. S. Weikert, D. L.
Veterans Bureau, Washington, D. C.	Automotive research-----	Research on fuels-----	Kreibiel, J. F. Brennen, F. T. Jeffrey, Ernest M. (trainees).
Weinstein Research Laboratories, 233 West Forty-second Street, New York, N. Y.	Pyrometry-----	Standardization of seger cones.	Coleman, jr., R. L.
	Radio-----	Instruction-----	Poppe, W. A.
	Dental research-----	Physical properties of dental materials.	

VIII. ACTIONS BY CONGRESS

USE OF SCIENTIFIC RESEARCH FACILITIES OF THE GOVERNMENT

The full text of the two actions by which Congress opened the way for the admission of qualified individuals to the use of the research facilities of the National Bureau of Standards is given below:

JOINT RESOLUTION OF 1892

[From the Supplement to the Revised Statutes of the United States, vol. 2, 1892-1901, pp. 71, 72, April 12, 1892. (27 Stat. L., p. 395)]

Joint resolution to encourage the establishment and endowment of institutions of learning at the National Capital by defining the policy of the Government with reference to the use of its literary and scientific collections by students:

Whereas, large collections illustrative of the various arts and sciences and facilitating literary and scientific research have been accumulated by the action of Congress through a series of years at the National Capital; and

Whereas it was the original purpose of the Government thereby to promote research and the diffusion of knowledge, and is now the settled policy and present practice of those charged with the care of these collections specially to encourage students who devote their time to the investigation and study of any branch of knowledge by allowing to them all proper use thereof; and

Whereas it is represented that the enumeration of these facilities and the formal statement of this policy will encourage the establishment and endowment of institutions of learning at the seat of Government, and promote the work of education by attracting students to avail themselves of the advantages aforesaid under the direction of competent instructors: Therefore,

Resolved, That the facilities for research and illustration in the following and any other governmental collections now existing or hereafter to be established in the city of Washington for the promotion of knowledge shall be accessible, under such rules and restrictions as the officers in charge of each collection may prescribe, subject to such authority as is now or may hereafter be permitted by law, to the scientific investigators and to students of any institution of higher education now incorporated or hereafter to be incorporated under the laws of Congress or of the District of Columbia, to wit: 1. Of the Library of Congress. 2. Of the National Museum. 3. Of the Patent Office. 4. Of the Bureau of Education. 5. Of the Bureau of Ethnology. 6. Of the Army Medical Museum. 7. Of the Department of Agriculture. 8. Of the Fish Commission. 9. Of the Botanic Gardens. 10. Of the Coast and Geodetic Survey. 11. Of the Geological Survey. 12. Of the Naval Observatory. (Approved, April 12, 1892.)

ACTION OF 1901

GOVERNMENT TO PROMOTE RESEARCH AND ENCOURAGE STUDENTS

[Par. 8, Deficiency Appropriation Act, Chap. 831, vol. 2, 1892-1901, Supplement to the Revised Statutes of the United States, p. 1532 (31 Stat. L. p. 1010), March 3, 1901]

That facilities for study and research in the Government departments, the Library of Congress, the National Museum, the Zoological Park, the Bureau of Ethnology, the Fish Commission, the Botanic Gardens, and similar institutions hereafter established shall be afforded to scientific investigators and to duly qualified individuals, students, and graduates of institutions of learning in the several States and Territories, as well as in the District of Columbia, under such rules and restrictions as the heads of the departments and bureaus mentioned may prescribe.



