U. S. DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS

ANNUAL REPORT OF DIRECTOR OF THE BUREAU OF STANDARDS

TO THE SECRETARY OF COMMERCE

FOR THE

FISCAL YEAR ENDED JUNE 30, 1931

MISCELLANEOUS PUBLICATION No. 131

U. S. DEPARTMENT OF COMMERCE
R. P. LAMONT, Secretary
BUREAU OF STANDARDS
GEORGE K. BURGESS, Director

Miscellaneous Publication No. 131

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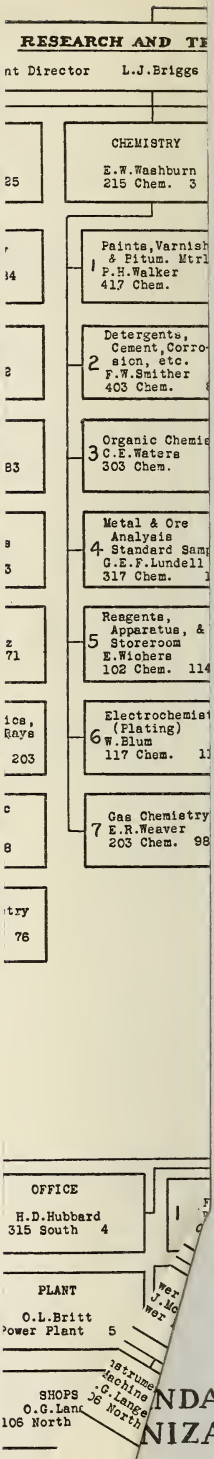
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BUREAU OF STANDARDS

DEPARTMENT OF COMMERCE,
BUREAU OF STANDARDS,
Washington, July 1, 1931.

The honorable the SECRETARY OF COMMERCE.

DEAR MR. SECRETARY: I submit herewith a brief report on the work of the Bureau of Standards during the fiscal year ended June 30, 1931. The various subjects are grouped under the appropriations provided by the Congress.

GENERAL ACTIVITIES

Organization.—The present organization of the bureau is shown by the chart opposite this page. Two additional sections, one dealing with testing and specifications and the other with waste-land products, were set up in the organic and fibrous materials division, and the staff engaged on the design and construction of the new hydraulic laboratory has been organized into a hydraulic laboratory section in the division of mechanics and sound. A section dealing with chemical and miscellaneous products has been added to the trade standards division.

The regular staff at the close of the fiscal year numbered 1,066 employees. With miscellaneous assignments the grand total was 1,171 persons, an increase of 10 as compared with last year. The turnover was 5 per cent, the lowest since the World War. In five of the bureau's division there was no turnover. There were 531 promotions and reclassifications to higher grades, and the average salary ($2,505) increased by $55.

Cooperation.—It is of interest to note that in spite of reduced industrial activities the number of research associates stationed at the bureau by trade and technical associations has not changed materially. As of June 30, there were 95 associates from 45 associations. as compared with 96 from 41 associations last year. The bureau has maintained the most cordial relations with all Government departments with which it deals as well as with hundreds of outside public and private organizations interested in its work.

Finances.—The congressional appropriations for the fiscal year were $3,647,971, including $350,000 for the hydraulic laboratory, $400,000 for land, $147,000 for two radio stations, $75,000 for remodeling the shop building, and $40,000 for a new track-scale test car—leaving $2,635,971 for operation, research, testing, and standardization, an increase of $129,225 over the previous year. There were transferred from other Government units $474,015, including reimbursements. The testing, research, and consulting work for other departments carried on bureau funds is very heavy and growing rapidly. Every effort was made to operate economically, and $102,000 was turned back to the Treasury.

Visiting committee.—The present personnel of the committee is: Dr. S. W. Stratton, Gano Dunn, John R. Freeman, Charles F. Kettering, and Charles L. Reese. The committe held one formal meet-

DIRECTOR'S OFFICE

DIRECTOR, GEORGE K. BURGESS
Secretary to Director, Miss D. E. Kingsbury
314 South tel. br. 1

RESEARCH AND TESTING

Assistant Director L.J.Briggs 101 West 224

ELECTRICITY
E.O.Crittenden
210 East 2

1 Resistance Measurements F. Wenner 118 East 28
2 Inductance & Capacitance H.L.Curtis 217 East 29
3 Electrical Instruments H.B.Brooks 109 East 25
4 Magnetic Measurements R.L.Sanford 114 East 31
5 Photometry J.F.Meyer 311 East 32
6 Radio J.H.Dellinger 207 Radio 40
7 Underground Corrosion E.H.Logan 207 East 44
8 Safety Standards W.G.Lloyd 209 East 38
9 Electrochemistry O.W.Vinal 404 East 93
10 Telephone Standards F.A.Wolff 430 West 38

WEIGHTS & MEASURES
H.V.Pierce 9
F.S.Holbrook 80
215 South

1 Length L.V.Judson 209 South 232
2 Mass A.T.Pienkowsky 101 South 81
3 Wire P.E.Gould 218 South 33
4 Capacity & Density E.L.Peffer 200 South 108
5 Gas Measuring Instruments R.S.Penn 211 NW 107
6 Thermal Expansivity & Identification R. Souder 108 South 79
7 Wts.& Meas Labs Administration R.W.Smith 210 South 223
8 RR Scales & Cafe R.W.Hosmer, Field Service. (F.S.Holbrook 215 South 80)
9 Gages D.H.Miller 202 NW 153

HEAT & POWER
H.C.Dickinson
206 West 12

1 Thermometry Miss J.Boese 203 West 74
2 Pyrometry H.T Kenaci 210 West 68
3 Heat Measurements W.F.Mueller 212 West 61
4 Heat Transfer M.S.Van Dusen 201 West 48
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8 Friction & Lubrication M.D.Peavy 8 West 97

OPTICS
C.A.Skinner
A15 South 125

1 Spectroscopy W.F.Meggers 212 South 84
2 Polarimetry F.J.Peter 306 West 22
3 Colorimetry I.G.Priest 400 South 83
4 Optical Instruments I.G.Gardner 407 East 103
5 Radiometry H.W.Coblentz 110 South 71
6 Atomic Physics, Radium, & Spectra P.L.Mohler 312 East 203
7 Photographic Technology R.Carl 338 Ind. 18
8 Interferometry C.G.Peters 112 South 78

CHEMISTRY
E.W.Washburn
215 Chem. 3

1 Paints, Varnishes, & Pigm. Mtrls. F.H.Walker 417 Chem. 47
2 Detergents, Cement, Corrosion, etc. F.H.Smither 403 Chem. 8
3 Organic Chemistry G.E.Matters 303 Chem. 62
4 Metal & Ore Analysis Standard Samples G.E.F.Lundell 317 Chem. 136
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MECHANICS & SOUND
L.J.Briggs
101 West 224

1 Engineering Instruments & Mech.Appliances W.F.Stutz 104 West 102
2 Sound Paul R. Heyl 305 NW 247
3 Aeronautic Instruments W.O.Brombacher 311 NW 226
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ORGANIC & FIBROUS MATERIALS
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1 Rubber A.T.McPherson 231 Ind. 89
2 Textiles G.S.Appel 106 Ind. 150
3 Paper C.G.Schubner 107 Ind. 127
4 Leather H.C.Parker 319 Ind. 13A
5 Testing and Specifications F.L.Worseley 227 Ind. 13
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METALLURGY
H.S.Rawdon
114 NW 19

1 Optical Metallurgy C.J Wcaies 105 NW 208
2 Thermal Metallurgy L. Jordan 102 NW 209
3 Mechanical Metallurgy W.H.Swanger 110 NW 65
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CLAY & SILICATE PRODUCTS
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1 Whiteware R.F.Geller 141 Ind. 147
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3 Refractories H.A.Heindl 246 Ind. 147
4 Enamels W.H.Harrison 147 Ind. 147
5 Heavy Clay Products R.T.Stull 149 Ind. 147
6 Cement, Concrete Materials J.Turner, Jr. 157 Ind. 15
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LIAISON WITH FEDERAL SPECIF. BOARD J.H.Fellows 318 South 185

COMMERCIAL STANDARDIZATION

Assistant Director A.S.McAllister 310 South 55

SIMPLIFIED PRACTICE
Edwin W. Ely
353 Ind. 280

1 Stone, Clay and Glass H.A.Goldsmith 361 Ind. 247
2 Wood, Textiles and Paper Geo. Schuster 359 Ind. 284
3 Metal Products & Construction Materials P.N.R.Dunn 359 Ind. 284
4 Containers W.E.Braithwaite 363 Ind. 264
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3 City Planning & Zoning D.M Wheeler 345 Ind. 256
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5 Mechanics Liens D.M.Wheeler 345 Ind. 258

SPECIFICATIONS
A.S McAllister
310 South 55

1 Certification - Producer Contacts A.S.McAllister 310 South 55
2 Labeling - Consumer Contacts A.S.McAllister 310 South 55
3 Directory of Specifications C.W.Ingels 310 South 85
4 Encyclopedia of Specifications G.A Nordlie 310 South 55

TRADE STANDARDS
I.J.Fairchild
310 South 56

1 Wood, Wood Products, Paper, Rubber, Glue H.M.Steidle 404 South 179
2 Metal Products I.J.Fairchild 310 South 56
3 Textiles and Carpets L.A.Olbert 404 South 179
4 Ceramic Products and Cement G.E.Wise 404 South 179
5 Chemical and Misc. Products F.H.Reynolds 404 South 179

OFFICE, PLANT, AND SHOPS

OFFICE
M.D.Hubbard
316 South 4

1 Licence J.K.Thomas 302 South 52
2 Personnel W.O.Pecil 308 South 180
3 Purchase & Stores O.M.Waneman 301 NW 160
4 Property & Transportation F.A.Ross Far West 18
5 Mail & Files R.W.Lamberson 419 South 90
6 Library A.Pantl 203 NW 75
7 Information H.G.Boutell 300-E South 330

PLANT
O.L.Britt
Power Plant 5

1 Power Plant L.J.Wolfrom Power Plant 24
2 Buildings & Grounds F.A.Peters Power Plant 95
3 Wiring & Electric Work A.A.Ludwig Far West 48
4 Plumbing and Piping E.G.Koch Far West 48

SHOPS
O.O.Lange
106 North 34

1 Instruments & Machine Shops O.O.Lange 106 North 34
2 Woodworking Shops L.M.Downs B North 50
3 Glassblowing Shops E.O Sperling 307 North 64
4 Glass Grinding Shops E.F.Webb 306 North 121
5 Photographic Shop W.B.Rice 338 Ind. 18
6 Construction Storey J.E.Kirby 110 North 129

BUREAU OF STANDARDS
CHART OF ORGANIZATION
REVISED TO- June 30, 1931

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ing and individually visited the bureau several times. (This committee, and its periodic visits of inspection to the bureau, was provided for by the act creating the Bureau of Standards.)

Hydraulic laboratory.—The design of this laboratory was begun in July, 1930, with the aid of an advisory committee, consisting of a number of prominent hydraulic engineers. The final design was adopted in January, 1931, and construction started on April 23. It is expected that the building will be completed about April 1, 1932.

The design provides for a building 285 feet long, 60 feet wide over two-thirds of its length, and 92 feet wide over the remainder. There will be three stories at one end and two stories at the other. The building will contain two large concrete supply basins from which water will be pumped through the flumes and other experimental apparatus to a concrete measuring basin from which it will be returned through channels to the supply basins. A maximum flow of 250 to 300 cubic feet per second will be possible in the main flume, which is the dominating piece of equipment with a cross section 12 feet square over a length of approximately 200 feet. A description of this laboratory appears in Civil Engineering for July, 1931.

International relations.—The International Committee on Weights and Measures met in April and approved, without change, the resolutions of its advisory committee recommending the adoption of a "black-body" radiator as the primary standard of light, and requested the national laboratories to give special study to the bureau's standard which operates at the freezing point of platinum. A resolution was adopted approving the use of 20° C. (68° F.) as the standard temperature for all industrial length-measuring instruments, gages, etc.

The international committee recommended that the national laboratories make observations with silver voltameters to determine anew the correct value for the international volt. To hasten agreement on this point, the bureau sent Doctor Vinal to Berlin to make the measurements jointly with the representatives of the German and British laboratories. Dr. F. Henning of the German laboratory spent two months at the bureau, working on methods of temperature measurement, and also devoting a great deal of attention to the new primary standard of light and the melting points of platinum, rhodium, and iridium. Doctors Dellinger, Dickinson, and Osborne attended the plenary session of the International Electrotechnical Commission at Stockholm, Doctor Dellinger as the official delegate of the Institute of Radio Engineers and Doctors Dickinson and Osborne in connection with standardization of requirements for prime movers in the generation of electric power. Doctor Wenner reported to the International Geodetic and Geophysical Union, also in Stockholm, on the development of seismometers and salinity meters at the bureau. Doctor Briggs represented the bureau at the International Congress of Applied Mechanics at Stockholm. Doctors Dellinger and McIlwraith took part in the second meeting of the International Technical Consulting Committee on Radio Communication at Copenhagen in May and June, 1931. Doctors Dellinger and Austin represented the bureau at the sessions of the International Scientific Radio Union which were held in Copenhagen at the same time.

The bureau has cooperated with other national laboratories, and particularly those of England, France, and Germany, in comparisons of standards of resistance, capacitance, and candlepower. The interlaboratory comparison of the thermoelectric portion of the international temperature scale has been completed and work on the optical part of the scale is under way.

Some correspondence has taken place on a proposed new unit of heat, continuing the discussion mentioned in the report for last year. The bureau has suggested that before adopting any unit based on the electrical units, there should be a definite understanding as to the values of the units to be employed. No decision has yet been reached.

Visitors.—The bureau has been honored by many distinguished visitors from all over the world, 25 countries being represented.

Weights and measures conference.—The twenty-fourth meeting of the National Conference on Weights and Measures was held under the auspices of the bureau on June 2 to 5, 1931. Important actions of the conference included the adoption of a code of regulations for penny-in-the-slot person-weighing scales; revision of the code of regulations for lubricating-oil bottles; and the adoption of a code for odometers. Subjects considered embraced testing equipment for large capacity scales, scales for determining wheel loads on motor trucks, inspection of postal scales, Federal regulation of baskets and hampers, quality labeling of canned goods, and many other matters.

Conference of State Utility Commission Engineers.—The ninth annual conference of State Utility Commission Engineers, held at the bureau on June 4 and 5, was attended by 25 engineers representing 16 States, the District of Columbia, and the Province of Ontario, Canada.

Other conferences.—Many other important conferences were held, including a two days' session, November 24 and 25, of chairmen of simplified practice project committees, attended by representatives of over 50 industries; the metallurgical advisory committees on May 19 and 20 with over 60 in attendance; several meetings of the underground pipe-corrosion group; conferences relating to trade standards, and many technical subjects.

Federal Fire Council.—This organization, with the Director of the Bureau of Standards as chairman, made up of representatives of Federal institutions and the District of Columbia, formed last year to function in advisory and informative capacity on matters relating to fire prevention and protection of Federal buildings, held four meetings during the year. Committee reports outlining the fire hazards present and the needed structural changes and fire protection equipment, were received and acted upon, covering the Senate side of the Capitol and the Senate Office Building, the buildings of the Smithsonian Institution, and those of the National Training School for Boys. Through cooperation with the National Fire Protection Association, surveys are being made by its engineers of Federal penal institutions and reports have been completed on the Atlanta Penitentiary, the Chillicothe Reformatory, and the Industrial Institution for Women at Alderson, W. Va. Fire hazard and safety surveys of the bureau's buildings and occupancy were made by local committees.

American Standards Association.—The bureau has continued its close cooperation with this association. The Director of the Bureau of Standards is a member of the board of directors, and two

members of the bureau's staff represent the Department of Commerce on the standard's council. The bureau is sponsor for 14 standardization projects and is represented on 73 sectional committees.

National Screw Thread Commission.—The National Screw Thread Commission, of which the director of the bureau is chairman, has continued its work on the standardization of screw threads. Connecting threads for gas cylinders and valves have received particular attention. In cooperation with the American Society of Mechanical Engineers, a survey was undertaken to determine the extent to which the commission's screw thread standards are being accepted and followed by industry. About 7,000 samples of bolts and nuts have been collected and are being measured at the bureau. Consideration has also been given to a possible revision of the class 4 fit (fine) in order to make this class of threaded work commercially feasible with the threading tools and gages now available.

American Gage Design Committee.—A report of the American Gage Design Committee, covering plain and thread plug and ring limit gages up to 4½ inches, was published in February. The committee has mapped out a standardization program for extending the size range up to 12 inches, and for covering snap gages and length snap gages over the same size range.

Federal Specifications Board.—This board, of which the Director of the Bureau of Standards is ex officio chairman, has promulgated its six hundred and ninety-sixth purchase specification, 208 this past year, including 165 revisions. A large part of the research and experimental work on which these specifications are based is performed in the bureau's laboatories, and the chairmanships of several of the board's technical committees are held by members of the bureau's staff.

Publicity, bureau reports, etc.—The number of papers published in the Bureau of Standards Journal of Research was 146. In addition, the Technical News Bulletin and Commercial Standards Monthly were issued each month. Forty-eight papers were published in the other series of the bureau, including simplified practice recommendations, building and housing, commercial standards, circulars, handbooks, and miscellaneous publications. The total, including 12 numbers of each of the periodicals, 146 reprints, and 48 publications in other series was, therefore, 230.

Approximately 170 papers were published in outside journals. Releases to the press totaled 299, including several feature articles. The fifth annual number of the Standards Yearbook was issued in March. In commenting on the distribution of Government publications the Public Printer referred to this yearbook as one of his "best sellers." Unusual demands have also been recorded in connection with the bureau's circular 383 on washing, cleaning, and polishing materials, building and housing publication No. 15 on care and repair of the house, and several others.

Exhibits.—The bureau participated in the exhibit of colonial products at Paris, the industrial exposition at Liege, Belgium, the commercial exhibition at Washington, and in the exhibit of testing apparatus and machines held by the American Society for Testing Materials at Chicago in June.

Medical officer.—The plan of stationing at the bureau a medical officer of the United States Public Health Service has worked out

most satisfactorily. Not only have emergency cases been promptly cared for, but the general health of the employees has been improved.

Testing.—Table 1 gives a summary of the bureau's test work for the past year. The total number of tests completed was 212,717, and the fee value $816,979.59. The corresponding figures for 1930 are 200,726 and $683,614.51.

TABLE 1.—*Numbers of test items, determinations, and fee value for tests completed during the fiscal year ended June 30, 1931*

Kind of instrument or material, class of test, or nature of service rendered	Number of test items for—			Total number of test items	Number of determinations	Fee value
	Public	Government departments and State institutions	Bureau of Standards			
Electrical standards, instruments, and materials	811	1,061	480	2,352	3,803	$18,852.60
Electric batteries		2,371	60	2,431	4,924	12,879.50
Electric lamps and lighting equipment	192	3,149	651	3,992	4,129	[1] 26,845.59
Length-measuring devices	146	129	6	281	1,875	2,337.25
Gages and gage steels	1,283	736	395	2,414	9,509	2,255.00
Hæmacytometers, sieves, thermal expansion, etc	3,538	321	290	4,149	19,857	11,138.85
Weights and balances	3,319	6,204	583	10,106	21,837	7,288.65
Scales	4	1,228		1,232	38,060	58,778.50
Timepieces	364	4	63	431	4,437	1,301.50
Volumetric apparatus	8,872	5,512	359	14,743	32,116	10,151.05
Hydrometers	801	617	27	1,445	3,669	1,897.00
Density determinations, etc			258	258	329	447.00
Laboratory thermometers	2,744	1,128	606	4,478	18,318	9,823.60
Clinical thermometers	27,954	64,361		92,315	411,956	12,006.50
Pyrometers, calorimeters, etc	223	53	133	409	5,754	4,631.50
Insulating materials	101	56		157	131	1,080.00
Fire-resisting materials	11	47		58	76	5,785.00
Fuels and lubricants	194	1,488	377	2,059	9,489	18,687.00
Automotive equipment, etc	10	152		162	471	9,525.00
Airplane engines		31		31	238	51,500.00
Optical instruments and materials	606	502	251	1,359	5,352	7,200.25
Carbohydrates	1	1,918		1,919	2,873	2,850.00
Radioactive materials	2,463	236	1	2,700	1,064	8,115.00
Engineering instruments and appliances	101	1,220	126	1,447	1,634	24,195.00
Aeronautic instruments	87	899	13	999	3,480	10,084.50
Aerodynamic tests of models	1	12		13	13	100.00
Physical properties of engineering materials	52	2,107	146	2,305	5,436	13,059.00
Sound producing and measuring instruments	9	30		39	45	1,086.00
Making of special castings		41	117	158	929	1,390.76
Fusible boiler plugs		397		397	794	993.50
Metallographic examinations		955	98	1,053	3,154	4,946.54
Miscellaneous metallurgical tests		1,000	540	1,540	4,002	8,260.90
Pottery and chinaware		47	9	56	331	418.50
Glass		21	38	59	131	231.00
Refractories and heavy clay products		479	50	529	1,591	4,935.90
Cement, concreting materials, lime, etc	26	19,950	57	20,033	89,428	[2] 221,363.75
Stone and sand-lime brick		77	125	202	889	2,659.00
Miscellaneous ceramic materials		5,301	6,745	12,046	26,694	38,625.90
Rubber		1,606	18	1,624	11,440	36,931.50
Textiles	22	5,900	712	6,634	15,900	34,861.50
Paper	18	1,664	1,101	2,783	8,299	25,528.50
Leather	1	315	39	355	1,769	3,698.50
Paint, varnish, and bituminous materials	6	2,780	150	2,936	23,375	63,413.00
Chemical analysis of metals	4	482	127	613	2,324	9,839.50
Chemical tests of miscellaneous materials	9	886	14	909	3,563	10,547.00
Distribution of standard samples	6,332	171	3	6,506	90	14,433.50
Total	60,305	137,644	14,768	212,717	[3] 805,578	[3] 816,979.59

[1] Includes fee value of $7,918.59 for inspecting 2,971,048 incandescent lamps at various factories for other branches of the Government.

[2] Includes fee value of $54,802 for sampling, testing, and shipping 6,610,000 barrels of Portland cement and 50,130 barrels of masonry cement.

[3] Of these totals 235,062 determinations were for the public, fee value, $71,380.65; 534,257 determinations were for the Government departments and State institutions, fee value, $683,170.67; 36,259 determinations were for the bureau, fee value, $62,428.27. The number of test items and determinations necessary in connection with the bureau's own work of research and standardization, with the resulting fee values, is not included in these totals.

SALARIES ($710,000)

Maintenance and intercomparison of electrical units.—Three 1-ohm resistance standards of a new type developed by the bureau, measured in the national laboratories of Germany and England, showed that the units of resistance in use in Germany and in England are, respectively, 10 parts per million and 27 parts per million greater than the unit maintained by the bureau. An absolute method of resistance measurement has been under development in which the regulation of the speed of the driving motor is one of the major phases of the problem. This has been solved satisfactorily. Measurements of inductance on a porcelain-core inductance standard showed that 1 international ohm (Bureau of Standards) = 1.00051 absolute ohms.

Improvements and refinements have been made in the measurement and control of the temperature of the oil baths for the standard cells. Comparisons with several foreign national laboratories indicate that the bureau's value of the international volt is 20 microvolts below that of England and 60 microvolts above that of Germany. Experiments with the silver voltameter in which the bureau is cooperating through a representative now in Berlin, were begun in Germany in May and will be continued in England and France in the effort to reduce these discrepancies. Measurements with the Rosa-Dorsey-Miller current balance showed that 1 international ampere (Bureau of Standards) = 0.99997 absolute ampere.

Waidner-Burgess standard of light.—A proposal was submitted to the advisory committee on electricity of the International Committee on Weights and Measures that the reproducible light standard, developed last year at the bureau, be adopted as an international standard. Final action, however, was not taken at the 1931 meeting, as the other national laboratories had not yet had time to give the proposal sufficient study.

Freezing point of iridium and its use for light standard.—The freezing point of pure iridium has been determined by the crucible method in an electric induction furnace, resulting in a figure of 2,452° C., ±3°.

Preliminary observations of the brightness of a black body at the freezing point of iridium, following the same technique as that for the Waidner-Burgess light standard using platinum, have shown that the iridium freezing point can be so used, but with much more difficulty. However, it can be used conveniently for stepping up from carbon filament to tungsten filament lamps. The preliminary figure obtained for brightness of this standard is 1,250 candles per square centimeter in terms of the bureau's derived tungsten standards.

Maintenance of unit of candlepower.—Carbon-filament incandescent lamps were sent to the laboratories in five foreign countries and remeasured after their return. The units of candlepower as maintained in the United States and Great Britain are in close agreement, but the French unit seems to be about 1 per cent larger, and the unit, derived from measurements in Hefner candles, maintained in Germany, smaller by more than 1 per cent than the unit maintained at the bureau.

Magnetic testing and research.—A method for standardizing magnetic permeameters at high values of magnetizing force was developed. Investigations were carried out on the relation between magnetic properties and torsional strength of tool steel. Data to aid in the interpretation of the results of thermomagnetic analysis, with special reference to the effects of carbide particle size and the tempering of quenched steel, were obtained.

Ruling of line scales by interference methods.—Two meter scales and several shorter ones have been ruled, using light wave lengths to step off the intervals. One of the meter scales was subdivided into centimeters, the other into decimeters. The smaller scales were subdivided down as low as one-thousandth of an inch. All were free of any error requiring the use of a correction chart.

Recalibration of tape bench.—A check on the 5-meter intervals of the bureau's 50-meter bench standard, used in testing steel tapes, shows no change in excess of 0.1 millimeter from the result of the previous calibration made in 1922, the average change being less than 0.04 millimeter.

Graduation and calibration of precision circles.—The graduation and calibration of precision circles has shown that while the bureau's equipment is capable of graduating circles to an accuracy of two seconds or better, extreme care must be exercised in the mechanical and heat treatment of the circles, both before and after graduation, in order to maintain this accuracy.

Effects of wire diameter and of large openings of sieves upon sieving values.—Detailed measurements of large numbers of sieves have been made in connection with work on standard samples of abrasives.

Nickel-chromium alloy for weights.—The accuracy and behavior of high-precision weights made of an alloy of 80 per cent nickel and 20 per cent chromium, have been studied under a variety of conditions to which standards may be subjected in practice. Thus far the material seems to be of satisfactory constancy.

Variation of electroplated weights with humidity.—This investigation has been completed and the results are being prepared for publication.

Precision clock.—The precision free-pendulum clock mentioned in last year's report, especially adapted to use with the photoelectric cell, has been constructed and installed in the constant temperature clock room. It has been found to give seconds signals of a higher accuracy than those obtained from the Riefler clock.

Effect of temperature changes on rates of watches.—Preliminary results of a cooperative research indicate that watches equipped with uncut, monometallic balance and elinvar hairspring can be more accurately adjusted to compensate for temperature changes than can the ordinary watch equipped with cut, bimetallic balance and steel hairspring.

Cooperation with Horological Institute.—Cooperation with the Horological Institute of America in its efforts to improve the quality of service rendered by watch repairmen has continued.

Density of creosote oils.—In cooperation with the preservatives committee of the American Wood Preservers Association, volume correction tables have been prepared for creosote oils and creosote coal-tar solutions.

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Density of chromic acid solutions.—The work on density of chromic acid solutions has been completed and the results published in the Journal of Research.

Ethyl alcohol tables.—A new series of ethyl alcohol density tables on the basis of percentage by volume was prepared at the request of the Association of Official Agricultural Chemists for publication in their "Methods of Analysis."

Orifice meter tests.—Data on several research projects involving orifice discharge coefficients and large capacity gas meters have been reviewed and correlated. Pulsating flows are now under consideration and the work done in this field is now being reviewed, preparatory to outlining the scope of the research which will be undertaken.

Absolute determination of gravity at Washington.—Work has been continued, but is not yet completed. One of three silica pendulums under construction is ready for preliminary work, and a Shortt clock has been installed and operated continuously for some months.

Spectroscopic investigations.—The arc and spark spectra and the Zeeman effect of zirconium, leading to a complete analysis of its spectral regularities, were obtained. Chlorine and bromine were specially excited by the electrodeless discharge to obtain the spectra of the singly and doubly ionized atoms. The hyperfine structure of certain lines of krypton and xenon was investigated by both the Fabry-Perot interferometer and the Lummer-Gehrcke Plate.

Laboratory intercomparison of methods for measuring ultra-violet radiation.—With the use of ultra-violet radiation for health purposes the demand for a reliable method of measuring this very difficult quantity has arisen. The bureau has cooperated with several other laboratories in measuring the ultra-violet output of the same samples of a specific type of lamp. Differences in the measurement by these laboratories appear to arise both from the inconstancy of the lamps and the inaccuracy of the measuring methods.

Photographic sensitometry.—The relation between photographic sensitivity and development time for several different types of emulsions has been investigated by using the three most common methods of measuring sensitivity. It is found that there is an optimum development time for obtaining maximum sensitivity.

Liquefaction of helium.—Helium was liquefied on April 3 for the first time in the United States, and with it a temperature of −271.3° C. (−456° F.) was attained, which is only 1.9° C.(3.4° F.) above the absolute zero of temperature.

Liquid nitrogen.—The construction of a new nitrogen liquefier was practically completed. The liquid nitrogen will be used for low-temperature work with flammable hydrocarbons, which would be dangerous if liquid air were used, because of the possibility of explosions.

Preparation of pure oxygen for use in international comparison of low-temperature thermometers.—This project required the design and construction of elaborate apparatus, and approximately two months of working time in its operation.

Specific heats at low temperatures.—In cooperation with the fixed nitrogen research laboratory of the Department of Agriculture, a project was undertaken for the determination of the specific heats of nitrogen organic compounds down to solid hydrogen temperatures,

and for the calculation of the entropies and free energies of the compounds from their specific heats. The construction of the apparatus was completed and the determination of the specific heat of primary amyl ammonium chloride is under way.

Oiliness of lubricating oils.—The frictional characteristics of a series of representative lubricating oils have been determined on the Grooved Specimen, Herschel, Kingsbury, and Timken oiliness machines. The results indicate that quantitative values obtained on each machine depend to a great extent upon the particular design and mode of operation. They indicate also that a more certain control of factors involved in oiliness tests is needed. This work was done in cooperation with the American Society of Mechanical Engineers.

Determination of the formula of a hydrocarbon.—A critical discussion of the measurements and calculations required in order to determine the molecular formula of any hydrocarbon containing not more than 100 carbon atoms has been published.

Standards of criteria for purity of hydrocarbons obtained from petroleum.—Satisfactory criteria for the purity and identification of hydrocarbons obtained from petroleum have been established.

Hydrocarbons from petroleum.—In cooperation with the American Petroleum Institute the investigation dealing with the determination of the composition of petroleum has been continued. The following hydrocarbons have been isolated and the quantities of each present in the petroleum have been determined: Ethane, propane, butane, cyclopentane, pentanes (2), benzene, methylcyclopentane, cyclohexane, *n*-hexane, 2, 3-dimethylbutane, 2-dimethylpentane, 3-methylpentane, toluene, methylcyclohexane, *n*-heptane, 2, 2-dimethylpentane, xylenes (mixture), *n*-octane, *n*-nonane.

Variation of transference number with concentration.—A new moving boundary method has been developed by means of which it is possible to measure the change in the transference number of a given electrolyte with its concentration in aqueous solution.

Chemical nature of rubber.—The investigation of pure rubber hydrocarbon has been continued in order to obtain photographic evidence of crystallinity, to make combustion analyses of extreme accuracy so as to detect any possible slight differences in composition, and to determine the molecular weight.

Painting plaster.—Information was collected and made available concerning the failure of paint on plaster, with suggestions as to possible causes of such failure and precautions necessary to reduce the probability of failure of the decorative coating.

Accelerated tests of asphalts.—In cooperation with the Asphalt Shingle and Roofing Institute, asphalt materials have been exposed to an accelerated cycle resembling that used on paint. The results obtained are similar to those produced by outdoor weathering.

Analytical reagent chemicals.—Sixty-three individual methods for the determination of various impurities in 18 reagent chemicals were critically studied, as the bureau's share in the preparation of specifications for reagent chemicals by the American Chemical Society. As a contribution to the study of the quality of analytical chemicals a report was prepared on the results of tests of all reagents bought by the bureau during a 2½-year period ended December, 1930.

Platinum metals.—Progress has been made in the second phase of the research on analytical methods for the metals of the platinum

group—methods of separation. Work on the separation of osmium was completed and published, together with the method for the determination of osmium, completed last year. A method for the strictly quantitative separation of iridium and rhodium from each other has been nearly completed.

Pure metals.—The physical properties of nickel of the highest attainable purity, 99.94 per cent with not over 0.001 per cent oxygen, have been determined and a report published. As part of the bureau's cooperation with the alloys-of-iron research committee of Engineering Foundation, the literature on pure iron has been critically reviewed and a monograph on the subject is in preparation. Laboratory work for preparing pure iron by precipitation and reduction methods is under way.

Thermal conductivity of metals.—A relatively simple comparison method for the determination of thermal conductivity of metals at elevated temperatures for commercial purposes has been developed. The thermal conductivity of pure metals and simple steels decreases with increase of temperature in the range from 50° to 550° C.; for high alloy steels, it increases. Transformation points in metals, as in nickel, can be readily located by thermal conductivity curves.

Magnetic change in iron.—The electronic changes underlying the magnetic change or A_2 transformation in iron are being studied by means of the β-ray spectrograph.

Elastic hysteresis research.—Theoretical study has been made and published of the vibration of elongated and short U-bars with special reference to their use in determining elastic hysteresis. In the experiments now in progress the results from tuning forks, U-bars, and straight bars have been compared, and show that the use of the elongated U-bar will be satisfactory, thus dispensing with the use of the expensive tuning fork.

Information circular on zinc.—A comprehensive review of the literature on zinc and its alloys has been completed. The results will form the basis of a circular similar to previous ones on copper, nickel, and aluminum.

Revision of Federal specification for industrial thermometers.—Federal Specifications Board Specification 472A was revised according to suggestions from the committee on thermometers and in cooperation with the Navy Department.

Federal specifications for rubber, textiles, paper, and leather.—During the year the committee on rubber products and packing materials, whose chairman is a member of the bureau, has prepared 46 specifications, and the bureau has assisted in the preparation of 40 specifications for textiles, 14 for paper, and 2 for leather.

Operation and maintenance of buildings.—The employees engaged in the maintenance and operation of the plant are divided into three groups, viz, power plant, guard, and janitorial groups. The duties of these groups, which include the operation and maintenance of the heat and power plant, the policing of the bureau's property, and the routine cleaning in the various buildings, were carried out, as heretofore.

Miscellaneous repairs and alterations.—This work included in addition to repairs to buildings, such interior alterations as were necessary to facilitate the work of the various laboratories. Extensive

alterations have been necessary in many buildings as a result of shifting all shops to the north building. Interior painting was continued and the excavation and fitting out of laboratory for optical work in the basement of the south building was completed.

Construction of instruments and apparatus.—The bureau's shops constructed most of the special instruments and apparatus, including blown-glass apparatus, required by the laboratories. In addition, cabinetwork, and the repair of furniture and woodwork required in the upkeep of buildings was taken care of, as heretofore. The necessary shop work was performed on specimens submitted for test, and standard steel and alloy samples were prepared. The alteration of the north building was completed in March, and most of the shops moved into this building, with a great increase in efficiency. Several new machine tools were installed and machines formerly belt driven were equipped with individual motor drives.

Additional research.—Of the 138 projects carried by this fund, only about 40 have been briefly described. A few others, which may be mentioned by title, are: Development of seismometers, electrical time-distribution systems, dimensional stability of invar, effect of temperature on rate of watches, fluidity of oils at low temperatures, establishment of color-temperature scale, methods of ultra-violet radiometry, microscope objectives, physical properties of paints, efficiency of gas ranges and water heaters, permeability of airship fabrics, and rubber core binders for foundry sand.

EQUIPMENT ($163,000)

Alteration and addition to north building.—A new third story was added to the north building, and many interior changes were made to accommodate the various instrument and machine shops which will be concentrated in this building.

Important purchases.—Important additions to the bureau's plant and laboratory facilities have been purchased under this fund. These include:

A new dead-weight testing machine for the engineering mechanics section, with a capacity of 10,000 pounds in increments of 100 pounds.

An interchangeable quartz prism spectrograph of high resolving power to be used by the spectroscopy section in the analysis and description of spectra in the ultra-violet.

A gas-fired steam boiler for supplying steam on a 24-hour basis to chemical baths.

Harmonic analyzer to be used in the analysis of radio waves in connection with experimental work on radio aids to air navigation.

A high-frequency radiotelephone set to be used in experiments involving communication between airplanes and the ground.

An improved saccharimeter for the polarimetry section to be used in determining the sugar content of solutions, especially in check analyses for the Customs Service.

A set of electrical filters is being constructed for the sound section and will be used in the analysis of noises. These were ordered during the fiscal year but will not be delivered for several months.

Two large metallographic microscopes have been added to the equipment of the section of optical metallurgy.

GENERAL EXPENSES ($64,000)

Maintenance of mechanical plant.—The usual maintenance work, such as replacement of piping, valves, and fittings has been carried on. Extensive piping changes have been made in the north building in converting it for the exclusive use of the shops.

Electrical construction and repair.—In addition to maintenance work, extensive new electrical installations have been made as a result of shifting some of the shops and laboratories.

Plumbing and pipe work.—Routine work on existing piping systems was performed, as well as much new work, made necessary by the many shifts in laboratories and in the refitting of the north building.

Library books.—The net number of volumes accessioned was 1,184, making the total number of accessioned volumes 36,403. Scientific and technical periodicals received number 1,275.

IMPROVEMENT AND CARE OF GROUNDS ($19,400)

Improvement of grounds.—Good progress has been maintained in the improvement of the grounds by grading, seeding, sodding, and the planting of trees and shrubs. The valley in the grounds fronting on Connecticut Avenue has been filled, preparatory to putting in a temporary road to the hydraulic laboratory. A new piece of permanent road and walk was completed between the chemistry and wind tunnel buildings. A storm and waste water sewer has been constructed along Van Ness Street.

TESTING STRUCTURAL MATERIALS ($320,000)

City planning and zoning.—Reports based on surveys of city planning and zoning in the United States have been issued and show widespread progress in the use of the recommendations of the advisory committee on this subject. The study of subdivision regulations has been continued. A pamphlet on the preparation of zoning ordinances, designed especially to aid smaller municipalities, has been completed and is being printed.

Home financing.—A detailed study of the experience of more than 5,000 purchasers of homes was completed, and the information obtained on the financing problems of these buyers is being studied in relation to data previously secured for issuance in a report.

Care and repair of the house.—A guide for householders who wish to keep their property in good condition was printed; 15,000 copies have been sold, and to meet new demands, 50,000 additional copies are being printed. The book has attracted much interest from the press, local merchandising houses, national trade associations, and educational institutions.

Cooperation with other agencies on building and housing problems.—Full or part time services of several members of the staff have been devoted to cooperative studies with the President's Conference on Home Building and Home Ownership, which finds it most helpful to have the assistance of members of the bureau's staff experienced in the study of problems of home ownership, construction, finance, city planning and zoning, and related subjects.

Absorption coefficients of acoustic materials.—Measurements have been made of the sound absorption coefficients of acoustic tile, acoustic plaster, and other materials designed to reduce the reverberation time of large rooms. Development of acoustic correctives has been so active that frequent revision of the tables showing the absorption coefficients has been necessary. These are now issued as letter circulars, three having been released during the year.

Protection for heating appliances.—Experiments on methods of preventing fires from household heating and cooking appliances were completed.

Tests of corrugated roofing.—Strength, absorption, heat, shock, and fire-spread tests were made, at the request of the Navy Department, of corrugated cement-asbestos and asphalt-covered steel boards.

Durability of concrete aggregates.—The average resistance of the commonly used concrete aggregates to the boiling and drying, freezing and thawing, sodium sulphate and sodium chloride tests was in the following order: Granite, trap, gravel, slag, limestone, and sandstone. Individual samples, however, varied greatly from this order, one sample of limestone being as resistant as the average granite. The absorption and porosity measurements were found to be of little value as criteria for judging the ability of the aggregate to withstand disintegration.

Cast stone.—Freezing and thawing tests on cast stone samples have been continued until the samples showed signs of disintegration. The resistance to freezing and thawing ranged from complete failure in 25 cycles to specimens that showed the first small signs of failure at 1,450 cycles. The average resistance to freezing of the samples made by the wet-cast process was equal to the average resistance of the specimens made by the dry-tamp process. The specimens formed by vibrating showed greater than the average resistance to freezing. A proposed Federal specification for cast stone has been drawn up and submitted to the industry for comment.

Waterproofing compounds.—The incorporation of 50 different waterproofing compounds in 1:3:6 concrete showed 16 per cent of the compounds to be effective in reducing the permeability of the concrete when it was subjected to a continuous water pressure of 20 pounds per square inch.

Fifty surface waterproofing materials coated on 1:2:4 concrete were less absorbent than uncoated concrete for the first few hours' immersion in water. The most efficient coatings after one year's immersion were asphalt emulsions and asphalt paints. Linseed oil, China wood oil, and varnish were the most efficient transparent coatings.

Aggregates for cinder concrete building units.—In cooperation with the National Building Units Corporation, samples of cinder aggregates from 60 plants are being tested to determine their grading, hardness, soundness, and concrete-making qualities.

Survey of the properties of common brick.—In cooperation with the Common Brick Manufacturers Association samples of bricks from 220 plants are being tested to determine their physical properties. Specification tests have been made on about 70 per cent of the samples.

Moisture penetration through brick and mortar.—Water under a head of from 0 to 8 inches penetrated more rapidly through bricks or mortar separately than through brick masonry specimens of the same size, a marked reduction in the rate of penetration occurring as the moisture passed from one material into the other.

Tests of Arlington Memorial Bridge.—Tests of one of the arch spans of the Arlington Memorial Bridge at Washington, D. C., have shown that the average temperature of the arch barrel has varied during two years from 28° to 85° F. The corresponding vertical crown movement was 1⅜ inches and the coefficient of expansion of the arch barrel was approximately 0.0000065 per degree Fahrenheit.

Durability and strength of bond between mortar and brick.—Masonry specimens of brick and mortar were subjected first to 50 freezings and thawings while saturated with water, and then to drying. The durability of the bond of the mortar to the bricks depended chiefly on the pressure on the mortar joints during exposure, the type of mortar used, and the moisure content of the bricks when set in the mortar.

Clay admixtures in concrete.—For concrete mixtures of the same consistency as determined by a penetration test, the substitution of clay either for 10 per cent of the volume of the cement or for 7½ per cent of the volume of the sand, in concretes containing about 5 cubic feet of cement per cubic yard of concrete, caused a slight increase in strength and a small decrease in the water permeability of the concrete.

Cement.—(1) It was found that the solubility of a cement in sugar solution was not a satisfactory index of its disintegration in sulphate solutions. (2) It has been found that CaO and $2CaO.SiO_2$ catalyze the decomposition of $3CaO.SiO_2$ into these products, and that the rate of decomposition is a maximum at 1,175° C. (3) The composition and melting points of the various anhydrous calcium borates have been determined. (4) A study of the reaction of water on the anhydrous calcium silicates has shown that $3CaO.SiO_2$ and beta $2CaO.SiO_2$ which have hydraulic properties give metastable solutions which subsequently precipitate out hydrated calcium silicates on approaching equilibrium. (5) The fields in which hydrated alumina hydrated tricalcium aluminate, hydrated tricalcium aluminate, and hydrated tetracalcium aluminate, respectively, are the solid phases in the system $CaO.Al_2O_3$—H_2O, have been determined.

Lime.—(1) Particle size distribution of hydrated lime: To calibrate the sedimentation apparatus, glass spherules have been separated into fractions wherein most of the material is within 2 microns of the average diameter. With this fractionated material check, sedimentation curves have been obtained with the automatic recording balance. (2) Soundness of finishing lime: The autoclave method of testing the soundness of lime has been found to be in agreement with correlating tests of the lime in plastered panels. (3) Federal specifications have been revised for quicklime and hydrated lime for structural purposes.

Gypsum.—(1) Volumetric changes of gypsum fiber concrete: It was found that the expansions of specimens of neat gypsum at the end of the fourteenth cycle of alternate drying and wetting ranged from 0.03 to 0.12 per cent of the original dry length, and 0.15 to 0.31

per cent for those specimens containing 12.5 per cent of wood chips. Specimens of the same materials showed much smaller changes when exposed alternately to air of low and high relative humidity. (2) Federal specifications have been revised for calcined gypsum, gypsum plaster, gypsum wall board, and gypsum plaster board.

Sand-lime brick.—It was found that both modulus of rupture and compressive strength are more indicative of the resistance of sand-lime brick to freezing and thawing than is total absorption. As a rule, sand-lime brick which had a rapid rate of absorption and high strength withstood freezing and thawing relatively satisfactorily. This statement is without reference to total absorption.

Building stone.—Forty-three samples of stone, most of which were limestone, were tested during the year in connection with the study of building stones. Weathering tests are in progress on 74 limestones, 21 sandstones, and 16 granites. Considerable attention has been given to studying the underlying causes involved in the destructive weathering of various types of stone.

Slate.—The investigation of the physical properties of slate from the important producing districts and the study of slate weathering are practically completed. This work has covered about 350 samples of new and old weathered slate. A test procedure for determining weathering characteristics has been developed which affords a means for selecting durable slate. In cooperation with the Federal Specifications Board a specification for roofing slate has been prepared.

Masonry cements.—An investigation of all the masonry cements on the market is under way. Workability, water-retaining capacity, strength, volume change, and specific gravity of the pastes and mortars are among the properties being studied.

Elastic cements.—Apparatus has been developed and a procedure established for the physical testing of pointing materials and slater's cements. During the year 153 samples have been tested for various departments of the Government. This has afforded a more satisfactory basis of acceptance for such materials as well as a means of enabling manufacturers to control their products.

Effects of variations in composition on vitreous enamels.—The fusibility of typical first-coat vitreous enamels is influenced more readily by changes in the boric oxide-sodium oxide ratio than by changes in the flint-feldspar ratio. The data obtained, when presented graphically, give a symmetrical figure. The fusibility has been measured in the following four ways, and the same general relationship to composition holds in all four cases: (*a*) Coarse deformation tests; (*b*) "fusion block" flow tests; (*c*) slumping temperature tests (by interferometer method); and (*d*) "button" tests (observing dimensions of the resulting "buttons" when cylinders of enamel powder are heated under standard conditions). Equipment has been assembled, and special means of preparing satisfactory specimens developed for measuring modulus of elasticity, coefficient of expansion, and tensile strength. Over 10,000 specimens have been prepared for these tests, and the measurements of expansivity with the interferometer have been nearly completed.

Cement reference laboratory.—The cement reference laboratory, a cooperative project of the Bureau of Standards and the American

Society for Testing Materials, continued its efforts to secure greater uniformity and improvement in cement testing. The field inspection of laboratories formed the greater part of the year's work, 122 laboratories having been visited. Requests for inspections during the second tour of the inspectors have been received from 196 laboratories.

Branch laboratories and inspection of cement.—The bureau's branch laboratories, maintained at Northampton, Pa., for the testing and inspection of cement; Denver, Colo., for the testing of cement and concreting materials; San Francisco, Calif., for testing cement and miscellaneous materials, together with the cement testing laboratory in Washington, have been engaged in testing service for Government purchasing agencies. During the year 2,311,000 barrels of cement, an increase of 42 per cent over last year, were sampled, and 1,830,000 barrels were shipped.

A 4,000,000-pound precision hydraulic compression machine, for testing concrete cylinders up to 3 feet in diameter, was installed at the Denver laboratory, and equipment for testing textiles, rubber, and leather was added to the branch in San Francisco.

Number of projects provided for.—In all, 43 research projects were authorized under this fund during the fiscal year. The general character of the work has been indicated in the preceding paragraphs.

TESTING MACHINES ($41,000)

Strength of welded joints in tubular members for aircraft.—In cooperation with the National Advisory Committee for Aeronautics and the Aeronautics Branch of the Department of Commerce, this investigation has been continued, using (1) a type of gusset-reinforced joint shown by previous tests to be most efficient, (2) joints heat-treated after welding, and (3) joints made from thin-walled tubing.

Fatigue of alclad.—Flexural fatigue tests were made on two groups of alclad sheets (approximately 0.1 inch thick) having core material of 17ST and 17ST special aluminum alloy. The maximum fiber stress (based on the total thickness of the sheet) for which longitudinal specimens withstood 100,000,000 cycles of stress without failure, was approximately 10,500 pounds per square inch for the alclad 17ST and 16,000 pounds per square inch for the 17ST core material. For the alclad 17ST special, the maximum fiber stress was about 12,800 pounds per square inch and 20,500 pounds per square inch for the core material. The tests on alclad specimens which had been subjected to 6, 12, and 18 months' exposure to salt spray, gave results which corresponded approximately to those on unexposed specimens. The tests on the core material, exposed for the same time, gave results corresponding to those obtained for alclad specimens.

Airship girders.—In cooperation with the Bureau of Aeronautics, Navy Department, an investigation is in progress on factors affecting the strength and rigidity of airship girders. Results of a series of compression tests show that the strength of the girders is dependent almost entirely upon the different types of critical instability. This, for some sizes and kinds of girders in the chord members, is torsion. In compression tests of short lengths of girders in which the twisting of the chord members alone was restrained, the strength of the girder was increased over 40 per cent. If practicable designs are

found for longitudinal members having high torsional rigidity, the strength of rigid airships can be considerably increased without increasing the weight.

Fixation of airplane struts.—In cooperation with the National Advisory Committee for Aeronautics and the Navy Department, a series of chrome-molybdenum steel tubular struts of different lengths has been tested in compression. The weight of aircraft structures may be reduced as a result, since the action of elastically restrained ends is now known more definitely.

Methods of locking screw threads.—Forty-one devices, representing all manufacturers who cared to participate, were tested, including nonproprietary devices, such as standard nuts, jam nuts, and slotted nuts with cotter pins.

Only about 22 per cent of the devices showed appreciable difference in static torque-tension characteristics from that of the coarse thread standard nut. In only one device was the screwing-off torque greater than the screwing-on torque at all stresses.

Federal specification for wire rope.—The specification for wire rope, No. 297, promulgated by the Federal Specifications Board in 1925, is now being revised to include some additional types of wire rope required by Government departments, and to bring the tables for strength into agreement with the values adopted recently by most manufacturers. Information on the care and use of wire rope will be included as a guide to users in obtaining satisfactory service from this important engineering product.

Other investigations.—Seven research projects were conducted under this fund, including studies of heat-treated bridge wire, measurements of hardness, and development of special devices to be used in testing machines.

INVESTIGATION OF FIRE-RESISTING PROPERTIES ($30,000)

Spontaneous heating and ignition of materials.—The research on susceptibility of jute to spontaneous heating and ignition, conducted in cooperation with the Bureau of Chemistry and Soils of the Department of Agriculture and a committee of the Marine Underwriters, was completed. As tested under a considerable range of conditions, no heating from microbial action in excess of 59° C. was obtained. Oxidizing oils, such as linseed oil and menhaden oil, applied to jute and to cotton fiber, induced heating culminating in ignition starting from initial temperatures in the range 30° to 50° C. No significant difference was noted between the results obtained with jute and with cotton.

Fire prevention and protection.—Activities in this field have been conducted mainly in conjunction with those of the Federal Fire Council and the National Fire Protection Association. Assistance was given in fire-hazard surveys of several Federal building groups and in the preparation of a committee report on protection of records from fire.

Fire tests of partitions.—Experimental work was initiated on a series of fire tests of interior partitions. Sixteen fire endurance or fire and water tests were made, the types tested including partitions built of magnesite-wood fiber blocks, fire-retardant treated wood, and of wood supports faced with gypsum plaster on plaster board.

Fire tests of welded steel floor construction.—Equipment for fire tests of a welded steel floor construction, conducted in cooperation with the American Institute of Steel Construction, was completed. This provides means for applying fire exposure from above as well as below on floor panels 13½ by 18 feet.

Additional research work.—Of the 15 research projects conducted under this fund, only 4 have been briefly described. Among the others were: Fire tests of brick walls, fire-protection devices, exit requirements, theater curtains, and standardization of fire-test procedure.

INVESTIGATION OF PUBLIC UTILITY STANDARDS ($107,290)

Electrical codes.—Manuscript was prepared for a new edition of the National Electrical Safety Code, containing revised tables of fiber stresses in wood poles as adopted by the American Standards Association. A report on low-voltage electrical accidents was prepared for the National Safety Council and printed in its transactions.

Measurement of high voltages and large currents.—Measurements made at about 100,000 volts with the large absolute electrometer indicated an agreement within 0.1 per cent with measurements made by means of a voltage transformer and an electrodynamic voltmeter. Refinements in the current-transformer testing equipment have materially increased the reliability and speed of this work. The upper limit for alternating-current tests now is 6,500 amperes at 60 cycles and 8,000 amperes at 25 cycles.

Surveys of telephone service in Government buildings.—Recommendations as to the telephone service in Federal buildings in 17 cities have been made in cooperation with the Office of the Supervising Architect, Treasury Department. Recommendations for telephone service have been made for the new buildings for the Department of Commerce, the Department of Agriculture, Public Health Service, and Federal Warehouse.

Standardization of gas service.—The bureau's representatives have served on six technical committees of the American Gas Association dealing with methods of test and performance of certain types of appliances, on the corrosion of materials used in the construction of gas appliances, and on other technical subjects. Assistance has been given in connection with the proposed revision of the gas-fitting regulations of the District of Columbia and the revision of the National Fire Protection Association relating to the same subject.

Testing and analysis of fuel gases.—Improvements have been made in the apparatus and methods employed for the analysis of gases and these have been incorporated into complete analytical units of superior accuracy and convenience which are now to be produced commercially. Commercial apparatus for the determination of carbon monoxide has been examined and tested, and a series of analyses of city gas was made for the Public Utilities Commission of the District of Columbia during the change from manufactured to mixtures of manufactured and natural gas.

Study of service standards for city gas supplies.—Existing State regulations for gas utilities have been completely summarized. Abstracting of the local service standards, both voluntary and required, of several hundred gas companies and municipalities has been par-

tially completed. A partial study has been made of the economics of the practice of "reforming" gases of high heating values to reduce their heating value before delivery. The improvement of existing standards for the control of heating value, meter testing, pressure control, the uniformity of the gas supplied, and service extensions have also received attention.

Corrosion of ferrous pipe materials.—About 1,000 specimens of ferrous pipe materials exposed to soil action for eight years have been examined and a report on the results prepared. Little difference in the rates of corrosion of the various materials is apparent, but the rates of corrosion differ greatly in different soils.

Corrosion of nonferrous pipe materials and coatings.—Results of the examination of about 2,000 specimens of nonferrous pipe materials exposed to soils four to six years indicate that copper and alloys high in copper resist the action of nearly all soils very well. Zinc coatings offer considerable resistance to soil action if sufficiently heavy and properly applied.

TESTING MISCELLANEOUS MATERIALS ($46,400)

Tests for Government departments.—An unusually large number of tests were made for Government departments on paints, varnishes, bituminous roofing and waterproofing materials, rubber goods, packings, inks, typewriter ribbons, carbon paper, textiles, boiler waters and compounds, detergents, chemicals, dental gold alloys, etc. Miscellaneous materials were tested to determine their fire hazard to guide the Steamboat Inspection Service in making rulings on the transportation of commodities on passenger vessels. A large quantity of mercury was purified for the use of the bureau's laboratories in research work.

Research.—Although this fund provides mainly for the testing of supplies purchased by the Government, four research projects were also carried on. These dealt with the turbidity method for determination of sulphur trioxide in Portland cement, paint and varnish test methods, varnish resins, and preparation of isoprene.

RADIO RESEARCH ($85,700)

Primary frequency standard.—The reliability of the equipment was increased. Checks made against the Arlington time signals, the Riefler and Shortt clocks of the bureau, and a quartz oscillator standard of the Bell Telephone Laboratories in New York by means of a wire transmission of an audio frequency, showed the standard to be reliable in continuous service to better than a part in a million.

Improvement of secondary frequency standards.—The performance of several temperature-controlled piezo oscillators was studied. They were found very satisfactory for controlling a transmitting set of exceptionally constant frequency. An improved piezo oscillator was constructed. Studies of the elasticity and vibration patterns of piezoelectric quartz were continued.

Standard frequency dissemination.—The bureau extended and improved its standard frequency service. The regular transmission of eight frequencies per month was continued. Beginning on Janu-

ary 6, these transmissions were augmented by highly accurate transmissions on 5,000 kilocycles, two hours in the afternoon and two hours at night on three days a month. These transmissions were controlled by a secondary standard piezo oscillator and maintained with an accuracy better than a part in a million. This work is a part of a program for eventually providing one or more frequencies continuously for check and control purposes.

Measurements of radio field intensity.—Field intensity measurements were made between Washington and Chicago on the 5,000-kilocycle standard frequency transmitter. Daytime field intensity measurements made on broadcast and airways phone transmissions indicated that existing formulas for field intensity are not reliable for overland paths at broadcast frequencies.

Improvements in radio measurement methods.—Improved methods of measuring the frequencies of transmitted radio waves with great precision were developed. New equipment for calibrating condensers, and an improved audio frequency oscillator incorporating a piezo oscillator have been designed and built.

Character and cause of variations of radio wave intensity and direction.—The technique of automatic recording of field intensities was developed and applied to observing the synchronized transmissions of certain broadcasting stations. The fading records taken on the Byrd Antarctic expedition were analyzed and prepared for publication. They showed that for frequencies of about 9,000 kilocycles per second over long paths the field intensity increased with the increase of darkness over the path; as the frequency increased to about 16,000 kilocycles per second the field intensity at first increased with increase of darkness until the path was about half dark and then decreased as the darkness increased.

Measurement of the height of the Kennelly-Heaviside layer.—Using the echo method, the height of the Kennelly-Heaviside layer was regularly recorded on frequencies from 590 to 10,000 kilocycles per second. Beginning in June, 1931, Kennelly-Heaviside layer height data were furnished to Science Service for publication in the Ursigrams each week. Transmitting and receiving apparatus for this work was developed so that pulses one ten-thousandth second in length can be transmitted and recorded. Plans for an automatic continuous recorder of Kennelly-Heaviside layer heights were developed.

Miscellaneous.—Eighteen projects were provided for under this fund. Among those not included in the preceding paragraphs may be mentioned: Improvement of radio standards of capacity, study of short waves, characteristics of receiving sets, and power factor of mica.

COLOR STANDARDIZATION ($15,800)

Transformation of color mixture data.—Methods for the determination of trilinear coordinates of color by visual photometric measurements have been improved; also methods of computing dominant wave length and colorimetric purity. Experimental data by Wright on equivalent color stimuli have been transformed so as to be more readily comparable with previous data. Methods of expressing tolerances in color specifications have been worked out.

Standardization of Lovibond glasses.—Methods of measurement have been improved, and 240 red glasses (making a total of 1,696 since January 1, 1928) were calibrated for use with 35 yellow, as in the vegetable-oil industry. Attention is now being given to standardization of the glasses in other connections urgently demanded.

Standard glass filters for testing spectrophotometers.—The rapidly increasing industrial use of spectrophotometers makes the establishment of this service a matter of urgent importance. Preparations have been made to issue filters of certified spectral transmission, which may be used in testing the performance of spectrophotometers.

Standards for railway signal glasses.—Although the bureau has made spectrophotometric tests of railway signal glasses for many years, the standard glasses established by the American Railway Association have heretofore been in private custody. These are now being transferred to the bureau.

Miscellaneous.—Fifteen research projects were conducted under this fund. In addition to those mentioned, the following may be listed: Life tests of lamps used for color-temperature determinations, measurement of diffuse reflection, color of daylight, spectral reflection of colored silk, and cooperation on new absolute standard of light.

INVESTIGATION OF CLAY PRODUCTS ($49,000)

Factors affecting the crazing of earthenware.—This investigation has been extended to include individual ceramic raw materials and a study of the effect of particle size. Data obtained indicate particle size to be an important factor, and the relative reaction of the various materials is shown by the following values: Feldspar, 2.5; lepidolite, 1.6; Cornwall stone, 1.4; clay, 0.4; flint, 0.05. Since it would be impracticable to replace feldspar entirely with one or more other fluxes, and since data on commercial ware show a fairly direct relation between porosity and moisture expansion, it would seem logical to correct susceptibility of earthenware to crazing by lowering the absorption.

Special low-fire, white-ware bodies.—With the development of means for heating electrically, the attention of the ceramic industry has been directed to this source of heat, and a study was undertaken to determine the possibilities of maturing white ware at, or below, 1,000° C. Wall tile, dry press plates, and cast ware were successfully matured and glazed at 950° C. The specimens produced withstood the autoclave test for resistance to crazing.

Feldspar and its effect on pottery bodies.—The final report has been published in the Journal of the American Ceramic Society.

Cutlery marking of chinaware.—A final report is in course of publication and will contain data of sufficient significance to justify the careful control, or elimination, of sulphur in decorating kiln atmospheres, thus aiding in the production of glazed ware which will not be susceptible to metal marking.

Changes in clay at high temperatures.—High temperature constitutional changes of clay, determined petrographically and by X rays, include complete dissociation of the clay molecule into silica and alumina at temperatures below 900° C. These combine in part at temperatures as low as 1,050° C. to form mullite.

Study of refractories.—Preliminary data obtained at 1,250° C. on 17 different brands of fire-clay brick show the modulus of elasticity to range from 70,000 to 300,000 pounds per square inch, and the modulus of rupture from 50 to 670 pounds per square inch. Bricks having either a very high alumina or silica content show much lower plastic deflections than do bricks having an approximately equal mixture. X-ray diffraction patterns established that the high rate of thermal expansion occurring in most fired clays between 100° and 200° C. is governed by the percentage of cristobalite present. For comparative purposes 23 brands of fire-clay brick were tested for resistance to thermal spalling according to the requirements of the two present standard methods and four modifications of these.

Resistance of metals to the abrasive action of plastic clay.—Tests have been made on 19 metals and alloys to determine their wear values. Also, the following fundamental factors have been determined: Relation between abrasion loss y and extrusion pressure x; relation between water content w of the clay and extrusion pressure; and relation between diameter d of the cylindrical orifice of the die and the extrusion pressure. These equations are, respectively: $\frac{y^n}{x}=c$; $wx^r=k$; and $d^2x=e$. In the order from highest to lowest resistance to abrasion the different types of metals and alloys tested are as follows: (1) Chrome-cobalt-tungsten compositions; (2) carbon-cobalt-chrome molybdenum steels; (3) vanadium steels; (4) high carbon steels; (5) cast irons; (6) rustless steels; (7) copper; (8) soft brass.

Problems relating to saggers.—Data obtained on the thermal expansion, moduli of elasticity and rupture, porosity, computed outer fiber strain, and plastic flow of specimen bars and small saggers prepared from each of 45 different sagger bodies fired at from one to three different temperatures indicate that it is very important to analyze the conditions of service under which saggers are to be used, because in most cases it is impossible to prepare from the usual run of clays sagger bodies which have properties ideally suited for longevity in all types of service.

Thermal dilation of special refractories from 20° to 1,800° C.—The linear thermal expansion was measured before and after heating to 1,700° C. or higher of California magnesite, silica brick, and Rhodesian, African, Grecian, and Indian chrome ores.

Properties of architectural terra cotta.—The investigation of terra cotta was continued in cooperation with the National Terra Cotta Society. Several buildings were inspected to determine what defects are developing in terra cotta in service. Laboratory research has continued for improving the quality by better manufacturing methods and to improve methods of setting the material in the building. Standard tests were developed and tentative specifications for terra cotta were prepared. It was found that certain glazes expand, because of the action of water, in a manner similar to bodies.

Columbus laboratory.—A study of the glassy bond present in fired ceramic materials has been started by preparing glasses likely to be formed by the constituents present and determining certain properties. Continued work on the properties of the colloidal separates of both English china clay and Ohio shales shows some general corre-

lations, but certain exceptions made necessary a study of the replaceable bases present in the clays, with promising results. In the temperature range 0° to 1,200° C. a number of commercially ground feldspars were found to give off relatively large volumes of water vapor, acid, and other gases. A number of new points were located in the multiple component system involved in the interaction of the slags and clay refractories of boiler settings.

Additional projects.—A total of 10 research projects were provided for by this fund. In addition to those mentioned, progress was made on the following: Physical properties of commercial English china clays, causes of failure of boiler refractories, and energy changes accompanying heating of clay materials.

STANDARDIZING MECHANICAL APPLIANCES ($51,321)

Testing of engineering instruments.—Approximately 1,300 instruments were calibrated, an increase of about 25 per cent over the previous year. In cooperation with the United States Geological Survey some experiments were made on meter equipment.

Postage metering and stamp vending devices.—The investigation and testing of mail metering and similar automatic devices for the Post Office Department have continued. There has been a rapid expansion in the development of machines of this nature, and the volume of work has shown a marked increase.

Fire extinguishing appliances and equipment.—Fire extinguishing appliances and systems have been tested for the Steamboat Inspection Service. Technical data on their effectiveness and reliability have been supplied. This work showed a marked increase in the past fiscal year.

Heating appliances for Government buildings.—A series of performance tests of radiator room temperature control valves for the new Commerce Department Building were made for the Office of the Supervising Architect of the Treasury Department. Performance tests of several types of radiator return line traps were also made for the same office.

Elevator safety interlocking devices.—Performance tests of elevator interlocking devices for compliance with the recently adopted "American Standard," have been extended to include additional devices. Results of these tests are used as the basis of approval by Government departments, certain State governments, and a group of casualty insurance companies.

Investigation of propeller fans.—A study was made of the effect of certain entrance conditions on the performance of 2-blade propeller fans and of the effect of increasing the number of blades from two to four. The results are described in the March, 1931, issue of the Journal of Research.

Plumbing investigations.—Investigations, partly financed by the plumbing industry, combining an experimental study of flow in pipes with field observations and measurements on plumbing systems in actual use, are in progress. A tower 100 feet high, surmounted by a 3,000-gallon tank and equipped with pumps and supply pipes delivering about 600 gallons per minute, has been erected and will provide equipment for measurements of capacity flow in sloping drains up to

6-inch diameters. A revision of those sections of the plumbing code relating to drainpipe sizes was completed in May, and the revised sections are being printed as a supplement to the report of the subcommittee, pending the completion of the present investigations.

INVESTIGATION OF OPTICAL AND OTHER TYPES OF GLASS ($27,300)

Production.—Thirty pots of optical glass, embracing five different kinds of glass, were melted. From these melts 37,955 blanks for optical elements, weighing 3,001 pounds, were made for the Navy Department.

Viscosity.—Viscosity measurements on six ordinary kinds of optical glass have been completed. Results show that the viscosity between 1,000° and 1,400° C. increases in the following order: Dense flint, medium flint, borosilicate crown, light barium crown, barium flint, ordinary crown.

Composition and physical properties of glass.—Relations between composition of certain soda-lime-silica glasses and their refractivities (N–1) can be more accurately expressed by simple equations than by exponential equations. The best solution obtained is $(N-1)=aA+bB+cC$, in which A, B, and C are the percentages of silica, soda, and lime, respectively, in the glass and a, b, and c have the following values in the indicated silica ranges:

Silica range	a	b	c
50 to 59.5 per cent	0.004836	0.005491	0.007521
59.5 to 73.75 per cent	.004785	.005568	.007598
73.75 to 100 per cent	.004584	.006127	.007977

Specific volumes (V) of these glasses can be computed from $V=a_1A+b_1B+c_1C+d_1C^2$, A, B, and C having the same significance as above and the values of the constants are:

Silica range	a_1	b_1	c_1	d_1
50 to 59.4 per cent	0.0042520	0.0035370	0.0025667	0.0000061
59.4 to 66.3 per cent	.0043028	.0034628	.0025000	.0000040
66.3 to 74.9 per cent	.0043922	.0032872	.0023190	.0000025
74.9 to 100 per cent	.0045400	.0023460	.0017900	.0000194

Additional research.—In addition to the two research projects described in the preceding paragraph, eight other researches were conducted under this fund, including: Properties of special glasses, chemical analysis of glass, molding and annealing, and methods of hardening glass.

INVESTIGATION OF TEXTILES, ETC. ($60,900)

Fastness to light of dyed textiles.—In cooperation with the American Association of Textile Chemists and Colorists a series of standards was selected for the different degrees of fastness. The relative fastness to light of 1,197 cotton, wool, silk, and weighted silk dyings,

representing 366 dyestuffs, when exposed to sunlight in the standard "sun test" of the association, were tabulated and classified into 7 fastness classes.

Weighted silk.—An accelerated aging test for weighted silk was developed. There is good agreement between the effects of exposure of silk to a carbon arc light for a few hours under certain conditions of temperature and humidity and those of exposure to a north light for several months.

Standardization of knit underwear.—As the result of a general conference of manufacturers, distributors, and users, the standards for undergarments developed in cooperation with the Associated Knit Underwear Manufacturers of America were approved as a commercial standard. The consumer should now be able to purchase underwear of proper size and fit regardless of where it was made or the price paid for it.

Properties of knit fabrics.—To obtain basic information on the effect of variables on such properties of fabrics as air permeability, thermal transmission, coefficient of friction (slipperiness), and moisture permeability, comparative samples of knit underwear fabrics of about 100 different constructions were tested. The results are now being summarized and collated.

Special textile test methods.—A study of new apparatus for measuring the thermal transmission of fabrics shows that it is much simpler to construct and to operate than the earlier apparatus, requires a smaller sample for test, gives results more rapidly, and is compact and portable. The values agree with those obtained at other laboratories. An instrument was constructed by which thickness can be read directly for any pressure on the fabric from zero to a given maximum.

Cotton fabric for parachutes.—Parachutes made from cotton cloth woven at the bureau and tested at Lakehurst by the Bureau of Aeronautics of the Navy Department, functioned nearly as well as silk parachutes. Two 75-yard lengths of cotton parachute cloth have been woven in the bureau's mill and will be submitted to the Bureau of Aeronautics for further trial. A report on the work has been published by the National Advisory Committee for Aeronautics.

Mercerization of cotton for aeronautical purposes.—A mercerizing machine for studies under strictly controlled conditions was built. An experimental procedure was developed for studying the factors of tension during mercerization, time, temperature, and concentration of caustic.

Government papers.—In cooperative research on paper currency with the Bureau of Efficiency and Bureau of Engraving and Printing, papers were made from highly-purified wood fibers which complied with the currency paper specifications and which had satisfactory printing qualities. Paper-making trials of pulp from redeemed paper currency show that satisfactory paper pulp can be made from this material. The addition of phosphoric acid to the gum of postage stamps was found to improve the adhesion of stamps to the more resistant types of envelope papers.

Paper-testing methods.—Methods of measuring grease, water, and air resistance, and acidity of paper have been standardized for the Technical Association of the Pulp and Paper Industry. The

American Society for Testing Materials was assisted in the establishment of a standard procedure for determining the folding endurance of insulating papers. Progress was made in the study of hygrometry as related to paper testing.

Standardization of commercial paper products.—The printing quality of lithographic papers is being studied in cooperation with the Lithographic Technical Foundation. As misregister is the most important problem, the work has been confined mainly to plant and laboratory studies of effect of variable humidity and tension. Paper towels, insulating boards, and binders boards were also studied.

Paper-making materials and processes.—Coating tests of domestic caseins were made to assist the Bureau of Dairy Industry of the Department of Agriculture in finding more suitable grading standards. Assistance was also given the American Newspaper Publishers Association and the Government Printing Office in correlating the printing qualities of newsprints with their components.

Preservation of records.—An accelerated test, using heat, for determining permanence of Government writing papers classifies them in the same way as sunlight. In paper-making experiments with highly purified wood fibers, papers were produced which compared favorably in stability and strength with the Government permanent record and currency papers. Data were obtained on the relation of sizing materials and fiber beating treatment to the stability of the papers. A survey of documents in public libraries shows the chief external deteriorating influences to be acid pollution of the atmosphere, high temperature, variations in atmospheric humidity, light, and dust. Laboratory studies of effect of acid-polluted air and of light are in progress. Tests of old publications stored in libraries revealed the importance of purity of paper fibers if papers are to resist deteriorating influences. The support of these studies by the Carnegie Corporation and the Brown Co. was continued.

Scope of the work.—This fund provided for a total of 20 research projects. The field covered is indicated in the preceding paragraphs, the examples selected being typical.

SUGAR STANDARDIZATION ($95,000)

Preparation of crystalline ribose.—This sugar is of great importance in the study of the physiological processes of the human body, but its cost is so high that but little attention has been paid to it. The bureau has undertaken a study of ribose to reduce its cost and to obtain information on its physical and chemical behavior and its relation to other sugars. A quantity of pure sugar has been obtained and an improved method of preparation developed which has resulted in a materially lowered cost.

Oxidation of sugars.—A new process has been developed for the manufacture of sugar acids and their salts. When it is desired to produce a salt the sugar is electrolytically oxidized in the presence of a bromide and a base. The bromide is continuously regenerated; hence a small amount will facilitate the oxidation of a large quantity of sugar. Since the raw materials are cheap, the new process has considerable commercial possibility for the manufacture of calcium gluconate and similar products.

Tariff act of 1930.—Much time was devoted to the investigations requested by the Congress during the drafting of the tariff act of

1930. In this act a radical change was made in the method of assessing duty upon molasses. The component of chief value is the total amount of sugar, and the new act orders the collection of the revenue on the total number of pounds of such sugar. This procedure necessitates changes in methods employed. These methods have been perfected, and in collaboration with the Bureau of Customs the necessary revision of the customs regulations has been made.

Method of levulose manufacture.—Gratifying results have been obtained in experiments with the semifactory-scale plant for the production of hard refined levulose. Portions of the plant were operated on a considerable scale and data secured to redesign unsatisfactory equipment. Among the more important new pieces now completed and in operation are: Converter temperature control, automatic defecator control, calcium levulate crystal grower, carbonator, and filter assembly. A carload of artichoke tubers was furnished gratuitously to the bureau by the Alabama Power Co., Birmingham, Ala., and transported free of charge by the Southern Railway.

Other work.—Eighteen pieces of research were provided for under this fund, including, in addition to those already described, oxidation of sugars by bromine water, optical constants of sugar, determination of density of molasses, lime precipitation of levulose, and optical identification of sugars.

GAGE STANDARDIZATION ($50,000)

Certification of master gages.—The American Petroleum Institute's grand and regional master cable tool joint gages have been remeasured. Many of the ring gages were found to be outside of tolerances on lead of thread, and the American Petroleum Institute arranged for correction of the gages by the gage maker. Complete sets for two sizes of joints have been corrected and remeasured. The remaining nine sets will be corrected and recertified during the summer and fall.

Gages for interchangeable ground-glass joints.—The manufacturers of ground-glass joints replaced the original master plain taper gages with more accurate gages made in this country. These were checked and found to be satisfactory.

Cooperation with the National Physical Laboratory and the Physikalisch-Technische Reichsanstalt.—Foreign manufacturers of oilfield equipment are using A. P. I. standards to a large extent, and the American Petroleum Institute has appointed both the National Physical Laboratory of England and the Physikalisch-Technische Reichsanstalt of Germany as official testing agencies for A. P. I. gages made in Europe. This has led to considerable correspondence between the bureau and these laboratories with regard to interpretation of A. P. I. gage specifications and standardization of methods of test.

New facilities.—Equipment added includes 31 internal micrometers for measuring plain-ring gages, attachment for measuring tapers on pitch diameter of ring gages, and comparators for determining variations in roundness and straightness and for comparing gage blocks and plug gages with an error of only two or three millionths of an inch.

INVESTIGATION OF RAILROAD AND MINE SCALES AND CARS ($102,300)

Master track scale calibrations.—Eighteen of the nineteen master scales in service were visited and calibrated by direct application of standard test loads. Minor modifications or adjustments were made on 10 scales and all were left accurate within an " adjustment tolerance " corresponding to an allowable error limit of 0.01 per cent.

Railroad track scales.—A total of 1,030 scales were tested, the greatest number ever covered in one year. Of these 75.9 per cent were correct within the bureau's tolerance which allows a mean maximum weighing error equivalent to 0.20 per cent of the applied test-load values. The average maximum weighing error was 0.21 per cent or but 0.01 per cent more than the allowable error limit. These values, in comparison with the results for the preceding year, indicate a higher proportion of correct scales but a slightly greater average weighing error.

Track scales for weighing grain.—Tests were made of 97 track scales utilized at grain elevators and mills for weighing carload consignments of grain. Slightly more than half were correct within the special tolerance of 0.10 per cent. A survey has shown that approximately half these scales are incapable of continuous maintenance within the tolerance recommended for them by the Interstate Commerce Commission. (I. C. C. Docket 9009.)

Test-car calibrations.—At the master scale depot, Clearing Station, Chicago, railroad track-scale test-weight car calibrations were made for 13 different owning systems on 28 different cars. The total number of calibrations was 57. In addition, 23 track-scale test-weight cars owned by railroads and industries which do not have access to master scales were calibrated by direct comparison with standard weight test loads in the field.

Paint coatings for test weights.—A study of the durability and protective characteristics of various paints recommended for application to 50-pound test weights is under way. Results thus far indicate that the constancy of test-weight values is dependent more upon conditions of handling and transportation than upon the nature of the paint coating. Loss of weight usually results from abrasion and chipping of the metal.

Contacts with technical bodies.—The bureau cooperated with the National Scale Men's Association and the American Railway Association in drafting a code of specifications for track-scale test-weight cars. Two new projects on which the bureau will cooperate with the first-named organization are: Preparation of a code of rules for operation and maintenance of track-scale test-weight cars, and definition of what constitutes a proper test of a railroad track scale.

Mine scales.—Tests were made of 140 scales in the coal-mining sections of West Virginia, Maryland, Indiana, and Ohio. About 48 per cent were found correct within the allowable tolerance of 8 pounds per ton of applied test load. A conspicuous increase in the proportion of correct scales is indicated. Improvement is most pronounced in the States of Maryland and West Virginia.

Improvements in field equipment.—Testing outfit No. 1, in use since 1913, will be replaced by new equipment, strictly modern in all re-

spects and containing improved facilities for handling and maintenance of weight standards. Testing outfit No. 3, which for some time has been in poor mechanical condition, has been shopped for replacement of journal bearings. This is expected to improve its transportability and eliminate it as a real or apparent transportation hazard. The outfit has been in steady service since 1918.

Postal scales and weighing.—At the request of the Post Office Department, laboratory studies were made of the speed and accuracy of weighing postal matter, and numerous samples of scales intended for postal weighings were tested. Assistance was also given the Post Office Department in the development of purchase specifications for postal scales and in the training of a field personnel which will conduct acceptance tests on new scales and routine service tests on scales in use in post offices throughout the United States.

Cooperation with Government departments.—Frequent consultations have been held with representatives of Federal departments on weighing and measuring problems and equipment, and numerous weighing and measuring devices have been tested or examined for these agencies, both in Washington and at Clearing Station, Chicago.

Cooperation with the States.—Formal State conferences were attended in Illinois, Indiana (two), Maine, Massachusetts, New Jersey, New York, Ohio, and Pennsylvania. The preparation of a digest of weights and measures court decisions was continued.

METALLURGICAL RESEARCH ($61,000)

Aeration and submerged corrosion.—With low oxygen contents the rate of initial corrosion of iron increases as the oxygen increases. With a high oxygen content a reversal occurs, and the rate of corrosion decreases with increase of oxygen. The pH of the water affects the form of the curve. Slight but consistent differences were observed with different compositions of iron and steel.

Copper roofing materials.—In cooperation with the Copper and Brass Research Association a study of these materials is in progress. Emphasis has been placed on corrosion failures, such as soldered seams and pitting.

Copper-base ingot metals.—A study of typical copper-base casting alloys is being conducted in cooperation with the Non-Ferrous Ingot Metal Institute, with the object of classifying such alloys on the basis of properties and thus simplifying specifications. The method of pouring specimens is being studied.

Fluidity of liquid metals.—A method has been developed for determining in the foundry the fluidity of any molten metal when cast into a mold. The length of the spiral casting made under carefully controlled foundry conditions has been found to be the most practicable test and to give very valuable information on the effect of different casting variables such as pouring temperature, sand "temper," etc.

Shrinkage of molten metals.—A method has been developed for measuring the shrinkage of metals in casting, and in cooperation with the American Foundrymen's Association it has been applied to measurements of cast iron.

Fatigue of metals—effect of inclusions.—A comparative study of two methods for determining the endurance of metals—the rotary beam and the axial-loading methods—has been made. The results indicate that the latter is a more "searching" test for determining the true endurance properties of material, such as rail steel, which contains inclusions.

Bridge wire.—Laboratory tests of specimens of heat-treated carbon steel wire from failed bridge cables did not reveal any characteristics to arouse suspicion, either in structure or properties. A method has been developed for testing the entire wire in fatigue. The results of fatigue and other tests on the entire wire indicate that the surface characteristics contributed greatly to the "spontaneous" failure of the wire under load. Long-time tension tests to demonstrate this are under way. The effect of possible changes in the wire by aging after heat treatment is being studied by thermomagnetic analysis.

Fatigue of metals.—In studying the effect of surface conditions on the endurance properties of bridge wire it has been found that galvanizing by hot dipping consistently lowers the endurance limit of annealed or heat-treated carbon steel, while zinc coating by electroplating has the opposite effect.

Rail steel.—Transverse fissures appear to be an outgrowth of secondary brittleness. By retarding cooling of a rail, after rolling, secondary brittleness can be minimized. Impact tests at high temperatures have shown a parallelism between secondary brittleness and low impact strength.

Spark testing of steel.—A chart showing the spark characteristics of steels has been prepared.

Machinability of metals.—A report has been issued on the relation between composition, heat treatment, and the machinability of steel forgings.

Additional projects.—Sixteen pieces of research were conducted under this fund. Ones not mentioned above, include: Study of Preece test for zinc-coated wire, corrosion of nonferrous metals, durability of screen wire cloth, effect of excessive cold working of metals, and properties of platinum metals.

HIGH TEMPERATURE INVESTIGATION ($10,200)

Melting and pouring temperatures of gray iron impact specimens.—The pouring of 380 test bars in 14 foundries was supervised, and pouring temperatures measured in cooperation with the American Society for Testing Materials.

Effect of elevated temperatures on micas.—The effect of temperature on the properties of 19 different kinds of mica, 12 of foreign and 7 of domestic origin, was determined.

Thermoelectric properties of platinum-rhodium alloys.—The study of the thermoelectric properties of the platinum-rhodium alloys has been completed.

Miscellaneous.—Work was also done on the effect of atmosphere on the freezing point of silver and on the establishment of a scale of color temperature, based on the color of black bodies.

SOUND INVESTIGATION ($11,260)

Ultra-sonic waves.—A research on the speed of transmission of ultra-sonic waves through various solutions and suspensions has been carried out. A report of this investigation, which is in a rather new field, will be published in the Journal of Research.

Sound-proof partitions.—The investigation of wall and floor structures designed to prevent or minimize the passage of sound has been continued. Noises resulting from direct impact with the partition, such as the impact of uncushioned heels on a bare floor, are transmitted more readily than air-borne sounds, and a special study has been made of floor structures designed to minimize such sounds.

Other projects.—Six projects are carried by this fund. In addition to the two mentioned are: Acoustical properties of materials, acoustics of auditoriums, standardization of tuning forks and bars, and the photographic recording of sound.

INDUSTRIAL RESEARCH ($225,000)

Storage battery construction and operation.—Paste mixtures from special samples of oxides having coarse particle sizes have been studied. Bismuth as an alloy in the construction of grids for storage-battery plates has not been found satisfactory. Automatic testing equipment has been installed for testing storage batteries.

Bituminous pipe coatings.—Approximately 90 varieties of bituminous pipe coatings are under observation. Methods of measurement which are independent of the observer have been developed. Examinations of specimens indicate that a large percentage of the coatings as applied contain pinholes, absorb moisture, and have low electrical resistivity after a year's exposure to moist soil.

Cable design.—In cooperation with the United States Coast Guard, a special submarine cable using rubber of low dielectric constant was designed. Over the armor of the cable there is a rubber jacket having properties similar to the tread of automobile tires. About 10 miles of this cable has been constructed and laid from Miami to a neighboring lighthouse.

Properties of electrical insulating materials.—A series of 17 compounds containing sulphur from 0 to 32 per cent in steps of 2 per cent, with pure rubber hydrocarbon, has been studied. The dielectric constant and power factor were measured at temperatures ranging from −80° to +260° C. at six frequencies between 60 and 1,000,000 cycles per second.

Wind pressure on structures.—Papers on wind pressure on circular cylinders and chimneys, and on measurements on a model of a mill building have been published. A contract has been placed for the construction of a model of one of the tall buildings recently completed in New York City.

Orifice meter research.—The work of analyzing experimental data has been continued and two papers have been prepared. The first deals with the difference of behavior between liquids and gases, and the second with experiments on the metering of large volumes of air.

Lag of aircraft thermometers.—The experimental determination of the thermometric lag of the various types of thermometers now used for measuring air temperature in aircraft was completed. With proper allowance for design limitations the electric resistance thermometer has a smaller lag than the bimetal and liquid-filled types.

Transfer of heat by convection.—A fundamental study of the phenomenon of transfer of heat by convection was initiated, attention thus far having been directed toward measurements of temperature distribution in fluids in the immediate neighborhood of heated bodies. An optical interference method, which utilizes the change of index of refraction of fluids with temperature, is employed. Measurements have been made of the temperature distribution in air surrounding flat plates and heated cylinders of various sizes.

Thermal conductivity of insulating materials at ordinary temperature.—Investigation of the mechanism of heat flow in fibrous materials was completed and published in the Journal of Research. (R. P. 243.) Useful data on the effect of arrangement of fibers and density of packing on the thermal conductivity are presented in the paper.

Pressure-volume-temperature relation of oil-gas mixtures.—In cooperation with the American Petroleum Institute measurements have been made of the volume and density of the liquid phases and the density of the gas phases of three crude oil-gas mixtures at various pressures and temperatures. The pressure range covered was 1 to 200 atmospheres and the temperature range 30° to 90° C.

Compressibility and thermal expansion of petroleum oils.—The results of this investigation, which was conducted in cooperation with the American Petroleum Institute, were published in the November, 1930, issue of the Bureau of Standards Journal of Research.

Thermal properties of oils.—This investigation has been carried on in cooperation with the American Petroleum Institute. Values have been obtained for the specific heats of (1) gasolines from 30° to 120° C., (2) gas oils from 30° to 180° C., and (3) lubricating oils from 30° to 200° C., which substantiate equation 5, page 26, Miscellaneous Publication No. 97, and the equation for specific heat on page 151, International Critical Tables, Volume II.

Vapor pressure of carbon dioxide.—Previous measurements at temperatures down to −50° C. have been made at this bureau. The range of observations has been extended to −78° C. Observations below this temperature are not considered necessary since sufficiently accurate measurements have been made at other laboratories. All available data are being correlated.

Properties of organic liquids.—Using the methods and apparatus previously developed for measurements of thermal properties of water and steam, values were obtained for the heat content and latent heat of vaporization of methyl alcohol, ethyl alcohol, and benzene, in the range 40° to 110° C. The results have been published in the Journal of Research.

Heat of combustion of methyl alcohol.—With an improved type of calorimeter the heat of combustion of liquid methyl alcohol at 25° C. has been found to be 726.34± 0.20 int. kilojoules per mole. This new value is about 1½ per cent higher than the highest previously reported result and completely removes certain discrepancies occur-

ring in the thermodynamic data in connection with the process of synthesis of methyl alcohol.

Heat of ionization of water.—This has recently been recalculated and the best value on the basis of existing data is 57,370 absolute joules per mole at 18° C.

Cryoscopic constant of camphor.—Discordant values for this constant have been reported in the literature. A new calorimetric determination of this quantity from the latent heat of fusion of pure camphor has therefore been carried out.

Heat content of phosphorus pentoxide.—As a contribution to the thermal data required in connection with industrial processes for the manufacture of fertilizer from phosphate rock, a determination of the heat content of phosphorus pentoxide between room temperature and 800° C. has been carried out.

Phase equilibrium diagram for the system Cr_2O_3–Al_2O_3.—This diagram has been determined and is characterized by complete miscibility of the two components in the crystalline state.

Acid in leather.—Leather tanned with quebracho-wood extract was found more resistant to deterioration by sulphuric acid than leather tanned with chestnut-wood extract. The influence of the degree of tannage was slight. No significant difference was found in leathers containing sulphuric acid, and to which 0, 10, and 20 per cent of cod oil and tallow had been added after the acid treatment. The rate of deterioration is greater with higher relative humidity. Commercial leathers tanned chiefly with a blend of chestnut and quebracho gave results between those obtained for leathers tanned with each of the materials alone. Chemical methods for determining the hydrolysis of the hide substance by sulphuric acid in these leathers gave results which parallel the deterioration of the leather on aging. Preliminary experiments show that the addition of salts to leather containing sulphuric acid decreases the rate of deterioration, and the addition of saturated oxalic acid solutions causes slight deterioration after six months' aging.

Salt for curing skins.—Analyses of 30 samples of typical rock and evaporated salts used for curing hides and skins show the salts to have a high degree of purity. The data have been presented for reference use in problems of damaging stains on hides and skins.

Fur-seal skins.—The thickness, tensile strength, stretch, and tear resistance of fur-seal skins were determined to aid in developing standards of quality.

Stress-strain recorder for rubber.—A simple and effective apparatus has been constructed for recording the stress-strain curves of rubber both on extension and on retraction. The behavior of rubber may be followed through any desired number of cycles of stress at any desired speed or elongation.

Repeated stressing of rubber.—The manner in which the stress-strain curve of rubber changes under various circumstances of stressing and the mode and extent of recovery on resting have been measured.

Photoelastic analysis of stresses in rubber.—The photoelastic effect in rubber has been shown to be proportional to stress, as is known to be the case for more rigid materials. Stress distribution around models of pigment particles in transparent rubber is being investigated.

Thermal conductivity of metals.—A comparatively simple yet accurate method and apparatus for measuring thermal conductivity of metals up to 600° C. has been developed. Measurements have been made on a few pure metals and on a number of steels and other alloys, mostly of the heat-resisting type.

Thermal expansion of heat-resisting alloys.—The research on heat-resisting alloys has been completed, and forms a valuable contribution to the literature on these alloys which are now being used extensively where resistance to tarnish and weathering is demanded.

Heat-resisting alloys.—Cooperation with the joint research committee, American Society for Testing Materials, and American Society of Mechanical Engineers has been continued with emphasis on the structural changes at high temperatures. Embrittlement by carbide precipitation at high temperatures has been studied with reference to the magnitude of the stresses to which the materials are subjected.

High-temperature properties of metals.—As a basis of all commercial alloys for high-temperature service the "creep" characteristics of the Cr–Fe–Ni series have been studied. The effect of various alloying elements for stabilizing austenitic steels has been studied in cooperation with a manufacturer of such materials.

"Gas content" of metals.—Two reports were issued, one summarizing in detail the analytical method. In the experimental work emphasis has been placed on the determination of "gases" in steel deoxidized in a special manner and on "abnormal" steels for carburizing.

Solubility of gases in metals.—A report on the carbon-oxygen solubility product in liquid steel has been issued. The value, 0.0025, has been found for this product, and 0.011 for the carbon-ferrous oxide product. The lower results reported by another research laboratory have been shown to be in error.

Quenching of steel.—As quenching media for steels, intermediate between water and oil, sodium silicate solutions appear much superior to glycerin and other solutions used commercially.

Wear resistance of metals.—The behavior of heat-treated carbon steels under abrasive wear by sand and under combined sliding and rolling metal-to-metal wear has been studied. The effect of grain size of the metal on its wear resistance and the influence of the atmosphere surrounding the specimens are also being studied.

Wear resistance of chromium-plated gages.—The advantages of chromium plating on gages of a simple shape have been clearly shown by tests in a special gaging machine.

Bearing bronzes.—In cooperation with a manufacturer, the relation of the wear resistance of bearing bronzes to the temperature at which they were cast has been studied; likewise, the effect of iron as an impurity in such bronzes. The most detrimental of the common impurities appears to be antimony.

Journal-bearing performance.—In cooperation with the American Society of Mechanical Engineers, the distribution of hydrostatic pressure in the oil film of a journal bearing has been determined. Nine tests were made covering a fairly wide range of typical conditions of operation.

Efficiency of gears.—In cooperation with the American Electric Railway Engineering Association, the friction losses under various

conditions of operation have been determined for three types of street-car reduction gearing. These include a single reduction, double reduction, and worm gear.

Anodic treatment of aluminum.—A rapid method for determining the quality of the coating, produced on duralumin by the anodic process of oxidation has been developed. The usefulness of this treatment as a preliminary before painting or varnishing has been established.

Analysis of silver-plating solutions.—Detailed methods for the analysis of silver-plating baths, including the determination of impurities and of their effects on the methods for other constituents, have been developed.

Dimensional changes in the manufacture of electrotypes.—In cooperation with the International Association of Electrotypers, the conditions for producing electrotype plates of uniform dimensions were defined. This information is especially useful in color printing, where the corresponding plates must register accurately.

Crystallography of organic compounds.—The optical properties of crystalline organic compounds have been determined for use in later identifications by optical methods. A photomicrographic technique was developed for use, especially, at very low temperature. Chemical microscopical examinations of special materials were carried out. The optical constants, densities, solubilities, and inversion temperatures of the formates of the metals in Group II were determined.

Spectrochemical analysis.—Several hundred samples of materials were analyzed, a large part of which were iridium and rhodium sponges prepared by the bureau in an attempt to obtain these metals in a higher state of purity than ever before accomplished. The effectiveness of the various chemical methods used was tested by spectrographic analysis, leading to final products of almost spectroscopically pure metals. Entirely new descriptions of the emission spectra, both arc and spark, of krypton, lutecium, ytterbium, columbium, and rhenium were obtained; that of rhenium being entirely new and serving, through the spectral regularities found, to deduce the structure of this last element to be discovered.

Optical instruments.—By combining the principles of the military range finder and the microscope, an optical depth gage has been designed and constructed by which lengths in the direction of sight may be measured with high precision. A sample instrument following the same design has been built by an optical manufacturer for use in assembling the sound reproducing mechanism of a motion-picture projector.

Photographic emulsions.—In the investigation of the principal independent variables of "after ripening" (ripening after washing), the effects of temperature, bromide, and hydrogen ion concentrations were tested on emulsions made by neutral and ammonia formulas, with varying gelatin and iodide content at varying stages of ripening. Emulsions made with normal gelatin were compared with those made with deactivated gelatin and known nuclear sensitizers. The results support the chemical-reaction theory of ripening.

Atomic structure investigations.—It has been found that metals bombarded by electrons even at potentials as low as one or two volts

emit a continuous spectrum extending through the visible and ultraviolet region. Most metals give a nearly identical spectrum which is evidently analogous to the continuous X-ray spectrum. Silver gives in addition a selective band of radiation corresponding perhaps to characteristic X radiation. These results fill a conspicuous gap in our knowledge of radiation processes and the atomic structure of metals.

Identifications.—Unusually heavy demands for testing and advisory service in this work have delayed the research on standardization. The bureau has made 22 official tests and was able to dispose of 16 additional requests by preliminary examination. In a single case in which a defendant pleaded guilty to a charge of fraud in connection with a claim for refund on income taxes the Federal Government was saved over $150,000 in principal and interest, and thousands of dollars additional by avoiding the expense of trial of the defendant. The plea of guilty was a direct result of identification established by the bureau. Lectures were given before each of the five groups of students trained by the Department of Justice as special agents.

Research associates.—The following table gives the names of associations and manufacturers cooperating with the bureau under the research associate plan, together with the number of associates and the problems on which they are engaged:

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

Assigned by—	Number	Specific project
Aluminum Co. of America, New Kensington, Pa.	1	Fatigue of alclad.
American Association of Textile Chemists and Colorists, Lowell, Mass.	2	Action of light on silk; determination of iso-electric point of wool; standards for fastness of dyed textiles; tests of waterproofed fabrics.
American Bureau of Welding, New York, N. Y.	1	Strength of welded joints.
American Electric Railway Engineering Association (Capital Traction Co., Washington, D. C.).	1	Lubrication and efficiency of transmission gears.
American Electroplaters Society, Chicago, Ill.	1	Protective coatings.
American Face Brick Association, Chicago, Ill.	1	Face brick absorption and transverse compression, efflorescence.
American Foundrymen's Association, Chicago, Ill.	1	Shrinkage in metals in casting.
American Gas Association, New York, N. Y.	2	Gas burner design; tests of proprietary pipe-line coatings and methods of identifying corrosive soils.
American Institute of Steel Construction, New York, N. Y.	2	Formed sheet steel floors; fire tests of welded steel floor construction.
American Petroleum Institute, New York, N. Y.	13	Engineering principles in pipe-line protection and tests of protective coatings; thermodynamic properties of petroleum hydrocarbons; chemical constituents of petroleum.
American Society of Mechanical Engineers, New York, N. Y.	8	Thermal properties of water; lubrication research.
American Society for Testing Materials, Philadelphia, Pa.	2	Research in cement; testing.
Asphalt Shingle and Roofing Institute, New York, N. Y.	2	Durability of felt fibers.
Associated Knit Underwear Manufactures of America, Utica, N. Y.	1	Standardization of underwear sizes; development of specifications; properties of knit underwear fabrics.
Atlas Lumnite Cement Co., New York, N. Y.	1	Research in cement; testing, etc.
Brown Co., Berlin, N. H.	2	Quality of purified wood fiber.
C. F. Brush Estate, Cleveland, Ohio	1	Spontaneous generation of heat.
The Bunting Brass & Bronze Co., Toledo, Ohio.	1	Properties of bearing bronzes.
Carbide & Carbon Chemical Co., New York, N. Y.	1	Thermal properties of liquids.
Cast Iron Pipe Research Association, Chicago, Ill.	1	Strength of corrosion products of cast iron, location of corrosive soils, and statistical study of corrosion data.

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

Assigned by—	Number	Specific project
Clock Manufacturers Association of America, Philadelphia, Pa.	3	Lubrication of fine mechanisms.
Committee of Marine Underwriters, New York, N. Y.	1	Spontaneous heating and ignition of jute.
Common Brick Manufacturers Association, Cleveland, Ohio.	3	Strength of brick masonry; moisture transmission of brick walls.
Commonwealth Fund Fellowship, New York, N. Y.	1	Combustion in engine cylinder.
Copper and Brass Research Association, New New York, N. Y.	1	Corrosion of copper roofing materials.
Cooper, Hugh L., Co. (Inc.), New York, N. Y.	1	Use of clays in concrete mixtures.
Dardelet Threadlock Corporation, New York, N. Y.	3	Methods of locking screw threads.
Gypsum Association (in cooperation with Federal Fire Council, United States Gypsum Co., Henry Klein & Co., and N. W. Magnesite Co.), Chicago, Ill.	2	Fire prevention and protection.
Indiana Limestone Association, Bedford, Ind.	1	Study of physical properties of Bedford limestone.
Johns Manville (Inc.), Manville, N. J.	1	Heat transfer between solids and fluids.
The Midvale Co., Philadelphia, Pa.	1	Properties of steels at high temperatures.
National Association of Dyers and Cleaners, Silver Spring, Md.	2	Properties of dry cleaning solvents; absorption of liquids by fibrous materials.
National Association of Hosiery and Underwear Manufacturers, New York, N. Y.	2	Cause and prevention of defects in hosiery; development of specifications; analysis of hosiery manufacturers' problems.
National Building Units Association, Philadelphia, Pa.	1	Concrete building units.
National Research Council, Washington, D. C.	3	Absorption coefficients of acoustic materials; preservation of records.
National Terra Cotta Society, New York, N. Y.	2	Investigation of architectural terra cotta.
Non-Ferrous Ingot Metal Institute, Chicago, Ill.	1	Properties of nonferrous ingot metals.
Portland Cement Association, Chicago, Ill.	5	Constitution and hardening of Portland cement.
Port of New York Authority, New York, N. Y.	1	Strength of bridge towers.
Radiological Research Institute, St. Louis, Mo.	1	X-ray investigations.
Society of Automotive Engineers, New York, N. Y. (in cooperation with National Automobile Chamber of Commerce and American Petroleum Institute).	15	Cooperative fuel research.
E. R. Squibb & Sons, New Brunswick, N. J.	2	Properties of gaseous mixtures.
Subcommittee on Research, Recommendations, and Interpretations for the Elevator Safety Code, New York, N. Y.	3	Elevator safeties and buffers.
Utilities Research Commission, Chicago, Ill.	3	Alternating current properties of insulating liquids; direct current properties of insulating liquids; preparation of pure hydrocarbons.
Vacuum Oil Co., New York, N. Y.	1	Properties of volatile liquid fuels.

NOTE.—In several cases one individual represented two or more supporting organizations. The total number of research associates stationed at the bureau on June 30, 1931, was 95.

Other research projects.—A total of 103 projects were carried by this fund. Only a few of the most important have been described. Thermal expansion measurements have been made on a great variety of materials, steam turbine and internal combustion engine oils have been studied, the efficiency of steam and hot water radiators has been measured, and many investigations, not mentioned, have been made on rubber, leather, and other industrial materials.

STANDARDIZATION OF EQUIPMENT ($235,000)

Facilitating the use of specifications.—Lists of sources of supply of commodities guaranteed to comply with the requirements of Federal specifications have been compiled for the use of agencies making purchases out of Federal, State, county, and municipal tax moneys. During the year the number of lists has been increased

from 271 to 335, the number of requests for listings from 8,175 to 13,267, and the number of firms registered on the lists from 2,892 to 5,161. Eleven lists of willing-to-certify manufacturers of commodities guaranteed to comply with certain commercial standards have also been compiled. The number of these lists has been increased from 10 to 21, the number of willing-to-certify firms from 199 to 628, and the number of requests for listing from 233 to 689. The total number of requests for listings is 13,956, received from 5,789 firms.

Facilitating the marketing of specification-made goods.—Increasing interest has been shown by organized producers and consumers, and by individual manufacturers and purchasers, in the application of the self-identifying quality-guaranteeing labeling system. Manufacturers are now using or planning to use quality-guaranteeing labels, or their equivalent, for brooms, dental alloys, dry cells, fireproof safes, gypsum, ink (writing, colored, and indelible), library paste, lime, linoleum, lumber, paint, paper (correspondence, carbon, blue-print, and brown-print), pipe, Portland cement, rope, soap, textiles, and wall board.

Labels, many of them underwritten by trade associations, are also being used in connection with commodities complying with commercial standards for aromatic red-cedar closet linings; diamond core drill fittings; brass, steel, and wrought iron pipe nipples; feldspar; men's pajamas; plate-glass mirrors; red-cedar shingles; staple porcelain and vitreous plumbing fixtures, Stoddard solvent; and wall paper.

Labels are now in use to identify commodities complying with simplified practice recommendations for: Abrasives, binder's board, composition books, hard-fiber and soft-fiber twine, lumber, kraft sealing tape, metal lath, paper grocers' bags, school furniture colors, tile, tissue paper, and woven wire fencing.

Nearly 100 trade associations and similar groups are using labels to identify or guarantee commodities complying with their specifications, which are often identical or in complete harmony with Federal specifications, commercial standards, or simplified practice recommendations.

Encyclopedia of specifications.—The second volume in the encyclopedia of specifications series was published under the title Standards and Specifications for Nonmetallic Minerals and Their Products. It contains all nationally recognized standards, specifications, and simplifications within its scope, presented either in full or by means of abstracts, tabulations, or cross references. Methods of testing, incidental to the formulation of commodity specifications, are included and form an important part of the work.

Simplified practice recommendations.—Twenty new simplified practice recommendations were developed by general conferences, thus raising the total to 149, exclusive of one regional recommendation and one limitation of variety recommendation. Both of the latter, and 117 of the 149 simplified practice recommendations, have been approved and accepted by the industries affected. Twenty-five recommendations are in process of acceptance. Recommendations covering 115 commodities have been issued in printed form.

Revision and reaffirmation conference.—Their respective standing committees reviewed 38 existing simplified practice recommendations.

Of these, 32, or 84.2 per cent, were reaffirmed without change, and 6 were revised. During the previous year, 34 recommendations of the 39 reviewed, or 85.3 per cent, were reaffirmed.

Adherence to simplified practice recommendations.—Surveys were made of adherence in the production, distribution, and use of 13 simplified commodities. The acceptors reporting indicated that approximately 90 per cent of their volume conformed to the recommendations. Similar surveys in 1930 showed that the percentage of adherence for 25 commodities averaged approximately 87 per cent.

Preliminary conferences and variety surveys.—Twenty-nine preliminary conferences were held for 21 different industries. Surveys of existing diversification of product have been conducted by simplified practice committees appointed by 11 of these industries, and plans were started for similar activity by the other 10 groups.

Commercial standards.—There were 62 active projects in this field at the close of the fiscal year. Eleven general conferences were held covering: Cotton fabric tents; tarpaulins and covers; mopsticks; seats for water-closet bowls; colors for sanitary ware; red-cedar shingles; knit underwear (exclusive of rayon); circular flat-knit rayon underwear; bag, case, and strap leather; plywood; Fourdrinier wire cloth; and steel-bone plates. Announcements that the following 11 projects had received a satisfactory majority of acceptances were issued: Plate-glass mirrors; mopsticks; aromatic red-cedar closet lining; boys' blouses, waists, shirts, and junior shirts; wrought-iron pipe nipples (first revision); cotton fabric tents, tarpaulins, and covers; staple seats for water-closet bowls; colors for sanitary ware; cotton goods for rubber and pyroxylin coated automotive fabrics; red-cedar shingles; and knit underwear (exclusive of rayon).

Twelve commercial standards were issued in printed form following a satisfactory acceptance by the industry: Interchangeable ground-glass joints; staple vitreous china plumbing fixtures; standard screw threads; special screw threads; feldspar; plain and thread plug and ring gage blanks; builders' hardware (nontemplate); aromatic red-cedar closet lining; mopsticks; plate-glass mirrors; boys' blouses, waists, shirts, and junior shirts; and wrought-iron pipe nipples (first revision).

Safety codes.—Members of the staff have participated in the work of the safety code correlating committee and other committees of national scope. Revision of the safety code for elevators, dumbwaiters, and escalators was completed, and text prepared for an elevator inspector's handbook. Codes for mechanical refrigeration, window washing, and floor and wall openings were completed. A revision was undertaken of the code for lighting school buildings and the code for automobile brakes and brake testing. Work was continued on codes dealing with walkway surfaces; conveyors and conveying machinery; mechanical power transmission; and cranes, derricks, and hoists. Assistance was given State and city officials in the preparation of local regulations.

Building codes.—The report, Recommended Minimum Requirements for Fire Resistance in Buildings, involving research in a highly complex field, was completed and published. Revised working stresses for brick masonry, based largely on experimental work at the bureau, were issued. Work was continued on the proposed

recommendations for exit requirements, involving studies of flow of people on stairways, ramps, and in other locations.

Plumbing codes.—New recommendations for sizes of horizontal branches, house drains, and house sewers were prepared. They are expected to result, as they become incorporated in State and local codes, in substantial economies to owners of buildings. Additional work is under way.

Designing of optical systems.—New formulas and standardized methods are being developed for the designing of optical systems. This work includes the derivation of algebraic formulas for the geometric aberrations of the first, seventh, ninth, and eleventh orders, and direct algebraic methods by which the phase differences at the image point corresponding to the geometric aberrations, may be determined.

Number of projects.—Twenty-four distinct lines of work are financed from this appropriation. Several of these, such as simplified practice and commercial standards, are made up of a large number of projects, reference to which has been made in the preceding paragraphs. Other work covers specifications for dry cells, standardization of storage batteries, minimum requirements for lighting of buildings, etc.

STANDARD MATERIALS ($10,600)

Distribution of standard samples.—During the year 6,506 samples were distributed, having a sales value of approximately $14,433.50, and approximately $10,200 worth of standard samples were added to the salable samples on hand. These included ores, ceramic, and metallurgical products, and pure chemicals. The number of samples on hand at the close of the year was approximately 89,000, and their value was $222,412, representing 95 different materials.

INVESTIGATION OF RADIOACTIVE SUBSTANCES AND X RAYS ($31,500)

X-ray protection.—An X-ray safety code was formulated and published as Handbook No. 15. It deals with X-ray insulation of operating rooms; X-ray and electrical insulation of X-ray equipment; protective devices for patients and operatives; fire precautions, especially in the storage of, and types of photographic films used; periodical tests; resuscitation from electric shock; and general precautions as to personnel working conditions.

International X-ray standards.—The portable secondary standard X-ray ionization equipment was improved in design, thoroughly tested in the bureau's laboratory and then in another laboratory in this country, preparatory to a comparison with the national standards of Great Britain, Germany, and France, which is now under way. It is anticipated that for the first time like values of the Röntgen may be obtained by this equipment in the various countries, and that it may be adopted as standard equipment at the International X-ray Conference in Paris.

Radium testing.—Twenty-four hundred preparations of radium—more than double the number reported last year—totaling over 20,000 milligrams of the element, and fixing the sales value of about $1,500,000, were tested.

Other investigations.—This fund provided for nine investigations. In addition to those referred to in the preceding paragraphs, the following may be mentioned: Photographic registration of alpha-ray tracks; X-ray study of the iron atom; application of the Geiger counter to cosmic rays; X-ray emission from thin targets; X-ray scattering by materials similar to the human body; performance of X-ray equipment used for radiological purposes; and electrical conduction in gases.

UTILIZATION OF WASTE PRODUCTS FROM THE LAND ($52,700)

Paper from wheat straw.—The efforts on this project have been continued, but the results are not yet wholly satisfactory. Many different methods of cooking straw to make paper pulp have been tried, but it seems that either the reaction is not sufficiently severe, so that the pulp does not have the required degree of whiteness, or else it is too severe, so that the yield of pulp is below the economic limit.

Insulating board from cornstalks.—This project has passed the experimental stage and is now in commercial use. Semicommercial work is being continued to improve the method of production and to make the product more resistant to fire and water. A new type of forming machine has been designed and placed in operation.

Pressed board from cornstalks.—If the mat of fibers used in making insulating board is subjected to heavy pressure, the product is hard, dense, and strong, and can be used as a substitute for lumber. Laboratory studies to find the optimum pressure, time, and temperature, are nearing completion, and equipment for semicommercial production is being designed.

Maizolith from cornstalks.—Further experiments are under way to improve the method of manufacture, and particularly to find a better way to dry the maizolith.

Xylose from cottonseed hull bran.—After several tons of xylose were produced, the factory at Anniston, Ala., was closed. Samples of xylose were sent to many medical laboratories to ascertain its effect on the human system, but it will be at least a year before any definite recommendations can be made. The industrial utilization of xylose is being investigated, the first step being the production of xylonic and trioxyglutaric acids for use in tanning and dyeing.

Starch from sweetpotatoes.—A new station was opened at Alabama Polytechnic Institute, Auburn, Ala., in July, 1930, to investigate the sweet potato as a source of starch for the southern textile industry. However, there is no definite information on the kind of starch needed. The uses of starch in various textile mills have been studied, and laboratory tests developed to determine the suitability of the material.

Kraft paper from southern pine.—Another station was opened at the University of Alabama at Tuscaloosa, in September, 1930. Improvement in the efficiency of the process of manufacturing kraft paper from southern woods is the main object of the work. Analytical methods are being developed for identifying and measuring the amounts of sulphur compounds present in the various wastes.

Refining cottonseed oil.—A cheap yet effective method has been developed for refining cottonseed oil, which is so simple and inexpensive that it seems feasible for the small oil press, or even for the

home. The oil produced is edible, and some soap is formed as a by-product. An investigation of the extraction of oil from seeds has also been started.

Analytical methods.—The analytical methods used for routine purposes are not adequate for the type of research conducted under this fund. Better methods have, therefore, been developed. A quantitative method for estimating xylose in the presence of glucose has been published. Refinements of the usual methods of pH measurement for estimating xylonic acid in the presence of trioxyglutaric acid have also been worked out and published.

Additional projects.—This fund was used for 14 projects. While only a portion of them have been described, the general character of the work is indicated.

INVESTIGATION OF AUTOMOTIVE ENGINES ($50,000)

Vapor lock.—Temperature measurements in airplane fuel systems show that many airplanes now in service require gasoline with low vapor pressure to insure freedom from vapor lock. Results of laboratory experiments suggest improvements in fuel system design which would permit the use of better fuels. Similar work with automobiles points to improper design of fuel systems as the major cause of vapor lock. As a result of this investigation, extensive changes are being made in forthcoming models, which will go far to minimize vapor-lock troubles.

Antiknock characteristics of fuels.—The octane number detonation scale has been adopted as recommended practice by the Society of Automotive Engineers. Approval of the test engine, developed by the cooperative fuel-research steering committee, is expected to follow completion of final tests now in progress. Definite procedure for testing motor fuels has been tentatively adopted and will soon be given final form. The objectionable feature of automobile engine detonation is noise; that of aircraft engines is overheating and mechanical shock. Recognizing this difference, the bureau initiated cooperative research on methods of measuring detonation of aviation fuels. The first symposium on this subject indicated need for such research, the results obtained by different methods being quite diverse.

Combustion in an engine cylinder.—Theoretical and experimental studies of gaseous explosions in constant volume bombs have been made to aid in interpreting recent stroboscopic observations of flame movement and pressure development in an engine cylinder. Preliminary measurements indicate that the progress and character of the explosion in the engine may also be investigated by analysis of the infra-red radiation through fluorite windows in the cylinder head.

Phenomena of combustion.—Using the soap bubble as a constant-pressure bomb, the relation between explosion temperature and rate of transformation in homogeneous mixtures of explosive gases at constant pressure is being studied in cooperation with the National Advisory Committee for Aeronautics.

Gumming characteristics of gasoline.—An investigation is in progress to develop significant test methods for determining the gum content of gasolines and its tendency to increase under storage conditions.

Automobile brakes and brake testing.—The safety code for brakes and brake testing, for which the bureau and the American Automobile Association were joint sponsors, is to be revised in view of the widespread use of 4-wheel brakes. The personnel of the revised sectional committee for this project was approved June 4 by the council of the American Standards Association.

Additional projects.—Only a few of the 17 projects under this fund have been touched upon. Others include: Measurement or road performance of automobile engines, oxidation of carbon monoxide in the exhaust, automobile spring suspension systems, causes of vibration of motor vehicles, and improvement of headlights.

INVESTIGATION OF DENTAL MATERIALS ($10,000)

Cooperation with American Dental Association.—The research associates of the American Dental Association and members of the bureau have made personal contacts with about 3,000 members of the dental profession through lectures, conferences, etc., in 19 cities well distributed over the United States. Tests of material for the Government have been more satisfactory than in any previous year, less than 10 per cent of the material supplied having been rejected, as compared with 50 per cent last year. No change has been made in the specifications. Many dental schools are inaugurating programs for investigating the properties of alloys, etc., supplied for their use. Some of these schools have arranged for their teachers to visit the bureau, thus insuring the fullest utilization of data on methods of test, selection of materials, and other benefits.

TRANSFERRED FUNDS ($468,283)

Organizations and projects.—During the year funds were transferred from the following departments and independent establishments of the Federal Government, covering the projects listed:

Bureau of Engraving and Printing: Electrodeposition; currency paper and stamps.

Department of Commerce: Promotion of use of specifications; aids to air navigation; aeronautical engineering problems; aircraft engine testing; engineering research.

Department of the Interior: Concrete testing for Colorado River Dam.

National Advisory Committee for Aeronautics: Aerodynamics; aircraft power plants; mercerization of cotton; embrittlement of duralumin and steel tubing; identification of steels.

Navy Department: Airship girders; aircraft instruments; gas-cell fabrics; identification of steels; embrittlement of duralumin; aircraft engine ignition; effects of humidity on engine operation; storage batteries; optical glass.

Post Office Department: Characteristics of automotive vehicles for postal service.

Smithsonian Institution: Safeguarding dome of Museum of Natural History.

Treasury Department: Radio receiving sets for the Coast Guard.

War Department: Gumming of gasoline; geared superchargers; substitute for shellac; substitute for sole leather; nontin bearing metal; development of machine guns; radio receiving sets; experimental gages; bomb ballistics.

Many of these projects were supported partly by bureau and partly by transferred funds. The more important of these have already been described under the appropriate bureau funds. The in-

vestigations supported wholly by transferred funds resulted in the following developments:

Air navigation facilities—radio.—In this field the bureau's attention was devoted particularly to radiobeacon systems, means for blind landing, and aircraft direction finders. Mention may be made of a transmitter for the simultaneous transmission of radiotelephone messages and visual type radiobeacon signals on the same radio frequency; refinements in the design and calibration of the vibrating reed indicator; a new course indicator which gives the beacon course indications on a zero-center, pointer-type instrument; a deviometer which permits a pilot to follow any chosen course within 15° on either side of the fixed beacon courses. Improvements in the system of blind-landing aids include: A combined instrument which indicates both lateral and vertical positions of the airplane as it lands; an improved marker beacon for defining the landing field boundary; a dual-control airplane equipped for blind flights on the system; a simplified aircraft direction finder giving visual indications; a symmetrical longitudinal T antenna for aircraft, having better mechanical and aerodynamic properties than the pole antenna. Work was begun on a radio system to aid in preventing collisions when flying under adverse visibility conditions.

Aviation lighting.—Photometric measurements and visibility tests have been made on 24 and 36 inch airway beacons, code beacons, boundary lights, traffic-control projectors, and flying lights. Tentative specifications for red and green glasses for use in beacons, boundary lights, and flying lights have been prepared. A traffic-control projector and a reflector, giving a desired light distribution for flying lights on airplanes, have been designed and constructed. Experiments on beacons flashing Morse code signals, and visibility tests on colors for aviation use are in progress.

Control surfaces of airplanes.—A wind-tunnel study of the hinge moments of ailerons at large angles of attack was completed with the cooperation of the Aeronautics Branch of the Department of Commerce and the National Advisory Committee for Aeronautics. The results are described in N. A. C. A. Technical Report No. 370. Measurements were also made of the yawing moments produced by several rudders at large angles of attack.

Measurement of turbulence.—In cooperation with the National Advisory Committee for Aeronautics, a study has been made of methods of reducing turbulence in wind tunnels, and the results published in N. A. C. A. Technical Report No. 392. The apparatus for measuring turbulence has been further improved by extending the frequency range, for which the response is uniform, to 4,000 cycles per second.

Reduction of noise in airplanes.—In cooperation with the Aeronautics Branch of the Department of Commerce, a set-up has been provided for the study of mufflers for airplane engines.

Crash-resistant tanks.—In cooperation with the Aeronautics Branch various methods for making airplane fuel tanks less susceptible to failure in accidents are being studied. A new, elastic, synthetic material for lining tanks offers some promise of success.

Type testing of commercial airplane engines.—Eleven radial engines, including 1 Diesel, 8 inverted in-line, 4 horizontal-opposed,

and 4 V-type engines, including a 12-cylinder inverted V, were tested at the Arlington laboratory for the Aeronautics Branch. Of the 27 engines received, 14 passed, 11 failed, and 2 were withdrawn. Eight of the engines which failed were of new types, and three had received one previous test each.

Effect of air humidity on engine performance.—Tests made for the Bureau of Aeronautics of the Navy Department show that power always decreases with increase in air humidity. Injection of water spray into the combustion chamber gives high antiknock action without loss of power when optimum timing of injection and spark advance is employed. Further research at high compression ratios is essential.

Aircraft instrument developments.—An improved fuel flow meter, an electric resistance thermometer, four cartridge-type maximum indicating accelerometers, two suspended head air-speed meters, an angle of attack indicator, an aircraft course protractor, and a supercharger pressure gauge were constructed for the Bureau of Aeronautics of the Navy Department. The construction and installation of the mooring force indicator for the airship *Los Angeles* was completed. An investigation of damping liquids for aircraft instruments was conducted for the National Advisory Committee for Aeronautics.

Accelerometer for study of earthquakes.—In cooperation with the Coast and Geodetic Survey an accelerometer is under development. It is intended, primarily, for obtaining records of ground movements from which the forces on buildings, located within an earthquake area, may be calculated.

Radio receiving sets for Coast Guard.—Six receiving sets submitted as bid samples to the Coast Guard were tested. Specifications were prepared for new, improved apparatus for determining precisely the electrical sensitivity, fidelity, and overload characteristics of receiving sets.

Corrosion of storage-battery plates.—A procedure for determining the acetic acid content of storage-battery electrolytes has been developed. Apparatus has been assembled for measuring the electrical resistance of storage-battery separators, and a series of measurements made. Apparatus has been developed for estimating the rate of corrosion by measuring the changes in electrical resistance of lead-antimony wires immersed in separator extract solutions.

High-frequency fatigue testing.—The series of high-frequency fatigue tests being made on light aluminum alloys, in cooperation with the National Advisory Committee for Aeronautics, is nearly completed. The results agree very well with those obtained by slower methods.

Prevention of embrittlement of sheet duralumin by atmospheric corrosion, and deterioration of magnesium alloys by corrosion.—The fourth year of the 5-year program of outdoor-exposure tests under three widely different climatic conditions has been completed. The bad effect of improper heat treatment on sheet duralumin and the relatively short life of most coatings have been established. Tests of the materials which so far appear to be satisfactory will be continued. Magnesium alloys exposed to the weather at the bureau still show good tensile properties after two years, although the coatings

soon lose their adherence. Tests in the typical marine atmosphere proved to be too severe for magnesium.

Distinguishing airplane steel tubing of different compositions.—A report was issued on several nondestructive tests for this purpose. The spark test was of very great value in the case of only two compositions. Attempts to develop a simple chemical "spot" test were fruitless, although a much more reliable and quicker analytical method for molybdenum than that now in use was developed.

Gas-cell fabrics for airships.—Several wholly synthetic materials have shown promise as possible substitutes for goldbeater's skin, but have not yet advanced to the production stage. Materials submitted by manufacturers were examined and technical advice given.

Bearing alloys.—A cooperative study with the War Department on bearing alloys containing little, if any, tin is in progress. The properties at elevated temperatures of the important lead-base bearing alloys have been determined, and observations are now being made on sample bearings in Army trucks. In the study of leaded bronzes particular emphasis is being placed on the use of addition elements for improving the dispersion of the lead in bronzes containing up to 50 per cent lead.

Substitute for shellac in food containers.—An investigation for the War Department, and in cooperation with manufacturers of tin cans used as food containers, developed the fact that shellac is not an important or necessary component of the so-called "lacquers" and "enamels" used on the inside of tin cans.

RECOMMENDATIONS

Patent policy.—There is need for the establishment of a uniform patent policy for the Government with respect to patents developed in the service. The patent policy of this bureau has always been that patentable devices developed by employees paid out of public funds belong to the public. The visiting committee, during the past three years, has given most careful consideration to this subject and strongly indorses the bureau's policy of public ownership of such patents. If this is thought by the administration to be desirable as a general policy, I believe this end can be attained by the President setting up through Executive order, as a condition of employment, such regulations as may be deemed necessary.

Increasing demands.—Although the past year has been one of lessened business activity, the demands for the bureau's services, both from the public and from the Government departments, have increased. This is reflected particularly in requests for tests of instruments and materials, which have been greater than in any previous year. It is to be expected, with returning prosperity, that these demands will increase at an accelerated rate; therefore it seems but reasonable to make the necessary provisions in personnel, facilities, and space that will be needed.

Building program.—As stated in previous reports, the most urgent need is a new administration building, at a cost of about $400,000. This would relieve about 40,000 square feet of space in laboratory buildings, badly needed for testing and experimental work, and would also make provision for adequately housing the nonlaboratory functions of the bureau, now scattered through the other buildings.

The second need is for a high-voltage laboratory of a size and type and with the equipment to take care of an increasingly important field of standardization, testing, and research, in which this Government is in arrears as compared with Great Britain, France, Germany, and Japan.

Other building needs, which have been presented under a 5-year program, include an enlarged low-temperature laboratory, a fire-resistance laboratory, and new buildings for mechanical engineering and for high-precision testing in weights and measures.

Although some provision has been made for increased space in the branch laboratories at San Francisco and Denver, to take care of Government testing, it is anticipated that increased demands from the Pacific coast for near-by service will render it desirable to provide facilities at San Francisco for public testing.

Very truly yours,

GEORGE K. BURGESS,
Director, Bureau of Standards.

APPENDIX

GENERAL FINANCIAL STATEMENT

During the fiscal year 1931 the bureau expended and accounted for funds aggregating $4,121,986.35, including $474,015.35 received by transfer and reimbursement from other departments for special researches.

The amounts and objects of each appropriation for the past fiscal year and two previous fiscal years, together with disbursements, liabilities, and balance for each appropriation, are shown in the following tables:

TABLE 3.—*Disbursements, liabilities, etc., 1931, 1930, and 1929 appropriations*

Appropriation	Total appropriation [2]	Disbursements	Liabilities	Balance
1931				
Salaries	$719,540.00	[1] $704,646.51		$14,893.49
Equipment	163,000.00	146,407.07	$16,179.28	413.65
General expenses	[3] 64,620.68	53,728.38	10,805.97	86.33
Improvement and care of grounds	19,400.00	18,039.89	1,243.71	116.40
Testing structural materials	320,000.00	302,826.02	3,237.21	13,936.77
Testing machines	41,000.00	33,169.91	6,800.00	1,030.09
Metallurgical research	61,000.00	58,299.84	779.06	1,921.10
Investigation of optical glass	27,300.00	24,892.09	186.55	2,221.36
Standard materials	10,600.00	10,437.74	53.68	108.58
Investigation of textiles	60,900.00	58,473.34	327.89	2,098.77
Sugar standardization	[4] 100,000.00	85,817.62	6,890.70	7,291.68
Gauge standardization	50,000.00	48,014.72	418.17	1,567.11
High-temperature investigation	10,200.00	10,182.20		17.80
Testing railroad-track, mine, and other scales	102,300.00	67,148.10	32,740.96	2,410.94
Investigation of fire-resisting properties	30,000.00	28,575.46	202.54	1,222.00
Testing miscellaneous materials	46,400.00	45,133.79	197.17	1,069.04
Investigation of public-utility standards	[5] 107,401.00	102,419.67	945.75	4,035.58
Radio research	85,700.00	80,394.96	824.68	4,480.36
Industrial research	227,860.00	207,980.37	5,020.53	14,859.10
Sound investigation	11,260.00	11,095.53	34.10	130.37
Investigation of clay products	49,000.00	47,438.40	488.67	1,072.93
Color standardization	15,800.00	15,260.64	354.48	184.88
Investigation of radioactive substances and X-rays	31,500.00	29,478.76	933.78	1,087.46
Standardizing mechanical appliances	51,321.00	46,468.21	3,724.84	1,127.95
Standardization of equipment	237,900.00	201,727.73	15,546.25	20,626.02
Investigation of automotive engines	[6] 60,000.00	56,056.92	1,184.63	2,758.45
Utilization of waste products from the land	52,700.00	47,862.78	17.71	4,819.51
Investigation of dental materials	10,000.00	8,470.73	1,342.84	186.43
Additional land	400,000.00	400,000.00		
Hydraulic laboratory	350,000.00	25,881.05	324,113.45	5.50
Facilities for radio research 1931-32	147,000.00			147,000.00
Appropriations transferred from other departments which are available for the current year:				
Aircraft in commerce	81,600.00	74,845.18	5,257.72	1,497.10
Air navigation facilities	111,600.00	105,077.19	5,435.16	1,087.65
Incidental expenses of Army	29,042.00	27,835.08	709.51	497.41
National Advisory Committee for Aeronautics	51,000.00	49,543.23	790.06	666.71
Salaries and expenses, Bureau of Engraving and Printing	15,000.00	14,225.67	485.42	288.91
Air Corps, Army	5,946.67	3,817.68	1,424.19	704.80
Signal Service of Army	1,800.00	1,542.31	220.67	37.02
Aviation, Navy	99,000.00	92,277.59	6,292.32	430.09
Export industries, Bureau of Foreign and Domestic Commerce	2,640.00	2,532.71		107.29
Gages, dies, and jigs for manufacture	2,900.00	2,583.57	250.00	66.43
Ordnance service and supplies, Army	2,555.00	1,894.52	650.00	10.48
General expenses, Coast and Geodetic Survey	200.00	174.29	17.58	8.13
Engineering, Bureau of Engineering	4,000.00	3,327.49	483.42	189.09
Contingent expenses, Coast Guard	3,000.00	2,783.21	205.81	10.98
Colorado River Dam fund	25,000.00	23,281.20	602.68	1,116.12
Construction and repair, Navy	1,000.00	672.30	100.00	227.70
Contingent expenses, Steamboat Inspection Service	500.00	108.64	385.73	5.63
Party expenses, Coast and Geodetic Survey	500.00	455.50	30.66	13.84
Appropriations transferred from other departments which are available for a period of two years: Ordnance and ordnance stores	21,000.00	14,947.38		6,052.62
Total	4,121,986.35	3,398,253.17	457,935.53	265,797.65

(Footnotes at end of table.)

TABLE 3.—*Disbursements, liabilities, etc., 1931, 1930, and 1929 appropriations*—Continued

Appropriation	Total appropriation [2]	Disbursements	Liabilities	Balance
1930				
Salaries	$686,146.00	$685,353.02		$792.98
Equipment	88,000.00	87,488.00	$327.08	184.92
General expenses	[7] 65,790.49	65,359.57		430.92
Improvement and care of grounds	14,400.00	14,351.56		48.44
Testing structural materials	[8] 272,407.96	272,312.26		95.70
Testing machines	41,000.00	40,985.32		14.68
Metallurgical research	[9] 51,059.56	50,997.24		62.32
Investigation of optical glass	27,300.00	27,289.75		10.25
Standard materials	10,600.00	10,575.04		24.96
Investigation of textiles	53,900.00	53,871.84		28.16
Sugar standardization	[10] 78,900.00	78,894.10		5.90
Gage standardization	40,000.00	39,958.34		41.66
High temperature investigation	10,200.00	10,171.20		28.80
Testing railroad scales	48,900.00	48,788.93		111.07
Investigation of fire-resisting properties	30,000.00	29,901.21		98.79
Testing miscellaneous materials	46,400.00	46,357.89		42.11
Investigation of public-utility standards	[11] 107,554.49	107,373.46		181.03
Radio research	85,700.00	85,630.56		69.44
Industrial research	[12] 207,000.00	206,124.66	752.00	123.34
Sound investigation	11,260.00	11,206.10		53.90
Investigation of clay products	49,000.00	48,864.28		135.72
Color standardization	15,800.00	15,784.44		15.56
Investigation of radioactive substances and X rays	31,500.00	31,352.52		147.48
Standardizing mechanical appliances	29,300.00	29,221.56		78.44
Investigation of mine scales and cars	13,400.00	13,107.67		292.33
Standardization of equipment	[13] 220,015.00	219,222.12	750.00	42.88
Investigation of automotive engines	26,500.00	26,438.83		61.17
Utilization of waste products from the land	52,700.00	52,608.02		91.98
Investigation of dental materials	5,300.00	5,240.00		60.00
Power plant equipment	100,000.00	99,582.77		417.23
Appropriations transferred from other departments which are available for the current year:				
Aircraft in commerce	101,600.00	101,229.62	250.00	120.38
Air navigation facilities	97,450.00	97,100.96		349.04
Incidental expenses of Army	29,042.00	29,033.48		8.52
National Advisory Committee for Aeronautics	46,000.00	45,971.56		28.44
Materials and miscellaneous expenses, Bureau of Engraving and Printing	15,000.00	14,975.62		24.38
Air Corps, Army	14,950.00	14,909.81		40.19
Signal Service of Army	1,800.00	1,790.53		9.47
Aviation, Navy	78,200.00	78,093.93		106.07
Export industries, Bureau of Foreign and Domestic Commerce	2,640.00	2,622.62		17.38
Gages, dies, and jigs for manufacture	2,800.00	2,786.89		13.11
Ordnance service and supplies, Army	2,555.00	2,531.63		23.37
General expenses, Coast and Geodetic Survey	100.00	45.15		54.85
Engineering, Bureau of Engineering	4,000.00	3,950.18		49.82
Contingent expenses, Coast Guard	2,000.00	1,981.05		18.95
Cooperative construction of rural post roads	4,500.00	4,462.63		37.37
Contingent expenses, Steamboat Inspection Service	1,000.00	907.48		92.52
Appropriations transferred from other departments which are available for a period of two years:				
Ordnance and ordnance stores	15,000.00	14,996.80		3.20
Total	2,938,670.50	2,931,802.20	2,079.08	4,789.22
1929				
Salaries	648,146.00	643,732.38		4,413.62
Equipment	[14] 88,014.11	87,803.23		210.88
General expenses	[15] 71,761.60	70,821.45		940.15
Improvement and care of grounds	14,431.00	14,397.60		33.40
Testing structural materials	[16] 268,653.68	261,982.99		6,670.69
Testing machines	41,003.00	40,288.99		714.01
Metallurgical research	51,614.00	49,213.14		2,400.86
Investigation of optical glass	27,420.00	27,067.00		353.00
Standard materials	10,824.00	10,657.41		166.59
Investigation of textiles	54,144.00	54,101.98		42.02
Sugar standardization	[17] 61,027.00	60,729.79		297.21
Gage standardization	40,713.00	39,998.06		714.94
High temperature investigation	10,401.00	9,321.28		1,079.72
Testing railroad scales	49,085.00	48,687.84		397.16
Investigation of fire-resisting properties	30,213.00	29,628.46		584.54
Testing miscellaneous materials	47,125.00	46,987.53		137.47
Investigation of public-utility standards	[18] 107,715.19	106,256.31		1,458.88
Radio research	[19] 56,429.03	56,328.52		100.51
Industrial research	[20] 205,679.78	204,080.23		1,599.55

(Footnotes at end of table.)

TABLE 3.—*Disbursements, liabilities, etc., 1931, 1930, and 1929 appropriations*—Continued

Appropriation	Total appropriation [2]	Disbursements	Liabilities	Balance
1929				
Sound investigation	$11,469.00	$11,297.45		$171.55
Investigation of clay products	49,370.00	46,632.72		2,737.28
Color standardization	10,950.00	10,930.39		19.61
Investigation of radioactive substances and X rays	31,741.00	31,581.59		159.41
Standardizing mechanical appliances	29,677.00	29,274.24	$61.63	341.13
Investigation of mine scales and cars	13,688.00	13,472.39		215.61
Standardization of equipment	[21] 192,584.51	187,838.12		4,746.39
Investigation of automotive engines	26,833.00	26,437.47		395.53
Utilization of waste products from the land	53,148.00	49,299.72		3,848.28
Investigation of dental materials	5,421.00	5,257.77		163.23
Power plant equipment	100,000.00	99,959.00		41.00
Testing structural materials, 1929–30	12,500.00	12,423.59		76.41
Appropriations transferred from other departments which are available for the current year:				
Aircraft in commerce	[22] 140,360.00	140,290.36		69.64
Party expenses, Coast and Geodetic Survey	2,000.00	1,927.73		72.27
Incidental expenses of Army	10,000.00	9,970.13		29.87
National Advisory Committee for Aeronautics	43,372.15	43,189.91		182.24
Air Corps, Army	11,500.00	11,487.22		12.78
Signal Service of Army	1,800.00	1,781.94		18.06
Materials and miscellaneous expenses, Bureau of Engraving and Printing	15,000.00	14,853.15		146.85
Aviation, Navy	66,140.00	66,031.51		108.49
Export industries, Bureau of Foreign and Domestic Commerce	2,640.00	2,615.26		24.74
General expenses, Coast and Geodetic Survey	200.00	200.00		
Air navigation facilities	15,700.00	15,681.46		18.54
Appropriations transferred from other departments which are available for a period of two years:				
Gages, dies, and jigs for manufacture	2,750.00	2,526.67		223.33
Ordnance stores, ammunition, 1929–30	1,000.00	996.66		3.34
Ordnance and ordnance stores	12,000.00	11,994.00		6.00
Safeguarding dome of rotunda, 1929–30	3,000.00	2,990.03		9.97
Automatic rifles, 1929–30	2,555.00	2,330.62		224.38
Total	2,751,798.05	2,715,355.29	61.63	36,381.13

[1] Includes $1,000 transferred to the Personnel Classification Board.

[2] Includes reimbursements and transfers received from other departments as shown under footnotes 3 to 22, as follows:

[3] $620.68.
[4] $5,000.
[5] $111.
[6] $10,000.
[7] $1,790.49.
[8] $4,257.96.
[9] $59.56.
[10] $3,900.
[11] $264.49.
[12] $3,000.
[13] $15.
[14] $14.11.
[15] $1,906.60.
[16] $1,595.68.
[17] $2,800.
[18] $418.19.
[19] $657.03.
[20] $2,052.78.
[21] $461.51.
[22] $360.