DEPARTMENT OF COMMERCE

CIRCULAR

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 24

PUBLICATIONS OF THE BUREAU OF STANDARDS

[5th Edition]
Issued April 14, 1919

PRICE, 25 CENTS
Sold only by the Superintendent of Documents, Government Printing Office
Washington, D. C.

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NOTE

In addition to the tests and comparisons made by the Bureau of Standards, its work includes such researches as are involved in the establishment and maintenance of the various standards and units of measurement, the development of measuring instruments and methods of measurement, the determination of physical constants, and the properties of materials. The results of these investigations are published in pamphlet form, and in the following pages are given descriptive lists of these papers. The papers are issued in four separate series—(1) Scientific Papers, (2) Technologic Papers, (3) Circulars, and (4) Miscellaneous Publications. They cover a wide range of subjects in the field of physical measurements and the properties of materials and are issued for general distribution to the scientific, technical, and industrial interests concerned with the subjects treated.

Single copies of these publications will be sent free upon request to specialists concerned with the subjects treated, to those collaborating with the Bureau in its investigations, to organizations exchanging like courtesies with the Bureau, and to designated Government depository libraries. Others, however, may purchase them from the Superintendent of Documents, Government Printing Office, Washington, D. C., at the prices stated. When applying to the Bureau of Standards for any of these publications, merely state the symbol and number preceding the title; when ordering from the Superintendent of Documents, give number, title of publication, and name of Bureau.

This list will be revised from time to time, and subsequent issues will be sent to those who request it. A supplement to this circular will be issued quarterly. It will contain a list of the Bureau's publications that are available only from the Superintendent of Documents, those that may be consulted only at some designated Government depository library, and the publications that have been delivered since this Circular was issued.

A subject index is to be found at the conclusion of these lists which will be useful in the more ready reference to subjects somewhat obscured by necessarily brief titles to the publications listed.

PUBLICATIONS OF THE BUREAU OF STANDARDS

SCIENTIFIC PAPERS

[For publications in the following list that are out of print or procurable only from Superintendent of Documents, Government Printing Office, Washington, D. C., see the supplement to this Circular.]

S1. Recomparison of the United States Prototype Meter.....*L. A. Fischer*

An account of a comparison made between the United States Meter No. 27 and the standards of the International Bureau of Weights and Measures, giving the observations in detail, and a description of the method of comparison and the apparatus. (June 15, 1904.) 15 pp. Price, 5 cents.

S2. A Study of the Silver Voltameter.....*K. E. Guthe*

A description of the various forms of silver voltameters that have been used for measuring the unit of electric current and a comparison of the results obtained by them, including especially the comparison of the filter-paper type with the porous-cup type. (Sept. 1, 1904.) 17 pp. [Superseded by S194, S195, S201, S220, S240, S271, S283, S285.]

S3. The So-called International Electrical Units..*Frank A. Wolff*

A paper presented to the St. Louis International Congress on the redefinition of the fundamental units, with a historical review and an appendix on laws concerning electrical units adopted by this and foreign governments. (July 1, 1904.) 38 pp. (See also S102.) [Superseded by Circular No. 60.]

S4. The Spectra of Mixed Gases.....*P. G. Nutting*

It is shown that in spectra of electrically conducting mixtures of gases, other things being equal, the spectrum of the gas of highest atomic weight will be brightest. (July 15, 1904.) 5 pp. Price, 5 cents.

S5. On Secondary Spectra and the Conditions under which they may be Produced.....*P. G. Nutting*

A determination of what elements give two different spectra and the conditions of excitation necessary for the production of each. (July 15, 1904.) 11 pp. Price, 15 cents.

S6. Some New Rectifying Effects in Conducting Gases..
.....*P. G. Nutting*

When electrodes differ in size, form, temperature, material, condition of surface, nature, and density of surrounding gas, the current tends to pass more easily in one direction than in the reverse, thus giving an excess of current in one direction. (July 15, 1904.) 6 pp. Price, 5 cents.

S7. On Fibers Resembling Fused Quartz in Their Elastic Properties.....*K. E. Guthe*

Owing to the difficulty of obtaining fibers of fused quartz of sufficient strength to carry a load of 500 g and at the same time to have a small elastic fatigue, experiments were made to find a substitute. It was found that fibers of steatite could be easily drawn and possessed the desired properties. (Sept. 1, 1904.) 7 pp. Price, 10 cents.

S8. On the Temperature of the Arc.....
.....*C. W. Waidner and G. K. Burgess*

Estimation of the black-body temperature of positive crater with Le Chatelier, Wanner, and Holborn-Kurlbaum optical pyrometers; variation of temperature with current; review of previous work. Measurements based on Wien-Planck equation for monochromatic radiation. (Sept. 1, 1904.) 16 pp. Price, 5 cents.

S9. The Absolute Measurement of Inductance.....
.....*E. B. Rosa and F. W. Grover*

The inductances of some standards are measured by the impedance method (using alternating current) in terms of resistance and the frequency of the current. The wave form of the current used is accurately determined and analyzed, and a correction applied for the harmonics present. (Oct. 15, 1904.) 28 pp. Price, 10 cents.

S10. The Absolute Measurement of Capacity.....
.....*E. B. Rosa and F. W. Grover*

The capacity of standard mica condensers is measured by the Maxwell bridge, in terms of resistance and time. Sources of error are carefully investigated, and results of measurements on a number of condensers given. (Nov. 1, 1904.) 35 pp. Price, 15 cents.

S11. Optical Pyrometry.....*C. W. Waidner and G. K. Burgess*

Review of the laws of radiation and their application to the measurement of high temperatures. Experimental investigation of various types of optical and radiation pyrometers as to methods of calibration, sources of error, order of accuracy, and necessary precautions. Applications to the radiation from platinum and other substances. (Sept. 15, 1904.) 61 pp. Price, 10 cents.

S12. On the Theory of the Matthews and the Russell-Léonard Photometers for the Measurement of Mean Spherical and Mean Hemispherical Intensities.....*Edward P. Hyde*

The accuracy of these instruments in measuring lamps with various simple polar distribution curves is investigated. The method is given for computing the best arrangement of any given number of mirrors to obtain relative values between lamps having different distribution curves. (Oct. 1, 1904.) 21 pp.

S13. The Testing of Clinical Thermometers.....
.....*C. W. Waidner and L. A. Fischer*

Description of apparatus and methods used in the testing of clinical thermometers. Specifications governing tests. (Nov. 1, 1905.) 15 pp. Price, 15 cents.

S14. Measurement of Inductance by Anderson's Method, using Alternating Currents and a Vibration Galvanometer.....*E. B. Rosa and F. W. Grover*

This method gives inductance in terms of capacity and resistance. The theory of the method is fully worked out and formulæ derived for the corrections depending on the residual capacities and inductances of the arms of the bridge. Results show that high accuracy is possible. A very convenient and reliable method for a wide range of inductances. (Aug. 15, 1905.) 44 pp. Price, 15 cents.

S15. Use of Serpentine in Standards of Inductance....
.....*E. B. Rosa and F. W. Grover*

Serpentine spools are shown to be unsuitable for standards of inductance, as the serpentine is slightly magnetic and its permeability variable. Hence the inductance of the coil depends to some extent on how much current is passing through the coil when it is in use. Marble is nonmagnetic and therefore better. Mahogany spools saturated with paraffin are quite satisfactory. (Aug. 15, 1905.) 12 pp. Price, 10 cents.

S16. The Silver Coulometer.....*K. E. Guthe*

A critical comparison of different forms of silver coulometer (or voltameter) with an account of some new work with various types and a discussion of the values that have been obtained for the electrochemical equivalent of silver. [Superseded by S285.] (Sept. 1, 1905.) 16 pp.

S17. History of the Standard Weights and Measures of the United States.....*L. A. Fischer*

A brief description of the standards of length and mass accepted at different periods by the United States Government. (June 30, 1905.) 17 pp. Price, 10 cents.

S18. Wattmeter Methods of Measuring Power Expended upon Condensers and Circuits of Low Power Factor.....*Edward B. Rosa*

The power expended upon a condenser may be measured by a wattmeter, but owing to the small power factor of the current accurate measurements are difficult. Several new null methods are given which permit sensitive instruments to be used and accurate results obtained. (Sept. 1, 1905.) 15 pp. Price, 10 cents.

S19. The Relative Intensities of Metal and Gas Spectra from Electrically Conducting Gases....*P. G. Nutting*

A study of the conditions which determine whether the spectrum of the electrodes shall be brighter or fainter than the spectrum of the surrounding gas. (Aug. 1, 1905.) 18 pp.

S20. The Use of White Walls in a Photometric Laboratory.....*Edward P. Hyde*

If proper black velvet screens are employed on a photometer bench, the leakage of light into the photometer, due to the diffuse reflection from white walls, is shown to be so small as to be negligible. (July 15, 1905.) 4 pp. Price, 5 cents.

S21. Influence of Wave Form on the Rate of Integrating Induction Wattmeters.....
.....*E. B. Rosa, M. G. Lloyd, and C. E. Reid*

Experiments on integrating wattmeters show a variation in the rate with changes in the frequency and wave form of the current. (Aug. 15, 1905.) 14 pp. Price, 10 cents.

S22. Detector for Small Alternating Currents and Electrical Waves.....*L. W. Austin*

An investigation of the rectifying effects obtained when using copper electrodes in a solution of copper sulphate. (Aug. 1, 1905.) 4 pp. Price, 5 cents.

S23. The Positive Charges Carried by the Canal Rays..
.....*L. W. Austin*

An experimental demonstration of the positive charges carried by the canal rays. (Aug. 15, 1905.) 3 pp. Price, 5 cents.

S24. Radiation from Platinum at High Temperatures..
.....*G. K. Burgess*

On a linear relation between the true temperature and the black-body temperature of a radiating substance. (Aug. 15, 1905.) 3 pp. Price, 5 cents.

S25. A Five-Thousand Volt Generator Set.....*P. G. Nutting*

A description of a set of 10 small generators giving a direct current of 0.2 ampere at 5000 volts. (Sept. 15, 1905.) 3 pp. Price, 5 cents.

S26. Talbot's Law as Applied to the Rotating Sectored Disk.....*Edward P. Hyde*

The apparent intensity of a source, before which a sectored disk is rotating rapidly, is found to be proportional to the total angular opening of the sectored disk for all angles between 288° and 10°. (Mar. 1, 1906.) 32 pp. Price, 15 cents.

S27. A New Determination of the Electromotive Force of Weston and Clark Standard Cells by an Absolute Electrodynamometer.....*K. E. Guthe*

An account of the construction and determination of the constant of a Gray absolute electrodynamometer and work done with the same in determining the absolute value of the electromotive force of standard cells, assuming the international ohm. (Later determinations of values for electrical standards are given in C60. See also S171.) (Jan. 15, 1906.) 38 pp. Price, 5 cents.

S28. The Gray Absolute Electrodynamometer...*Edward B. Rosa*

A discussion of the theory of the instrument, showing the order of magnitude of certain possible errors and how the dimensions should be taken to conform to the conditions assumed in the formula for the dynamometer. (Jan. 30, 1906.) 16 pp. Price, 5 cents.

S29. Construction and Calculation of Absolute Standards of Inductance.....*J. G. Coffin*

A description of two standards of self-inductance and the calculation of their inductance. Two formulas for the calculation of their self-inductances are derived, and several other formulas for the calculation of inductances are given. (Feb. 1, 1906.) 57 pp. Price, 10 cents.

S30. An Efficiency Meter for Electric Incandescent Lamps.....*E. P. Hyde and H. B. Brooks*

By means of a variable resistance in series with the voltage circuit of a wattmeter and controlled by the position of the photometer screen the wattmeter is made to indicate watts per candle directly. (Mar. 15, 1906.) 16 pp. Price, 10 cents.

S31. Calculation of the Self-Inductance of Single-Layer Coils.....*Edward B. Rosa*

Single layer cylindrical coils are the best form of absolute self-inductances to construct and measure, but the formulas used in their calculation all assume that the current flows in a continuous sheet over the cylindrical surface. In this paper formulas are derived and tables given for calculating two correction terms to be applied to the results obtained from the current sheet formulæ to give the true self-inductance of an actual coil. (Mar. 15, 1906.) 29 pp. Price, 10 cents.

S32. Heat Treatment of High-Temperature Mercurial Thermometers.....*Hobert C. Dickinson*

Review of previous work. Results of annealing thermometers of different kinds of glass at various temperatures for long periods. Suggestions concerning the proper heat treatment of thermometers, electric annealing furnaces, and the pointing of thermometers to read true gas-scale temperatures. (Apr. 15, 1906.) 36 pp. Price, 10 cents.

S33. A New Potentiometer for the Measurement of Electromotive Force and Current.....*H. B. Brooks*

Theory and design of a new instrument for accurate measurements. Consists of a potentiometer with one dial, on which the larger part of the quantity is read off, the remainder being shown by the deflection of a pivoted galvanometer. [Superseded by S172 and S173.] (Mar. 30, 1906.) 17 pp. Price, 10 cents.

S34. Spectrum Lines as Light Sources in Polariscopic Measurements.....*Frederick Bates*

A theoretical investigation of errors incidental to the use of a two-line source. An international standard source is advocated and a measurement made of the ratio of the rotation of quartz for this source and the sodium lines. (May 1, 1906.) 11 pp. Price, 10 cents.

S35. Polarimetric Sensibility and Accuracy.....*P. G. Nutting*

A theoretical investigation of analyzers and light sources for obtaining the highest possible sensibility and accuracy in polarimetry. (May 6, 1906.) 13 pp.

S36. On the Platinum Point Electrolytic Detector for Electrical Waves.....*L. W. Austin*

An experimental study of the platinum-point electrolytic detector, including the sensibility of the detector for electrical waves from a distance as well as from apparatus in the same laboratory. (Mar. 30, 1906.) 15 pp. Price, 5 cents.

S37. Influence of Frequency upon the Self-Inductance of Coils.....*J. G. Coffin*

A mathematical discussion of the variation of the self-inductance of a single layer coil with the frequency of the current. (Mar. 30, 1906.) 23 pp. Price, 10 cents.

S38. Experiments on the Heusler Magnetic Alloys.....*K. E. Guthe and L. W. Austin*

Experimental study of seven samples of Heusler magnetic alloys, which are made from nonmagnetic metals. The magnetic properties of these samples are given in tables and curves. (Mar. 30, 1906.) 21 pp. Price, 10 cents.

S39. A Pocket Spectrophotometer.....*P. G. Nutting*

A description of a modified spectrophotometer on the plan of a pocket spectroscope. (July 15, 1906.) 3 pp. Price, 5 cents.

S40. Preliminary Measurements on Temperature and Selective Radiation of Incandescent Lamps..*C. W. Waidner and G. K. Burgess*

Measurement of temperature and selective radiation of filaments of tantalum, tungsten, and carbon. On the melting point of tungsten. (Sept. 30, 1906.) 11 pp. Price, 5 cents.

S41. Revision of the Formulæ of Weinstein and Stefan for the Mutual Inductance of Coaxial Coils..*Edward B. Rosa*

Weinstein's formula is accurate only for coils at distances large as compared with the cross section, and Stefan's only at near distances. Weinstein's is revised and corrected, and a new formula derived to replace Stefan's, the two agreeing closely and giving very accurate results. (Sept. 1, 1906.) 27 pp. Price, 5 cents.

S42. The Mutual Inductance of Two Circular Coaxial Coils of Rectangular Section.....*E. B. Rosa and Louis Cohen*

Various formulas for calculating the mutual inductance of coaxial circles and coaxial circular coils of rectangular section are investigated, and some new formulas derived. The best formulas for particular cases are indicated; it is shown where some formulas fail, and numerous examples are given to illustrate the formulas. (Sept. 1, 1906.) 56 pp. Price, 10 cents.

S43. On the Determination of the Mean Horizontal Intensity of Incandescent Lamps by the Rotating Lamp Method . . . *E. P. Hyde and F. E. Cady*

A study of the errors incident to this method, due (1) to the distortion of the filament on rotation, and (2) to the inability of the eye to estimate accurately a badly flickering illumination. By the use of a single stationary mirror accurate measurements of mean horizontal candlepower can be made even with badly flickering lamps. (Sept. 1, 1906.) 23 pp. Price, 10 cents.

S44. Purity and Intensity of Monochromatic Light Sources . . . . . *P. G. Nutting*

A mathematical treatment of spectral impurity and center of luminosity, with the results of an investigation of available light sources. (Sept. 1, 1907.) 18 pp. Price, 5 cents.

S45. Radiometric Investigations of Infra-Red Absorption and Reflection Spectra . . . . . *W. W. Coblentz*

The fact that certain groups of elements have characteristic absorption bands is applied to substances containing water of constitution and water of crystallization. It is shown that in the former the oxygen and hydrogen atoms are not united, while in the latter they are united, giving the characteristic absorption spectrum of water. The second part of the paper gives the reflecting power of various metals, not investigated heretofore, and of various minerals, especially of the silicates. (Sept. 1, 1907.) 22 pp. Price, 10 cents.

S46. A Vacuum Radiomicrometer . . . . . *W. W. Coblentz*

This is a modification of the instrument devised by Boys, and includes also a combination of the Nichols radiometer with the radiomicrometer. The paper indicates directions in which further improvements are possible. (Sept. 15, 1907.) 5 pp. Price, 5 cents.

S47. On the Geometrical Mean Distances of Rectangular Areas and the Calculation of Self-Inductance . . . . . *Edward B. Rosa*

It is shown in this paper that Maxwell's correction term in the formula for the self-inductance of a coil of wire, depending on the difference in the mutual inductances of round and square wires, is wrong, and Stefan's only approximately correct. The formulas are fully worked out by the method of geometrical mean distances and verified by other methods, and the true correction term for different cases is calculated. Further use of the method of geometrical mean distances in the calculation of inductances is indicated. (Nov. 1, 1906.) 41 pp. Price, 10 cents.

S48. The Compensated Two-Circuit Electrodynamometer . . . . . *Edward B. Rosa*

The instrument is used especially for the accurate measurement of alternating current and power. The theory of the instrument is given and a compensation provided so that when calibrated by means of direct current it is correct for alternating currents of different frequencies and any magnitude. (Nov. 1, 1906.) 16 pp. Price, 10 cents.

S49. Complete Form of Fechner's Law . . . . . *P. G. Nutting*

A mathematical investigation of the quantitative relation between luminous intensity and visual sensation based on König's data on least perceptible increment. (Dec. 15, 1906.) 6 pp. Price, 5 cents.

S50. A Comparison of the Unit of Luminous Intensity of the United States with those of Germany, England, and France . . . . . *Edward P. Hyde*

A number of seasoned incandescent lamps were carried abroad and measured in authoritative laboratories in the three countries named. The ratios of the units obtained through them are compared with the ratios generally accepted and with those obtained in other recent investigations. (Jan. 15, 1907.) 16 pp.

S51. Geometrical Theory of Radiating Surfaces with Discussion of Light Tubes.....*Edward P. Hyde*

Assuming Lambert's cosine law and the inverse square law to apply to infinitesimal surfaces, the errors incident to applying them to finite surfaces are deduced for several simple cases. From a consideration of the case of an infinitely long, uniformly bright strip of finite width a theory of light tubes is developed. (Jan. 15, 1907.) 24 pp. Price, 10 cents.

S52. The Influence of Basic Lead Acetate on the Optical Rotation of Sucrose in Water Solution.....
.....*F. J. Bates and J. C. Blake*

An experimental investigation of the change in the polarization of sucrose produced by the addition of different amounts of basic lead acetate. (Jan. 15, 1907.) 9 pp. Price, 5 cents.

S53. On the Colorimetric Determination of Iron with Special Reference to Chemical Reagents.....
.....*H. N. Stokes and J. R. Cain*

A method of separating iron from materials in which it exists in minute traces and of determining it colorimetrically as sulphocyanate. (Jan. 20, 1907.) 42 pp. Price, 10 cents.

S54. On Sulphocyanic Acid.....*H. N. Stokes and J. R. Cain*

An improved method of preparing sulphocyanic acid, especially for colorimetric iron determinations, with observations on its properties and those of some of its derivatives. (Jan. 20, 1907.) 5 pp. Price, 5 cents.

S55. Radiation from and Melting Points of Palladium and Platinum.....*C. W. Waidner and G. K. Burgess*

Radiation from platinum by several methods: Measurements of black-body temperature of iridium furnace at instant of melting of these metals. Melting point on thermoelectric scale. Optical determinations of temperature, using red, green, and blue light, based on Wien's equation for monochromatic radiation. (Mar. 4, 1907.) 46 pp. Price, 10 cents.

S56. The Mutual Inductance of a Circle and a Coaxial Single-Layer Coil. The Lorenz Apparatus and the Ayrton-Jones Absolute Electrodynamometer.....*Edward B. Rosa*

A series formula is developed for calculating the mutual inductance of a circle and a coaxial single-layer coil. The formula is more convenient than one using elliptic integrals and is very accurate. Several examples are given to test and illustrate the formula. (Mar. 1, 1907.) 28 pp. Price, 10 cents.

S57. On the Establishment of the Thermodynamic Scale of Temperature by Means of the Constant-Pressure Gas Thermometer.....*Edgar Buckingham*

A discussion of the methods for finding the thermodynamic corrections of the gas thermometer, together with computations of these corrections for the nitrogen thermometer and comparisons with values given by previous writers. (Feb. 4, 1907.) 57 pp. Price, 15 cents.

S58. An Exact Formula for the Mutual Inductance of Coaxial Solenoids.....*Louis Cohen*

An exact formula in elliptic integrals is derived for the mutual inductance of two coaxial, concentric single-layer solenoids. (Mar. 14, 1907.) 9 pp. Price, 5 cents.

S59. The Mutual Inductance of Coaxial Solenoids.....
.....*E. B. Rosa and Louis Cohen*

A critical examination of various formulas for calculating the mutual inductance of coaxial solenoids, with numerical examples to test and illustrate the formulas. (Mar. 30, 1907.) 22 pp. Price, 10 cents.

S60. The Production of High Frequency Oscillations from the Electric Arc.....*L. W. Austin*

An experimental study of the "singing arc" as a source of high frequency oscillations. (Apr. 1, 1907.) 16 pp. Price, 5 cents.

S61. An Explanation of the Short Life of Frosted Lamps.....*Edward P. Hyde*

The rapid decrease in candlepower of frosted lamps is due, at least partly, to the increased absorption of the carbon film deposited on the inner side of the bulb. Owing to the diffuse reflection at the frosted surface a relatively large part of the emitted light is compelled to traverse the absorbing carbon film three or more times before finally emerging. Results of confirmatory experiments are given. (Mar. 23, 1907.) 4 pp. Price, 5 cents.

S62. Melting Points of the Iron-Group Elements by a New Radiation Method.....*G. K. Burgess*

Minute quantities of substances melted on platinum ribbon, the temperature of which is measured by means of an optical pyrometer. Method designed for rare substances was tested by determining melting points of Fe, Ni, Co, etc. (Apr. 5, 1907.) 11 pp. Price, 10 cents.

S63. On the Determination of the Mean Horizontal Intensity of Incandescent Lamps.....*E. P. Hyde and F. E. Cady*

A continuation of a previous investigation on this subject. (See reprint No. 43.) Other types of lamps are studied, and the methods and results of similar experiments by Uppenborn are discussed. (Apr. 30, 1907.) 13 pp. Price, 10 cents.

S64. The Simultaneous Measurement of the Capacity and Power Factor of Condensers.....*Frederick W. Grover*

Four methods for obtaining the ratio of the capacities and the difference of the power factors of two condensers are described and critically compared. Using air condensers as standards, examples are given to show what values of power factor occur in mica and paper condensers by different manufacturers. (May 23, 1907.) 61 pp. Price, 15 cents.

S65. A New Determination of the Ratio of the Electromagnetic to the Electrostatic Unit of Electricity.....*E. B. Rosa and N. E. Dorsey*

An extended experimental investigation of the problem, by the method of capacities, employing spherical, cylindrical, and plane condensers. A detailed mathematical discussion of the theory and of sources of error is given. The result, reduced to vacuo, obtained for the ratio of the units is $2.9971 \times 10^{10} \left[\frac{\text{cm. Int. } \Omega}{\text{sec}}\right]^{\frac{1}{2}}$. (The National Physical Laboratory has found (Phil. Trans., 214A, pp. 27–108, 1914) that 1 international ohm is equal to 1.00052 absolute ohms. On the substitution of this value in the above ratio it becomes $2.9979 \times 10^{10} \frac{\text{cm}}{\text{sec}}$. The estimated uncertainty is 1 in 10 000.) (May 20, 1907.) 170 pp. Price, 20 cents.

S66. A Comparison of the Various Methods of Determining the Ratio of the Electromagnetic to the Electrostatic Unit of Electricity.....*E. B. Rosa and N. E. Dorsey*

A discussion of the relative advantages and disadvantages of the various methods of determining the ratio of the units that have been used or proposed. (June 21, 1907.) 18 pp. Price, 5 cents.

S67. Preliminary Specifications for Clark and Weston Standard Cells.....*F. A. Wolff and C. E. Waters*

Specifications for the construction of Clark and Weston Standard Cells and for the preparation and purification of the materials employed, based in the main on the results obtained in an investigation on the reproducibility and constancy of both types. (See S70.) (Aug. 16, 1907.) 18 pp. Price, 5 cents.

S68. Calorimetric Resistance Thermometers and the Transition Temperature of Sodium Sulphate. .....*H. C. Dickinson and E. F. Mueller*

Description of platinum resistance thermometers having very small time constant. Calibration on International Hydrogen Scale and application to determination of transition temperature of sodium sulphate. [Superseded by S200.] (June 21, 1907.) 21 pp. Price, 5 cents.

S69. On the Standard Scale of Temperature in the Interval 0° to 100°..*C. W. Waidner and H. C. Dickinson*

Results of intercomparisons of primary standard mercurial thermometers and relation of the temperature scale of the Bureau of Standards to the International Hydrogen Scale of Temperature. The depression and zero recovery of verre dur glass. Description of thermometer comparator, standard barometers, etc. (May 3, 1907.) 66 pp. Price, 20 cents.

S70. Clark and Weston Standard Cells..... .....*F. A. Wolff and C. E. Waters*

An investigation of the accuracy attainable in the reproduction of standards of electromotive force, with detailed descriptions of the purification and preparation of the necessary materials and of the apparatus and methods employed. The results obtained and the close agreement of the Bureau cells with those set up by other investigators establish the suitability of the cell as a fundamental electrical standard. (Sept. 17, 1907.) 80 pp. Price, 20 cents.

S71. The Electrode Equilibrium of the Standard Cell... .....*F. A. Wolff and C. E. Waters*

A study of the conditions of equilibrium in both limbs of the cell, made in order to detect possible causes of variation in electromotive force due to secondary chemical reactions which may take place between the ingredients of the cell. (Oct. 4, 1907.) 9 pp. Price, 5 cents.

S72. A Comparative Study of Plain and Frosted Lamps. .....*E. P. Hyde and F. E. Cady*

The various effects of frosting the bulbs of carbon filament incandescent lamps are studied as changes in (1) absorption, (2) distribution, and (3) life.

(1) New lamps show an absorption of only 2 or 3 per cent, which increases rapidly as the lamps burn. (2) The distribution of light around frosted lamps depends on (a) the distribution curve of the bare lamps, and on (b) the shape of the bulb. (3) The theory advanced in a previous paper (see reprint No. 61) to account for the short life of frosted lamps is further substantiated. Readings are given of the temperatures of the bulbs of plain and frosted lamps, both new and old. (July 15, 1907.) 30 pp.

S73. On the Variation of Resistances with Atmospheric Humidity.....*E. B. Rosa and H. D. Babcock*

It is shown in this paper that resistances that have been coated with shellac undergo changes in value due to the absorption of moisture by the shellac, and that the resistance increases in a moist atmosphere and decreases in a dry atmosphere. This occurs even if the resistances are kept submerged in oil. A thorough study has been made of resistances of various kinds, and the magnitude of changes occurring and methods of preventing it are given. (Oct. 4, 1907.) 20 pp. Price, 10 cents.

S74. On the Self-Inductance of a Toroidal Coil of Rectangular Section . . . . . *Edward B. Rosa*

The simple formula for the self-inductance of such a coil assumes that the current flows in a thin current sheet about the core. Fröhlich's correction formula was derived on the assumption that a winding of round wires is equivalent to a thick current sheet. It is shown in this paper that this assumption leads to a wrong result, and the correct expression is given, enabling the self-inductance to be calculated when the size and spacing of the wires are given. (Aug. 10, 1907.) 7 pp. Price, 5 cents.

S75. On the Self-Inductance of Circles . . . . . *E. B. Rosa and Louis Cohen*

It is shown in this paper that some of the formulas that have been given for the self-inductance of circular conductors of circular cross section are incorrect, while the most accurate formulas and the most convenient approximate formulas are indicated and tested by numerical examples. (Aug. 10, 1907.) 11 pp. Price, 5 cents.

S76. The Influence of Frequency on the Resistance and Inductance of Solenoidal Coils . . . . . *Louis Cohen*

A theoretical investigation of the effect of frequency on the resistance and inductance of solenoids. The work of previous investigators is discussed, and it is pointed out that they do not agree with experiment. New formulas are derived which agree with the experimental results of M. Wien, and also with new experiments carried out by the author. (Aug. 16, 1907.) 19 pp. Price, 10 cents.

S77. The Atomic Weight of Hydrogen . . . . . *W. A. Noyes*

A determination of the ratio of hydrogen to oxygen by direct synthesis of water by the action of hydrogen on copper oxide and by the union of hydrogen and oxygen over palladium foil. (Sept. 11, 1907.) 26 pp. Price, 10 cents.

S78. The Best Method of Demagnetizing Iron in Magnetic Testing . . . . . *Charles W. Burrows*

An experimental investigation to determine a method of freeing iron from previous magnetization preliminary to a permeability test. The influence of the frequency of reversal, the number of reversals, the upper and lower limits of the current, and the method of regulating the demagnetizing current, as well as the influence of eddy currents, temperature, and gentle vibrations, are investigated. A method of procedure for a complete ballistic test is outlined. (Sept. 3, 1907.) 70 pp. Price, 15 cents.

S79. A Deflection Potentiometer for Voltmeter Testing . . . . . *H. B. Brooks*

In this paper the theory of the deflection potentiometer is extended (see Paper No. 33 preceding). The instrument is used for the measurement of electromotive force and current by a combination of the null and deflection methods. A second instrument constructed on this plan is described, and a brief outline of the method of design of such instruments is given. [Superseded by S172 and S173.] (Oct. 11, 1907.) 26 pp. Price, 10 cents.

S80. The Self and Mutual Inductance of Linear Conductors . . . . . *Edward B. Rosa*

Formulæ are given for the self and mutual inductance of straight wires, flat strips, and rectangles, for the so-called noninductive arrangement of strips and sheets folded on themselves, and for a "noninductive" winding of wires on a cylinder or in a plane. It is shown how, by the use of geometrical mean distances and arithmetical mean distances and arithmetical mean square distances, certain formulas are derived independently and some approximate formulas made more accurate. (Sept. 15, 1907.) 44 pp. Price, 15 cents.

S81. The Atomic Weight of Chlorine.....
.....*W. A. Noyes and H. C. P. Weber*

A determination of the atomic weight of chlorine by the direct synthesis of hydrochloric acid by means of hydrogen and potassium chloroplatinate. (Oct. 1, 1907.) 20 pp. Price, 10 cents.

S82. The Preparation of Chloroplatinic Acid by Electrolysis of Platinum Black.....*H. C. P. Weber*

A method of preparing chloroplatinic acid free from nitric acid by the electrolysis of finely divided platinum in concentrated hydrochloric acid. (Oct. 8, 1907.) 3 pp. Price, 5 cents.

S83. The Self-Inductance of a Coil of any Length and any Number of Layers of Wire....*Edward B. Rosa*

The formulas of Weinstein and Stefan for the self-inductance of a circular coil of rectangular section are not accurate for long coils and no other formula yet given is accurate for such cases. In this paper it is shown how to calculate accurately the self-inductance of a coil of any length and any number of layers of wire, taking account also of the corrections depending on the size of the wire and the thickness of the insulation. (Oct. 12, 1907.) 23 pp. Price, 5 cents.

S84. The Self-Inductance of a Solenoid of any Number of Layers.....*Louis Cohen*

In this paper is given the derivation of a simple approximate formula for the calculation of the self-inductance of a long coil of any number of layers, and examples are given to illustrate its use. (Oct. 11, 1907.) 8 pp. Price, 5 cents.

S85. Instruments and Methods used in Radiometry....
.....*W. W. Coblentz*

An experimental investigation of sensitivity and relative advantages of the bolometer, radiomicrometer, radiometer, and thermopile, with a review of published data relating to these instruments and to galvanometers of high sensitivity. (Oct. 1, 1907.) 70 pp. Price, 15 cents.

S86. A Quartz Compensating Polariscope with Adjustable Sensibility.....*Frederick Bates*

The theory and description of a new type of quartz-wedge polariscope which gives the maximum theoretical sensibility, whatever the character of the substance polarized. (Oct. 15, 1907.) 6 pp. Price, 5 cents.

S87. An Apparatus for Determining the Wave Form of Magnetic Flux.....*M. G. Lloyd and J. V. S. Fisher*

Gives a description of apparatus by means of which the form factor of an electric wave may be directly determined and waves of magnetic flux or of electric current or voltage plotted. (Nov. 15, 1907.) 10 pp. Price, 10 cents.

S88. The Effect of Wave Form upon the Iron Losses in Transformers.....*Morton G. Lloyd*

This article considers the two elements of core losses in transformers, hysteresis and eddy currents, and the effect of variations of wave form upon them. Assuming the effective voltage to be maintained constant, it is shown that the loss by eddy currents will be constant, while the hysteresis loss varies in a way which can be determined if the form factor of the applied voltage be known. Experimental data are given which substantiate the theoretical results. (Oct. 31, 1907.) 34 pp. Price, 10 cents.

S89. The Luminous Properties of Electrically Conducting Helium Gas.....*P. G. Nutting*

An experimental study of the amount of light emitted by a column of helium gas as affected by the current, potential gradient, gas density, diameter of tube, orientation of tube, current frequency, and with age. The results are discussed from the point of view of a possible primary light standard. (Dec. 1907.) 13 pp. Price, 10 cents.

S90. Function of a Periodic Variable given by the Steady Reading of an Instrument; with a Note on the Use of the Capillary Electrometer with Alternating Voltages.....*Morton G. Lloyd*

In general, instruments read the *effective* and not the average value of the quantity measured, even when the instrument has a proportional scale. It is shown that the capillary electrometer may be used with alternating voltages, but it is not well adapted for this class of work. (Dec. 30, 1907.) 8 pp.

S91. Selective Radiation from the Nernst Glower..*W. W. Coblentz*

An experimental investigation of the distribution of energy in the spectrum of the Nernst glower when operated at various temperatures, from the lowest to the highest. It is shown that the infra-red emission spectrum, which is discontinuous at low temperatures, becomes continuous at high temperatures, but in neither case is there any evidence of the glower having a radiation law similar to that of a complete radiator. (Feb. 10, 1908.) 18 pp. Price, 10 cents.

S92. The Testing of Glass Volumetric Apparatus.....
.....*H. S. Osborne and B. H. Veazey*

Specifications of glass volumetric apparatus accepted for test. Discussion of these specifications. Experimental work on burette drainage and on effect of contamination on capacity of volumetric apparatus. Methods of testing. Tables for usé in determination of capacity. (Apr. 10, 1908.) 49 pp. Price, 15 cents.

S93. Formulæ and Tables for the Calculation of Mutual and Self-Inductance .....*E. B. Rosa and Louis Cohen*

The first part of the paper contains 121 formulas for the calculation of the mutual and self-inductance of coils of various kinds and of single conductors of different forms, together with the corrections to be applied in certain cases to convert the results of current sheet formulas and formulas assuming a uniform distribution of current over the section of a coil to the actual cases of current flowing in insulated wires. The formulas have all been tested in actual practice, and formulas that were found inaccurate or not practically useful have been eliminated in making the collection. The second part of the paper contains numerous examples to illustrate the use of the formulas. In an appendix 14 tables of functions and constants are given which are useful in the calculation of inductances. (Oct. 1, 1907.) 132 pp. [Superseded by S169.]

S94. Some Contact Rectifiers of Electric Currents...*L. W. Austin*

An experimental study of the unilateral conductivity of certain contacts (silicon-steel, carbon-steel, and tellurium-aluminum) for small currents. The percentage of rectification is independent of the frequency and the rectified current is roughly proportional to the square of the alternating current. (Apr. 27, 1908.) 15 pp. Price, 10 cents.

S95. A Method for Producing Feebly Damped High Frequency Electrical Oscillations for Laboratory Measurements.....*L. W. Austin*

In this method the aperiodic pulses produced in a circuit of small inductance and large capacity connected across a buzzer contact are used to excite a highly inductive circuit to vibrate in its own natural period. (Apr. 27, 1908.) 4 pp. Price, 5 cents.

S96. On the Advantages of a High Spark Frequency in Radio-Telegraphy.....*L. W. Austin*

It is shown that the telephone is much more sensitive to high tones and that the highly pitched spark is more easily heard in the midst of disturbing noises, also that the energy losses in sending stations are less with high spark frequency and lower potentials. (Apr. 27, 1908.) 5 pp. Price, 5 cents.

S97. Selective Radiation from Various Solids. I..*W. W. Coblentz*

A spectrobolometric investigation of the radiation from various solids (oxides, silicates, etc.) in the form of (1) electrically heated rods similar to a Nernst glower, and (2) of solids in the form of a fine powder on a heater. It is shown that the partition of energy in the spectrum, of all the substances examined, is generally in the form of sharp emission lines superposed upon a weak continuous spectrum. With rise in temperature the spectrum usually becomes continuous. (May 20, 1908.) 32 pp. Price, 10 cents.

S98. Remarks on the Quartz Compensating Polariscope with Adjustable Sensibility.....*Frederick Bates*

A simplified equation for calculating the zero point displacement is developed. Reply is made to Schönrock's criticism that it is necessary to consider the reflection and absorption in the small nicol of a Lippich system. It is shown that all the functions involved can be divided into linear and nonlinear functions and that the former, which include reflection, absorption, etc., impose no difficulties in the construction of the instrument. (June 2, 1908.) 6 pp. Price, 5 cents.

S99. Methods of Obtaining Cooling Curves.....*G. K. Burgess*

The experimental methods available for obtaining cooling curves in thermal analysis with thermocouples for slow cooling, with and without registration, are classified and described. A simplification of the Roberts-Austen method is suggested. A brief analytical discussion of the characteristics of the several types of cooling curves is given. It is shown that the time-temperature and differential methods may be combined to give the highest sensibility over great temperature ranges. (Aug. 3, 1908.) 27 pp. Price, 10 cents.

S100. Note on the Approximate Value of Bessel's Functions for Large Arguments.....*Louis Cohen*

A simple demonstration to show that the values of the Bessel's functions of complex arguments will be given approximately by certain exponential functions, when the absolute values of the arguments become very large. (Aug. 24, 1908.) 4 pp. Price, 5 cents.

S101. The Influence of Terminal Apparatus on Telephonic Transmission.....*Louis Cohen*

A complete mathematical discussion of the problem of wave propagation along conductors taking into consideration the disturbing influences of terminal apparatus. It is shown that for short lines the telephone receiver increases the distortion while for very long lines the disturbing influences of the receivers are very slight. It is also shown that the introduction of a condenser of proper magnitude in series with the receiver will improve telephonic transmission. (Aug. 3, 1908.) 12 pp. Price, 10 cents.

S102. The Principles Involved in the Selection and Definition of the Fundamental Electrical Units to be Proposed for International Adoption...*F. A. Wolff*

A discussion prepared for the London Electrical Conference of 1908 on the relative merits of the standard cell and the silver voltameter as fundamental electrical standards. The superiority of the Weston standard cell in the light of the evidence at hand is pointed out and its adoption urged. (Sept. 3, 1908.) 18 pp. Price, 10 cents.

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S103. The Luminous Equivalent of Radiation.....*P. G. Nutting*

An extended study of the essential relations existing between light and radiation, visible sensation, and stimulus. A general theory of sensibility stimulus, and scale reading, applicable to all measuring instruments, is mapped out and the eye treated as a special case. The best available data are used to illustrate the theory, and finally special problems and practical applications are discussed. (Sept. 3, 1908.) 48 pp. Price, 15 cents.

S104. The Temperature Formula of the Weston Standard Cell.....*F. A. Wolff*

This paper gives the results of a redetermination of the temperature formula of the Weston normal cell. Over 150 cells, set up with material prepared or purified by different methods, including a number of cells exchanged with other investigators, were found in most excellent agreement between 0° and 40° C. (The formula proposed has been since adopted by the London International Electrical Conference.) (Sept. 3, 1908.) 28 pp. Price, 10 cents.

S105. Radiation Constants of Metals.....*W. W. Coblentz*

A spectrobolometric investigation of the radiation constants of various metals, including tungsten, tantalum, osmium, and platinum; also various forms of carbon filaments. Theoretical and experimental data are given to account for the high efficiency of the metal filament lamps. (Aug. 22, 1908.) 40 pp. Price, 10 cents.

S106. Dependence of Magnetic Hysteresis upon the Wave Form.....*Morton G. Lloyd*

Apparatus is described for measuring hysteresis with different wave forms, using the same definite value of maximum flux density, and it is shown that the hysteresis varies slightly with wave form. The separation of hysteresis and eddy-current losses by determining the total energy loss at two frequencies, using the Steinmetz formula, is not accurate, but is a close approximation when thin sheets are used. (Oct. 10, 1908.) 30 pp. Price, 10 cents.

S107. A New Form of Standard Resistance.....*E. B. Rosa*

A new form of standard resistance is described which has been found more constant and reliable than those heretofore used at the Bureau as standards, and which is also very convenient in use. These standards are so inexpensive and simple that any laboratory where precision measurements of resistance are made can afford to use them. Results of a long series of tests of the new standards are given. (Oct. 1, 1908.) 22 pp. Price, 15 cents.

S108. Errors in Magnetic Testing with Ring Specimens .....*Morton G. Lloyd*

Discussion of the errors which arise in measurements of permeability and hysteresis in rings of circular or rectangular section, due to nonuniform distribution of flux. Tables and curves are given showing, for rings of various dimensions, the ratio of mean intensity of magnetizing field to the intensity at the mean radius, and the ratio of hysteresis with uniform distribution to the actual hysteresis. (Aug. 19, 1908.) 19 pp. Price, 10 cents.

S109. The Testing of Transformer Steel.....
.....*Morton G. Lloyd and J. V. S. Fisher*

A discussion of the conditions which should be realized in the measurement of energy losses in sheet steel subjected to alternating magnetization, and description of an apparatus giving 1 per cent accuracy with less than 2 kg. of material. Results are given for domestic and foreign steels, showing a wide range of quality. Measurements at two frequencies have enabled the hysteresis and eddy-current losses to be separated. The effects of aging are shown to depend upon the flux density used for test, and are usually negligible in silicon steels. (Jan. 29, 1909.) 30 pp. Price, 5 cents.

S110. A New Method for Determining the Focal Length of a Converging Lens.....*Irwin G. Priest*

An exposition of the theory, a description of the experimental procedure, and a discussion of the accuracy of a method giving the focal length in monochromatic light by means of the relation between focal length and the diameter of a circular interference fringe in the real image formed by the lens. The chief advantages of the method are (1) correct definition of focal length, (2) use of definitely specified wave lengths, affording a precise test of achromatism, and (3) simplicity of observation and calculation. 1(Mar. 18, 1909.) 15 pp. Price, 10 cents.

S111. A New Method for the Absolute Measurement of Resistance.....*E. B. Rosa*

A method is described in which two coils of wire at right angles to one another form an armature, which revolves in a magnetic field produced by two parallel coils of many layers. Each revolving coil is connected to a 2-part commutator, which rectifies the current flowing through the coil. The method makes use of a 3-circuit differential galvanometer, by means of which the electromotive force generated by the revolving coils is balanced against the difference of potential at the terminals of the resistance to be measured, which may be from 1 to 10 ohms. The mutual inductance of the fixed and moving coils is determined by comparison with a standard of mutual inductance. (Feb. 27, 1909.) 10 pp. Price, 5 cents.

S112. The Theory of Coupled Circuits.....*Louis Cohen*

A mathematical discussion of direct and electromagnetically coupled circuits. The frequency constants and damping factors are completely determined in both cases. For the case of electromagnetically coupled circuits expressions are also derived for the currents and potentials in the primary and secondary circuits. (Feb. 1, 1909.) 30 pp. Price, 5 cents.

S113. A Volt Scale for a Watts-per-Candle Meter..*Herbert E. Ives*

The ordinary watt scale in a watts-per-candle or efficiency meter is replaced by a volt scale calculated on the voltage-watts-per-candle relation for the type of filament investigated. Incandescent lamps are photometered at a single voltage, and the photometer setting indicates on the volt scale the voltage to give a desired watts-per-candle. (Feb. 27, 1909.) 5 pp. Price, 5 cents.

S114. The Coefficient of Reflection of Electrical Waves at a Transition Point.....*Louis Cohen*

An electric wave in passing from one conductor to another of different electrical constants will be partly reflected and partly transmitted. In this paper expressions are obtained giving the ratios of the amplitude of the reflected and transmitted waves to the incoming wave. It is shown that in some cases the potential may rise to double its value at a transition point. (Feb. 27, 1909.) 6 pp. Price, 5 cents.

S115. A Tungsten Comparison Lamp in the Photometry of Carbon Lamps..*Herbert E. Ives and L. R. Woodhull*

A tungsten lamp is substituted for the usual carbon comparison lamp in commercial incandescent lamp photometry. Operated at low voltage the tungsten lamp gives a color match with carbon lamps of all commercial efficiencies, therefore eliminating the errors due to color differences. At the voltage used such a comparison lamp is very constant in candlepower and has an extremely long life. (Feb. 27, 1909.) 4 pp.

S116. The Determination of the Ratio of Transformation and of the Phase Relations in Transformers..
.....*E. B. Rosa and Morton G. Lloyd*

A discussion of the factors affecting the ratio and phase relations in potential and current transformers, with experimental results. The effect of wave form upon the ratio is given especial attention. (Feb. 25, 1909.) 30 pp. Price, 5 cents.

S117. The Determination of the Magnetic Induction in Straight Bars.....*Charles W. Burrows*

A modification of the double-yoke method of magnetic measurements on straight bars. Uniform solenoids surround the two straight test pieces. Short coils are placed over the ends of the rods as close to the yoke as possible. The currents through these three sections are adjusted until the flux throughout the magnetic circuit as indicated by the test coils is uniform. The induction is then determined by balancing the electromotive forces, induced in a test coil and in the secondary of a variable mutual inductance. Both the induction and magnetizing force are determined by zero methods, and the constants of the apparatus are so adjusted that these quantities are read directly from the settings of a potentiometer. The effects of yokes, joints, leakage, compensating magnetomotive forces, position of test coils, nonuniformity of specimen, etc., are investigated experimentally. (May 1, 1909.) 58 pp. Price, 15 cents.

S118. A Method for Constructing the Natural Scale of Pure Color.....*P. G. Nutting*

Measurements of the least difference in wave length perceptible as a difference in color give reciprocal visual sensibility. The general integral of sensibility as a function of wave length gives the color scale desired. Discussion of color units and application of method to the best recent data on the difference limen. (Apr. 27, 1909.) 5 pp. Price, 5 cents.

S119. An Approximate Experimental Method for the Analysis of EMF Waves.....*P. G. Agnew*

A method is discussed which gives approximate values of two harmonics of an emf wave, without the use of special apparatus, and requiring only voltmeter, ammeter, and condensers. It is shown by experimental results that an accuracy of 2 or 3 per cent may be attained. (Apr. 5, 1909.) 12 pp. Price, 5 cents.

S120. The Thermoelectric Properties of Tantalum and Tungsten.....*W. W. Coblentz*

This paper gives an account of an examination of the thermoelectric behavior of tantalum, tungsten, and constantan through the temperature range between −190° to +270° C. (Jan. 15, 1909.) 4 pp. Price, 5 cents.

S121. The Estimation of the Temperature of Copper by Means of Optical Pyrometers.....*G. K. Burgess*

An experimental determination of the corrections to be added to the readings of optical and total-radiation pyrometers when sighted upon liquid copper and cuprous oxide. These corrections, in the case of liquid copper, are over 125° C for pyrometers using red light and over 450° C for total-radiation pyrometers. The emissivities of copper and copper oxide are also determined. (June 17, 1909.) 9 pp. Price, 5 cents.

S122. The Resolving Power of Objectives.....*P. G. Nutting*

A half tone screen illuminated with monochromatic light as test object gave a simple and sensitive means of testing the well-known formula for resolving power. Different values of the resolving power constant were interpreted in terms of quality of image. The performance of telescope and camera objectives was compared as regards resolving power and residual axial aberrations. (Aug., 1909.) 5 pp. Price, 5 cents.

S123. The Theory of the Hampson Liquefier..*Edgar Buckingham*

The paper contains an account of the theory of the action of the Hampson apparatus for liquefying gases, and shows how the behavior of such an apparatus may be predicted from the known properties of the gas to be liquefied. The theoretical deductions are tested by comparison with the published results of experiments on the liquefaction of air and shown to agree with those results. Several questions concerning the operation of the liquefier are discussed in the light of the theory with a view to dispelling misunderstandings which have occurred. (May 15, 1909.) 33 pp. Price, 5 cents.

S124. Platinum Resistance Thermometry at High Temperatures.....*C. W. Waidner and G. K. Burgess*

Determination of the freezing and melting points of the metals Sn, Cd, Pb, Zn, Ag-Cu, Ag, and Cu, with thermometers of platinum of different degrees of purity, and of different types of construction, on the scale of the platinum thermometer, when calibrated in ice, steam, and sulphur vapor; comparison of this scale with the thermoelectric scale; variations in thermometers caused by high temperatures; differences in freezing points of metals obtained from different sources; heating of thermometers by measuring current; the boiling point of sulphur as a fixed point; modification of Callendar method of calibration for impure platinum; the Dickson formula; the Palladium thermometer; etc. (June 25, 1909.) 82 pp. Price, 10 cents.

S125. The Daylight Efficiency of Artificial Illuminants .....*Herbert E. Ives*

Paper discusses the possibility of screening high-efficiency illuminants so that the color is that of average daylight. The intensity of the source before and after screening is compared, and the values used to give a "daylight efficiency." Two methods of obtaining white-light efficiency are developed; the first, from consideration of absorbing screens; second, from the consideration of the white light which with a spectrum ray will match the color. The first method is limited to sources with continuous spectra and is dependent on an arbitrary "screening point." The second is applicable to all sources. A graphical combination of the results of the two methods enables all light sources to be represented in a form to be easily compared and to show the qualities desired by the illuminating engineer. (May, 1909.) 16 pp. Price, 5 cents.

S126. Coupled Circuits in which the Secondary has Distributed Inductance and Capacity.....*Louis Cohen*

A mathematical discussion of the oscillations in two circuits which are inductively connected, and one of which has distributed capacity and inductance. (July 29, 1908.) 8 pp. Price, 5 cents.

S127. Effect of Phase of Harmonics upon Acoustic Quality.....*M. G. Lloyd and P. G. Agnew*

A description of experiments which indicates that quality is independent of the phase of harmonics. Two electric generators giving frequencies in the proper relation are connected in series, and a telephone receiver used as a detector. By running the two generators slightly out of synchronism, a recurring shift of phase is produced. The sound from a telephone has also been analyzed by resonators and found to contain harmonics not present in the electrical wave used to excite it. (June 30, 1909.) 9 pp. Price, 5 cents.

S128. White Light from the Mercury Arc and its Complementary.....*Herbert E. Ives*

Various artificial light sources were measured for color with the Ives colorimeter and expressed in terms of average daylight. By plotting them in a color triangle (Maxwell) it appeared that the mercury vacuum arc was nearly complementary to all of the more usual yellowish illuminants. The Welsbach mantle and the tungsten lamp were found to be nearest the ideal complementary. The intensity relations were investigated and it was found that to 1 cp of mercury light should be added 0.57 cp of Welsbach, 0.54 cp of tungsten, or 0.50 cp of 3.1-watts-per-candle carbon glow lamp for the best approach to daylight. Illumination of colored objects showed the mercury-tungsten combination to be the best, rendering color values very much better than the mercury arc alone. The mercury-tungsten combination has an efficiency of 0.8 watt per candle, the carbon 1.4 watts per candle. (Aug. 1, 1909.) 7 pp. Price, 5 cents.

S129. The Regulation of Potential Transformers, and the Magnetizing Current....*M. G. Lloyd and P. G. Agnew*

A formula for regulation is derived by vector method and by use of complex quantities. The principal object is to show that the customary formula involving magnetizing current is incorrect. Experiments are given showing that regulation is independent of magnetizing current. (June 21, 1909.) 8 pp. Price, 5 cents. [Superseded by S211.]

S130. The Determination of the Constants of Instrument Transformers.....*P. G. Agnew and T. T. Fitch*

A null method for the simultaneous determination of the ratio and the phase angle of both potential and current transformers, which depends upon the potentiometer principle, is described. Curves are given showing the performance of typical transformers. It is shown that the constants of a current transformer may be changed by its magnetic treatment, but this effect may be removed by demagnetization. (July 5, 1909.) 19 pp. Price, 5 cents.

S131. Selective Radiation from Various Solids. II.....
.....*W. W. Coblentz*

The present paper is a continuation of previous work (No. 97) on this subject. Several minerals are shown to be solid solutions instead of definite chemical compounds, which suggests that this method of analysis might be of use in studying the physical condition of highly fusible oxides. The spectral energy curves of carbon and tungsten are set to a "color match," and it is shown that the eye is incapable of detecting a difference in emissivity of 5 per cent or more in the extreme red end of the spectrum. (Aug. 14, 1909.) 18 pp. Price, 10 cents.

S132. Luminous Efficiency of the Firefly.....
.....*Herbert E. Ives and W. W. Coblentz*

For the purpose of obtaining the spectral energy distribution of the firefly light, photographs were taken of the spectrum of the species "Photinus pyralis" and also of the carbon glow lamp. The densities of the negatives were measured, and the spectrophotometric curve of the firefly light thereby obtained was compared with that of carbon lamp. The spectral energy curve of the carbon lamp was determined by radiometric methods, and, by means of the ratios of the spectrophotometric intensities of the firefly light to the glow lamp, the spectral energy curve of the firefly was obtained. The luminous efficiency of the firefly and glow lamp was obtained from the spectral energy curves. The glow lamp (4 watt) proved to have 0.4 per cent efficiency, the firefly 96.5 per cent. (Aug. 1, 1909.) 15 pp. Price, 5 cents.

S133. Luminosity and Temperature.....*P. G. Nutting*

Making use of the luminosity function developed in a previous paper, the complete expressions for luminosity and luminous efficiency of bodies of known temperatures are worked out. In conclusion, numerical values are calculated in candles per watt for various lamps and other bodies and the results found to be in close agreement with known data. (July, 1909.) 10 pp. Price, 5 cents.

S134. A Theoretical and Experimental Study of the Vibration Galvanometer.....*F. Wenner*

The importance of the electromotive force developed by the relative motion of the magnet and winding of a galvanometer is pointed out and the general theory of the vibration galvanometer developed. Equations are derived which show how the amplitude of the vibration depends upon the constants of the instrument and the conditions under which it is used. The design of an instrument to be used in bridge work is considered, and it is shown that the mechanical power necessary to maintain a vibration is the principal factor in determining its sensibility. (May 25, 1909.) 32 pp. Price, 5 cents.

S135. Specific Heat of some Calcium Chloride Solutions between $-35°$ C and $+20°$ C. . . . . *H. C. Dickinson, E. F. Mueller, and E. B. George*

A continuous flow calorimeter for specific heat of solutions at low temperatures. The Dewar flask adapted for use directly as the calorimeter. Energy and temperature measurements made electrically. Specific heats of chemically pure and commercial calcium choride solutions of various densities at temperatures from $-35°$ to $+20°$ C determined by these two methods. (Nov. 4, 1909.) 30 pp. Price, 10 cents.

S136. On the Definition of the Ideal Gas. . . . . *Edgar Buckingham*

The paper contains a discussion of the nature, origin, and limitations of the notion of an ideal or standard gas having properties to which those of real gases may be considered as approximations, a comparison of the more common ways of defining these properties in terms of Boyle's and Joule's laws and the Joule-Kelvin effect, showing to what extent the various forms of definition are equivalent; and a discussion of the term "cohesion-pressure" and of its use in the definition of the ideal gas. (Nov. 13, 1909.) 21 pp. Price, 5 cents.

S137. Mica Condensers as Standards of Capacity. *Harvey L. Curtis*

The important methods of measuring capacity are discussed with reference to their use in the case of mica condensers. It is shown that: (1) The temperature coefficient of a mica condenser can be made small by compressing it, when the paraffin is molten, between metal clamps; (2) the effect of changes in the atmospheric pressure on the capacity is small, but not always negligible; (3) the capacity is independent of the voltage except in the case of silvered-mica condensers; (4) the capacity of a mica condenser kept at constant temperature and pressure remains constant to a few parts in a hundred thousand; (5) the capacity with alternating current of infinite frequency is the same as the capacity with instantaneous discharge using direct current. (Apr. 22, 1910.) 58 pp. Price, 10 cents.

S138. The Mutual Inductances of Two Parallel Coaxial Circles in Terms of Hypergeometrical Series . . . . . *Frederick W. Grover*

In a paper published in the Journal de Physique of 1901, Mathy derived a formula for the mutual inductance of two parallel coaxial circles, in which the result is expanded in hypergeometrical series. This formula was tested by the author of this paper and found to give erroneous results. In this paper the derivation of Mathy's formula is investigated and the corrected formula obtained. Part of the error in Mathy's formula is shown to be due to use of erroneous equations in Halpher's "Fonctions elliptiques." Finally numerous examples are given to illustrate the use of the formula. (Feb. 1, 1910.) 14 pp. Price, 5 cents.

S139. A New Method for the Absolute Measurement of Electric Quantity. . . . . *Burton McCollum*

In the methods previously used for the absolute determination of the electrochemical equivalent of silver it is necessary first to measure a current absolutely, and then hold this current constant for a measured length of time from which the quantity is calculated. It is here shown how an electrodynamometer of a modified Gray type may be used to indicate directly either the current or the total quantity of electricity that has passed through it, and a method is given for determining the constant of the instrument in such a way that errors in measuring the coils or small variations in their dimensions are reduced many times in their effect on the calculated value of electric quantity. (May 20, 1910.) 24 pp. Price, 5 cents.

S140. The Comparative Sensitiveness of some Common Detectors of Electrical Oscillations...*Louis W. Austin*

Article describes method of producing high-frequency currents in a buzzer circuit and two methods of comparing the sensitiveness of detectors.

I. By varying the coupling between the exciting and the receiving circuits until the signals become inaudible in the detector telephones.

II. By noting the shunt across the telephones necessary to produce silence.

The detectors in the order of their sensitiveness are as follows: The Audion (Vacuum Detector); the Electrolytic; the Perikon with emf; the Magnetic; the Perikon without emf; and the Fleming Vacuum Detector. (Mar. 1, 1910.) 16 pp. Price, 5 cents.

S141. Photometric Units and Nomenclature.....*E. B. Rosa*

A systematic discussion of the mathematical and physical relations of photometric quantities, and a derivation of some useful formulas. Photometric nomenclature is considered and some new proposals made. Several problems are given for illustration. (May 10, 1910.) 30 pp. Price, 5 cents.

S142. A Modified Method for the Determination of Relative Wave-Lengths.....*Irwin G. Priest*

A method especially adapted to the establishment of secondary standards.

Characteristics of the Method: (1) Use of circular interference fringes. (2) Use of the double increment in the distance between two mirrors as difference of path. (3) Use of method of flexure to measure "fractions."

Accuracy attained: (1) Average residual (7 determinations) 1 part in 8 400 000. (2) Maximum residual (7 determinations) 1 part in 3 900 000. (3) Error of method is within accidental errors.

Advantages of Method: (1) Rigorous control of errors. (2) Small chance of apparatus and personal error. (3) Few chances for accidental error. (4) Automatic elimination of temperature error without thermostat. (5) Automatic elimination of error of "dispersion of phase." (June, 1910.) 34 pp. Price, 5 cents.

S143. Note on the Temperature Scale Between 100 and 500° C .....*C. W. Waidner and G. K. Burgess*

A continuation of the work of Reprint 124, being the determination of the boiling point of naphthaline and benzophenone by means of the platinum resistance thermometer on the scale defined by ice, steam, and sulphur (444.70).

Discussion of the work of other observers on these points suggests the following scale good to 0.1 C as defined by constant volume nitrogen thermometer.

Freezing points.		*Boiling points.*	
Tin	231. 9 C	Naphthaline	218. 0 C
Cadmium	321. 0 C	Benzophenone	306. 0 C
Zinc	419. 4 C	Sulphur	444. 7 C

(May 13, 1910.) 8 pp. Price, 5 cents.

S144. A New Form of Direct-Reading Candlepower Scale and Recording Device for Precision Photometers.....*George W. Middlekauff*

The photometer settings are automatically recorded by dots on a sheet of paper on which is printed a new form of candlepower scale that perfectly adapts itself to the record, thus permitting the candlepower to be read off directly in terms of one or more standards without computation. (June 6, 1910.) 33 pp. Price, 10 cents.

S145. A Device for Measuring the Torque of Electrical Instruments.....*P. G. Agnew*

A device is described which was designed specifically for the measurement of the torque of electrical instruments, but which is generally applicable to the measurement of small horizontal forces. It consists essentially of a pendulum, of which the bob traverses a scale ruled concentrically on a concave spherical surface. (June 27, 1911.) 4 pp. Price, 5 cents.

S146. The Intensities of Some Hydrogen, Argon, and Helium Lines in Relation to Current and Pressure.....*P. G. Nutting and Orin Tugman*

The intensities of spectrum lines are known to vary widely with the condition of the gas or vapor emitting them. This paper contains the results of a study of the visible spectra of hydrogen, argon, and helium contained in Plucker tubes. The curves given show the variations in the intensities of about 20 lines with varying current and gas density. Potential gradient as a function of current was determined for hydrogen and helium, so that for these gases line intensity is known as a function of the internal energy of the gas.

Finally a summary of the important new results is given. (Aug. 6, 1910.) 22 pp. Price, 10 cents.

S147. The Temperature Coefficient of Resistance of Copper.....*J. H. Dellinger*

For representative samples of the copper now furnished for electric uses, the temperature coefficient was found to be very nearly proportional to the conductivity. The 20° C temperature coefficient of a sample of copper is given by multiplying the number expressing the per cent conductivity by 0.00394. (Conductivity of 100 per cent is taken as corresponding to a resistivity of 0.153022 ohm (meter, gram) at 20° C.) Expressed otherwise, the change of resistivity per degree centigrade of any sample of copper is 0.000598 ohm (meter, gram) or 0.00681 microhm-centimeter.

[June 4, 1914.—Since this paper was written an international conductivity standard has been adopted. The temperature coefficient corresponding to the resistivity adopted as standard is 0.00393 at 20° C, replacing 0.00394 above.]

Bending and winding are shown to produce no material change in the temperature coefficient.

It is shown that the measurement of temperature coefficient offers an advantageous substitute for the direct measurement of conductivity in a number of cases. (July 12, 1910.) 31 pp. Price, 10 cents.

S148. The Electrical Conductivity of Commercial Copper.....*F. A. Wolff and J. H. Dellinger*

The mean per cent conductivity found for a large number of samples of annealed copper wire from important refiners and wire manufacturers was 100.07 per cent. A mean communicated by a large wire-manufacturing company of careful tests representing over 100 000 000 pounds of wire was 100.25 per cent. It is therefore proposed that the formerly assumed standard value, 0.153022 ohm (meter, gram) at 20° C, be used in the preparation of wire tables for annealed copper and in the expression of per cent conductivity. The resistivity of hard-drawn No. 12 copper wire was found to be 2.7 per cent greater than that of annealed copper. The advantages of the expression of resistivity in ohms (meter, gram) are set forth. The desirability of an international agreement on copper conductivity standards is urged. (Aug. 1, 1910.) 24 pp. Price, 10 cents.

June 4, 1914.—An international agreement was attained in September, 1913. The International Electrotechnical Commission adopted a value based on this experimental work, but slightly different from it numerically. The international standard resistivity is 0.15328 ohm in a uniform wire 1 m long weighing 1 g, at 20° C.]

S149. On the Constancy of the Sulphur Boiling Point...
.....*C. W. Waidner and G. K. Burgess*

The constancy of the temperature within the standard form of S. B. P. apparatus is studied both with a resistance thermometer of 9 mm length and 13.1 ohms and with thermocouples. When the latter are homogeneous, both methods give consistent results showing temperatures within the radiation shield to be constant to within 0.05° C over 27 of 30 cm of S vapor column. (Dec. 6, 1910.) 4 pp. Price, 5 cents.

S150. Note on Oscillatory Interference Bands and Some of Their Practical Applications.....
.....*G. O. Squier and A. C. Crehore*

Simple applications of optical interference were studied from the standpoint of their use in measuring periodic phenomena. The instrument used was essentially a pair of parallel glass plates in contact, illuminated by a mercury-vapor lamp. Vibration produced by varying mechanical pressure, by local variations of heat produced electrically, by alternating magnetic or electric fields operating on a metal plate on which the glass plates were mounted, all produced measurable displacements of the interference bands. The sensitiveness of these arrangements was not great with the form of apparatus used. (Sept. 1, 1910.) 12 pp. Price, 10 cents.

S151. The Effect of Preliminary Heating Treatment upon the Drying of Clays.....*A. V. Bleininger*

Investigation undertaken to ascertain the possibility of using excessively plastic clays which on drying show losses due to cracking and checking, by subjecting the clays in the crude state to a preliminary heat treatment before working them by the usual methods.

Preheating offers a possible commercial method for the treatment of excessively plastic clays which can not be worked and dried successively by other means, subject to certain limitations. Methods and conditions are discussed. (Dec. 6, 1910.) 53 pp. [Now known as T1.]

S152. The Reflecting Power of Various Metals....*W. W. Coblentz*

This paper gives an illustrated description of an investigation of the reflecting power of various pure metals, including tungsten, molybdenum, tantalum, graphite, antimony, silicon, chromium, etc. The results obtained give additional evidence to previous observations, showing that a common property of pure metals is a low reflectivity in the visible spectrum and explains the high luminous efficiency of the tungsten and other metal filament lamps. Several supplementary notes are added in which are given the thermoelectric power of molybdenum-copper, comments on the radiation laws of metals, etc. (Dec. 6, 1911.) 53 pp. Price, 10 cents.

S153. The Action of Sunlight and Air upon Some Lubricating Oils.....*C. E. Waters*

By the combined action of sunlight and air certain lubricating oils were found to yield a solid oxidation product within six hours, the amount increasing at a slowly diminishing rate, but not ceasing after four months' continual exposure. The oils gained in weight in spite of the water and carbon dioxide, as well as traces of volatile oily matter, that were given off.

The increase in the acidity of the oils was also determined.

The oil filtered from the oxidation product was found to contain considerable combined oxygen. (Sept. 29, 1910.) 8 pp. Price, 5 cents.

S154. The Visibility of Radiation. A Recalculation of König's Data.....*P. G. Nutting*

This is a supplementary note and correction to the previous paper on the Luminous Equivalent of Radiation. From the paper reprinted in his works, it appears that König's data on Equivalent Slit Widths had not been corrected for variable prismatic dispersion. This dispersion is given in a later paper and is now applied to correct the visibility curves so much used in spectrophotometry and in problems in illumination. The most notable effect of the correction is the shift of the maximum at high intensities from 565 back to 544. (Oct. 1, 1910.) 4 pp. Price, 5 cents.

S155. A Photometric Attachment for Spectroscopes....
.....*P. G. Nutting*

For simplicity and convenience the polarization spectrophotometers are far ahead of other types, but have lacked sensibility and precision. In the new form an image of the finely ruled dividing surface is thrown on the slit of any spectroscope (wave length, high intensity, high dispersion). Tests of an instrument show that it has the highest sensibility of which the eye is capable, good light, economy, and, of course the dispersion of any spectroscope to which it is attached. The scale correction is shown to be negligible by three different tests. (Oct. 1, 1910.) 3 pp. Price, 5 cents.

S156. Selective Radiation from Various Substances. III.....*W. W. Coblentz*

An investigation of the emission and the absorption of the acetylene flame and the Welsbach mantle. The acetylene flame has an absorption band in the orange yellow, with regions of greater transparency in the violet and in the red.

It is shown that the spectral energy curves of the Welsbach mantle and of the same material used as a solid electrically heated glower are entirely different, due to the great difference in the thickness of the radiating layer. Further experiments are described on the question of color match versus spectral intensity match, showing that the superposition of the spectral energy curves of two widely different sources of radiation holds true over only a very short spectral region. (Nov. 9, 1910.) 52 pp. Price, 10 cents.

S157. The Measurement of Electric Oscillations in the Receiving Antenna.....*L. W. Austin*

The paper shows a method of calibrating a crystal detector connected to a galvanometer by comparing it with a thermoelement. The detector and galvanometer can then be used for quantitatively measuring the received oscillatory current in the antenna, even in the case of the weakest signals detectable by ordinary methods. (Oct. 1, 1911.) 5 pp. Price, 5 cents.

S158. Some Experiments with Coupled High-Frequency Circuits.....*L. W. Austin*

The author measures the current strength in two tuned circuits with different values of the coupling and of the logarithmic decrement of the sending circuit, and treats similarly the case where one of the two circuits is untuned. The effect on the damping of increasing the coupling of the detector circuit is also investigated. The importance of providing means for varying the amount of energy drawn from the antenna is emphasized, since it is shown that if the coupling of the detector circuit is made stronger than is required for the maximum effect, the damping is increased, resulting in loss of sharpness of tuning. (May 1, 1910.) 14 pp. Price, 5 cents.

S159. Some Quantitative Experiments in Long Distance Radiotelegraphy.....*L. W. Austin*

Being an account of experiments carried on between the U. S. S. *Birmingham*, U. S. S. *Salem*, and the wireless station at Brant Rock, Mass. Measurements were made on sending and received currents at distances up to 1000 miles. From these observations a formula has been deduced which gives the received current which may be expected in the day for any sending current, any distance, any antenna height, and any wave length. The formula has been verified for sending currents from 7 to 30 amperes, antenna heights from 30 to 130 feet, wave lengths from 300 to 3750 meters, and distances up to 1000 miles. Night signals do not accord with this formula, but are entirely irregular, sometimes being no stronger than the day signals, and sometimes being of vastly greater intensity. (Feb. 1, 1911.) 49 pp. Price, 10 cents.

S160. The Behavior of High-Boiling Mineral Oils on Heating in the Air.....*C. E. Waters*

Results of "carbonization" tests of gas-engine oils when heated in flasks; also when heated in tubes of glass, brass, cast iron, and different steels. The tests made in tubes show some evidence of catalytic effects and indicate possible variations due to fatty oil, a question which will be taken up in the near future. (Dec. 14, 1910.) 12 pp. Price, 5 cents.

S161. The Determination of Vanadium in Vanadium and Chrome-Vanadium Steels.....*J. R. Cain*

Errors in the usual methods for determining vanadium in steels are considered and methods of eliminating or correcting for some of these are discussed. A new method, based on precipitation of the vanadium by cadmium carbonate, followed by electrolysis, reduction, and titration, is described. (Apr. 24, 1911.) 16 pp. Price, 5 cents.

S162. On the Computation of the Constant c_2 of Planck's Equation by an extension of Paschen's Method of Equal Ordinates.....
.....*Edgar Buckingham and J. H. Dellinger*

Two methods of computing the maximum wave length and the constant c_2 of Planck's equation from an observed energy curve of a blackbody radiator, by a modification of Paschen's method of using the wave lengths for equal ordinates, are given. The first is an approximate method, substituting the corrected values of the observed wave lengths in the usual Paschen equation. The second method gives an expression based directly on Planck's equation, which is very simple in application. The paper concludes with a note on "corresponding points" of energy curves. (Apr. 26, 1911.) 14 pp. Price, 5 cents.

S163. A Comparison of American Direct-Current Switchboard Voltmeters and Ammeters.....
.....*T. T. Fitch and C. J. Huber*

The article is an account of a comparative test of American switchboard voltmeters and ammeters. Tables are given showing the performance and construction, and the relation between the two is discussed. Some figures and photographs are also included. The different makes of instruments do not differ greatly from one another in design and performance. (Mar. 1, 1911.) 22 pp. Price, 5 cents.

S164. A Study of the Current Transformer with Particular Reference to Iron Loss.....*P. G. Agnew*

It is shown that the ratio and phase angle of the current transformer may be predicted from the magnetic constants of the core, and quantitative relations are established connecting the slope of the ratio curve with the empirical equations for iron loss. Quantitative determinations of the amount of wave distortion introduced by the transformer and of the effect of wave form on the ratio and phase angle are given. Incidentally it is shown that the methods commonly in use for the determination of the Steinmetz exponent are incorrect for the case for a variable exponent. (June 1, 1911.) 52 pp. Price, 10 cents.

S165. Thermodynamics of Concentration Cells..*Henry S. Carhart*

This paper discusses the equation $A=H+T.\ dA/dT$ as a general expression of the laws of thermodynamics, and particularly in the specific form of the Helmholtz equation $E=H/nF+T.\ dE/dT$.

The two cases selected for special attention are: First, when H the change in internal energy is a constant, dA/dT, or dE/dT, is then zero and the relation between A or E and T is linear; second, an examination of Nernst's expression for A in terms of integral powers of T. Nernst makes the coefficient of the first power of T necessarily zero.

After a mathematical demonstration that this coefficient is not zero the paper proceeds to the experimental investigation of the emf of various concentration cells with amalgams of different concentration as the electrodes, and in every case a linear relation is established between the emf and temperature. This relation is excluded by the Nernst hypothesis.

The paper concludes with a description of two calomel cells, one with a positive temperature coefficient and the other with an equal negative one. When the two are connected in series the sum of their electromotive forces is independent of temperature. (June 1, 1911.) 20 pp. Price, 15 cents.

S166. The Capacity and Phase Difference of Paraffined Paper Condensers as Functions of Temperature and Frequency .....*Frederick W. Grover*

Measurements of the capacity and phase difference of 13 paper condensers were made at temperatures ranging from 10° to 35° C, with alternating current of frequencies of from 33 to 1000 cycles per second. Then results are given in the form of curves, which show that the changes of the

capacity and phase difference, under these varying conditions, are important, and in the majority of cases of such a nature as to render paper condensers unsuitable as standards of capacity. In many cases the observed energy losses in the condensers were very large. The observed curves are compared with those demanded by various theories of absorption, with the result that only the modification of Pellat's theory, suggested by Von Schweidler, was found competent to represent all the observations. (Feb. 28, 1911.) 82 pp.

S167. The Steam-Turbine Expansion Line on the Mollier Diagram and a Short Method of Finding the Reheat Factor.....*Edgar Buckingham*

After general introductory sections the form of the steam-turbine expansion line on the Mollier diagram is discussed and a method is given for finding the reheat factor—a quantity useful to the designer in drawing the expansion line. (Mar. 2, 1911.) 39 pp. Price, 10 cents.

S168. Radiometric Investigation of Water of Crystallization, Light Filters, and Standard Absorption Bands.....*W. W. Coblentz*

The present paper contains further contributions (see S45) to the question of the manner in which water is contained in minerals. A detailed examination was made of the absorption spectra of opal and tremolite in various states of dehydration. The former shows the absorption bands of water, while the latter does not, although it is supposed to contain dissolved water. The radiometric test finds no distinction between "water of crystallization," "dissolved water," "absorbed water," and water in "solid solution," all of which give absorption bands identical with those of water in its free liquid state. Minerals containing "water of constitution" do not show the absorption bands of water.

The paper contains also the transmission and reflection spectra of a miscellaneous collection of substances, including sylvite and quartz glass.

On "light filters" it is shown that a 2-cm thickness of a 2 per cent solution of cupric chloride absorbs all the infra-red beyond 0.67 μ and transmits 80 per cent in the green and blue. Standard spectral lines are given for calibrating prisms. (May 16, 1911.) 45 pp. Price, 10 cents.

S169. Formulas and Tables for the Calculation of Mutual and Self-Inductance. (Second edition, revised and enlarged).....*Edward B. Rosa and Frederick W. Grover*

This second edition of formulas and tables for the calculation of mutual and self-inductance is based on the first edition by Edward B. Rosa and Louis Cohen. (See S93.) It includes practically all the matter contained in the first edition, but in addition to a thorough revision, in which some errors have been corrected and some formulas extended, a large amount of new matter has been added both in the body of the paper and in the tables. [See also S320.] (Jan. 1, 1911.) 237 pp. Price, 15 cents.

S170. The Correction for "Emergent Stem" of the Mercurial Thermometer.....*Edgar Buckingham*

The paper contains a description of Guillaume's and Mahlke's methods for determining the stem correction, with convenient tables for use with Mahlke's method. The theory of the two methods is discussed, together with several subsidiary matters necessary to the precise exposition of the theory, and the treatment is illustrated by numerical examples. (July 13, 1911.) 29 pp. Price, 5 cents.

S171. A Determination of the International Ampere in Absolute Measure.....*E. B. Rosa, N. E. Dorsey, and J. M. Miller*

The paper gives an account of the development of an improved form of Rayleigh current balance, and the accurate determination of the ratio of the radii of the fixed and moving coils of the balance by electrical means,

without direct measurement of the radii. It then gives the result of several series of measurements in which the emf of the Weston normal cell in terms of the international ohm and the current balance is found to be 1.01822 semiabsolute volts. Experiments at the Bureau during the past year show that the absolute ampere as determined by the current balance gives for the electrochemical equivalent of silver, using both the porous pot form and the nonseptum form of voltameters, 1.11804 mg per coulomb instead of 1.11800 mg as adopted by the London conference.

The computed probable error of the above value of the emf of the Weston normal cell (so far as the current balance measurements are concerned) is 3 parts in 1 000 000. The authors give 2 in 100 000 as the possible uncertainty in the value due to all causes. (Sept. 9, 1911.) 125 pp. Price, 20 cents.

S172. Deflection Potentiometers for Current and Voltage Measurements.....*H. B. Brooks*

This paper gives an outline of the elementary principles of the null potentiometer as used for current and voltage measurements. The essential principles of the deflection potentiometer (see S33 and S79, preceding) are stated, and two recent instruments of this kind are described, each of which is suitable for both current and voltage measurements. The theory of the deflection potentiometer used with current shunts is developed, and a special set of values for such shunts is shown to give economy of time in testing, with reduced computation and less liability of error. (June 23, 1911.) 23 pp. Price, 10 cents.

S173. Outline of Design of Deflection Potentiometers, with Notes on the Design of Moving-Coil Galvanometers.....*H. B. Brooks*

This paper outlines the principles on which deflection potentiometers are designed, and gives a numerical example. It includes some notes on the fundamental constants of the moving-coil galvanometer, and shows how to change the field strength, spring strength, and size of wire in order to secure a desired galvanometer performance. A procedure is outlined which is intended to facilitate the production in quantity of galvanometers whose resultant performance is satisfactory, while allowing some latitude in the values of individual constants. (June 23, 1911.) 26 pp. Price, 5 cents.

S174. The Determination of Total Sulphur in India Rubber.....*C. E. Waters and J. B. Tuttle*

Comparative determinations by different methods, especially a number of variations of the method of Henriques. These determinations were made on rubber and also on a sample of very dilute sulphuric acid. The amount of error caused by the presence of lead sulphate was also determined.

The method adopted and used for some time in our routine work is a modification of that of Henriques. The rubber is attacked by nitric acid saturated with bromine, instead of using nitric acid alone. (July 19, 1911.) 9 pp. Price, 5 cents.

S175. The Measurement of the Inductances of Resistance Coils.....*Frederick W. Grover and Harvey L. Curtis*

The method to be chosen for the measurement of a given inductance depends on the order of magnitude of its time constant. In this paper are considered only time constants of less than 10^{-5} second, such as occur in "noninductive resistances" and multipliers. The measurements naturally fall into two classes, those on coils with resistances of 1000 ohms or less, and those on coils of resistances greater than 1000 ohms. In the case of coils of the latter class effects due to the capacity of the coil with respect to earth become important, and the absolute potential of the coil must be taken into account. Methods are developed by which a good degree of accuracy may be attained with time constants of the order of 10^{-7}. (Sept. 1, 1911.) 31 pp. Price, 10 cents.

S176. The Luminous Properties of Electrically Conducting Helium Gas. II. Reproducibility . . *P. G. Nutting*

This paper gives the results of photometric and spectrophotometric tests of a set of 38 helium tubes made up and operated as shown most advisable by preliminary work. The tubes do not differ measurably in color. In light emission per cm of capillary the average deviation is 1.15 per cent, the maximum deviation 3 per cent, the uncertainty in observation being 1 per cent. (Aug. 25, 1911.) 8 pp. Price, 5 cents.

S177. Resistance Coils for Alternating Current Work . . . . . *H. L. Curtis and Frederick W. Grover*

An ideal resistance coil for alternating current work would have zero phase angle at all frequencies and its resistance would be independent of the frequency. Commercial coils do not fulfill these conditions. In this paper there is given a discussion of the conditions which must be fulfilled in order that such a coil may be realized, and this discussion is followed by an application of the principles evolved to the design of coils of resistances varying from 0.1 to 10 000 ohms. There is also a discussion of the methods of connecting the coils in resistance boxes. (Sept. 1, 1911.) 23 pp. Price, 5 cents.

S178. The Hydrolysis of Sodium Oxalate and Its Influence Upon the Test for Neutrality . . . . . *William Blum*

In connection with the testing of sodium oxalate for use as a primary standard for acidimetry and oxidimetry, a knowledge of the normal alkalinity of the pure salt is important. The purest sodium oxalate that could be made was found to produce in 0.1 molar solution a pink color with phenolphthalein, equivalent to 4 per cent transformation of the indicator, and 6 per cent in 0.2 molar solution. This value was not in accord with that calculated from the theory of hydrolysis, using the present accepted values for the various constants. The error produced by neglecting this alkalinity in determinations of the purity of the salt was found to equal about 0.02 per cent, which is negligible for practical purposes. The action of sodium-oxalate solution on various kinds of glass, and the behavior of such solutions on heating, was also studied. A method for the accurate testing of the neutrality of sodium oxalate is described. (Nov. 9, 1911.) 20 pp. Price, 5 cents.

S179. Wave Lengths of Neon . . . . . *I. G. Priest*

Ten wave lengths resulting from determinations by the method described in Reprint 142, Bulletin of the Bureau of Standards, are presented in a table. The precision, reliability, and accuracy of these values are discussed. The probable errors are all less than 1 part in 10 000 000, and the values are considered accurate to within about 1 or 2 parts in 6 000 000. (Nov. 23, 1911.) 6 pp. Price, 5 cents.

S180. On the Deduction of Wien's Displacement Law . . . . . *Edgar Buckingham*

The deduction contains the following four parts, which are, in substance, common to all such deductions: (*a*) The treatment of the change of period of diffuse radiation when it is compressed adiabatically; (*b*) the treatment of the accompanying change of energy density; (*c*) the demonstration that black radiation remains black in such a process; and (*d*) the use of the Stefan-Boltzmann law to correlate the results of (*a*), (*b*), and (*c*). Some novelties are introduced in the methods used in the steps (*a*) and (*b*), while the remaining steps of the argument are given, more briefly and with no innovations, for the sake of completeness of form. The object of the paper is to improve the clearness and simplicity of the deduction without sacrifice of vigor. (Feb. 28, 1911.) 13 pp. Price, 5 cents.

S181. The Four-Terminal Conductor and the Thomson Bridge . . . . . *Frank Wenner*

The conditions which must be fulfilled in order that a four-terminal conductor have a definite resistance or both a definite resistance and inductance are pointed out. The relation between the different resistances and some of the points to be observed in the design of resistance standards

which are to carry large alternating current are discussed. The way in which measurements with the Thomson bridge are carried out at the Bureau is described and it is shown that the adjustments made give the same simple relations between the resistances whether the four-terminal conductors are linear or not. The adjustments which should be made when alternating current is used are also considered. (Mar. 8, 1912.) 52 pp. Price, 5 cents.

S182. Standardization of Potassium Permanganate Solution by Sodium Oxalate . . . . . *R. S. McBride*

The effects of temperature, acidity, volume of solution, rate of titration, access of air, and presence of added manganous sulphate upon the value obtained for a permanganate standardized against sodium oxalate were determined and the necessary end-point corrections fixed. Loss of oxygen during titration is probably responsible for the observed variations, but none of these exceeds one-half per cent. The following procedure is recommended: Dissolve 0.25–0.3 g of sodium oxalate in 200–250 cc of 5 per cent (by vol.) sulphuric acid at 80–90°, and titrate at once, *stirring the solution vigorously and continuously.* The main part of the permanganate should be added not more rapidly than 10–15 cc per minute, and the last ½–1 cc dropwise. A correction for the amount of permanganate necessary to produce the end point is desirable. (June 1, 1912.) 32 pp. Price, 5 cents.

See also (on pp. 90, 91, 92) Circulars 14, 19, 25, and 26.

S183. Benzoic Acid as an Acidimetric Standard . *George W. Morey*

The value of benzoic acid as an acidimetric standard was tested by comparing the values obtained by standardizing a hydrochloric-acid solution by several standard methods with the values obtained by standardizing both sodium and barium hydroxide with benzoic acid. The results show that the benzoic-acid method is accurate, and that fact, combined with other advantages, makes benzoic acid an excellent material for an acidimetric standard. (May 4, 1912.) 8 pp. Price, 5 cents.

S184. A Tubular Electrodynamometer for Heavy Currents . . . . . *P. G. Agnew*

The instrument described has a capacity of 5000 amperes. The field "coil" consists of two coaxial copper tubes, and since there is axial symmetry the torque is independent of the current distribution in the tubes. Hence it is suitable for an a. c.–d. c. transfer instrument. Details of construction are given. (July 17, 1912.) 8 pp. Price, 5 cents.

S185. Thermometric Lag . . . . . *D. R. Harper 3d*

The theory of the lag of a thermometer in acquiring the temperature of a medium in which it is immersed, and experimental tests of the theory. The dependence on the nature of the medium and the rate of stirring of the same is considered. Common "chemical" mercurial thermometers-Beckmann thermometers, thermocouples, electrical resistance thermo, meters, and galvanometers are each treated in turn. Special cases, including calorimetry, are developed fully, with numerous examples and instructions for the computation of lag corrections to thermometer readings. (Mar. 5, 1913.) 56 pp. Price, 10 cents.

S186. Determination of Manganese as Sulphate and by the Sodium Bismuthate Method . . . . . *William Blum*

The most accurate method of obtaining a known amount of manganese to serve as a primary standard is by weighing $MnSO_4$. A study of the temperature of decomposition of this salt showed that it may and must be heated for a considerable period at 450°–500° to obtain the pure compound. The use of sodium oxalate for standardizing permanganate solutions for the bismuthate method is recommended, as it is more convenient to use than manganous sulphate and is equally accurate. A study of the effect of conditions upon the results by the bismuthate method showed that accurate results may be obtained over a wide range of conditions, making this method applicable to the analysis of materials containing large or small amounts of manganese. (June 21, 1912.) 26 pp. Price, 5 cents.

S187. A New Precision Colorimeter.....*P. G. Nutting*

A new colorimeter of high precision recently designed by the author is described. This is of a new type, namely, a monochromatic analyzer. Its readings give the dominant hue (or its complementary) and per cent white in the color analyzed, whether from a source of light, a transmission screen, or a mat surface. The theory and various methods of use of the instrument are described. (July 25, 1912.) 5 pp. Price, 5 cents.

S188. Instruments and Methods Used in Radiometry—II
.....*W. W. Coblentz*

The paper gives an account of the attainments in spectroradiometry since 1907. (See S85.) This includes air and vacuum bolometers, thermopiles, and radiomicrometers; linear and surface thermopolies of bismuth and silver; new combinations of instruments; and (Note I) the Callendar radiobalance. (Dec. 8, 1911.) 27 pp. Price, 10 cents.

S189. Antenna Resistance.....*L. W. Austin*

As shown in a previous note, antenna resistance varies, in accordance with theory, approximately inversely as the square of the wave length, for wave lengths less than twice the fundamental of the antenna. Above this the resistance increases in proportion to the wave length. This increasing resistance is believed to be connected with the losses due to the currents in the earth near the antenna. The results were verified by three methods, the "artifical-antenna," the "decrement," and the "half-deflection" methods. The minimum resistance in well-installed ship antennas was a little above 2 ohms, which was lower than for land stations. (Mar. 1, 1912.) 8 pp. Price, 5 cents.

S190. Energy Losses in Some Condensers Used in High-Frequency Circuits.....*L. W. Austin*

The energy loss in a compressed-air condenser was measured by the "decrement" method, and the loss in various other condensers was obtained by substitution of the former with resistance in series. Leyden jars in air had an equivalent resistance of 1.0 to 1.8 ohms, at 14 500 volts. Their resistance in oil was only a few tenths of an ohm, showing that the loss in air is largely due to brush discharge. Condensers in which brush discharge was prevented by their construction had only a few tenths of an ohm resistance, which did not change, from 4000 to 20 000 volts. The resistance of paper and micanite condensers was 2 to 3 ohms. The resistance of Leyden jars in air, between 10 000 and 20 000 volts, increased approximately in proportion to the square of the voltage. (Mar. 1, 1912.) 8 pp. Price, 5 cents.

S191. Selective Radiation from Various Substances, IV.
.....*W. W. Coblentz*

The present paper contains further contributions to the study of the radiating properties of various substances. (See S91, S97, S131, S156.) This includes a determination of (I) the radiation constants of platinum (see S105), (II) the emission spectrum of neon and helium, (III) the emissivity of different parts of an acetylene flame, (IV) the variation of emissivity with thickness of the radiating layer, (V) the radiation from a uniformly heated cavity and from its inclosing walls, (VI) standard spectral energy curves (Note I), light filters which absorb all the infra-red (see S168), and (Note II) transmission of prism material. (June 5, 1912.) 37 pp. Price, 10 cents.

S192. On a Modified Form of Stability Test for Smokeless Powder and Similar Materials.....*H. C. P. Weber*

The test consists in the determination of the length of time which elapses until the sample explodes at various constant temperatures. The temperatures chosen are 160° C, 170° C, 180° C, and 200° C. Comparisons are made with samples of powder tested according to the customary methods. The curves which are obtained are discussed from the point of view of change of the rate of decomposition with change of temperature. The necessary

apparatus is described and the classification of powders according to this test is indicated. The accuracy with which results may be expected to be duplicated is shown by numerous repetitions and check results. (June 22, 1912.) 11 pp. Price, 5 cents.

S193. Atomic Weight of Bromine.....*H. C. P. Weber*

The ratio of the atomic weights of hydrogen and of bromine is obtained by determining the amount of bromine which a weighed quantity of hydrogen will remove from potassium bromplatinate. The hydrobromic acid formed is also weighed. From 10 determinations 20 values are obtained giving the ratio H: Br equal to 1: 79.306 ^{6} with a probable error of ±0.0014. Taking the atomic weight of hydrogen as 1.00779 (O=16) the atomic weight of bromine is 79.924. (Nov. 1, 1912.) 20 pp. Price, 5 cents.

S194. The Silver Voltameter—Part I. First Series of Quantitative Experiments.....
.....*E. B. Rosa and G. W. Vinal*

This paper reviews briefly the large amount of material that has been previously published on the silver voltameter and outlines the present investigation, which is to be published in four papers, this being the first. The apparatus and methods used throughout the investigation for making the deposits are described in detail. The results of 121 deposits, which constitute the first series of quantitative experiments, are recorded. They were mostly made in the filter-paper and porous-cup voltameters and show a marked difference in the results of these two forms. Proof is given that this is due to the filter paper being chemically active and not due to a complexion, as previously supposed. [See also S285.] (Aug. 1, 1912.) 57 pp. Price, 10 cents.

S195. The Silver Voltameter—Part II. The Chemistry of the Filter-Paper Voltameter and the Explanation of Striations.....
.....*E. B. Rosa, G. W. Vinal, and A. S. McDaniel*

Part I of this series of papers showed that the difference between the porous-cup and filter-paper voltameters was due to the filter paper acting on the silver nitrate. The object of the present paper is to discover the nature of this effect. Some other substances, mostly organic, were found to produce similar effects to filter paper. It was found that filter paper spontaneously decomposes into oxycelluloses that by reduction cause a precipitate of colloidal silver in the electrolyte. Striations were found to be due to the presence of this silver colloid which breaks up the crystalline structure of the silver deposit and causes it to grow in the direction of the convection currents of liquid. [See also S285.] (Oct. 1, 1912.) 74 pp. Price, 20 cents.

S196. The Diffuse Reflecting Power of Various Substances..... .....*W. W. Coblentz*

This paper gives data on the reflection power of matte surfaces of various substances, for the spectral regions of 0.54, 0.60, 0.95, 4.4, 8.8, and 24μ. The substances examined include lampblack, plantinum black, pigments, white paints, green leaves, cloth, and building material. The object of the investigation was to find the blackest and the whitest substances, the former to be used as absorbing surfaces of radiometers, the latter to be used as a covering for observatory buildings exposed to intense sunlight. The paper gives also the variation in the reflecting power of polished silver with variation in the angle of incidence. (Nov. 4, 1912.) 43 pp. Price, 10 cents.

S197. Density and Thermal Expansion of Ethyl Alcohol and of Its Mixtures with Water.....
.....*N. S. Osborne, E. C. McKelvy, and H. W. Bearce*

This paper contains the description of and experimental results on the purification and preparation of anhydrous ethyl alcohol, the thermal expansion and density of this alcohol and its mixtures with water, the alcoholometric tables derived from these results, accompanied by a comparison with the results of other investigators, and a bibliography of the literature of the subject. (Apr. 15, 1913.) 148 pp. Price, 25 cents.

S198. A Micropyrometer.....*G. K. Burgess*

An incandescent lamp is mounted within the Huyghens eyepiece of an ordinary microscope, which is then used as a Morse or Holborn-Kurlbaum pyrometer. Combined with a suitable furnace such as a Pt strip heated electrically in vacuo or suitable gas as H, melting points and emissivities of minute specimens (0.01 to 0.001 mg or less) are readily observed. Best calibrated empirically with known melting points. (Dec. 9, 1912.) 4 pp. Price, 5 cents.

S199. A Simplified Formula for the Change in Order of Interference Due to Changes in Temperature and Pressure of Air.....*I. G. Priest*

In the interference method for expansion coefficients a correction must be applied to the observed change in the order of interference, to take account of any change in the density of the air. A much simpler formula is presented in this paper as a substitute for the Pulfrich formula. (October, 1912.) 3 pp. Price, 5 cents.

S200. New Calorimetric Resistance Thermometers.....*H. C. Dickinson and E. F. Mueller*

Description of new calorimetric resistance thermometers designed by the authors and now in use at the Bureau. A simplified method for making the calculations is given. (Jan. 1, 1913.) 10 pp. Price, 5 cents.

S201. The Silver Voltameter—Part III. Second Series of Quantitative Experiments and the Preparation and Testing of Silver Nitrate.....*E. B. Rosa, G. W. Vinal, and A. S. McDaniel*

The second series of quantitative experiments extending from December 17, 1909, to April 1, 1910, is given in detail together with investigations of the "volume effect," the temperature coefficient, and the material for the cathode. The methods employed to test the electrolyte for acidity and for reducing impurities are described and the methods of purifying the silver nitrate discussed. It is shown that the processes ordinarily used are insufficient, but that it is possible to obtain salt of sufficient purity by following the special procedure which is outlined. [See also S285.] (Jan. 1, 1913.) 59 pp. Price, 10 cents.

S202. Note on Cold-Junction Corrections for Thermocouples.....*P. D. Foote*

This paper directs attention to the considerable errors that may be introduced into technical measurements by failure to apply the cold-junction correction and considers in detail the methods of applying this correction together with a brief consideration of the devices used for the elimination of the cold-junction correction. (Apr. 15, 1913.) 13 pp. Price, 5 cents.

S203. Analysis of Alternating-Current Waves by the Method of Fourier, with Special Reference to Methods of Facilitating the Computations.....*F. W. Grover*

The natural method for the analysis of alternating electromotive force and current curves is by means of the classic equations of Fourier, but on account of the labor involved, recourse is often had to graphical or approximate methods. Runge has shown that, by grouping similar terms the number of terms which need to be calculated in the Fourier method may be materially reduced, but his work does not seem to be generally known. The present paper has for its purpose the presentation of the method of Runge in a form which shall be of especial service in making numerical computations. By systematic arrangement of the work and by use of tables here given the labor of calculation has been very considerably reduced. Examples of the analysis of actual, experimentally obtained curves are given, which illustrate the methods of computation and the practical applications which may be made of the results of the analyses. (May 15, 1913.) 80 pp. Price, 20 cents.

S204. The Constants of Spectral Radiation of a Uniformly Heated Enclosure or So-called Black Body, Part I.....*W. W. Coblentz*

In the present paper are given the results of a determination of the constants of spectral radiation from a uniformly heated enclosure. This enclosure was formed within a long narrow porcelain tube, around which was wound a thin platinum ribbon, which was heated to incandescence by means of electric current. The spectrum was produced by means of a mirror spectrometer and a perfectly clear fluorite prism. The distribution of energy in the spectrum was measured by means of a vacuum bolometer, and the constants were computed by means of the Planck equation. (Jan. 15, 1913.) 77 pp. Price, 10 cents.

S205. Melting Points of the Refractory Elements. I. Elements of Atomic Weight from 48 to 59.. .....*G. K. Burgess and R. G. Waltenberg*

Micropyrometric measurements of the melting points in hydrogen of the elements Ni, Co, Fe, Mn, Cr, Va, Ti. Discussion of methods. Results:

Ni 1452±3	Mn 1260±20	Va 1720±20
Co 1478±5	Cr 1520 to>Fe?	Ti 1794±12.
Fe 1539±5		

(April 25, 1913.) 14 pp. Price, 5 cents.

S206. High-Frequency Ammeters.....*J. H. Dellinger*

For the measurement of current in the range of radiotelegraphic frequencies, 50 000 to 2 000 000 cycles per second, it is general practice to use the hot-wire ammeter or a modification of it. Its superiority is due to the simplicity of form which the portion of the circuit within the instrument may have, permitting a minimum of self-inductance and capacity. When the instrument is required to carry relatively large currents, a simple single wire is not sufficient, and more than one elementary path must be provided for the current. Then the current distribution, and consequently the indicated current, change as the frequency is varied. All types of ammeters in use for the measurement of large high-frequency currents are found to be subject to serious errors at radiotelegraphic frequencies. Mutual inductance between parts is in some cases the determining factor in the change of current distribution. Capacity of parts is found to cause no error for frequencies below 1 000 000; although above that, it may, so that two instruments in series may be carrying different amounts of current. Inductive action of the instrument leads in some cases causes appreciable errors. The various types of instrument are investigatedboth experimentally and theoretically, and ways of overcoming the various errors are devised. (Apr. 3, 1913.) 69 pp. Price, 10 cents.

S207. A Comparative Study of American Direct-Current Watthour Meters.....*T. T. Fitch and C. J. Huber*

A large amount of numerical data is given in regard to the performance and construction of six types of American meters. The total friction torque is separated into four parts—brush, gearing, bearing, and windage friction—and curves are plotted of these components of torque against speed. Also a description is given of the method used in obtaining these curves. The load curve is analyzed and its shape is shown to depend upon the heating of the series element, the variation in the friction torque, and the back electromotive force. (July 11, 1913.) 30 pp. Price, 15 cents.

S208. Windage Resistance of Steam-Turbine Wheels... .....*Edgar Buckingham*

A general equation deduced from the theory of dimensions is shown to agree with such experimental data on windage as have been published, but these data are not adequate as a basis for the computation of windage corrections, except in a few simple cases. The data are analyzed and suggestions offered as to practical computation. By applying the principle of dynamical similarity it is shown that model experiments may be utilized and the practicability of such experiments is discussed. (July 25, 1913.) 44 pp. Price, 10 cents.

S209. Latent Heat of Fusion of Ice.....
H. C. Dickinson, D. R. Harper 3d, and N. S. Osborne

Measurements by two independent methods in a precision calorimeter are described in the paper. Samples of ice containing from 100 to 500 g each were cooled to fixed known temperatures, weighed, and introduced into the water of the calorimeter. In one method the heat to melt the ice was supplied electrically, the temperature of the calorimeter remaining nearly constant; in the other, the method of mixtures, the heat was supplied by the cooling of the calorimeter. The first gives the result primarily in joules based on the electric units; the second gives it in calories. The apparatus, the procedure, and the results obtained are fully discussed. (Aug. 20, 1913.) 32 pp. Price, 10 cents.

S210. Observations on Ocean Temperatures in the Vicinity of the Icebergs and in Other Parts of the Ocean.....
....*C. W. Waidner, H. C. Dickinson, and J. J. Crowe*

The paper discusses the records of ocean temperatures obtained in the vicinity of icebergs and in other parts of the ocean by the Bureau party on board the U. S. S. *Chester* and U. S. S. *Birmingham* in June and July, 1912. The records show that in parts of the ocean where some of these records were taken the temperature variations due to mixing currents are so large that no certain conclusion can be drawn from temperature records as to the proximity of icebergs. The results of other experiments, such as variation in salinity, the detection of echoes both aerial and submarine, temperature records in approaching icebergs along different courses, vertical temperature distribution near icebergs, etc., are briefly considered. (Aug. 1, 1913.) 14 pp. Price, 10 cents.

S211. Accuracy of the Formulas for the Ratio, Regulation, and Phase Angle of Transformers.....
.....*P. G. Agnew and F. B. Silsbee*

A derivation of the formulas for ratio, regulation, and phase angle is given, showing by numerical example the magnitude of the approximations involved. Values computed for two types of lighting transformers from short-circuit data are compared with values obtained from direct measurement and the results found to agree within the experimental error. (July 11, 1913.) 15 pp. Price, 5 cents.

S212. Melting Points of Some Refractory Oxides....*C. W. Kanolt*

The materials were heated in a graphite resistance furnace and heating curves were plotted. The temperatures were measured with an optical pyrometer. CaO and MgO could not be melted in a vacuum on account of vaporization, but were heated at atmospheric pressure. In this case special precautions were necessary to avoid smoke, which causes low pyrometer readings. One method consisted of inserting into the material to be melted a tube of tungsten or graphite, removing smoke from the tube by a current of gas, and sighting the pyrometer into the tube. A method applied to lime consisted of making the lime into a tube, supporting the tube by its open upper end, which was at a low temperature, and sighting the pyrometer into the lower end, which was heated, smoke being removed by a current of hydrogen.

Oxide	Melting point	Supporting material
Cr_2O_3	1990°	Tungsten, graphite
Al_2O_3	2050°	Tungsten, graphite
CaO	2572°	Tungsten, CaO
MgO	2800°	Graphite

(June 1, 1913.) 19 pp. Price, 5 cents.

S213. Critical Ranges A2 and A3 of Pure Iron.....
.....*G. K. Burgess and J. J. Crowe*

Following a summary of previous work, an account is given of a thermal study of the location and nature of A2 and A3 using 15 samples of Fe and improved experimental methods. Some 130 heating and cooling curves were taken. The effects of preparation of the sample and of rate of heating were determined. Reduced to zero rate, and for gas-free iron in vacuo, $Ac2=Ar2=768\pm0.5$, $Ac3=909\pm1$, and $Ar3=898\pm2$. (Sept. 22, 1913.) 56 pp. Price, 20 cents.

S214. Note on the Setting of a Mercury Surface to a Required Height.....*M. H. Stillman*

The paper describes an improvement in the method of setting a mercury surface to a given height by bringing it just into contact with a downward projecting pointer. The improvement consists in placing a parallel-ruled scale back of the pointer so that its image will appear in the mercury surface at the end of the pointer. Distortion of the lines of this image indicates contact. Results of experiments showing the accuracy of this method are given. (Sept. 20, 1913.) 4 pp. Price, 10 cents.

S215. Micrometer Microscopes.....*Arthur W. Gray*

The first section points out numerous sources of error generally overlooked in using micrometer microscopes, and gives examples to illustrate the magnitude of the corrections needed for a few microscopes that have been investigated. The second section describes a simple and rapid method of applying the proper corrections when making length measurements of precision. The third section explains an accurate means of measuring screw errors and a graphical procedure for computing convenient correction tables. (Nov. 5, 1913.) 16 pp. Price, 5 cents.

S216. The Pentane Lamp as a Working Standard.....
.....*E. C. Crittenden and A. H. Taylor*

This paper recommends the use of tested pentane lamps as secondary standards of candlepower when electric standards are not available, and gives a detailed statement of the method of testing followed at the Bureau, with general directions for the use of the lamps. The effects of variation in pentane and in atmospheric conditions are discussed, a correction for the former is proposed, new determinations of the humidity correction factor are given, and a chart is provided to facilitate the reduction of observations to normal candlepower. (Aug. 2, 1913.) 27 pp. Price, 5 cents.

S217. Testing Potential Transformers.....*H. B. Brooks*

Describes a method of measuring the ratio and phase angle of a potential transformer in terms of the known ratio and phase angle of another transformer used as a standard. The instruments required are a portable wattmeter and an ammeter. The test may be carried out with current from commercial circuits, as ordinary fluctuations of voltage have no effect on the readings. The accuracy is ample for commercial requirements. The method may also be used to determine the regulation of power transformers. (Feb. 7, 1914.) 6 pp. Price, 5 cents.

S218. Comparison of the Silver and Iodine Voltameters and the Determination of the Value of the Faraday.....*G. W. Vinal and S. J. Bates*

Simultaneous measurements made with the silver and iodine voltameters have afforded a direct determination of the ratio of the silver deposit to the iodine deposit. The following results were obtained:

Ratio of silver to iodine.....	0.85017
Electrochemical equivalent of iodine	1.31502 mg per coulomb
Value of the Faraday (I=126.92)...	96,515 coulombs
Value of the Faraday (Ag=107.88).	96,494 coulombs

At the time of these experiments it was not known how great the error due to inclusions of foreign material in the silver deposits might be. It was assumed to be negligible. In S271 the inclusions have been determined to be 0.004 per cent of the deposit on the average. In S271 the above figures are revised and further discussed. (Jan. 2, 1914.) 26 pp. Price, 10 cents.

S219. Production of Temperature Uniformity in an Electric Furnace.....*Arthur W. Gray*

After discussing some fundamental principles underlying temperature control, and reviewing previous attempts to secure temperature uniformity in electric furnaces, the paper outlines experiments that show how a double plug, conducting transversely while insulating longitudinally, has been used to reduce the temperature gradient in a column of heated air. It then describes the application of such a plug, combined with end-heating coils, to electric furnaces. The results obtained show that it is possible to heat a region of considerable length to any desired temperature up to about 700° C so uniformly that irregularities in the temperature distribution will be less than the effect of heterogeneity in thermoelements of the best quality, and probably less than the uncertainties at present existing in our knowledge of the temperature scale itself. (Feb. 3, 1914.) 23 pp. Price, 15 cents.

S220. The Silver Voltameter—Part IV. Third Series of Quantitative Experiments and Special Investigations.....*E. B. Rosa, G. W. Vinal, and A. S. McDaniel*

Following the work of the international committee in 1910 the work on the silver voltameter was continued for the purpose of comparing the porous pot and the Smith forms of voltameters and to obtain such further data as were necessary for writing the specifications. The result of the third series of quantitative experiments is the value 1.01827 international volts for the Weston normal cell at 20° C. The relation between the acidity of the electrolyte (x) and the resulting decrease in deposit (y) in parts per million is found to be according to the equation $y = -4.5x + 0.02x^2$. The action of porous pots on silver nitrate and the conditions of reversibility of the voltameter were also investigated. [In S271 the values here found have been revised. See also S285.] (Dec. 1, 1913.) 62 pp. Price, 10 cents.

S221. Influence of Atmospheric Conditions in the Testing of Sugars.....*Frederick Bates and Francis P. Phelps*

A simplified form of Marvin's evaporation equation has been applied to the evaporation of raw-sugar solutions during filtration. Marvin's formula reduces to $\frac{dQ}{dt} = C(P_s - P_a)$; $\frac{dQ}{dt}$ being the rate of evaporation; C, a constant for the particular case considered; $(P_s - P_a)$, the difference between the vapor pressure of the solution and the partial pressure of the water vapor already in the air. C has been evaluated by two different methods—(1) by weighing; (2) by polarization. Having determined C by the polarization method, it is then possible to compute a correction for evaporation to be applied to the polarization of a raw sugar under any known atmospheric condition. The calculated values of $\frac{dQ}{dt}$ agree satisfactorily with the observed values. (Feb. 1, 1914.) 19 pp. Price, 10 cents.

S222. Flame Standards in Photometry.....*E. B. Rosa and E. C. Crittenden*

This paper gives results of experimental work with flame lamps of the types which have claims to consideration as primary standards of light, viz, the Carcel, the Hefner, and the Harcourt pentane lamp, with a general discussion of the defects and advantages of the several types. Effects of atmospheric conditions are discussed rather fully because some previously accepted correction factors were not in accord with the observed effects. In consistency of results obtained with a single lamp the pentane type is best, and hence is useful as a secondary standard, but ordinary pentane lamps differ considerably in candlepower. Hefner lamps have many faults, but different ones agree closely, giving this type an advantage as primary standards. By specifying construction and operation more exactly, it appears possible to obtain from either kind of lamp a useful check on our present electric reference standards. (Apr. 1, 1914.) 39 pp. Price, 10 cents.

S223. The Testing of Potentiometers.....
.....*Frank Wenner and Ernest Weibel*

A theory is developed which explains the operation of the various kinds of potentiometers in use. This is then used in stating the corrections to a potentiometer and gives a direct indication of the measurements necessary to determine these corrections. Various methods which have been used to determine the corrections are given. A piece of apparatus designed especially for use in the calibration of potentiometers is described and the way in which it is used in the calibration of several of the common types of potentiometers is explained and illustrated. (June 10, 1914.) 40 pp. Price, 15 cents.

S224. The Emissivity of Metals and Oxides. I. Nickel Oxide (NiO) in the Range 600 to 1300° C
.....*G. K. Burgess and P. D. Foote*

The monochromatic emissivity, E_λ, throughout the visible spectrum and the total emissivity, E, of nickel oxide (NiO) have been measured for the temperature interval 600° to 1300° C. The monochromatic emissivity increases linearly with increasing wave length and decreases linearly with increasing temperature over the region investigated. For example, at 1160° C, E_λ, increases from 0.86_5 at 0.5μ to 0.88_2 at 0.7μ, and for $\lambda=0.65\mu$, E_λ decreases from 0.95_8 at 800° C to 0.84_5 at 1300° C. The total emissivity increases with increasing temperature, but the relation is not linear. Temperatures and E have, respectively, values as follows: 600°, 0.54; 800°, 0.68; 1000°, 0.76; 1200°, 0.85; 1300°, 0.87. (Apr. 15, 1914.) 24 pp. Price, 10 cents.

S225. Adjustments of the Thomson Bridge in the Measurement of Very Low Resistances.....
.....*Frank Wenner and Ernest Weibel*

The paper points out a difficulty in the accurate comparison of extremely low resistances by the Thomson-bridge method, if the desired adjustments are made in the usual way. This difficulty arises on account of the resistance of and the necessity for opening and closing the low-resistance connection between the resistances under comparison. Two procedures are given for making the desired adjustments, neither of which requires the opening and closing of this connection. (May 25, 1914.) 4 pp. Price, 5 cents.

S226. Quantitative Experiments in Radiotelegraphic Transmission.....*L. W. Austin*

Experiments between Arlington and U. S. S. *Salem*, Colon, St. Augustine, etc. (Apr. 1, 1914.) 18 pp. Price, 5 cents.

S227. Measurements on Standards of Radiation in Absolute Value.....*W. W. Coblentz*

In this paper is given the flux of radiant energy per square centimeter at a distance of 1 m from (1) the Hefner lamp, (2) the standard sperm candle, and (3) seasoned carbon incandescent lamps which were calibrated against a uniformly heated inclosure or so-called black body. These standards may be used in calibrating radiometers for absolute measurements. The flame standards are useful for approximate comparisons; but for precision work calibrated carbon incandescent lamps are recommended. In a supplementary note are some direct measurements in absolute value, including some preliminary values of the constant of total radiation. (June 24, 1914.) 14 pp. Price, 5 cents.

S228. An Experimental Study of the Koepsel Permeameter.....*Charles W. Burrows*

This paper gives in detail the results of an experimental study of the possibilities and limitations of the Koepsel permeameter. Data are given to show the influence of the length, cross section, and material of the specimen, and other factors which may affect the accuracy of the readings. For small and moderate inductions the measured magnetizing force is usually in excess of its true value, sometimes by as much as 100 per cent, while at high inductions it is usually too low, sometimes by as much as 25 per cent.

However, with the use of proper correction curves, these errors will not exceed 5 per cent. Uncorrected hysteresis data for hard steels show values of the residual induction that are too small and of the coercive force that are too large by errors of 10 per cent and 40 per cent, respectively. The chief value of such an instrument is for comparative work in which it is desired to determine the degree of uniformity of material or the relative values of similar materials. (Aug. 1, 1914.) 20 pp. Price, 10 cents.

S229. Various Modifications of Bismuth-Silver Thermopiles Having a Continuous Absorbing Surface.....*W. W. Coblentz*

In this paper data are given on the radiation sensitivity of a thermopile as a function of the area exposed, the thermal conductivity and emissivity; also as a function of the external and internal resistance. Data are also given on the relative sensitivities of thermopiles of which one element is bismuth and the other element is either copper, iron, or bismuth alloys. A modification is given of the Angström pyrheliometer for measuring radiation in absolute value. A radiometer attachment to monochromatic illuminators is described, which is of importance to physiologists, psychologists, biologists, and physicists who are investigating the effect of light stimuli upon matter. Note 1 describes plane galvanometer mirrors of extreme lightness and note 2 describes experiments with a vacuum galvanometer. (Mar. 20, 1914.) 57 pp. Price, 20 cents.

S230. Combustion Calorimetry and the Heats of Combustion of Cane Sugar, Benzoic Acid, and Naphthalene.....*H. C. Dickinson*

Various factors, viz, temperature measurement, stirring, thermal conduction, convection, boundaries of the calorimeter, cooling corrections, and lag effects, affecting the accuracy of calorimeters are discussed, and some of the principles involved in the design of an accurate calorimeter are pointed out. An electrical method used in the calibration of bomb calorimeters is described and discussed. The results of an extended series of determinations of the heats of combustion of sucrose, benzoic acid, and naphthalene are tabulated and discussed. The paper also contains a partial bibliography of the subject. (July 16, 1914.) 69 pp. Price, 15 cents.

S231. Specific Heat of Copper in the Interval 0° to 50° C, with a Note on Vacuum-Jacketed Calorimeters.....*D. R. Harper 3d*

The specific heat of a specimen of copper 99.87 per cent pure was determined by a precise electrical method. The heat was supplied electrically and measured by potentiometer and clock; the temperature rise was measured by a resistance thermometer. "True specific heat," i. e., mean value over a short temperature interval (4° to 5°), was obtained. Apparatus, procedure, and results are fully described. A feature of the paper is a very complete review of all measurements of the specific heat of copper from the earliest to 1913. The use of a vacuum jacket as a means of reducing the cooling correction in calorimetry is discussed from the point of view of indicating the degree of exhaustion which it is profitable to attain with a fixed set of radiation conditions when thermal insulation by means of a vacuum jacket is sought. (May 30, 1914.) 71 pp. Price, 25 cents.

S232. Equilibrium in the System; Lead Acetate, Lead Oxide, Water at 25°.....*Richard F. Jackson*

Lead acetate, lead hydroxide, and water were mixed in varying proportions and the equilibria at 25° determined after several days' agitation. The solid phases capable of existence in equilibrium with aqueous solutions are as follows: The neutral acetate $Pb(C_2H_3O_2)_2.3H_2O$, which can exist in acid, neutral and slightly basic solutions, the tetralead monoxy-hexaacetate $3Pb(C_2H_3O_2)_2PbO.3H_2O$, which possesses great solubility but depends for its existence in equilibrium upon an excess of dissolved basic lead; the trilead dioxy-diacetate, whose saturation curve indicates very high solubility in less basic solutions and slight solubility in more basic solutions; and lead hydroxide, which can exist in equilibrium with dilute basic lead acetate solutions. The equilibria of the chemical reactions are discussed. (Aug. 19, 1914.) 15 pp. Price, 5 cents.

S233. A Watthour Meter Method of Testing Instrument Transformers.....*P. G. Agnew*

The ratio and phase angle of instrument transformers may be determined by two similar watthour meters, either of the portable type or the house type having the disks graduated in 100 divisions. For voltage transformers, an auxiliary current is passed in series through the current coils of the two meters, and the voltage coils are then connected alternately to the two transformers. For current transformers, the connections are inverted. Ratios are obtained by working the meters at unity power factor and the phase angles from readings at low power factors. The accuracy obtainable is ample for commercial purposes. (July 18, 1914.) 11 pp. Price, 5 cents.

S234. Insulating Properties of Solid Dielectrics. .*Harvey L. Curtis*

In this paper are treated two properties of insulators, viz, conduction through the material and leakage over the surface. The volume resistivity of a large number of materials is tabulated, and the results of studies upon the effect of temperature and of the magnitude and length of time of application of the voltage are stated. Curves are given showing the change of surface resistivity with atmospheric humidity for 75 different materials. For high humidities of the surrounding air, leakage over the surface is usually determined by the thickness and conductivity of the film of moisture. The effect of temperature and of exposure to light are also determined. (June 18, 1914.) 64 pp. Price, 15 cents.

S235. A Direct-Reading Instrument for Measuring the Logarithmic Decrement and Wave Length of Electromagnetic Waves.....*Frederick A. Kolster*

An instrument for facilitating the measurement of the logarithmic decrement of high-frequency oscillations, such as exist in the wave trains emitted from radio transmitting stations, is described. The instrument contains a variable condenser, the capacity of which varies in accordance with the law of geometric progression. The logarithmic decrement is read directly from a scale attached to this condenser, and the task of making observations and necessary calculations required by the Bjerknes formula is eliminated. The complete theory and design of the instrument are given as well as experimental data. The measurement of the logarithmic decrement at radio stations is important, since the United States laws governing radio communication specify, among other things, that the logarithmic decrement per complete oscillation in the wave trains emitted by the transmitter shall not exceed two-tenths. (Aug. 15, 1914.) 35 pp. Price, 10 cents.

S236. Electrical Resistance and Critical Ranges of Pure Iron.....*G. K. Burgess and I. N. Kellberg*

The electrical resistance of pure iron has been determined from 0° to 950° C. The critical range A_2 is characterized by a reversible inflexion in the resistance temperature curve (or cusp in the curve of temperature coefficients) at 757° C. The Ac_3 range is located above the Ar_3 range, both beginning at 894° and each extending over a 25° C interval. There are no other critical ranges in iron between 0° and 950° C. (Aug. 21, 1914.) 14 pp. Price, 5 cents.

S237. Absorption, Reflection, and Dispersion Constants of Quartz.....*W. W. Coblentz*

This paper gives quantitative data on the absorption, reflection, and dispersion of quartz extending from the ultraviolet to 3μ in the infra-red. The data are to be used in determining spectral energy curves. Quartz begins to absorb heavily beyond 1.8μ in the infra-red; and tabulated data are given for eliminating this absorption in a quartz prism. (Dec. 9, 1913.) 11 pp. Price, 5 cents.

S238. Characteristic Equations of Tungsten Filament Lamps and Their Application in Heterochromatic Photometry.....
.....*G. W. Middlekauff and J. F. Skogland*

Color difference is a source of considerable difficulty when comparing the candlepower of lamps not closely alike in color. A convenient method of avoiding this difficulty is by the use of color screens to bring the lamps to a color match; but the calibration of the screens must first be made. This paper describes a new method of eliminating color difference by the use of tungsten standardized lamps. These are adjusted to color match the lamps under test and the correction to apply to the standards is then computed by a formula developed by the authors, or derived directly from the printed tables which were computed by means of the formula. By the above method the photometric difficulties arising from color difference are dealt with, once for all in determining for tungsten lamps the characteristic relations from which the formula was derived, and all subsequent measurements are reduced to the photometry of lights of the same color. (Oct. 10, 1914.) 52 pp. Price, 10 cents.

S239. A Vibration Electrometer.....*Harvey L. Curtis*

In this paper is described a modification of the quadrant electrometer for use as a vibration instrument. The instrument is of such form that the capacities can be approximately computed. The mathematical theory of the instrument is developed and experimental data are given to show the agreement between theory and experiment. (Sept. 29, 1914.) 18 pp. Price, 10 cents.

S240. Studies on the Silver Voltameter.....
.....*G. A. Hulett and G. W. Vinal*

A comparison has been made of the voltameter apparatus and methods in use at Princeton University with those of the Bureau. In a preliminary comparison important differences were found. The cause of these has been traced to the method of preparing the porous cups and to a hitherto unsuspected source of error in the method of washing the deposit. Evidence has been obtained of a galvanic action by which silver, in contact with platinum and immersed in distilled water, passes into solution and is thereby lost to the deposit. A comparison of the effect of porous cups of different makers has been made and also a further comparison of gold and platinum cathodes. [See also S285.] (July 1, 1914.) 18 pp. Price, 10 cents.

S241. A Wheatstone Bridge for Resistance Thermometry
C. W. Waidner, H. C. Dickinson, E. F. Mueller, and D. R. Harper 3d.

The paper describes a high precision mercury contact bridge designed with especial reference to flexibility of use in measurements with resistance thermometers. Measurements by the Thomson double-bridge method are also provided for. Full details of design and construction are shown by photographs, supplemented by brief description in the text. Special features are the use of shunt dials for the 0.0001, 0.001, and 0.01 ohm decades, a new form of hermetically sealed coil, and complete oil immersion of contacts as well as coils in order to reduce thermoelectromotive forces. (Oct. 1, 1914.) 20 pp. Price, 20 cents.

S242. The Emissivity of Metals and Oxides. II. Measurements with the Micropyrometer.....
.....*G. K. Burgess and R. G. Waltenberg*

Measurements of monochromatic emissivity for wave lengths of 0.65μ and 0.55μ have been taken with the micropyrometer of some 23 metals and 12 oxides in the solid and liquid states. For most metals there is no temperature-coefficient of emissivity; some show a marked and others a slight or no discontinuity in emissivity at the melting point. Palladium shows an undercooling radiation phenomenon and the discontinuity of platinum at M. P. would render the Violle unit of light uncertain. (Oct. 24, 1914.) 15 pp. Price, 5 cents.

S243. The Emissivity of Metals and Oxides. III. The Total Emissivity of Platinum and the Relation Between Total Emissivity and Resistivity.. .....*Paul D. Foote*

The theory of radiation from metals developed by Aschkinass has been extended and the following general equation has been derived for the total emissivity of a metal:

$$E=0.5736\sqrt{rT}-0.1769rT$$

where E is the total emissivity at the absolute temperature T and r the volume resistivity of the metal at this temperature. Experimental observations upon platinum obtained by the use of radiation pyrometers confirmed the above theoretical relation. A table of corrections is given for converting temperatures observed with a radiation pyrometer sighted upon platinum, to true temperatures. The following table represents the total emissivity of pure platinum as a function of the temperature:

°C	0	200	400	600	800	1000	1200	1400	1700
E	.030	.051	.070	.089	.108	.124	.140	.155	.175

(Jan. 30, 1915.) 6 pp. Price, 5 cents.

S244. A Comparison of Stellar Radiometers and Radiometric Measurements on 110 Stars...*W. W. Coblentz*

This paper gives quantitative data on an intercomparison of thermocouples and bolometers designed for measuring heat from stars. It was found that the thermocouples were the more sensitive. An improved method for maintaining a vacuum by means of calcium is described. The thermocouples were used in connection with a 3-foot mirror and measurements were made on 112 celestial objects. This includes measurements on the bright and the dark bands of Jupiter, Saturn's rings, etc. It was found that red stars emit about three times as much total radiation as do blue stars having the same photometric magnitude. Quantitative measurements were made on stars down to the 5.3th magnitude and high-grade qualitative measurements were made on stars down to the 6.66 magnitude. The transmission of stellar radiation through a cell of water was found. The measurements show that blue stars have from two to three times as much radiation in the visible spectrum as have red stars. An estimate of the total radiation from all stars was obtained. (Nov. 5, 1914.) 44 pp. Price, 15 cents.

S245. Temperature Coefficient of Magnetic Permeability Within the Working Range ..... *Raymond L. Sanford*

It is shown in this paper that the temperature coefficient of magnetic permeability is of such a magnitude that it can not be neglected in precision work and also that it varies through wide limits with different materials or the same material with different heat treatments. Temperature control offers the only means of avoiding errors due to change in temperature. (Jan. 30, 1915.) 10 pp. Price, 5 cents.

S246. Methods of Measuring the Inductances of Low-Resistance Standards..... .....*Frank Wenner, Ernest Weibel, and F. B. Silsbee*

Two methods are described for measuring the inductance of a low "non-inductive" resistance standard. Either of these methods gives values which do not depend upon the calculation, from dimensions, of the inductance of some low-resistance standard. The experimental work described was done for the purpose of testing the practicability of the methods for use in measuring the residual inductances of low-resistance standards. Determinations were made of the inductances of standards having resistances of 0.01, 0.001, and 0.000337 ohm. (May 28, 1915.) 11 pp. Price, 5 cents.

S247. An Aneroid Calorimeter.....
.....*H. C. Dickinson and N. S. Osborne*

An account is given of a calorimeter utilizing for equalization of temperature the thermal conductivity of a solid copper shell in connection with a built-in heating coil and a built-in platinum resistance thermometer. Details of the design, construction, and operation are described. Results of the standardization of the instrument are given and also results of experimental determinations of the specific heat of water in the interval from 0° C to +40° C. (July 26, 1915.) 26 pp. Price, 10 cents.

S248. Specific Heat and Heat of Fusion of Ice.....
.....*H. C. Dickinson and N. S. Osborne*

An account is given of a series of experimental determinations of the specific heat of ice in the temperature range from −40° C to 0° C and of the heat of fusion of ice. The measurements were made by means of a calorimeter of aneroid type. The specific heat of four samples of ice, all of high but of different degrees of purity, was determined. By analysis of the results conclusions are drawn as to the specific heat and heat of fusion of pure ice. Total heat tables for ice are appended. (July 16, 1915.) 33 pp. Price, 10 cents.

S249. The Emissivity of Metals and Oxides. IV. Iron Oxide.....*George K. Burgess and Paul D. Foote*

Iron oxide in the spectral region $\lambda=0.65\mu$ is almost black, having an emissivity varying from 0.98 to 0.92 in the range 800 to 1200° C. The corrections necessary to apply to the readings of an optical pyrometer in this temperature range vary from 0 to 10° C. The total emissivity of iron oxide increases from 0.85 at 500° C to 0.89 at 1200° C. The corrections necessary to apply to the readings of a radiation pyrometer in this temperature range vary from 30 to 50° C. The drop in temperature through the oxide layer formed on the iron is of considerable importance; the iron may be 100° hotter than the outside of the oxide at 1000 C. (June 24, 1915.) 7 pp. Price, 5 cents.

S250. Characteristics of Radiation Pyrometers.....
.....*George K. Burgess and Paul D. Foote*

Contains a discussion of the principles of radiation pyrometry, descriptions of the usual types of radiation pyrometers, their calibration, errors, methods of use, and applications. (Aug. 10, 1915.) 88 pp. Price, 20 cents.

S251. Interference Measurements of Wave Lengths in the Iron Spectrum (2851–3701), with Notes on Comparisons of Lengths of Light Waves by Interference Methods, and Some Wave Lengths in the Spectrum of Neon Gas.....
.....*Keivin Burns and W. F. Meggers*

One hundred and thirty-one lines were measured in the iron spectrum by means of the Fabry and Perot interferometer. The standard wave length was furnished by a Michelson H tube containing cadmium. The interferometer plates were coated with nickel. The lines were separated by means of a 21-foot Rowland grating mounted in parallel light. As far as possible both faint and strong lines were measured in all parts of the spectrum and lines were chosen at intervals of about 10 ångstroms.

The second part of the paper outlines a convenient method for correcting interference measurements for phase change. The method of determining the distance between the interferometer plates is also discussed. Provisional wave lengths of several neon lines are given. (July 15, 1915.) 27 pp. Price, 10 cents.

S252. Effective Resistance and Inductance of Iron and Bimetallic Wires.....*John M. Miller*

A method is developed for determining exact permeability curves for the circular magnetization which results when a current of electricity flows through an iron wire. Comparisons are made with permeability curves for axial magnetization. The effective resistance and inductance of copper-clad wires and iron telephone wires are measured with an Anderson bridge at frequencies up to 3000 cycles per second and current strengths up to 10 amperes. Formulas are developed for the calculation of the skin effect in bimetallic wires and comparisons made with measured values for copper-clad wire. A table gives computed values of effective resistance and inductance of copper-clad wires for the even sizes from No. 0 to No. 12 (A. W. G.) and 30, 40, and 50 per cent conductivities. (Aug. 3, 1915.) 61 pp. Price, 20 cents.

S253. A Direct-Reading Device for use in Computing Characteristics of Vacuum Tungsten Lamps.. .....*J. F. Skogland*

A computing device consisting of volt, watts per candle, and per cent candlepower scales is presented. This device is ready for use after detaching the volt scale. Settings of the volt scale to observed values within the range of from 0.70 to 2.05 wpc permit direct reading from the proper scales of any one of the variables at any point within this range.

Tables of values used in constructing this device and a full description of every point relating thereto, practical examples, and a brief mathematical discussion are presented in the paper. The chief merit of the device is a great saving of time with practically no sacrifice of precision. (July 31, 1915.) 20 pp. Price, 10 cents.

S254. A Study of the Quality of Platinum Ware..... .....*George K. Burgess and P. D. Sale*

Undertaken at the suggestion of a committee of the American Chemical Society. A thermoelectric method for determining platinum purity has been devised which does not mar the material tested, and applied to 164 samples. Methods for determining exactly losses in weight after acid treatment have been developed and applied to 14 crucibles of several degrees of purity. It is shown that losses in weight may be predicted from emf and microscopic examinations; the iron content is found not proportional to magnetic susceptibility; suggestions are offered concerning specifications for platinum crucibles; and nature of disintegration is briefly discussed. (Aug. 25, 1915.) 28 pp. Price, 10 cents.

S255. Calculation of the Maximum Force Between Two Coaxial Circular Currents.....*Frederick W. Grover*

In the absolute measurement of electric current it is important to so place the coils of the apparatus that the force exerted between these coils will be a maximum. In this paper two formulas have been developed which determine the distance between the coils corresponding to maximum force. This distance can be determined only by a series of approximations, but by the use of differential formulas the desired approximation is readily obtained. When the maximum distance has thus been obtained, it may be substituted in well-known formulas to obtain the maximum force. Numerous examples are given to show the application of the formula, and tables are compiled to facilitate their use. (Aug. 30, 1915.) 57 pp. Price, 15 cents.

S256. Construction of Primary Mercurial Resistance Standards..... .....*F. A. Wolff, M. P. Shoemaker, and C. A. Briggs*

The paper deals with the construction of four 1-ohm mercury standards of resistance in accordance with the specifications of the London Conference on Electrical Units and Standards (1908).

The tubes were selected, straightened, and graduated by Baudin in Paris and carefully calibrated at the Bureau of Standards. The ohm

lengths were then determined approximately, the tubes cut, and the ends optically polished.

Determinations of the L_o of the finished tubes were made by direct comparisons with standard meter bars at 0°, and fillings for the determination of M_o were made by the Reichsanstalt method.

The Thomson bridge method of electrical comparison was employed. The results obtained show the relative agreement of the four tubes to be very good, the average deviations of the individual tubes from their mean being ± 5 millionths of an ohm. (Oct. 9, 1915.) 90 pp. Price, 25 cents.

S257. Note on the Resistance of Radiotelegraphic Antennas.....*L. W. Austin*

It is well known that for the longer wave lengths most land radio stations show an increase in antenna resistance with increasing wave length, although the radiated energy decreases with the wave length. This phenomenon may be explained on the supposition that the antenna and ground water act as plates of a condenser. The earth above the ground water acts as a poor dielectric, the equivalent resistance of which is known to increase with the wave length. (Oct. 16, 1915.) 4 pp. Price, 5 cents.

S258. A Method of Measuring Earth Resistivity..*Frank Wenner*

The paper describes a method for measuring the effective resistivity for portions of earth which are large in comparison with samples which might be taken into the laboratory for test. By the method the resistivity may be found to a considerable depth without placing electrodes at corresponding depths and without disturbing the portion of earth to be tested. (Oct. 11, 1915.) 10 pp. Price, 5 cents.

S259. A New Relation Derived from Planck's Law.....
.....*Paul D. Foote*

The product of the absolute temperature and the λ—coordinate of the center of gravity of the spectral energy curve of a black body is a constant of the following value: $\theta\lambda_c = 0.37021\ C_2$. (Dec. 3, 1915.) 4 pp. Price, 5 cents.

S260. "Center of Gravity" and "Effective Wave Length" of Transmission of Pyrometer Color Screens, and the Extrapolation of the High Temperature Sale.....*Paul D. Foote*

A new method for determining the "effective wave length" of the color and absorption screens used in optical pyrometry is derived and applied to several specific screens and glasses. The shift of effective wave length with change in temperature of the source and the effect this shift may have upon the accuracy of temperature measurements are discussed. It is shown both theoretically and experimentally that for precise work at high temperatures with pyrometers using color screens a thorough knowledge of the change of the effective wave length with temperature is required. (Mar. 13, 1916.) 19 pp. Price, 10 cents.

S261. Studies of Instruments for Measuring Radiant Energy in Absolute Value: An Absolute Thermopile.....*W. W. Coblentz and W. B. Emerson*

This paper gives the results of an investigation of a radiometer, consisting of a thin blackened strip of metal with a thermopile back of it, for measuring radiant energy in absolute units. The strip of metal functions (1) as a receiver for absorbing radiant energy, (2) as a source of radiation (by heating it electrically) which may be evaluated in absolute measure, and (3) as a standard source of radiation for testing the sensitivity of the radiometer, which includes both galvanometer and thermopile. The effect produced by varying the width and the thickness of the strip was investigated and the loss of energy was found to be satisfactory for refined radiometric measurements. (Mar. 4, 1916.) 49 pp. Price, 15 cents.

S262. Present Status of the Determination of the Constant of Total Radiation from a Black Body
.....*W. W. Coblentz*

In this paper are given the results of an inquiry into the probable value of the constant of total radiation as determined by different observers. It is shown that all these determinations cluster closely about the mean value of $\sigma=57$. Experimental data are given on the lack of blackness of the radiator, on the absorption by atmospheric water vapor, etc. The data obtained in a preceding paper are corrected for diffuse reflection. The mean value of 304 sets of measurements gives for the coefficient of total radiation of a uniformly heated inclosure or so-called black body, a value of $=5.72 \times 10^{-12}$ watt cm^{-2} deg^{-4} or 1.37×10^{-12} gr-cal cm^{-2} deg^{-4}. (Feb. 25, 1916.) 30 pp. Price, 10 cents.

S263. Illumination from a Radiating Disk.....*Paul D. Foote*

A complete solution is given for the illumination produced by a diffusely and uniformly radiating circular disk at any point in space on a surface parallel to the disk. The correct solution is shown to be just as convenient to use as many of the approximate solutions appearing in the technical journals. (Mar. 13, 1916.) 4 pp. Price, 5 cents.

S264. Photometry of the Gas-Filled Lamp.....
.....*G. W. Middlekauff and J. F. Skogland*

The gas-filled lamp introduces variables not hitherto met with in the photometry of incandescent lamps. It is found that both current and candlepower have different values at constant voltage when the lamp is rotating than when it is stationary. Also for any change in speed there is a corresponding change in current in one direction and in candlepower in the opposite direction. Furthermore, the direction of these changes depends upon whether the speed is above or below a certain value. From the standpoint of photometry it is fortunate that at this particular speed both current and candlepower at constant voltage have the same values as when the lamp is stationary. Hence, by rotating the lamp at that speed the mean horizontal candlepower may be determined without introducing errors caused by rotation. (Mar. 16, 1916.) 18 pp. Price, 10 cents.

S265. Life Testing of Incandescent Lamps at the Bureau of Standards.....
..*G. W. Middlekauff, B. Mulligan, and J. F. Skogland*

The method employed by the Bureau of Standards in the inspection and life testing of incandescent lamps for the Federal Government is outlined and a description of the power plant, the life racks, and the photometer is given. Particular attention is directed to the special equipment of the photometer. This includes a watts-per-candle computer and a recording device by which observed values of candlepower, watts, watts-per-candle, and actual life are recorded on a separate card for each lamp. These records are made in such a way that life at forced efficiency is corrected to life at normal without computation or reference to tables of factors. The procedure in actual measurement and testing is described with considerable detail. (Mar. 16, 1916.) 26 pp. Price, 10 cents.

S266. Preparation of Pure Iron and Iron-Carbon Alloys
.....*J. R. Cain, E. Schramm, and H. E. Cleaves.*

Previous work on the iron-carbon thermal diagram is incomplete or is unsatisfactory because of impurities in the alloys used, hence the present series of alloys having a purity of 99.96 per cent was made up at the Bureau as a preliminary to a reinvestigation of the subject. The iron was prepared electrolytically from a chloride electrolyte using commercially pure ingot iron anodes; the carbon was made from pure sugar. The melting was done in a vacuum furnace in crucibles made from specially purified magnesia prepared by a method described in the paper. (Feb. 29, 1916.) 26 pp. Price, 10 cents.

S267. Colorimetric Determination of Acetylene and Its Application to the Determination of Water
.....*E. R. Weaver*

This paper combines the article on "A qualitative test for water by the use of the acetylene-cuprous chloride reaction" with the paper on the "Colorimetric determination of acetylene," both published in the Journal of the American Chemical Society. Some rearrangement and condensation have been necessary, otherwise the two former papers are followed closely. (Feb. 29, 1916.) 39 pp. Price, 15 cents.

S268. Constants of the Quartz-Wedge Saccharimeter and the Specific Rotation of Sucrose. I. The Constants for the 26-Gram Normal Weight
.....*Frederick Bates and Richard F. Jackson*

The accepted basis of standardization for the saccharimeter is that known as the Herzfeld-Schönrock determination of the 100° sugar point. This is predicted on the so-called conversion factor or normal quartz-plate rotation for sodium light, which they found to be 34°.657. In the present research sucrose was prepared by concentrating the sirup in a vacuum boiling apparatus at about 35° C and crystallizing in motion. The questions of caramelization and elimination of reducing sugars and water were carefully studied. Approximately normal solutions were prepared and the rotations measured on both polarimeter and saccharimeters under conditions favorable to high precision. The reading of the normal sugar solution on the saccharimeter is found to be 99°.895 S instead of 100° S. The Herzfeld-Schönrock scale is, therefore, concluded to be in error by over 0°.1 S. The new conversion factors are found to be 40°.690 for λ=5461.A and 34°.620 for λ=5892.5A and the rotations of the normal solution are 40°.763 and 34°.517, respectively, for these wave lengths. For the specific rotations the following are obtained

$$\left[\alpha\right]^{20}_{\lambda=5892.5A} = 66°.529$$

$$\left[\alpha\right]^{20}_{\lambda=456} = 78°.342.$$

The values of a number of additional constants have also been given (Apr. 6, 1916.) 62 pp. Price, 15 cents.

S269. Effect of Imperfect Dielectrics in the Field of a Radiotelegraphic Antenna.....*John M. Miller*

It is shown by measurements at telephone and wireless frequencies that the linear rise in resistance of an antenna with increasing wave length, which takes place at the longer wave lengths, is caused by absorption in the antenna, acting as a condenser, as advanced by Austin. The phenomenon, however, is not due to the ground but to the presence of absorbing dielectrics in the field of the antenna, such as wooden masts, trees, insulation, buildings, etc. The importance of reducing this absorption to a minimum in the design of an antenna is pointed out. (Mar. 20, 1916.) 8 pp. Price, 5 cents.

S270. Luminosity of a Black Body and Temperature...
.....*Paul D. Foote and C. O. Fairchild*

The relation between luminosity of a black body and temperature has been derived by a new method. The Rasch equation is shown to be unsatisfactory, while the Nutting equation or a slight modification of the Nutting equation holds exceedingly well. The exact meaning of the Crova wave length is defined and is shown to be of the form

$$\lambda_L = a + b/\theta + c/\theta^2$$

(Mar. 21, 1916.) 9 pp. Price, 5 cents.

S271. Inclusions in the Silver Voltameter Deposits.....
.....*G. W. Vinal and William M. Bovard*

Silver voltameter deposits have been heated to 600° C and over to expel the small amounts of inclusions of foreign material that they contain. On the average, these are found to be 0.004 per cent of the deposit. In using this method a serious source of error arises from the alloying of the platinum and the silver. Means of avoiding this error are indicated. The value for the absolute electrochemical equivalent of silver given in S220 is revised. It is found to be 1.11800 mg per coulomb. The value for the Faraday (S218) is further discussed. (See also S285.) (Mar. 24, 1916.) 26 pp. Price, 5 cents.

S272. Correlation of the Magnetic and Mechanical Properties of Steel .....*Charles W. Burrows*

This paper is a review of the work done in correlating the magnetic and mechanical properties of steel with special reference to the commercial application of the magnetic data as criteria of the mechanical fitness of a given steel and of magnetic changes of steel under stress as indications of the state of strain. The evidence presented shows that the interrelation of magnetic characteristics and the mechanical behavior of steel is so close that the magnetic examination in conjunction with the mechanical tests may be expected to add considerably to our knowledge of the material.

The magnetic method tests the whole amount of material and not merely some surface layer. It does not destroy the test piece, but leaves it unaltered, so that it is possible to apply a magnetic test to the identical material that is to enter into a given structure. (Mar. 29, 1916.) 38 pp. Price, 15 cents.

S273. General Design of Critically Damped Galvanometers.....*Frank Wenner*

The relations between the operating constants (sensitivity, period, etc.) with which the user of the galvanometer is concerned and the intrinsic or construction constants with which the designer and builder of the galvanometer are concerned are given. These relations are then used in establishing a procedure for the design of galvanometers to have specified values for their operating constants. This is done for each of four sets of operating constants corresponding to the four classes of work in which galvanometers are used critically damped. (Apr. 12, 1916.) 34 pp. Price, 10 cents.

S274. Interference Measurements of Wave Lengths in the Iron Spectrum (3233A–6750A).....
..*Keivin Burns, W. F. Meggers, and Paul W. Merrill*

The wave lengths of 403 iron lines were measured by means of interferometers. Faint as well as strong lines were measured at intervals of about 10 angstroms throughout the greater part of the spectrum from 3233A to 6750A. They constitute a satisfactory group of standards in this region. The mean difference between these observations and the international standards is about 1 part in 4 000 000.

Over 600 lines, including those measured, were examined by means of three or more interferometers in order to determine their sharpness. The relation of sharpness to intensity, pole effect, and behavior under pressure was sought from this data. In general, faint lines are sharpest. Change of wave length from the center of the arc to the poles, and by pressure, is more common with broad lines. (Apr. 11, 1916.) 28 pp. Price, 10 cents.

S275. Relation Between Composition and Density of Aqueous Solutions of Copper Sulphate and Sulphuric Acid.....*H. D. Holler and E. L. Peffer*

The densities of solutions of copper sulphate and sulphuric acid varying in concentration from 0 to 20 per cent of each solute were determined at 25° and 40° C. From the results obtained a simple method may be devised for determining and adjusting the composition of such solutions. (Apr. 7, 1916.) 9 pp. Price, 5 cents.

S276. Protected Thermoelements.....*Arthur W. Gray*

The paper describes a mounting for protecting laboratory thermoelements from damage by contamination or by mechanical strains. It is easy to construct, convenient to use, and applicable to elements for either high or low temperatures. It may also be used with multiple thermoelements divided into two equal portions for the purpose of checking. The mounting, which includes the ice bottle, is the latest model of a type that has been in regular use in expansion determinations during the past few years. (May 10, 1916.) 3 pp. Price, 5 cents.

S277. An Interlaboratory Photometric Comparison of Glass Screens and of Tungsten Lamps, Involving Color Differences.....
.....*G. W. Middlekauff and J. F. Skogland*

A report is given of a comparison of interlaboratory photometric measurements involving a considerable difference in color. The results are of value in showing the agreement which is to be expected between the results of groups of experienced observers working by different methods and with different kinds of photometers. The characteristics of those engaged in photometric work at the Bureau of Standards are discussed, and there is obtained additional evidence of the accuracy of the values assigned to the Bureau's 1.5-wpc tungsten standards, which had previously been verified in an intercomparison with the National Physical Laboratory of England. (June 17, 1916.) 21 pp. Price, 10 cents.

S278. An Investigation of the Laws of Plastic Flow....
.....*Eugene C. Bingham*

A means is worked out for distinguishing sharply between a viscous and a plastic substance. The laws of plastic flow are discovered. The two quantities "friction" and "mobility," as applied to plastic flow, are defined and calculated for the mixtures used. It is shown how the plasticity of a material depends upon the fineness of grain of the solid. (June 5, 1916.) 45 pp. Price, 10 cents.

S279. Distribution of Energy in the Visible Spectrum of an Acetylene Flame.....
.....*W. W. Coblentz and W. B. Emerson*

The distribution of energy in the visible spectrum of a cylindrical acetylene flame was investigated by means of three types of spectroradiometers. The data were found in excellent agreement, and they are presented for publication to supersede similar data published some years ago. The latter data pertained to a flat acetylene flame, which the recent investigation shows to be lacking in sufficient reproducibility to be considered as a standard source of spectral energy. (May 29, 1916.) 10 pp. Price, 5 cents.

S280. Further Experiments on the Volatilization of Platinum.....*G. K. Burgess and R. G. Waltenberg*

In this paper are given the results of an investigation, made at the suggestion of a committee of the American Chemical Society, on the loss in weight on heating of platinum crucibles of various makes and degrees of purity. The results obtained should prove of considerable value to the analytical chemist in aiding him to eliminate a troublesome source of error. It is shown that all grades of platinum contain at least traces of iron, that there is no appreciable loss in weight of crucibles heated to 900° C, but that above this temperature the loss increases very rapidly with temperature, is greatest for platinum containing iridium, and least for platinum alloyed with rhodium. (June 16, 1916.) 9 pp. Price, 5 cents.

S281. A Study of the Inductance of Four-Terminal Resistance Standards.....*Francis B. Silsbee*

A description of methods of measuring the inductance of resistance standards in the range below 1 ohm, with measurements on various types of standard now in use and suggestions as to the design of low-resistance standards of negligible inductance. The paper also contains a discussion of the errors in phase angle of mutual inductors of large current capacity. (July 12, 1916.) 48 pp. Price, 15 cents.

S282. Sensitivity and Magnetic Shielding Tests of a Thomson Galvanometer for use in Radiometry.....*W. W. Coblentz*

In this paper are given the results of an investigation of the force exerted by various galvanometer coils when operated under standard conditions. Numerical data are given relating to coils wound in sections of graded wire. A coil is described wound with a single kind of wire, which was found to be very efficient. A comparison is made of various astatic magnet systems, and data are given showing the importance of using small mirrors in order to increase the sensitivity.

Experimental data are given on shielding the galvanometer needle from external magnetic disturbances. By imbedding the coils in blocks of Swedish iron and surrounding this support with cylindrical shells of wrought-iron pipe the effect of external magnetic perturbations upon the astatic needle system is easily reduced to 1/2000 of its original value. Note I is a discussion of vacuum thermopiles. (June 30, 1916.) 24 pp. Price, 10 cents.

S283. Volume Effect in the Silver Voltameter.....*E. B. Rosa and G. W. Vinal*

The volume effect consists in an excess weight of deposit in the large-size voltameters over that in the smaller sizes and it is due to the presence of certain impurities in the electrolyte. An analysis of earlier experiments, together with a few recently made, is given in the present paper. The results show that the volume effect is not confined to any one form of voltameter but is common to all forms. The volume effect may be eliminated by purifying the electrolyte or it may be greatly exaggerated by adding impurities to the electrolyte. A theory to account for the manner in which the impurities increase the weight of the deposited silver is given. [See also S285.] (July 10, 1916.) 11 pp. Price, 5 cents.

S284. Constants of Spectral Radiation of a Uniformly Heated Inclosure or So-Called Black Body, II.....*W. W. Coblentz*

The present paper gives the results of a recomputation of the data published in a previous paper (S204). This recomputation was necessitated as the result of the adoption of a new calibration curve of the fluorite prism used in obtaining the data. The new value of the constant is C=14 353, which is about 0.7 per cent lower than the value previously published. The new value is very close to the theoretical value as obtained from a consideration of the coefficient of total radiation recently published in this Bulletin (S262). (July 8, 1916.) 19 pp. Price, 10 cents.

S285. Summary of Experiments on the Silver Voltameter at the Bureau of Standards and Proposed Specifications.....*E. B. Rosa and G. W. Vinal*

The investigations of the silver voltameter made in the Bureau of Standards between 1908 and 1916 have been published in eight separate papers. The present paper contains a summary of these eight papers and specifications for the use of the silver voltameter. These specifications, which are the practical result of seven out of the eight preceding papers, are put forward as the Bureau's proposals for international adoption. A bibliography of papers dealing with the silver voltameter is given as an appendix, and a list of corrections (mostly typographical) to the eight papers preceding this is given as a second appendix. (Oct. 5, 1916.) 36 pp. Price, 15 cents.

S286. Determination of Aluminum as Oxide . . . . . *William Blum*

From observations made with a hydrogen electrode and with suitable indicators, the conditions for the quantitative precipitation of aluminum hydroxide by ammonium hydroxide were determined. In practice the completion of precipitation may be defined by means of methyl red or of rosolic acid. The effect of various factors upon the precipitation, washing, and ignition of the precipitate was determined. The procedure for obtaining accurate results is also described. (Aug. 10, 1916.) 20 pp. Price, 10 cents.

S287. Calculation of Planck's Constant C_2 . . . . . *J. H. Dellinger*

This constant, which is of great importance in high-temperature measurements, has heretofore been obtained from radiation data by processes involving the use of a graph. It may be very easily determined directly from any two observations, the formula being scarcely more complicated than the familiar one for equal ordinates. All graphical difficulties are eliminated, and the method is not limited by experimental conditions such as absorption bands. The power of the method in investigating the departure of observations from the Planck law is strikingly shown by application to experimental data. Calculations made from observations all on one side of the maximum gave abnormally high values of C_2. The same method of calculation is applicable to the determination of the maximum and other points of the isothermal curve for which the displacement law holds. (Aug. 16, 1916.) 11 pp. Price, 5 cents.

S288. Wheatstone Bridges and Some Accessory Apparatus for Resistance Thermometry . . . . . *E. F. Mueller*

Simple types of Wheatstone bridges are described in which by suitable arrangement of circuits the degree of accuracy formerly attained by the use of mercury contacts may be secured by the use of plugs or switches. A method of measuring potential terminal resistances with the Wheatstone bridge is described and also an interchanger for connecting several thermometers to a single bridge. (Oct. 23, 1916.) 15 pp. Price, 10 cents.

S289. The Damping of Waves and Other Disturbances in Mercury . . . . . *M. H. Stillman*

The paper describes an electromagnetic method of damping the large oscillations of a mass of mercury and also the smaller waves and ripples which result from the movements of the support of the vessel containing the mercury. Experiments illustrating the method are described. (Sept. 30, 1916.) 6 pp. Price, 5 cents.

S290. A Variable Self and Mutual Inductor . . . . . *H. B. Brooks and F. C. Weaver*

The development of a new form of variable inductor is outlined. This instrument was required in the testing of current transformers, but is applicable wherever it is necessary to vary the self-inductance of a circuit or the mutual inductance between two circuits. It consists of two pairs of fixed coils held in ebonite disks between which rotates a third disk carrying a pair of coils. The form and arrangement of the coils are such as to give the instrument the following advantages: (1) High time constant; (2) scale divisions of uniform length; (3) astaticism. Curves are given showing the performance of the new instrument and of other instruments for the same purpose. Data are given for the design of inductors of the new form. (Oct. 12, 1916.) 12 pp. Price, 10 cents.

S291. A System of Remote Control for an Electric Testing Laboratory . . . . . *P. G. Agnew, W. H. Stannard, and J. L. Fearing*

The system described gives complete control of a group of motor-generator sets in several laboratory rooms, so that in testing a wattmeter, for example, a small multiple-lever controller gives both coarse and fine adjustment of frequency, current, voltage, power factor, and an auxiliary direct-current voltage. The field rheostats are very long slide-wire motor-operated

rheostats, motor-operated by means of pulley and cord. A large, motor-operated, low-voltage rheostat for currents up to 10 000 or 12 000 amperes is included in the system. In the latter, laminated brushes bear directly on water-cooled resistance tubes. (Oct. 12, 1916.) 17 pp. Price, 10 cents.

S292. International System of Electric and Magnetic Units.....*J. H. Dellinger*

The international electric and magnetic units, while representing the electromagnetic units, may be looked upon as a distinct and complete system, differing dimensionally from the electrostatic and electromagnetic systems. They are the units actually used in electrical work. The dimensional expressions in the international system are particularly simple. The ampere-turn is the basis of a set of magnetic units which are shown to be "rationalized" in a surprisingly satisfactory manner. The nomenclature of magnetic units is discussed. (Oct. 11, 1916.) 33 pp. Price, 10 cents.

S293. The Saccharimetric Normal Weight and Specific Rotation of Dextrose.....*Richard F. Jackson*

Dextrose is purified by repeated crystallization from aqueous solution, a portion being many times fractionated. It loses its water of crystallization at 60° C and its residual moisture in a vacuum at 60° to 80°. The densities of dextrose solutions are indicated by the formula: $D\,{}^{20°}_{4°} = 0.99840 + 0.003788\ p + 0.00001412\ p^2$ where p is per cent by weight in vacuo. The weight required to rotate 100 S on the saccharimeter is 32.231 g. The photometric field is slightly heterochromatic. At lower concentrations a table gives the corrections for deviation from proportionality. The rotation of the normal solution for $\lambda = 5461$ A is 40°.897. The specific rotation varies with concentration according to the formula $[\alpha]^{20.0}_{5461A} = 62.032 + 0.04257\ c$ where c is grams of anhydrous dextrose in vacuo and contained in 100 cc of solution. (Oct. 27, 1916.) 21 pp. Price, 10 cents.

S294. Freezing Point of Mercury.....*R. M. Wilhelm*

The temperature of the freezing point of mercury was determined, using three platinum resistance thermometers. Nineteen determinations were made on three samples of mercury purified by different methods. The result of all the measurements gives −38°.873 for the freezing point. The maximum deviation of any determination from the mean is 0°.005. (Oct. 26, 1916.) 7 pp. Price, 5 cents.

S295. Determination of the Degree of Uniformity of Bars for Magnetic Standards ....*Raymond L. Sanford*

Magnetic standard bars are used for the calibration of permeameters and the comparison of methods of magnetic testing with a standard method. One requisite of a magnetic standard bar is that it shall be magnetically uniform along its length. If this condition is not met, errors may arise which can not be calculated or eliminated from the measurements and which may be of considerable magnitude. This paper (1) describes a method for determining the degree of magnetic uniformity of straight bars, (2) indicates the magnitude of the effect of nonuniformities on the accuracy of magnetic measurements, and (3) gives a criterion for the degree of uniformity of bars for magnetic standards. (Nov. 21, 1916.) 14 pp. Price, 10 cents.

S296. Thermoelectric Measurement of Critical Ranges of Pure Iron.....*George K. Burgess and H. Scott*

Adapting the apparatus described in S213, a new method of determining thermoelectric power directly in terms of temperature has been devised and applied to the couple iron platinum, using metals of highest purity in vacuo over the range 0 to 1000° C. The thermoelectric characteristics of the critical points A_2 and A_3 are also demonstrated. (Nov. 22, 1916.) 7 pp. Price, 5 cents.

S297. A Study of Electromagnet Moving Coil Galvanometers for Use in Alternating-Current Measurements.....*Ernest Weibel*

The theory of the electromagnet moving coil galvanometer is given and is used to determine the performance and proper design of such instruments. The paper contains descriptions of the construction and performance of several instruments on direct current and on alternating currents of frequencies up to 2100 cycles per second. The sensitivities and other operating constants are comparable with those of the best permanent-magnet moving coil galvanometers for direct-current measurements. (Feb. 17, 1917.) 36 pp. Price, 10 cents.

S298. Standard Substances for the Calibration of Viscometers....*Eugene C. Bingham and Richard F. Jackson*

The viscosities of 20, 40, and 60 per cent sucrose solutions have been determined over a wide range of temperatures. The available data on the viscosity of water, ethyl alcohol-water mixtures, and sucrose solutions have been reviewed in view of their possible use for comparative purposes. The use of the centipoise, as a practical unit of viscosity, has been suggested. (Mar. 19, 1917.) 28 pp. Price, 5 cents.

S299. An "Average Eye" for Heterochromatic Photometry, and Comparison of a Flicker and an Equality-of-Brightness Photometer.....*E. C. Crittenden and R. K. Richtmyer*

Comparisons of lights of different colors are supposed to be based on "the average normal eye." This paper records an attempt to approximate the results of such an eye on typical color differences by using a large number of observers. In particular, results obtained by a flicker photometer and by an equality-of-brightness photometer, with different degrees of color differences, are compared. (May 26, 1917.) 29 pp. Price, 5 cents.

S300. Emissivity of Straight and Helical Filaments of Tungsten.....*W. W. Coblentz*

In this paper data are given on the radiation from the inside and the outside of the turn of a helically wound tungsten filament in an atmosphere of nitrogen. The intensity of the light from within the helix is 90 per cent greater than from the outside of the turn. This is accounted for on the basis of multiple reflection within the helix, which modifies the quality of the light so that it appears redder than the light from the outside of the turn. The observed infra-red measurements on the radiation from within the helix and the computed values are in agreement, showing that the increased brightness is due to internal reflection. Polarization measurements show that the light is highly polarized and hence not comparable with the radiation from a black body. The character of the radiation from within the helix are not sufficiently close to black-body radiation to permit the use of the filament as a means of determining temperatures. (June 8, 1917.) 79 pp. Price, 5 cents.

S301. Aneroid Calorimeter for Specific and Latent Heats.....*N. S. Osborne*

The unstirred type of calorimeter has been embodied with important refinements in an instrument specially designed for determination of specific heat and latent heat of refrigerating media. Heat developed and measured electrically is distributed automatically to the calorimeter and contents whose temperatures are measured by a platinum thermometer. Heat from other sources is excluded by a null method.

The calorimeter is adapted fo use between $-50°$ and $+50°$ C in experiments where the measured heat added is used either to change the temperature of the contents or to evaporate a portion of the contents withdrawn as superheated vapor; in the first case the specific heat of the liquid and in the second the latent heat of vaporization being obtained when proper corrections are made. (June 8, 1917.) 27 pp. Price, 10 cents.

S302. Wave Lengths of Stronger Lines in Helium Spectrum . . . . . *P. W. Merrill*

Wave lengths of 21 of the stronger helium lines have been measured by means of Fabry and Perot interferometer of different separations to an accuracy approaching 0.001A. Nine of them were compared directly with the standard cadmium line. The helium lines will thus become available as convenient standards for the determination of other wave lengths. The precision previously attained was insufficient for many uses.

The possibility of eliminating effects of the so-called "phase change" at reflection from the interferometer minors is noted.

The Kayser and Runge formula for spectral series with constants derived from three consecutive lines will not reproduce accurately even the next member in any one of the six series. (June 18, 1917.) 8 pp. Price, 5 cents.

S303. Relative Sensibility of Average Eye to Light of Different Colors and Some Practical Applications to Radiation Problems . . . . . *W. W. Coblentz and W. B. Emerson*

This paper gives data on the relative visibility of radiation of the average eye based upon a group of 130 observers. The data were obtained by means of a flicker and an equality-of-brightness photometer. The energy evaluation of the light stimulus was made with great care.

The point of maximum visibility of the average eye is at $\pm 0.5576\mu$. A mathematical equation is given of the average visibility curve, which is applied in a subsequent paper in calculating the luminous energy emitted by a black body at various temperatures and the mechanical equivalent of light. The eye responds to light having an intensity less than 1×10^{-16} watt. The paper describes tests on diffuse light and on a physical photometer. A screen is described which transmits radiations proportional to the average eye. (June 29, 1917.) 77 pp. Price, 15 cents.

S304. Calculations of Constants of Planck's Radiation Equation: Application of Theory of Least Squares . . . . . *Harry M. Roeser*

The problem of computing the constants c_1 and c_2 of Planck's radiation equation for the distribution of energy in the spectrum of a black body,

$$E = c_1 \lambda^{-5} \left(e^{\frac{c_2}{\lambda \theta}} - 1 \right)^{-1}$$

is attacked for the first time by the method of least squares. The rationale of the method is given and an outline of the computations stated. The theory of errors is applied to show that current methods of solution have not agreed because a system of weighting inherent in the manipulation of the observations has previously been neglected, and further, this system of weights being applied, the solutions tend to agree with that of least squares. (June 29, 1917.) 18 pp. Price, 5 cents.

S305. Luminous Radiation from a Black Body and Mechanical Equivalent of Light . . . . . *W. W. Coblentz and W. B. Emerson*

This paper gives applications of the curve of visibility of radiation for the average eye (see S.303) to radiation problems, including the luminous intensity of a black body at various temperatures, the luminous efficiency, and the mechanical equivalent of light. The data at hand indicate that 1 watt of radiant power of maximum visibility amounts to about 50 candles. The paper gives also a determination of the radiant luminous efficiency of a vacuum tungsten lamp. (June 30, 1917.) 12 pp. Price, 5 cents.

S306. An Experimental Study of the Fahy Permeameter. . . . . *Charles W. Burrows and Raymond L. Sanford*

This paper presents the results of a critical experimental study of the Fahy permeameter. The accuracy of normal induction measurements on solid materials is within 5 per cent of the magnetizing force required for a given induction. Hysteresis measurements are accurate within the limits of commercial requirements and the uniformity of commercial materials. (Aug. 27, 1917.) 34 pp. Price, 10 cents.

S307. Note on Electrical Conduction in Metals at Low Temperatures. . . . . *Francis B. Silsbee*

Measurements at the University of Lei den have shown that at extremely low temperatures certain metals show an enormously high electrical conductivity. This superconducting state ceases to exist and ordinary resistance appears if either the current used to measure the resistivity, or the magnetic field in which the metal is placed, is increased above a certain critical value. This paper points out that these two phenomena are not independent, but that the former effect is a necessary consequence of the existence of the latter; that is, the threshold value of current is that at which the magnetic field due to the current itself is equal to the critical magnetic field. The experimental evidence available is in agreement with this relation. (July 23, 1917.) 6 pp. Price, 5 cents.

S308. The Reflecting Power of Tungsten and Stellite. . . . . *W. W. Coblentz and W. B. Emerson*

The reflecting power of tungsten in the region of the spectrum from 0.5 to 6 was determined by comparison with silver and by a new method employing a total reflection prism. Four samples in the form of plane, highly polished mirrors were examined. All the samples showed a depression in the reflecting curve at 0.8μ. A similar indentation occurs at 1.3 in the reflecting curve of the pure metal but not in the impure tungsten. The bands of selective reflection at 0.8μ and 1.3μ render tungsten conspicuous as being the only metal, thus far investigated, which has bands of selective reflection in the infra-red. The application of these data to the question of increasing the luminous efficiency of incandescent lamps is discussed.

The reflectivity of stellite is similar to that of other metals; being low in the visible spectrum and increasing to high values in the infra-red. (Aug. 10, 1917.) 20 pp. Price, 5 cents.

S309. A Method for Testing Current Transformers. . . . . *Francis B. Silsbee*

A general method is described for comparing the ratio and phase angle of one current transformer with those of a previously tested transformer of the same nominal ratio. The two transformers are corrected in series on both primary and secondary and a shunt circuit is provided to measure the difference of the secondary currents. Two of the many possible arrangements are described in detail. This method is intended for use under shop conditions and does not require the use of sensitive apparatus. (Nov. 3, 1917.) 13 pp. Price, 5 cents.

S310. Some Electrical Properties of Silver Sulphide. . . . . *George W. Vinal*

Silver sulphide may be prepared in the form of short wires or thin strips like a metal. The wire, which must be drawn hot, was found to conduct electricity like a metal of high specific resistance and practically zero temperature coefficient. The strip of sulphide rolled at room temperature has a large temperature coefficient and shows both metallic and electrolytic conduction. It has a volt-ampere curve characteristic of a pyroelectric conductor. The strips are sensitive to small alternating currents which increase the resistance enormously, while small direct currents have the opposite effect. The specific resistance has been measured and experiments made on the electrochemical decomposition. (Nov. 24, 1917.) 9 pp. Price, 5 cents.

S311. Axial Aberrations of Lenses. . *E. D. Tillyer and H. I. Shultz*

The errors which affect the definition of a lens are discussed and methods of graphically representing the central errors described. The condition for freedom from coma near the axis is arrived at. The relative importance of the errors in different types of lenses is discussed. Hartmann's method is expanded, permitting one set of measurements to give all the important central errors—spherical aberration, zonal variation of equivalent focal length, axial and oblique achromatism. The apparatus and procedure are described, and the accuracy of the adjustments and the measurements discussed. The method is applicable to all systems of relatively short focus and large aperture, such as photographic lenses, projection lenses, and telescope objectives, and also to complete optical systems. The results of the method as applied to a complete telescope are discussed and shown to be independent of the accommodation of the observer. Seventeen sets of curves are given for as many different lenses, and an illustrative discussion of one set of curves, together with a general description of the types of lenses represented by each group of curves. (Nov. 3, 1917.) 29 pp. Price, 5 cents.

S312. Wave-Length Measurements in Spectra from 5600A to 9600A. . . . . *W. F. Meggers*

The arc spectra of 20 of the chemical elements have been photographed in the red and adjacent infra-red regions. The photographs were made on dicyanin-stained plates with the aid of a concave grating of 640 cm radius. Wave-length measurements in international angstroms are given for the following elements: Lithium, sodium, potassium, rubidium, caesium, copper, calcium, strontium, barium, and magnesium. These results are of importance in spectroscopic analysis and for the discussion of regularities in spectra. (Jan. 16, 1918.) 25 pp. Price, 10 cents.

S313. The Specific Heat of Liquid Ammonia. . . . . *Nathan S. Osborne and Milton S. Van Dusen*

The specific heat of liquid ammonia has been determined throughout the temperature interval $-45°$ to $+45°$ C. by use of a calorimeter specially designed for the peculiar conditions. This calorimeter is of the aneroid or unstirred type and contains important refinements affecting the accuracy of measurements.

Two independent methods of measurement were employed, each of which avoids sources of error possessed by the other, and each of which gives results which are reducible to the same basis, namely, the specific heat of the liquid, kept saturated.

Heat developed and measured electrically is distributed automatically by conduction and convection to the calorimeter and contents whose temperatures are measured by a platinum thermometer. In one method the material is kept at saturation, in the other at constant pressure. (Dec. 13, 1917.) 36 pp. Price, 5 cents.

S314. The Latent Heat of Pressure Variation of Liquid Ammonia. *Nathan S. Osborne and Milton S. Van Dusen*

The latent heat of pressure variation of liquid ammonia has been determined by three independent methods—first, directly by calorimetric measurement; second, by computation from the expansivity directly observed; and, third, by computation from the specific volume of the saturated liquid and the compressibility.

The purpose of the determinations was to furnish data for use in correlating measurements of specific heat of liquid ammonia made at constant pressure with measurements made under saturation conditions. (Nov. 19, 1917.) 6 pp. Price, 5 cents.

S315. The Latent Heat of Vaporization of Ammonia. . . . . *Nathan S. Osborne and Milton S. Van Dusen*

The latent heat of vaporization of liquid ammonia has been determined throughout the temperature interval $-42°$ to $+52°$ C by direct measurements, using a calorimeter specially designed for the particular problem. This instrument is of the aneroid or unstirred type, the ammonia being the only liquid in the calorimeter. Heat developed and measured electrically

in a coil is transmitted by conduction and convection to the ammonia, and is expended in the evaporation of a determined amount which is withdrawn as superheated vapor. Accessory data from other sources are required only in the computation of small correction terms. The results are expressed by an empirical equation and a table of values given for every degree from $-45°$ to $+55°$ C.

By combining the data for the heat of vaporization with the data for specific heat of the saturated liquid from a previous investigation, the specific heat of saturated ammonia vapor is obtained and a table of values of this quantity is given in an appendix. (Dec. 21, 1917.) 34 pp. Price, 10 cents.

S316. Gas Interferometer Calibration.....*J. D. Edwards*

Describes a simple and accurate method of calibrating the Zeiss-Rayleigh gas interferometer. (Dec. 8, 1917.) 7 pp. Price, 5 cents.

S317. Resonance and Ionization Portentials for Electrons in Cadmium Vapor...*John T. Tate and Paul D. Foote*

The object of this investigation has been the determination of the resonance and ionization potentials for electrons in cadmium vapor. Resonance collision of the electron with the atom was observed at 3.88 volts, and inelastic impact resulting in ionization was observed at 8.92 volts. The single line spectrum of cadmium is 3260.17 A. If we substitute the frequency corresponding to this wave length in the relation $h\nu=ev$ where $h=6.56\cdot10^{-27}$ erg. sec., e electronic change and v the resonance potential we obtain $v=3.79$ volts in good agreement with the above. On the basis of Bohr's theory the ionization potential should be 8.97 in most excellent agreement with the experimentally determined value. (Feb. 9, 1918.) 8 pp. Price, 5 cents.

S318. The Application of Dicyanin to the Photography of Stellar Spectra.....*Paul W. Merrill*

The Bureau has had considerable success in photographing extreme red and infra-red radiations on plates sensitized with dicyanin. This article describes the application of these plates to stellar spectroscopy. The experiments were carried out at the Harvard College Observatory, employing the 24-inch reflector with objective prism. Fraunhofer's A band (wave length 0.760) and a considerable region of greater wave length were photographed in numerous stellar spectra. Several new stellar bands were discovered. The general conclusions are as follows: (1) Many stellar spectra can be photographed with dicyanin in the region of wave length 0.80; (2) in favorable cases they can be well observed to 0.85; and (3) the region 0.70 contains features of importance, especially in the latter types. (Apr. 13, 1918.) 19 pp. Price, 10 cents.

S319. Instruments and Methods Used in Radiometry III: The Photoelectric Cell and Other Selective Radiometers.....*W. W. Coblentz*

The present paper deals with the application of certain physical and chemical properties of matter as a means of quantitatively measuring radiant energy. Three types of selective radiometers are discussed, viz, the photoelectric cell of potassium and other alkali metals, the selenium cell, and the photographic plate. The photoelectric cell appears to meet the requirements of a quantitative radiometer and may be used for measuring ratios of intensities extending from the blue throughout the ultra-violet part of the spectrum. (June 17, 1918.) 30 pp. Price, 10 cents.

S320. Additions to the Formulas for the Calculation of Mutual and Self Inductance.....*F. W. Grover*

This paper furnishes a list of formulas for the calculation of mutual and self inductance which have appeared since the publication of the earlier paper dealing with same subject (S169).

Some of the formulas here given, notably those for eccentrically placed circles, provide a solution for cases where none has been previously available; others of the formulas are extensions of formulas already well known, or cover cases where earlier useful expressions are available.

No attempt has been made to include all the recent formulas, but in making a selection the author has endeavored to present only those whose

form is well adapted to numerical computation or those for which tables have been prepared which render calculations reasonably simple. (June 24, 1918.) 34 pp. Price, 10 cents.

S321. Thermal Expansion of Alpha and of Beta Brass Between 0° and 600° C, in Relation to the Mechanical Properties of Heterogeneous Brasses of the Muntz Metal Type. *Paul D. Merica and L. W. Schad*

In the course of investigation of the failure of brass articles, rods, bolts, etc., by cracking, instances have been observed in which cracking occurred in brass articles which had been quickly cooled from a forging or annealing temperature by quenching or otherwise, and it was considered possible that this may have been due to the development of local stresses in the brass during such cooling. This study was made with a view to ascertaining the approximate magnitude of the local stresses which might be set up in heterogeneous brasses of the type of Muntz metal owing to the difference in thermal expansivity between the two constituents of it. (May 9, 1918.) 20 pp. Price, 10 cents.

S322. Photoelectrical Sensitivity of Bismuthinite and Various Other Substances. . . . . *W. W. Coblentz*

This paper summarizes the results of an investigation of various substances (1) for an increase in electrical conductivity caused by the action of light upon them, and (2) for electrical discharging activity when they were charged to a negative potential, in an evacuated chamber and exposed to light.

Photoelectrical activity was observed in gallium, silver sulphide, selenium, stibnite, boulangerite, jamesonite, cylindrite, bismuthinite, and molybdenite. No activity was observed in tellurium, boleite pyrites, silicon, and mixtures of sulphides of lead and antimony. Experiments are described on selenium, platinum, gold leaf, etc., when used with an audion amplifier as a photophone. (June 14, 1918.) 14 pp. Price, 5 cents.

S323. Some Characteristics of the Marvin Pyrheliometer. . . . . *Paul D. Foote*

The calibration of a Marvin pyrheliometer by two methods—the electrical method ordinarily used and also a radiometric method—is described. The two methods are substantially in agreement. The calibrated instrument gave results differing by about 2 per cent from those of a Smithsonian standard pyrheliometer, when the two were used simultaneously in solar measurements. The need of further work is recognized and some of the necessary methods indicated. (June 28, 1918.) 30 pp. Price, 10 cents.

S324. Wave Lengths in the Red and Infra-Red Spectra of Iron, Cobalt, and Nickel Arcs. . . . . *W. F. Meggers and C. C. Kiess*

The arc spectra of iron, cobalt, and nickel were photographed in the red and infra-red regions on plates stained with pinacyanol and dicyanin. A large concave grating was used, and exposures up to 10 hours' duration registered many lines with wave lengths greater than 10 000 A, or 1 micron. In the arc spectrum of iron, 298 lines were measured between the wavelength limits 6750 A and 10 689 A; 606 lines were measured between 5503 A and 11 623 A in the arc spectrum of cobalt, and 290 lines between 5504 A and 10 843 A in the arc spectrum of nickel. These results demonstrate that an invisible long wave interval as large as the entire visible spectrum is accessible to photography with dicyanin-stained plates. (June 29, 1918.) 15 pp. Price, 5 cents.

S325. Spectroradiometric Investigation of the Transmission of Various Substances. . . . . *W. W. Coblentz, W. B. Emerson, and M. B. Long*

This paper gives the spectral transmission of various substances, especially colored fluorite, molybdenite, and colored glasses. In some scientific investigations it is desired to expose large areas to radiant energy

stimuli of a fairly high spectral purity. Some of the substances described in this paper provide a simple means of obtaining narrow spectral bands of energy of high intensity and large area without employing a spectroscope.

By properly combining these substances one can obtain a screen having a narrow band of high transmission at 0.38, 0.50, 0.55, 0.7, 0.8, 1, and 2.2μ.

The data on glasses are also useful in connection with the question of protecting the eyes from injurious radiations. (Aug. 8, 1918.) 24 pp. Price, 5 cents.

S326. Electrical Oscillations in Antennas and Inductance Coils.....*John M. Miller*

An application of the theory of circuits with uniformly distributed inductance and capacity to the oscillations in antennas and inductance coils. The paper treats the natural frequencies of oscillation, etc., and shows how these circuits may be replaced by simple circuits with lumped constants in frequency computations. (Oct. 23, 1918.) 20 pp. Price, 5 cents.

S327. Measurements on the Index of Refraction of Air for Wave Lengths from 2218 A to 9000 A.....
.....*W. F. Meggers and C. G. Peters*

A form of the Fabry and Perot interferometer was used for the measurement of the refractive index of air for various wave lengths at intervals of about 40 A from the extreme ultra-violet at 2200 A, through the visible spectrum and into the infra-red to 9000 A. Complete sets of observations were made on dry air at atmospheric pressure and at temperatures of 0°, 15°, and 30° C. These observations were used in the construction of a table giving the corrections which must be applied to wave lengths measured in air whose density is not normal. The table of corrections to covert wave lengths or frequencies measured in air to their values in a vacuum is also given. (Oct. 31, 1918.) 44 pp. Price, 10 cents.

S328. Variance of Measuring Instruments and Its Relation to Accuracy and Sensitivity.....*Frederick J. Schlink*

This paper treats of the types of error in a measuring instrument which are evidenced by the failure of such instrument to give identical indications for repeated identical values of the quantity being measured. The causes of variance inherent in mechanical couplings are discussed and means proposed for diminution of this error. Means of determining and delineating the variance characteristics of an instrument are illustrated, and the important relation which variance bears to the qualities of accuracy and sensitivity is explained. (Sept. 30, 1918.) 24 pp. Price, 5 cents.

S329. Measurements of Wave Lengths in the Spectrum of Neon..*Keivin Burns, W. F. Meggers, and P. W. Merrill*

Measurements of 55 lines in the neon spectrum have been made by means of the interferometer, in the region 3369 A to 8495 A. The strong lines in the visible and ultra-violet were compared directly with the fundamental standard. Other lines were compared with well-determined neon lines. One hundred eighty-nine faint lines in the region 5343 A to 8783 A were measured by means of a concave grating.

The constant differences discovered by Watson are found to hold with remarkable exactness in the case of lines which are strong enough to be measured with the highest accuracy. In fact, the differences are exactly constant within the limits set by the accuracy of the wave lengths. (Nov. 12, 1918.) 10 pp. Price, 5 cents.

S330. The Decrease in Ultra-Violet and Total Radiation with Usage of Quartz Mercury Vapor Lamps.
.....*W. W. Coblenz, M. B. Long, and H. Kahler*

In this paper experimental data are given on the decrease in intensity of the ultra-violet and of the total radiation with usage of quartz mercury vapor lamps.

The measurements were made with a thermopile and a yellow (Noviol shade B) glass. Quartz mercury lamps from the Cooper-Hewitt and the R. W. V. Lamp Co., were examined.

It is shown that there is no marked difference in the per cent of ultra-violet emitted by these lamps when new. The total intensity, as well as the ultra-violet, decreases to one-half to one-third in 1000 to 1200 hours.

Comparative data are given on the ultra-violet component in the radiations from the sun and from the quartz mercury vapor lamp; also data on the dye fading carbon arc lamp. (Nov. 12, 1918.) 20 pp. Price, 5 cents.

S331. A Relation Connecting the Derivatives of Physical Quantities.....*M. D. Hersey*

In this paper it is shown how the theory of dimensions may be used in a differential form; a procedure which appears fruitful particularly in investigating the effect of given sources of error on the performance of measuring instruments.

The examples which led to the necessity for developing this method are discussed at the end of the paper and illustrated by experimental data. (Dec. 30, 1918.) 9 pp. Price, 5 cents.

S332. Preliminary Determination of the Thermal Expansion of Molybdenum.....*Lloyd W. Schad and Peter Hidnert*

The thermal expansion of an exceptionally pure specimen of molybdenum was determined from $-142°$ to $+305°$ C. A short description of the oil bath and of the method used in obtaining high and low temperatures is given.

The results are shown in the form of tables, from which were computed by the method of least squares, the two following empirical equations which satisfy the observations:

$L_t = L_0 (1 + 5.15\, t \times 10^{-6} + 0.00570\, t^2 \times 10^{-6})$ and

$L_t = L_0 (1 + 5.01\, t \times 10^{-6} + 0.00138\, t^2 \times 10^{-6})$

where L_t is the length of the specimen at any tempearture t within the proper range; in the first case $19°$ to $-142°$ and in the second case $19°$ to $+305°$ C. The probable error of the length computed from these equations is less than 3×10^{-6} per unit length. (Jan. 29, 1919.) 9 pp. Price, 5 cents.

S333. Optical Conditions Accompanying the Striae which Appear as Imperfections in Optical Glass.
.....*Lieut. Commander A. A. Michelson, U. S. N.*

Striae are conveniently divided into two classes: (1) Those which appear as isolated bright streaks; and (2) those in which such streaks are numerous, forming bright irregularly continuous bands. Optical investigation with two forms of interferometers show that the former are due to laminæ of smaller index and of thickness of the order of one-hundredth of a mm. They do not seriously affect the optical qualities of lenses or prisms. The second class of striae, in general, does not affect the optical performance; but, in the case of lenses and plane parallel plates, etc., in which the light traverses the striae at approximately normal incidence, the performance may be quite as good as with a perfect specimen.

S334. New Forms of Instruments for Showing the Presence and Amount of Combustible Gas in the Air.
.....*E. R. Weaver and E. E. Weibel*

A study has been made of the combustion of small amounts of gas in the air at the surface of electrically heated wires and the application of this phenomenon to the design of instruments for the purpose of detecting the presence and indicating the amount of combustible gas in the air. As a result of this study three types of instruments, each especially adapted to certain uses, have been designed, tested, and found to work satisfactorily.

The action of one of these instruments depends upon a resistance change, one upon a heating effect upon an adjacent bimetallic strip, one upon a light emitted from the heated wire. A discussion of the principles involved in the design of the instruments and specifications for their construction are given.

TECHNOLOGIC PAPERS

[For publications in following list that are out of print or procurable only from Superintendent of Documents, Government Printing Office, Washington, D. C., see the supplement to this Circular.]

T1. Effect of Preliminary Heat Treatment upon the Drying of Clays.....*A. V. Bleininger*

Investigation undertaken to ascertain the possibility of using excessively plastic clays which on drying show losses due to cracking and checking, by subjecting the clays in the crude state to a preliminary heat treatment before working them by the usual methods.

Preheating offers a possible commercial method for the treatment of excessively plastic clays which can not be worked and dried successively by other means, subject to certain limitations. Methods and conditions are discussed. (Dec. 6, 1910.) 53 pp. Price, 10 cents.

T2. The Strength of Reinforced Concrete Beams—Results of Tests of 333 Beams (First Series) ..
.....*Richard L. Humphrey and Louis H. Losse*

NATURE OF TESTS.—These tests form a part of the study of the behavior of reinforced concrete beams under load. This series consisted of tests of gravel, granite, limestone, and cinder concrete, with seven percentages of reinforcement varying from 0.5 to 2 per cent. Beams were accompanied by cylindrical and cubical test pieces for determining compressive strength, initial modulus of elasticity, yield point, bond, etc.

METHODS.—The beams were 8 by 11 inches in section and 13 feet long, tested on 12-foot centers by applying loads at the third points. Observations were made of deformation of upper and lower fibers, deflection of beam at the center, slip of the reinforcement, and development of cracks as the loads were applied.

RESULTS.—Complete data are given of the beam tests, results are summarized and illustrated by typical curves, diagrams, and photographs, and studies are made of the values usually used in the design of a beam. (June 27, 1911.) 200 pp. Price, 50 cents.

T3. Tests of the Absorptive and Permeable Properties of Portland Cement Mortars and Concretes, Together with Tests of Damp-proofing and Waterproofing Compounds and Materials..
.....*Rudolph J. Wig and P. H. Bates*

NATURE OF TESTS.—Results of tests of the absorption of water and permeability to water of Portland cement mortars and concretes, together with tests of 40 commercial so-called "damp-proofing" and "waterproofing" compounds.

METHODS.—Tests were made by exposing one surface of small slabs to water, both permitting absorption by capillarity and subjecting one surface to hydrostatic pressure, measuring the quantity of water passing through.

RESULTS.—None of the integral compounds was found to be of much value as damp-proofing or waterproofing mediums nor in reducing the absorption. Well-made Portland cement mortar and concrete were found to be impermeable to the passage of a sensible quantity of water under hydrostatic pressures of 20 pounds per square inch, and rich mortars if aged sufficiently will be impermeable to 60 and 80 pounds per square inch hydrostatic pressure. (Aug. 22, 1911.) 127 pp. Price, 20 cents.

T4. The Effect of Added Fatty and Other Oils Upon the Carbonization of Mineral Lubricating Oils.. ..... *C. E. Waters*

Continuation of work published in Bul. 7, p. 365 (1911). Known mixtures of mineral oil with fatty oils, etc., subjected to the carbonization test. The amount of insoluble precipitate is variously affected. Rosin, asphalt, etc., caused an increase; rosin oil, lard oil, rapeseed oil, and tallow caused a decrease. Oil exposed to the oxidizing action of sunlight and air, and oil mixed with ferric oxide yielded more of the carbonized product.

The addition of fatty oils is not yet recommended. More work is to be done with a view to determine the corrosive action on metals. (Aug. 24, 1911.) 14 pp. Price, 5 cents.

T5. The Effect of High-Pressure Steam on the Crushing Strength of Portland Cement Mortar and Concrete..... *Rudolph J. Wig*

NATURE OF TESTS.—Results of tests made to determine the accelerating action of steam on the hardening of Portland cement mortar and concrete. Tests were made varying the steam pressure, duration of exposure, age and consistency of mixtures, etc.

METHOD.—Cylindrical test pieces 8 inches in diameter by 16 inches in length were exposed in a steel tank equipped with removable head, steel cars, and track, and provided with regulating valves for controlling steam pressure. The ultimate compressive strength, initial modulus of elasticity, and yield point were then determined.

RESULTS.—Steam under pressure greatly accelerated the hardening of the mortar and concrete. Under certain conditions, a compressive strength was obtained greatly in excess of that obtained by aging normally for one year. (Sept. 5, 1911.) 25 pp. Price, 10 cents.

T6. The Determination of Chromium and Its Separation From Vanadium, In Steels..... *J. R. Cain*

Sources of error in certain methods used for this determination, which limit their accuracy, are described. A procedure is given for the quantitative precipitation of chromium (and of vanadium) from solutions of steels (permitting a separation from most of the iron), for its separation from this precipitate in pure condition and for its determination. (Nov. 1, 1911.) 6 pp. Price, 5 cents.)

T7. The Testing of Clay Refractories, With Special Reference to Their Load Carrying Ability at Furnace Temperatures..... ..... *A. V. Bleininger and G. H. Brown*

NATURE OF TESTS.—General consideration of the refractoriness of fireclay bricks, their viscosity at furnace temperatures, nature and manufacture of refractory clays, effect of accessory constituents upon softening temperatures, effect of fluxes upon refractoriness, effect of heat upon dehydration, contraction, crystallization, and load carrying capacities.

RESULTS.—General conclusions are stated and specifications proposed for No. 1 and No. 2 refractories. (Dec. 15, 1911.) 78 pp. Price, 15 cents.

T8. A Rapid Method for the Determination of Vanadium in Steels, Ores, etc., Based on Its Quantitative Inclusion by the Phosphomolybdate Precipitate..... *J. R. Cain and J. C. Hostetter*

Vanadic acid may be precipitated quantitatively by ammonium phosphomolybdate. The vanadium may be separated from the precipitate, or it can be accurately determined in it by reduction and titration with permanganate. (Oct. 26, 1911.) 20 pp. Price, 5 cents.

T9. The Density and Thermal Expansion of Linseed Oil and Turpentine.....*H. W. Bearce*

The paper describes an experimental determination of the density and thermal expansion of linseed oil and turpentine. The work was undertaken for the purpose of obtaining the necessary data for preparing tables to give the density of these substances at any temperature between 10° and 40° C. from the density at any other temperature. The data obtained are herein presented, together with the tables prepared therefrom. There are included also tables for converting pounds to gallons and gallons to pounds. (Apr. 15, 1912.) 27 pp. Price, 10 cents.

T10. The Melting Points of Fire Brick.....*C. W. Kanolt*

Determinations have been made of the melting points of 62 samples of fire brick and of material of importance in the manufacture of fire brick. These samples included fire-clay brick, bauxite brick, silica brick, magnesia brick, chromite brick, kaolin, pure alumina, pure silica, bauxite, bauxite clay, and chromite. The materials were heated in an electric vacuum furnace. Temperatures were measured with an optical pyrometer. An improved method of calibrating optical pyrometers is described. (June 15, 1912.) 17 pp. Price, 5 cents.

T11. Comparison of Five Methods Used to Measure Hardness.....*Ralph P. Devries*

The static tests of hardness studied are the cone and Brinell sphere. The dynamic tests are the Shore Scleroscope and Ballantine. The Bauer drill test for measuring the workability of metals is also included. The tests were made on a series of metals which ranged from very hard steels to comparatively soft alloys. The laws governing the resistance to indentation are experimentally deduced for spheres of different sizes and cones of different degrees of angular opening. The effect of elastic deformation of the sphere upon the results of sphere tests is determined by means of a method which involves the exact measurement of the depth of indentation. This method of measurement is also applied to the cone tests. The study of the individual methods shows (1) the possibility of obtaining rational hardness numerals for the cone and sphere tests, and (2) that the dynamic tests for hardness do not agree in general with the results of static tests. (July 22, 1912.) 27 pp. Price, 5 cents.

T12. Action of the Salts in Alkali Water and Sea Water On Cements.....
.....*P. H. Bates, A. J. Phillips, and Rudolph J. Wig*

NATURE OF TESTS.—A series of laboratory and field investigations made to determine the suitability and permanency of various cements in structures exposed to the chemical and mechanical action of the salts present in sea water and alkali water.

METHODS.—The laboratory investigation consisted in subjecting various typical cements to salt solutions for a period of months and their action noted by analyzing the solutions as removed and the residue at the end of the test. Small hollow cylinders of cement and cement mortar were made and exposed to the percolation of various salt solutions. Field investigations were made by exposing cements in the form of briquets and concrete test pieces to sea water at a branch laboratory established at Atlantic City, N. J.

RESULTS.—Tentative conclusions are drawn showing that concrete is subject to disintegration by the mechanical force exerted by the crystallization of salt in its pores if sufficient quantity is permitted to accumulate; that there is no relation between the chemical composition of a cement and the rapidity with which it reacts with sea water when brought into intimate contact; and that marine construction appears to be a problem of method rather than materials, as concrete sets and permanently hardens as satisfactorily in sea water as in fresh water or in the atmosphere, if it can be placed in the forms without undue exposure to the sea water while being deposited. (Nov. 1, 1912.) 157 pp. Price, 25 cents.

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T13. The Evaporation Test for Mineral Lubricating and Transformer Oils.....*C. E. Waters*

Concordant duplicate results can not be obtained unless oils are heated in vessels of the same size. The loss in weight on heating a given oil depends, other things being equal, on the area of surface exposed and to a less extent on the depth of the tube in which the oil is heated, and still less (for the first few hours) on the amount of oil taken. Gill's method (heating the oil absorbed in filter paper) was tried and gave very discordant results. (Jan. 1, 1913.) 13 pp. Price, 5 cents.

T14. Legal Specifications for Illuminating Gas.....*E. B. Rosa and R. S. McBride*

A paper written for the seventh annual meeting of the American Gas Institute discussing changes under consideration for C32 of the Bureau. The relative merits of gross, net, and total heating values of gas for standards of specification, the standard candlepower test burner, and the "standard conditions," so called, for gas measurement are discussed from the standpoint of technical gas specifications. [See C32.] (Jan. 10, 1913.) 31 pp. Price, 10 cents.

T15. Surface Insulation of Pipes as a Means of Preventing Electrolysis.....*Burton McCollum and O. S. Peters*

This paper describes a series of tests intended to determine whether or not it is practicable to protect underground metallic structures from corrosion by stray electric currents by means of insulating coatings of paints, dips, wrappings, etc. A number of letters from water and gas companies are also included as illustrating what has been the practical experience with these coatings in the field. The general conclusion arrived at is that the protection to be derived from the use of these coatings is only temporary. (Jan. 5, 1914.) 44 pp. Price, 15 cents.

T16. The Manufacture of Lime.....*W. E. Emley*

An account of the methods of lime manufacture at various plants, including a description of the plants. (Jan. 1, 1913.) 130 pp. Price, 25 cents.

T17. The Function of Time in the Vitrification of Clays.....*G. H. Brown and G. A. Murray*

Time is an exceedingly important factor in the maturing of clays and bodies. A certain result may be obtained either by the use of a higher temperature for a shorter time or a lower temperature for a longer time. This fact we see constantly illustrated in the firing of all kinds of clay products, the melting of glass, the softening of pyrometric cones, etc. Yet there are definite thermal limits to which such relations are confined. These correspond to the lowest temperature at which partial softening, which is a necessary condition of vitrification, can take place. The plan the present work followed was that of Bleininger and Boys, consisting in heating clays to their maturing temperatures at definite rates and comparing the heat effect by means of porosity and shrinkage determinations. Six clays were studied in this connection. (May 20, 1913.) 26 pp. Price, 5 cents.

T18. Electrolysis in Concrete.....*E. B. Rosa, Burton McCollum, and O. S. Peters*

Description of experimental researches on the effects of electric currents on concrete. The investigation has consisted of three parts: (*a*) Laboratory investigations relating to the nature and cause of the phenomena produced by the passage of electric currents through concrete; (*b*) investigations in the field with the view of establishing the probable extent of the danger in practice and the circumstances under which trouble is most likely to occur; (*c*) a study of the various possible means of mitigating trouble from this source leading to specific recommendations. (Mar. 19, 1913.) 137 pp. Price, 35 cents.

T19. Physical Testing of Cotton Yarns.....*W. S. Lewis*

PURPOSE.—Investigation of the desirability of improving the technical regulations of the trade, of developing cotton-yarn specifications, to improve methods of testing, and to determine some of the physical properties of cotton yarns.

NATURE OF TESTS.—General consideration of single and two-ply yarns relative to their size, twist, and tensile strength within cops, bobbins, skeins, respectively, etc., and also their behavior under various relative atmospheric humidities.

RESULTS.—Coarse yarns are not more difficult to spin to the required size than fine yarns. "Singles" yarns are spun with greater uniformity in size than "two-ply" yarns. Under usual atmospheric changes the size of a cotton yarn can be increased as much as five counts, or over 6 per cent, and the yardage to the extent of 3,500 yards per pound with No. 80 "singles" and 2,000 yards per pound with No. 100 two-ply yarns. Tensile strength is best determined upon single strands rather than by the "lea" method. The strength of "singles" yarns can be increased 18 per cent and "two-ply" yarns 16 per cent by increasing the relative atmospheric humidity from 45 to 85 per cent. The yarn number or count can be determined upon 30-yard specimens with an accuracy much greater than it can be manufactured. (Apr. 1, 1913.) 31 pp. Price, 10 cents.

T20. Determination of Sulphur in Illuminating Gas....
.....*R. S. McBride and E. R. Weaver*

Six common forms of apparatus or modifications of these were tested; the results show that the amount of sulphur in a gas can be determined with sufficient accuracy for official or commercial testing with any of the apparatus used. For general use the Referees, the Hinman-Jenkins, or perhaps the new model Elliott will be most satisfactory. Directions as to form and methods of operation of these are given. For the determination of the sulphate in the solutions obtained from the apparatus, two gravimetric, one volumetric, and one turbidimetric procedures were used; all of these were satisfactory, but some better adapted for certain circumstances than the others. (Mar. 7, 1913). 46 pp. Price, 10 cents.

T21. The Dehydration of Clays.....
.....*G. H. Brown and E. T. Montgomery*

The paper gives a review and a statement of results of experimental work upon the dehydration of clays. The combined water appears to behave as if in solid solution, and can not be said to have a definite dehydration temperature. Dehydration begins at 450° C, becomes very rapid at 500°, but not complete until 800° is reached. Contrary to usual idea, it is shown that the clay substance of impure clays represents a type essentially different from that of the purer materials. Dehydration need not destroy plasticity, hence the combined water appears not to directly affect the phenomenon of plasticity. Organic compounds can not be primary cause of plasticity, since these are oxidized in pure air at 500°. Finally, drying shrinkage was shown not to be a true criterion of plasticity. (Apr. 25, 1913.) 23 pp. Price, 5 cents.

T22. The Effect of Overfiring Upon the Structure of Clays.....*A. V. Bleininger and E. T. Montgomery*

Many clays develop a vesicular structure either just before vitrification sets in or during vitrification, or immediately after complete contraction has been reached. Owing to the injurious effect of this development, it seems important to trace its extent for different types of clays. This is especially important where products like paving brick, sewer pipe, glass pots or similar dense articles are concerned. It is likewise of considerable interest to determine whether upon vitrification equilibrium is approached. It has been found that the determination of the vesicular pore space is of considerable importance, although its determination has been neglected hitherto. It shows clearly why it is unsafe to use certain clays for exacting conditions. At the same time it has been proved that clays even after vitrification are far from having reached molecular equilibrium which is shown by the constant slope of the true specific gravity curve. (Apr. 6, 1913.) 23 pp. Price, 5 cents.

T23. The Technical Control of the Colloidal Matter of Clays. . . . . *H. E. Ashley*

In its briefest terms the argument of this paper is (1) that the plasticity of a clay is directly conditioned by the character and amount of the colloid matter in the clay; (2) consequently by measuring and controlling the colloid matter present it should be possible to control the plasticity of the clay and to obtain the great advantages incident to such control. The first of these statements, though generally accepted, is supported by additional evidence in this paper, but the main aim is to justify the second statement. The argument is preceded by a short sketch of the present status of the chemistry of colloids, in so far as it pertains to the subject in hand, and by necessary definitions and brief discussions of certain physicochemical concepts. Then follows a general discussion supported by experimental work on clays, concluding with some applications of the work to specific problems. (Dec. 18, 1912.) 118 pp. Price, 15 cents.

T24. The Determination of Phosphorus in Steels Containing Vanadium . . . . . *J. R. Cain and F. H. Tucker*

As a preliminary to the determination of phosphorus as phosphomolybdate in steels containing vanadium, the proper conditions for reducing the vanadium to the tetravalent state by ferrous sulphate are described, together with the other conditions to be observed in this determination. (May 17, 1913.) 11 pp. Price, 5 cents.

T25. Electrolytic Corrosion of Iron in Soils. . . . . *Burton McCollum and K. H. Logan*

The paper deals with the fundamental laws of electrolytic corrosion in soils and presents data showing the effects of the various factors which may influence electrolytic corrosion, such as current density, moisture content of soil, temperature, depth of burial, oxygen supply, chemical constituents of the soil, different kinds of iron, and effect of very low voltage. The relation of earth resistance to electrolysis is discussed very briefly and the laws of variation of earth resistance with moisture, temperature, and pressure are discussed. A list of conclusions is presented giving a brief summary of the results of the investigations. (June 12, 1913.) 69 pp. Price, 15 cents.

T26. Earth Resistance and its Relation to Electrolysis of Underground Structures. . . . . *Burton McCollum and K. H. Logan*

This paper presents some of the results of laboratory and field work of the Bureau of Standards in connection with the study of electrolysis. Three methods of measuring the specific resistance of soil are described, two of which do not require the removal of the soil from its original position.

Results of a large number of measurements show the resistivity of soil to vary in most cases between 1000 and 5000 ohm-centimeters.

The effects of the principal factors which influence soil resistance, i. e., pressure, moisture, temperature, and polarization, are described and the relation of each to electrolysis is discussed. (Dec. 20, 1915.) 48 pp. Price, 15 cents.

T27. Special Studies in Electrolysis Mitigation. I. A Preliminary Study of Conditions in Springfield, Ohio, with Recommendations for Mitigation and Control. . *E. B. Rosa and Burton McCollum*

This paper is divided into two main parts. After a brief discussion of railway and electrolysis conditions in Springfield, Ohio, Part I takes up in detail the different methods of electrolysis mitigation with the general conclusion that the potential gradients should be reduced by a system of insulated return feeders. Part II discusses the application of the insulated return-feeder system to the railways of Springfield, points out various ways of improving the rail return, and offers a complete redesign of the negative feeder system, with the conclusion that the changes shown will give practical immunity from electrolysis. [Superseded by T54.] (June 19, 1913.) 55 pp. Price, 15 cents.

T28. Methods of Making Electrolysis Surveys.....
.....*Burton McCollum and G. H. Ahlborn*

This paper deals with the methods of procedure to be followed in examining underground pipes and cables and the return systems of electric railways, in order to determine the liability of the pipes and cables to damage from stray electric currents from the railways.

The various classes of electrical measurements are described and methods of procedure are outlined in some detail. The selection of instruments for making such tests is treated, and some of the more important considerations involved in the interpretation of the results of electrolysis surveys are discussed. (Aug. 26, 1916.) 84 pp. Price, 20 cents.

T29. Variation in Results of Sieving with Standard Cement Sieves.....*R. J. Wig and J. C. Pearson*

PURPOSE OF TESTS.—This investigation was undertaken to determine the possible variations obtainable in determining the fineness of cements by using standard cement sieves, and to determine the tolerance which should be allowed for the "personal equation" and differences in the sieves.

METHODS.—The tests were made on 68 different sieves by different operators, an attempt being made to determine the variation due to differences in the methods of sieving by the same operator and by different operators.

RESULTS.—A tolerance of 1 per cent from the specification should be allowed with a No. 200 sieve and 0.5 per cent from the specification with the No. 100 sieve, when every care is taken to conduct the test in strict accordance with standard methods. (Aug. 1, 1913.) 16 pp. Price,5 cents.

T30. Viscosity of Porcelain Bodies.....
.....*A. V. Bleininger and Paul Teetor*

In the vitrification of ceramic bodies there is assumed to be a considerable superficial force tending to contract the mass, and lowered viscosity or softening which will permit the rearrangement of the molecules. Owing to the fact that no numerical values are available with reference to the degree of softening of ceramic bodies, it was thought desirable to carry on experiments with the purpose of determining the degree of viscosity reached by a series of bodies of the porcelain type. As a measure of the viscosity, the deformation under tensile strain was used. The results are tabulated and given in the form of curves. This method of studying ceramic bodies is capable of producting valuable results and might, with advantage, be applied to clays and other mixtures. (Nov. 20, 1913.) 11 pp. Price, 5 cents.

T31. Some Leadless Boro-Silicate Glazes Maturing at about 1100° C.....*E. T. Montgomery*

In this work the most promising glaze compositions, deduced from the work of Seger, Stull, Mellor, and others, have been applied to a standard American pottery body of the vitreous type. In addition, the calcium oxide was in part replaced by magnesium, barium and strontium oxide. The glazes were examined for their dipping quality, fusion range, brilliancy, hardness, crazing, and their effect upon underglaze colors. The results of Seger have been confirmed. Some good leadless glazes were produced. Compared with the plumbiferous glaze they lack somewhat in brilliancy and show a much shorter fusion range. Their effect upon some of the underglaze colors is deleterious. Other colors, however, are developed very satisfactorily. The kiln losses because of the use of leadless glazes would undoubtedly be higher than with the present glazes. (Dec. 15, 1913.) 22 pp. Price, 5 cents.

T32. Electrolysis from Electric Railway Currents and Its Prevention: Experimental Test on a System of Insulated Negative Feeders in St. Louis.....
.....*E. B. Rosa, Burton McCollum, and K. H. Logan*

This paper gives the details of the cost and design of an installation of insulated negative feeders with resistance taps which was constructed for the purpose of mitigating troubles due to stray currents from the electric

railways in the territory supplied by one of the substations of St. Louis. A comprehensive electrolysis survey of the city was made both before and after the installation of the negative feeders, and the details of this survey are given and discussed. A comparison of the costs of insulated and uninsulated negative feeder systems is also given. (Dec. 27, 1913.) 34 pp. Price, 10 cents.

T33. Determination of Carbon in Steel and Iron by the Barium Carbonate Titration Method.....*J. R. Cain*

There are described sources of difficulty and error in carrying out the barium carbonate titration method, with means for obviating these. (Jan. 31, 1913.) 12 pp. Price, 5 cents.

T34. Determination of Ammonia in Illuminating Gas... .....*J. D. Edwards*

Four common forms of apparatus and a new form designed on the principle of the Cumming wash bottle were tested; the results show that the amount of ammonia in a gas can be determined with sufficient accuracy for official or commercial testing with any of the five forms. Tests were made on different indicators and their suitability for this determination pointed out. The choice of indicator was found to be of more importance than the form of apparatus chosen. (Mar. 2, 1914.) 23 pp. Price, 10 cents.

T35. Combustion Method for the Direct Determination of Rubber.....*L. G. Wesson*

The method consists in forming an insoluble nitrosite of rubber by the action of nitrogen trioxide gas upon a finely ground, acetone-extracted sample of the rubber suspended in chloroform. The nitrosite is filtered out, dissolved in acetone, and an aliquot portion of the acetone extract is concentrated and then distributed over alundum in a porcelain boat, using ethyl acetate to complete the transfer. After expulsion of all acetone and ethyl acetate, the residue is burned in a combustion apparatus and the resultant carbon dioxide absorbed and weighed. From the carbon found the rubber is calculated upon the assumption that the nitrosite burned contains all the carbon of the rubber. Details of the combustion apparatus and operation are given. Results on samples of known composition show the method to be fairly accurate for raw rubber and high-grade vulcanized products. (Feb. 13, 1914.) 11 pp. Price, 5 cents.

T36. Industrial Gas Calorimetry..*C. W. Waidner and E. F. Mueller*

An investigation of some of the methods of calorimetry available for the industrial measurement of the heating values of gases, the sources of error to which such measurements are liable, the important precautions necessary, and the accuracy attainable in these measurements. Eight calorimeters of the flow type and one of the comparison type were included in the investigation. (Mar. 1, 1914.) 150 pp. Price, 40 cents.

T37. Iodine Number of Linseed and Petroleum Oils... .....*W. H. Smith and J. B. Tuttle*

The iodine values of raw, boiled, and burnt linseed oils, and petroleum oils, were determined by the Hanus method, varying widely the amounts of oil and iodine used and the time of absorption. A study of the effect of temperature on the iodine value was made. It is shown that in order to obtain concordant results a prescribed procedure must be followed and exact conditions stated. (Apr. 28, 1914.) 17 pp. Price, 10 cents.

T38. Observations on Finishing Temperatures and Properties of Rails.....*G. K. Burgess, J. J. Crowe, H. S. Rawdon, and R. G. Waltenberg*

Measurements were made in four rail mills of ingot and finishing temperatures. The former range from 1075° to 1150° C, and the latter from 880° to 1050° C, but are usually within 50° of 935°. The temperature of every rail can readily be measured and methods of temperature measurement for rolling mills are discussed. The mechanical properties, chemical

analyses, and microstructure were determined as well as melting range (1470° to 1525°), critical region on heating (732° ±7) and on cooling (650° to 680°), and temperature distribution in cooling of a 100-pound section from 1070°. Measurements of expansion showed Bessemer rails have a coefficient (0 to 1000°) of 0.0_4 146 and O. H. of 0.0_4 156. The "shrinkage clause" is discussed, and it is shown that it (A. S. T. M.) permits finishing rails at 1120° C. (Apr. 28, 1914.) 63 pp. Price, 35 cents.

T39. Analysis of Printing Inks.....*J. B. Tuttle and W. H. Smith*

A procedure of analysis of some of the common printing inks is given. This is the result of the experience of the Bureau during five years. It is claimed that the procedure is sufficiently accurate to determine the approximate composition of the ink. (June 12, 1914.) 20 pp. Price, 10 cents.

T40. The Veritas Firing Rings..*A. V. Bleininger and G. H. Brown*

The veritas firing rings are an adaptation of the Wedgwood pyrometer and consist of unburned clay rings of uniform composition and size. These are placed in different parts of ceramic kilns and are withdrawn during various stages of the firing. By determining the shrinkage of the pieces, using a simple calipering instrument, the progress of the heat effect due to increase in temperature is observed. The arbitrary shrinkage numbers of the device, as well as the actual shrinkages of the discs, were correlated with the temperatures and determined by means of thermocouples, both for rapid and slow firing. The shrinkage curves of the rings were found to be quite regular and hence these are suitable for the work for which they are intended. A new series of rings designed to be used for lower temperatures was found to behave irregularly. (June 5, 1914.) 10 pp. Price, 5 cents.

T41. Lead Acetate Test for Hydrogen Sulphide in Gas..
.....*R. S. McBride and J. D. Edwards*

The effects of numerous variations in the procedure and apparatus used in the detection of hydrogen sulphide in gas by the lead acetate test have been investigated; the results obtained show both the absolute and the relative sensitivity of the various methods which may be used in official or works laboratories. A method is recommended for use which is quick and convenient and gives reproducible results; a simple and inexpensive form of apparatus is described. The quantitative as well as the commercial significance of the results is pointed out. (Aug. 19, 1914.) 46 pp. Price, 25 cents.

T42. Standardization of No. 200 Cement Sieves.....
.....*R. J. Wig and J. C. Pearson*

An investigation was made of the magnitude and cause of variation in results obtained with standard sieves, and to devise means of improving the accuracy of fineness determinations. While the Bureau specifications for standard sieves had caused an improvement in their quality, a wide discrepancy still exists in sieving values. Cooperative sieving tests were made in 80 outside laboratories and at the Bureau, 162 standard sieves being tested. Studies were made of methods of standardizing sieves, of sieve variables, and the variables of manipulation. The suitability of materials suggested for use as standard samples for checking sieves was also studied.

RESULTS.—(1) No. 200 sieves as now standardized may vary 5 per cent or more in sieving value; (2) there is carelessness in making the fineness determination in many laboratories; (3) sieve cloth is subject to improvement (4) a correction factor can be applied to make determinations reproducible to within 0.5 per cent of a fundamental standard. The Bureau of Standards will maintain fundamental standard sieves and issue a standard sample of cement at a nominal price for checking sieves. A revision has been made in the specification for standard No. 200 sieves. (July 30, 1914.) 51 pp. Price, 10 cents.

T43. Hydration of Portland Cement . . . . . *A. A. Klein and A. J. Phillips*

The Geophysical Laboratory established the constitution of the compounds present in Portland cement clinker. It was thought advisable to study the effects of various amounts of water and steam at atmospheric and high pressures on the individual cement compounds and on Portland cement itself. The work included preparation of the compounds, their hydration on microscope slides with excess of water, their hydration in a cylinder with steam at various temperatures and pressures, the molding of the specimens with water in normal consistencies, and the study of the products so formed with the petrographic microscope to determine the changes. The results indicate how the hydration of cements is brought about and show the reactions and crystallographic changes. (Apr. 18, 1914.) 71 pp. Price, 20 cents.

T44. Investigation of the Durability of Cement Drain Tile in Alkali Soils . . . . . *R. J. Wig and G. M. Williams (with S. H. McCrory, E. C. Bebb, and L. R. Ferguson)*

Laboratory investigations show that cement concrete is subject to disintegration by alkali salts. Practical experience indicates that some concretes are less susceptible to such action than others and are quite permanent even if exposed in very concentrated alkali soils. Several millions of dollars are being spent annually in the drainage of alkali soils in the west, so that its economic importance makes it advisable to observe on cement drain tile of known composition exposed under normal service conditions in operating drains in concentrated alkali soils.

About 9000 drain tile (16 different types), a sufficient number to extend the investigation over a period of more than 10 years, were shipped to projects where concentrated alkali was found, in Wyoming, Montana, Utah, Washington, Arizona, New Mexico, and Colorado, and to fresh-water projects in Missouri and Minnesota.

RESULTS.—The first year's tests were made in 1914, the tile being crushed at the site in a portable tile-testing machine. With few exceptions the tile were found to be in good condition. A few failures or weakened tile were found among the leaner mixtures at several projects, while at others where the alkali appeared to be concentrated no failures were discovered.

The results indicate that special care should be observed to employ only the best materials and workmanship and relatively rich mixtures in the manufacture of tile to be exposed in concentrated alkali soils. No further conclusions can be drawn until additional results are available. (July 22, 1915.) 56 pp. [Superseded by T15.]

T45. A Study of Some Recent Methods for the Determination of Total Sulphur in Rubber . . . . . *J. B. Tuttle and A. Isaacs*

The results show that the Waters and Tuttle method, now in use at this Bureau, is the most satisfactory and entirely reliable. A new procedure is suggested for the determination of total sulphur in rubber which will be of particular value in the analysis of rubber compounds containing high percentages of free sulphur. (May 5, 1915.) 16 pp. Price, 5 cents.

T46. A Study of the Atterberg Plasticity Method . . . . . *Charles S. Kinnison*

Atterberg evaluates the plasticity of a clay in accordance with the range of water content within which it can be considered plastic. The plasticity value is expressed by a number obtained by subtracting the water content of the clay at the lower plasticity limit from the water content at the upper limit. The work of this investigator on Swedish clays is described and the results critically reviewed. The method was tried on 20 American clays and the results compared with evaluations based on per cent water of plasticity, per cent shrinkage, and per cent water absorbed by the clay powders while in an atmosphere of high humidity. It was brought out that the Atterberg method does not give results which check

observations made from actual experience with the clays, principally because it does not account for a sufficient number of factors. A revised adaptation of the Atterberg method is suggested in which the plasticity number is coordinated with the amount of water required to develop the best working properties of the clays. This scheme grouped the clays satisfactorily into those varieties which are sticky and would give trouble in working in a stiff-clay machine, and those which are nonsticky and admit of ready working. (May 25, 1915.) 18 pp. Price, 5 cents.

T47. Value of the High-Pressure Steam Test of Portland Cement.....*Rudolph J. Wig and Herbert A. Davis*

This report contains the results of tests made to ascertain the value of the high-pressure steam test as a means of determining the soundness and cementing quality of Portland cement. The physical properties, such as tensile and compressive strength of mortars, compressive strength of concrete, linear change of neat cement prisms when stored in air or water, or treated in high-pressure steam, were determined on cements that passed the proposed high-pressure steam test and cements which failed to meet the requirements of this test. The results of the investigation show that a high-pressure steam test should be used where cement or cement products are to be treated or "cured" in steam under pressure, and is of value in indicating the possible action of neat cement when stored in dry air. However, there is nothing to indicate that cement passing this test is superior in cementing quality when used in concrete. Furthermore for work under practical conditions of construction the high-pressure steam test is of no value as indicating the ultimate soundness of concrete. (Aug. 18, 1015.) 34 pp. Price, 15 cents.

T48. An Air Analyzer for Determining the Fineness of Cement.....*J. C. Pearson and W. H. Sligh*

A study of various types of elutriators has led to the development of an air analyzer for mechanically analyzing that portion of cement passing a No. 200 sieve. An apparatus of this kind has been greatly needed to aid in determining the value of fineness in cements, an investigation which is now in progress.

Special attention has been given to the mechanical features of the analyzer, not only to insure pure and complete separations of fine material, but also to make possible the calibration of the apparatus in absolute terms. The calibration consists in determining with the microscope the "sizes of separation"; that is, the average limiting diameters of the particles in the several fractions. For most purposes the nominal sizes of separation are sufficiently close to apply to all normal Portland cements, but special calibrations can be readily made in cases requiring the maximum attainable accuracy.

Several methods of measuring the sizes of particles have been studied, and a simple system of measurement has been tentatively adopted as a basis for plotting the fineness curves. These curves are analogous to the mechanical analysis curves of sands and other aggregates, and show the granulometric composition of cements in terms of size of particles and percentage of total. This method of standardizing the analyzer greatly increases its usefulness and adapts it to the study of many finely divided materials. (Sept. 8, 1915.) 74 pp. Price, 20 cents.

T49. Emergent-Stem Correction for Thermometers in Creosote-Oil Distillation Flasks.....*R. M. Wilhelm*

The emergent-stem corrections for a type of thermometer much used in creosote-oil distillation were determined for four types of flasks in common use. Emergent-stem correction tables based on these results are given. Some other sources of error affecting the temperature measurements are considered. The magnitude of the error in the results of distillation tests, due to neglecting the emergent-stem corrections, is shown. A method is suggested for determining the total corrections under working conditions of thermometers in distillation flasks by observing the readings of the thermometers successively in the vapors of naphthalene and of anthracene, when these substances are boiled in the flasks. (Aug. 14, 1915.) 21 pp. Price, 10 cents.

T50. Viscosity of Porcelain Bodies High in Feldspar.. .....*A. V. Bleininger and C. S. Kinnison*

The degree of softening of previously fired porcelain bars under a tensile stress of 14.5 pounds per square inch and at temperatures between 1275° and 1380° C was determined for a series of 18 compositions. The elongation of the specimens was used to obtain data for selecting such mixtures of clay, flint, and feldspar which would show the greatest rigidity at the kiln temperatures and hence cause least loss due to deformed ware. (Sept. 25, 1915.) 7 pp. Price, 5 cents.

T51. Use of Sodium Salts in the Purification of Clays and in the Casting Process.....*A. V. Bleininger*

An investigation was made of the effect of small quantities of sodium carbonate and sodium silicate in separating impurities from kaolins and in reducing the water content in raw porcelain mixtures composed of kaolin, ball clay, feldspar, and quartz. This mixture is ground together in water to form a suspension which is used to cast clay wares. The effect of the alkalies upon different American kaolins and clays used in the pottery industry was determined with reference to the viscosity of the clay suspensions, the absorption of the reagents, the strength of the treated mixtures in the dried state, and the influence of time on the stability of the system. The effect of the different clays upon each other was also studied. (Sept. 25, 1915.) 40 pp. Price, 15 cents.

T52. Electrolysis and Its Mitigation..... .....*E. B. Rosa and Burton McCollum*

The paper gives a brief general statement regarding electrolysis and corrosion and presents a detailed discussion of the various methods of electrolysis mitigation that have been proposed or tried for protecting underground structures. Methods of mitigation are treated under two heads, namely, those applicable to pipes and those applicable to the railway return system. The conclusion is drawn that while certain of the methods applicable to pipes, particularly pipe drainage and insulating joints, are often valuable, they should in general be used as auxiliary measures only, the chief reliance being placed on reducing potential drops in the railway return to reasonably low values. Where return feeders are necessary for accomplishing this, insulated feeders are preferable because more economical. In the last chapter there is presented a discussion of the principles on which regulations concerning electrolysis mitigation should be based, and the responsibilities of owners of underground utilities as well as of the railway companies are emphasized. (Dec. 27, 1915.) 143 pp. Price, 30 cents.

T53. An Investigation of Fusible Tin Boiler Plugs..... .....*George K. Burgess and Paul D. Merica*

A report is made of the investigation and tests of about 1100 fusible tin boiler plugs furnished by the courtesy of the Steamboat-Inspection Service, Department of Commerce. The types of failure or deterioration of the used plugs were studied and classified, and investigation made by thermal and chemical analysis of the purity of the tin in such plugs, both new and used. Oxidation of impure tin was found to be the main cause of failure. Conclusions are reached regarding specifications for fusible plugs and the testing of the purity of the tin in them. Zinc, even in quantities as small as 0.3 per cent, was found to be detrimental. (Oct. 15, 1915.) 37 pp. Price, 20 cents.

T54. Special Studies in Electrolysis Mitigation. III. A Report on Conditions in Springfield, Ohio, With Insulated Feeder System Installed.... .....*Burton McCollum and George H. Ahlborn*

This report dealing with electrolysis mitigation in Springfield, Ohio, reviews the earlier work done there and describes the general conditions affecting electrolysis and the insulated return feeder system as finally installed. The data taken during the last survey are presented, with a description of

the methods employed, and these data are compared with those taken during the preceding winter given in another report. See T27.] The effect of frost is evident in the potential difference and pipe current data. Cost data showing that the operation expense is slightly greater than before any mitigation system was installed but less than with the first mitigation system are given, and recommendations concerning construction and administration, with the object of maintaining the present satisfactory conditions, are offered. The report contains 25 tables and 13 figures. (Feb. 5, 1916.) 64 pp. Price, 25 cents.

T55. Special Studies in Electrolysis Mitigation. IV. A Preliminary Report on Electrolysis Mitigation in Elyria, Ohio, with Recommendations for Mitigation.....*Burton McCollum and K. H. Logan*

From data furnished by the city and the Cleveland Southwestern & Columbus Railway Co., the feeding distances of the Elyria power house are found to be too long and the potential gradients too high. It is recommended that the gradients be reduced to 0.3 volt per 1000 feet average for 24 hours by the addition of a substation, the interconnection of the tracks of the two electric railways, and the installation of an insulated return feeder system.

The saving in power due to the reduced feeding distance is shown to be more than sufficient to pay the annual charges on the additional investment of $34,373. The plan provides for 800 kilowatts additional substation capacity, improved operating conditions, and substantial elimination of electrolysis. (Jan. 22, 1916.) 49 pp. Price, 20 cents.

T56. Protection of Life and Property Against Lightning .....*O. S. Peters*

This paper is a report of a survey of statistical data relating to life and property hazards from lightning, and also of existing methods of protection against lightning. The field covered does not include electrical power and signal systems. In the course of the preparation of the paper an examination was made of the available literature on the subjects of lightning phenomena and protection against lightning and of the reports of fire marshals and insurance companies. A considerable amount of data was also obtained from reports of the Census Bureau. Manufacturers of lightning rods were also asked to submit their opinions and the results of their experience as to how a system of lightning rods should be installed. Appendices are included, giving rules concerning the installation and maintenance of lightning rods which have been in some cases followed in England, Germany, and the United States, and also rules for first-aid treatment in cases of persons injured by lightning. (Dec. 15, 1915.) 127 pp. Price, 35 cents.

T57. Difference in Weight Between Raw and Clean Wools.....*Walter S. Lewis*

The term "shrinkage," as used in this paper, is the total loss, by weight, of all grease and dirt. This refers to wool fleeces exclusive of the skirts. It is the commercial practice to leave from 1 to 3 per cent of the natural-wool grease in scoured wool.

The difference between the percentage shrinkage and 100 gives the percentage of clean wool. Forty-nine fleeces were thoroughly scoured and the fiber then extracted of all grease and dirt. The shrinkages varied from 19.5 to 54 per cent according to the breed of sheep.

Shrinkage determinations of each fleece, upon samples which in each case represented an average of the whole fleece (exclusive of the skirts), showed differences as great as 6 per cent, with an average of 1 per cent. The difference in shrinkage between two fleeces of the same breed was 9.5 per cent in one case and an average of 4.5 per cent in 13 different fleeces. The results obtained are given in detail in tables. (Sept. 28, 1915.) 5 pp. Price, 5 cents.

T58. Strength and Other Properties of Concretes as Affected by Materials and Methods of Preparation....*R. J. Wig, G. M. Williams, and E. R. Gates*

This paper is a collation of the results of about 20 000 tests of mortars and concretes made with about 300 aggregates consisting of limestone, granite, gravels, and trap rock. It shows the effect with age on compressive strength, modulus of elasticity, and yield point of varying the proportions of cement to coarse and fine aggregate, the consistency of the mixture, the workmanship in fabricating, the condition of storage, and the value of void, gradation, and density tests. The greatest value of this paper is in emphasizing the necessity of having a knowledge of all the materials used in fabricating concrete and the necessity of exercising extreme care in every phase of the manufacture if a concrete of known quality is to be produced. Both Fuller's method of graduation to a "theoretical curve" and the "void" method of proportioning the constituents of concrete to obtain maximum strength were found to be incorrect. With the percentage of cement to total aggregate fixed, the strength varies as the density of the mixture. (June 20, 1916.) 172 pp. Price, 35 cents.

T59. Standard Test Specimens of Zinc Bronze (Cu 88, Sn 10, Zn 2)—Parts I and II.....*C. P. Karr and Henry S. Rawdon*

PART I.—Preparation and Specifications.....*C. P. Karr*

This paper is a report of work done at the Bureau of Standards upon the standardization of zinc-bronze test bars. In this investigation it was endeavored to ascertain the most suitable methods of molding, mixing, melting, and pouring test bars of this material and to make a record of their physical properties, such as tensile strength, ductility, and hardness, and to study the effect of heat treatment upon these properties. From a study of the results of the investigation tentative specifications were prepared for the preparation of such a bronze.

PART II.—Microstructure.....*Henry S. Rawdon.*

Part II continues the study of the properties of the zinc bronze (Cu 88, Sn 10, Zn 2) already described in Part I. The microstructure and its influence upon the physical properties are discussed in detail. The properties of the bronze were found to be influenced most by the presence of inclusions of foreign matter; this is particularly true of oxides which often occur in the form of thin films separating otherwise sound material. The change of structure accompanying heat treatment is also discussed. A series of typical photomicrographs illustrates the main points of the structure observed. (Mar. 15, 1916.) 67 pp. Price, 25 cents.

T60. Microstructure of Changes Accompanying the Annealing of Cast Bronze (Cu 88, Sn 10, Zn 2).....*Henry S. Rawdon*

The microstructure of commercial brasses and bronzes changes materially upon annealing. The aim of this study is to show the various stages through which the metal passes in going from the cast condition to the annealed or "recrystallized" state and the conditions necessary for these changes. The alloy Cu 88, Sn 10 Zn 2 is used as a type. The observations show that "recrystallization" follows only distortion of the structure; although, in effect, such distortion may be produced by very sudden cooling of the metal. The results obtained very materially substantiate one of the two main theories of the "recrystallization" of metals upon annealing. (Jan. 25, 1916.) 17 pp. Price, 10 cents.

T61. Some Foreign Specifications for Railway Materials: Rails, Wheels, Axles, Tires.....*G. K. Burgess and P. D. Merica*

Statistics, gathered through the Department of State, on specifications for rails, wheels, tires, and axles are given for several European countries, together with a discussion and digest of same, as well as some accident statistics. (Apr. 20, 1916.) 132 pp. Price, 25 cents.

T62. Modern Practice in the Construction and Maintenance of Rail Joints and Bonds in Electric Railways.....*E. R. Shepard*

The paper gives a historical and descriptive discussion of all types of modern rail joints and rail bonds. This is followed by a compilation and analysis of data submitted by 42 electric-railway companies in answer to inquiries sent out by the Bureau. Modern practices and tendencies are discerned and discussed and some recommendations made. (Mar. 10, 1916.) 123 pp. Price, 35 cents.

T63. Leakage of Currents from Electric Railways.....*Burton McCollum and K. H. Logan*

In this paper the theory of the leakage of current from electric-railway tracks is developed mathematically. Assuming, first, a single track of uniform construction and, later, a track whose sections vary in conductivity, leakage resistance, and loading, the effects of rail and leakage resistance and of the length of the line on the distribution and amount of leakage current are calculated for systems with both grounded and ungrounded negative buses. (Mar. 14, 1916.) 31 pp. Price, 10 cents.

T64. Determination of Barium Carbonate and Barium Sulphate in Vulcanized Rubber Goods.....*John B. Tuttle*

When barium sulphate only is used in rubber compounds, the amount present is readily ascertained by determining the total amount of barium present. If barium carbonate is used, it is necessary to separate the two salts. By means of tests made on compounds of known composition prepared at the Bureau of Standards, a method has been devised which permits the quantitative determination of barium carbonate in the presence of either lead sulphate or barium sulphate, the two sulphates most commonly used in rubber goods. The accuracy of the determination is satisfactory for all practical purposes. (Jan. 21, 1916.) 5 pp. Price, 5 cents.

T65. Determination of Oil and Resin in Varnish.....*E. W. Boughton*

Some existing methods include precipitation of "gums" by petroleum ether and extraction of oxidized films with chloroform to dissolve out the resin, or both of these steps. It is shown that these methods give erroneous results with certain types of varnish. Determination of the glycerol yield and calculation of the oil content therefrom gave fairly satisfactory results except with varnish that contained Chinese wood oil. The proposed method included saponification of the varnish, separation of unsaponifiable matter, and separation of fatty acids from resin acids by the Twitchell or Wolff methods of esterification. Ethyl ether is used as solvent after esterification. A correction is applied for resinous matter that is weighed as fatty acids. The greatest error in the average results with the proposed method was 2.2 per cent, expressed as percentage of the varnish. (Feb. 19, 1916.) 32 pp. Price, 10 cents.

T66. Detection of Resin in Drier.....*E. W. Boughton*

For the detection of resin in drier, three steps are proposed: (1) The Liebermann and Storch test for rosin; (2) treatment of the mixture of unsaponifiable matter, fatty acids, and resin acids obtained from the drier with 97 per cent alcohol (if the drier contains much Kauri or similar resin, a turbidity or insoluble deposit will result); (3) esterification by absolute alcohol and concentrated sulphuric acid with subsequent titration with alkali. (If the resulting acid number—mg of KOH per gram of the mixture of unsaponifiable matter and acids taken—is over 10, resin is present in the drier. By this procedure resin can be detected where the amount is at least 6 per cent.) (Jan. 15, 1916.) 9 pp. Price, 5 cents.

T67. Some Qualitative Tests for Gum Arabic and Its Quantitative Determination . . . . . *C. E. Waters and J. B. Tuttle*

A study of many of the published tests for the gum, as well as a research for others than the few that proved to be reliable. It was found that basic lead acetate gives the most characteristic reaction, while mixtures of copper sulphate and sodium hydroxide and of neutral ferric chloride and alcohol are of value as confirmatory tests. Dextrin and gum ghatti were subjected to the same tests.

A summary of the more important methods that have been proposed for the quantitative estimation of gum arabic is next given, followed by a description of the steps that led the authors to the use of alcoholic copper acetate-ammonia solution for this determination.

NOTE.—The greater part of this paper is a compilation, but in no other place known to the authors are so many qualitative and quantitative methods brought together with the corresponding references to the literature. (Jan. 31, 1916.) 15 pp. Price, 5 cents.

T68. Standardization of Automobile-Tire Fabric Testing . . . . . *Walter S. Lewis and Charles J. Cleary*

(1) Definite information was obtained as to the common methods of testing tire fabric; (2) series of comparative tests were made to determine which method would give most reliable results for each particular physical property; (3) variations in test results were found to be due chiefly to different testing machines, size of test specimen, moisture in test specimen, method of sampling, and lack of uniformity of the fabric; (4) to give best results (*a*) testing machines must be calibrated often, (*b*) in size the tensile-strength test specimens should be 1 inch wide, in strip form, and clamped between jaws 3 inches apart, (*c*) test specimens to be bone-dry when breaking stress is determined, and (*d*) test specimens should be selected to give an average of the full width and length of fabric. (Mar. 17, 1916.) 18 pp. Price, 10 cents.

T69. Determination of Carbon in Steels and Irons by Direct Combustion in Oxygen at High Temperatures . . . . . *J. R. Cain and H. E. Cleaves*

A method for the determination of carbon by direct combustion in oxygen, finishing at temperatures above the fusion point of the oxides formed, has been devised. By this method it is shown that the probable error affecting the certificate results of carbon on the Bureau's standard analyzed irons and steels is negligible for present uses of these samples. (Feb. 18, 1916.) 10 pp. Price, 5 cents.

T70. Durability of Stucco and Plaster Construction . . . . . *R. J. Wig, J. C. Pearson, and W. E. Emley*

Many inquiries received regarding the causes of failures and the probable life of "stucco" as used in residence construction has led to an investigation of stucco construction by the Bureau in cooperation with an advisory committee composed of representatives from technical and industrial organizations and a number of expert contracting plasterers. The plans of this committee materialized in the erection in 1915 of a test structure 200 by 26 by 24 feet, containing 56 stucco panels, representing practically all the common types of stucco construction. In April, 1916, a careful inspection was made of the test panels, and only two were found to be entirely free from cracks. About 40 per cent of the panels were found to be in more or less satisfactory condition, the remainder being in various stages of deterioration. While the committee do not feel justified in drawing general conclusions at the present time, much information of value can be obtained from a study of this first progress report. (Jan. 31, 1917.) 74 pp. Price, 15 cents.

T71. Effect of Certain Pigments on Linseed Oil..*E. W. Boughton*

The effect of storage of white-lead and linseed-oil paste on the constants of the oil is shown. Effect of storage of mixtures of various pigments with linseed oil on the constants of the oil is shown. An examination was made of oils from partially oxidized films of pigment and linseed-oil mixtures. The action of linseed-oil fatty acids on white lead and white zinc was investigated. The relative effects of certain pigments on the oxidation of linseed oil in paint films are shown. (Apr. 13, 1916.) 16 pp. Price, 5 cents.

T72. Influence of Frequency of Alternating or Infrequently Reversed Current on Electrolytic Corrosion.....*Burton McCollum and G. H. Ahlborn*

This paper describes experimental work done to determine the coefficient of corrosion of iron and lead in soil with varying frequencies of alternating or reversed current with 60 cycles per second as the highest frequency and a two-week period as the lowest, some direct-current tests being made as a check on the methods. The results show (1) that a decrease of corrosion occurs with an increse in frequency; (2) that the corrosion is practically negligible below a five-minute period; (3) that there is a limiting frequency above which practically no corrosion occurs; (4) that certain chemicals affect the natural and electrolytic corrosion of the two metals quite differently; (5) that the loss of lead in soil on direct current is about 25 per cent of the theoretical loss; and (6) that alternating or reversed current with as long periods as a day or a week would in the case of iron materially reduce the damage to underground structures.

The importance of these results grows out of the fact that there are large areas in practically every city in which the polarity of the underground pipes reverses with periods ranging from a few seconds to an hour or more, due to the shifting of railway loads. The investigation shows that the corrosion under such conditions is much less than has generally been supposed. (Aug. 15, 1916.) 31 pp. Price, 10 cents.

T73. Data on the Oxidation of Automobile Cylinder Oils.....*C. E. Waters*

A study of the rate of oxidation of three automobile-cylinder oils when exposed to sunlight and air. The increase in weight, acidity, and carbonization value, as well as changes in the Maumené and iodine numbers and in the demulsibility, were determined. Changes in the carbonization values of these three oils and of eight others, when heated for different lengths of time at a given temperature and for the same time at different temperatures, were studied. The bearing of the work upon the testing of oils is pointed out. (May 31, 1916.) 20 pp. Price, 5 cents.

T74. Investigation of Cartridge-Inclosed Fuses.....
E. B. Rosa, H. B. Brooks, Burton McCollum, W. J. Canada, and F. W. Glading

This report represents the results of the investigation carried out by the Bureau of Standards acting as referee on the joint request of the Economy Fuse & Manufacturing Co. and Underwriters' Laboratories (Inc.) on the question of the relative fire and accident hazard of Economy refillable fuses and fuses at present listed as standard by Underwriters' Laboratories (Inc.).

The evidence on which the decision was based includes a large number of tests of fuses under widely different conditions, as well as inspections of numerous fuse installations in practice, personal interviews with many fuse users, evidence and arguments submitted by the Economy Fuse & Manufacturing Co. and Underwriters' Laboratories (Inc.), both at a public hearing and by correspondence, and evidence and arguments submitted by a number of manufacturers of fuses at present listed as standard by Underwriters' Laboratories (Inc.).

The question was carefully considered in its various aspects by a committee of technical experts of the Bureau of Standards and has been decided solely on the technical questions at issue.

The question submitted for decision was as follows: "Has it been shown that the use of the fuses manufactured by the Economy Fuse & Manufacturing Co. results in no greater fire or accident hazard than the use of other cartridge-inclosed fuses at present listed as standard by Underwriters' Laboratories (Inc.)."

The Bureau's investigation resulted in the following finding:

"It has not been shown that the use of the fuses manufactured by the Economy Fuse & Manufacturing Co. will result in no greater fire or accident hazard than the use of inclosed cartridge fuses at present listed as standard by the Underwriters' Laboratories (Inc.).

"On the other hand, the evidence in the case does not show that the use of Economy fuses has on the whole resulted in any greater fire or accident hazard than is involved in the use of standard inclosed cartridge fuses." (Dec. 1, 1916.) 199 pp. Price, 55 cents.

T75. Data on Electric Railway Track Leakage....*G. H. Ahlborn*

This brief report gives data and calculations on the leakage and roadbed resistance of three trolley lines of simple geometrical form and having different types of roadbed, elevations, and soil conditions. The leakage varies from 28 to 93 per cent of the total current flowing in lines having about the same length, but one having rather high-resistance roadbed and low-resistance track and the other low-resistance roadbed and high-resistance track. The unit resistances of both rails and roadbed are calculated from data on the different lines. The results corroborate figures of the resistance of soil and roadbed as determined by the Bureau of Sandards by methods of direct measurement on short lengths of track. (Aug. 22, 1916.) 22 pp. Price, 10 cents.

T76. Determination of Volatile Thinner in Oil Varnish.. .....*E. W. Boughton*

With samples of varnish containing turpentine or "mineral spirits" (light petroleum oil), methods based on (1) steam distillation, (2) on evaporation of the thinner from a film at 115° C, and (3) on evaporation of the thinner from a very thin film at room temperature, were all found to be sufficiently accurate for practical purposes. The results should be reported as the whole percentages next above the figures obtained. (June 21, 1916.) 6 pp. Price, 5 cents.

T77. Density and Thermal Expansion of American Petroleum Oils.....*H. W. Bearce and E. L. Peffer*

This paper gives an account of the experimental investigation on which are based the density and volume tables of C_{57} of the Bureau of Standards, entitled "United States Standard Tables for Petroleum Oils." (Aug. 26, 1916.) 26 pp. Price, 10 cents.

T78. Properties of the Calcium Silicates and Calcium Aluminate Occurring in Normal Portland Cement.....*P. H. Bates and A. A. Klein*

The three constituents of normal Portland cement (tricalcium silicate, dicalcium silicate, and tricalcium aluminate) have been prepared in pure form. From these, after grinding, tensile specimens of both neat and 1:3 standard mortars have been prepared and tested at various periods up to one year. The strengths developed by these pure compounds have been determined, their setting properties, rate, and amount of hydration. These compounds have also been mixed in various proportions and the same data determined. It is intended to show in this paper the function of each of these constituents in normal Portland cement and how each affects the various properties. (June 9, 1917.) 38 pp. Price, 25 cents.

T79. Properties of Some European Plastic Fire Clays... .....*A. V. Bleininger and H. G. Schurecht*

The properties of five well-known European plastic fire clays used in the manufacture of glass refractories, graphite crucibles, etc., have been studied. The content of shrinkage and pore water, the drying shrinkage, fineness of grain, mechanical strength in the dried state, the Atterberg plasticity

number, rate of vitrification, and softening temperature have been determined. A comparison is made of these materials as to their suitability for several purposes, and tentative specifications are suggested for the selection of clays which might be used as substitutes for these foreign materials. American clays are available which, if used as mixtures, can take the place of the imported ones with equally as good or superior results. (Aug. 24, 1916.) 34 pp. Price, 10 cents.

T80. Constitution and Microstructure of Porcelain . . . *A. A. Klein*

A petrographic microscopic study of laboratory-prepared porcelain bodies, of kaolin, feldspar-kaolin, and feldspar-quartz mixtures burned at various known temperatures, and of commercial porcelains representing the practices of United States, England, Germany, France, Austria, Denmark, and Japan. It has been found possible to correlate the constitution of a porcelain with its burning temperature so that the latter may be predicted with an error not greater than 25° from the microscopical examination of a fragment of porcelain much too small for even a chemical analysis. (Dec. 8, 1916.) 38 pp. Price, 25 cents.

T81. Liquid-Measuring Pumps . . . . . *F. J. Schlink*

On the design, installation, inspection, testing, and sealing of the types of measuring pumps in use, for the guidance of weights and measures officials. (Oct. 27, 1916.) 27 pp. Price, 15 cents.

T82. Failure of Brass. 1.—Microstructure and Initial Stresses in Wrought Brasses of the Type 60 Per Cent Copper and 40 Per Cent Zinc . . . . . *Paul D. Merica and R. W. Woodward*

An investigation has been made of the causes of failure of a number of articles, particularly bolts, of wrought brass of the type 60:40, with particular reference to the presence of initial stress. In the course of this investigation the physical properties, microstructure, and initial stress distribution have been studied in failed and sound materials from the Catskill Aqueduct construction, the filtration plant of the city of Minneapolis, the Navy Department, and the Panama Canal, and in new material from a number of manufacturers, some 250 materials in all. Failure has occurred (1) as a result of faulty practice in forging bolt heads, flanging plates, etc., (2) as a result of the presence of initial stress, and (3) as a result of service overstress due to drawing bolts up too tightly. An average initial stress of 5000 pounds per square inch is to be regarded as a safe limit for rods and bolts of this type of material under ordinary service conditions, in which the service load is itself not greater than from 5000 to 10 000 pounds per square inch. (Jan. 29, 1917.) 72 pp. Price, 25 cents.

T83. Failure of Brass. 2.—Effect of Corrosion on the Ductility and Strength of Brass . . . . . *Paul D. Merica*

A study has been made of the effect of tensile stress on the electrolytic solution potential of brass to various solutions, the results indicating an increase of emf of about 0.1 millivolts for 10 000 pounds per square inch of stress. An explanation is given, based upon this effect, of the decreased ductility and strength exhibited by brass when corroded while under tensile stress, and describes the growth and extension inward of a fissure in brass under such conditions. (Nov. 14, 1916.) 7 pp. Price, 5 cents.

T84. Failure of Brass. 3.—Initial Stress Produced by the "Burning In" of Manganese Bronze . . . . *Paul D. Merica and C. P. Karr*

Investigation has been made of the initial stress produced by the burning in, without preheating, of constrained parts of castings of manganese bronze. Results have shown that in general tensile stresses will be produced within the burned-in area equal in value to the true elastic limit of the material. The conclusion is drawn that burning in of such material should not be practiced without thorough preheating or subsequent annealing of the whole casting. (Nov. 17, 1916.) 7 pp. Price, 5 cents.

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T85. Manufacture and Properties of Sand-Lime Brick. . . . . *Warren E. Emley*

Gives historical sketch and description of sand-lime brick as a common building material. Describes the process of manufacture and the properties of the resulting product. The tests suitable for sand-lime brick are outlined, and in the appendix is given a description of various plants. It is shown that where sand of good quality is abundant the ability to make brick of the sand is placed within the reach of the user, furnishing a cheap, durable, noncombustible building material which is a home product, with reasonable transportation costs. (Mar. 22, 1917.) 41 pp. Price, 10 cents.

T86. Resistance of an Oil to Emulsification. . *Winslow H. Herschel*

As no suitable test has been described in print, an original apparatus and method of test were devised by means of which the resistance to emulsification could be expressed by a single numerical value. The test here described has been adopted by the General Supply Committee and is under consideration by a committee of the American Society for Testing Materials. (Feb. 17, 1917.) 37 pp. Price, 10 cents.

T87. Recovery of Paraffin and Paper Stock from Waste Paraffin Paper. . . . . *W. H. Smith*

In order to recover the paraffin and paper stock in waste paraffin paper, a process is described utilizing a vertical steam boiler, tanks for receiving the paraffin, and a beater. The waste is pulped with exhaust steam. The wax rises to the surface and the paper stock settles in the boiler. In the beater the stock is treated with an alkaline solution in hot water to remove ink. The residual wax is collected on a metal cylinder, internally water chilled, and partly submerged in the hot water of the beater. Paper prepared from the recovered stock was free from wax and entirely satisfactory. Practically all of the paper stock is recovered, but about 10 per cent of the paraffin is lost. (Dec. 15, 1916.) 4 pp. Price, 5 cents.

T88. Studies on Paper Pulps. . . . . *W. H. Smith*

Samples of paper pulps, each representing a different method of preparation and with one exception of American manufacture, have been examined to determine their chemical properties. These consist of the amount of ash, cellulose, and methoxyl, the yield of furfural and methylfurfural, and the copper number. Using the same pulps, the loss in weight produced by reagents causing oxidation and hydrolysis and the increase in weight when nitrated have been determined. The effects of sunlight, temperature, and ozonized air on the chemical constants obtained with ground wood have been ascertained. (Feb. 9, 1917.) 13 pp. Price, 5 cents.

T89. A Specific Gravity Balance for Gases. . . . . *Junius David Edwards*

An apparatus is described which provides a quick and accurate means of determining the specific gravity of gases. The principle of the method employed is based upon the laws of the compressibility and the buoyant effect of gas. The portable type of apparatus combines simplicity, lightness of weight, convenience in use, and durability, without any great sacrifice of accuracy. (Feb. 23, 1917.) 20 pp. Price, 5 cents.

T90. Structure of the Coating on Tinned Sheet Copper in a Specific Case of Corrosion. . . . . *Paul D. Merica*

A curious case of pitting in tinned sheet-copper roofing has been investigated, the phenomena observed having directed attention to the question of the structure and properties, particularly the corrodibility and electrolytic emf of the tin coating on copper. This coating, approximately 0.01 mm thick, is shown to consist of at least three layers, the inner alloy layers being hard, brittle, and less readily corroded than the tin and the copper itself; they are electronegative to the base copper. An explanation, based upon the galvanic action between the copper and the tin alloy layer, is given of this type of corrosion, and attention is drawn to the consideration of the extent of mechanical abuse received and of the uniformity and thickness of the tin coating as affecting the resistance to corrosion of this type of material. (Apr. 21, 1917.) 18 pp. Price, 5 cents.

T91. Temperature Measurements in Bessemer and Open-Hearth Practice.....*George K. Burgess*

The problem of temperature measurement and pyrometric control of furnace-casting and ingot-teeming temperatures is shown, by a series of observations taken in several steel plants, to present no serious difficulties or uncertainties. The application of the optical pyrometer to steel and iron manufacture is discussed at length. (May 8, 1917,) 29 pp. Price, 5 cents.

T92. Measurement and Specification of the Physical Factors which Determine the Saturation of Certain Tints of Yellow.....
.....*Irwin G. Priest and Chauncey G. Peters*

States and explains a specification, in terms of relative reflecting powers, designed to set a limit to the saturation of tints of yellow in certain particular cases. The method and apparatus used to test in terms of this specification are also described. Data relative to a number of samples of butter and oleomargarine are given. (June 30, 1917.) 11 pp. Price, 5 cents.

T93. Glasses for Protecting Eyes from Injurious Radiations.....*W. W. Coblentz and W. B. Emerson*

This paper gives general information concerning certain newly developed types of glasses which are very opaque to infra-red or so-called heat rays, and hence are suitable for protecting the eyes of glass blowers, ironworkers, etc. It is shown that gold-plated and Corning "Noviweld" glass are the most efficient protection against infra-red rays. Green, bluish-green, and very deep black glasses are also very efficient in obstructing the infra-red. Green, yellow, and amber colored glasses are the most efficient in obstructing the violet and ultra-violet rays. (Second edition, Apr. 4, 1918.) 25 pp. Price, 10 cents.

T94. Effusion Method of Determining Gas Density....
.....*J. D. Edwards*

The results of an investigation of the theory and practice of the effusion method of determining gas density are reported. Recommendations are made for the design and operation of suitable apparatus. The limitations of the method are pointed out. (June 20, 1917.) 30 pp. Price, 10 cents.

T95. Durability of Cement Drain Tile and Concrete in Alkali Soils.....
.....*R. J. Wig, G. M. Williams, and A. N. Finn,* in cooperation with.....
.....*S. H. McGrory, E. C. Bebb, and L. R. Ferguson*

The use of concrete, particularly for drainage structure, in soils containing quantities of alkalies found in the arid regions of the United States, has been restricted because of lack of confidence on the part of some engineers as to its durability. It was considered advisable to make observations on cement drain tile and mass concrete of known composition which would be exposed under normal service conditions. The results to date indicate that special care should be observed to employ only the best materials and workmanship, and that the present commercial methods of manufacturing cement drain tile should be improved. No conclusions are yet available as to the endurance of mass concrete except to emphasize the necessity of special care in selection and proportioning of aggregates as well as the use of proper methods of fabrication. (Nov. 15, 1917.) 94 pp. Price, 35 cents.

T96. Comparative Tests of Stitches and Seams...*Walter S. Lewis*

The paper describes tests of seams produced by two methods of stitching by the sewing machines most extensively employed. Seams of the double-locked stitch and the shuttle stitch were tested to show their relative strength and other characteristics. (June 25, 1917.) 7 pp. Price, 5 cents.

T97. Some Unusual Features in the Microstructure of Wrought Iron.....*Henry S. Rawdon*

The microscopic examination of different grades of commercial wrought iron shows that the structure of this material is not always as simple as is usually described. Certain grades, if the microscopic examination is properly carried out, show a peculiar characteristic mottled or banded appearance upon etching. This is shown to be associated with a nonuniform distribution of phosphorus within the individual ferrite crystals. The occurrence of this unusual type of microstructure in specimens which failed in service and which had the appearance of "fatigue" breaks suggests a possible relation between this type of structure and failure by "fatigue." (Sept. 20, 1917.) 25 pp. Price, 5 cents.

T98. The Effects of Heat on Celluloid and Similar Materials.....*H. N. Stokes and H. C. P. Weber*

A study of the behavior of celluloid, and of pyroxylin plastics in general, when heated to different temperatures under varying conditions. Decomposition was found to commence in the neighborhood of 100° C, and above this temperature the heat of decomposition may raise the temperature of the mass to the ignition point. At 170° C, decomposition takes place with explosive violence. Pyroxylin plastics can be ignited by momentary contact with bodies having a temperature of 430° C, and upward. The rate of combustion is 5 to 10 times that of poplar, pine, or paper under the same conditions. The vapors evolved during the decomposition of pyroxylin plastics are poisonous and extremely combustible, and may be ignited by the heat of decomposition. (Oct. 15, 1917.) 40 pp. Price, 5 cents.

T99. Gas-Mantle Lighting Conditions in Ten Large Cities in the United States..*R. S. McBride and C. E. Reinicker*

From a careful inspection of about 4500 gas-mantle lamps in service in 10 cities a summary of the condition of mantles, glassware, pilot light, and other particulars was made in order to determine to what extent the customer benefited through periodic maintenance service.

By these observations it is found that a lamp not on regular maintenance is likely to be defective 5½ times as frequently as a lamp which is regularly maintained. Also it is shown that on the average one in three of the lamps on regular maintenance was not in good condition, whereas the defects noted in the lamps not so maintained average more than one for every lamp.

The principal defects in maintenance systems were also investigated and one satisfactory system of estimating the expenses for maintenance work together with a set of unit costs is presented, based upon the analysis of the operation of 10 gas companies. A suggested table of costs for each type of unit is given. (Oct. 29, 1917.) 37 pp. Price, 10 cents.

T100. Determination of Absolute Viscosity by Short-Tube Viscosimeters.....*Winslow H. Herschel*

The Engler and the Saybolt Universal viscosimeters, which are the instruments usually employed in the oil trade, have such short outlet tubes that the equation for the flow through long capillary tubes is not applicable without correction factors. The literature has been carefully reviewed and further experimental work has been done. The conclusion is reached that water is not a suitable liquid for use in finding the relation between viscosity and time of discharge for short-tube viscosimeters, and that Ubbelohde's equation, and all others based upon it, are seriously in error. (Nov. 9, 1917.) 55 pp. Price, 10 cents.

T101. Tests of Large Bridge Columns.*J. H. Griffith and J. G. Bragg*

The investigation gives a comparative analysis of the experimental data found upon 18 large bridge columns when they were tested in the 10 000 000-pound testing machine. The action of each column as a whole was studied in a range of loadings taken to destruction of the members. Numerous observations were made to determine the behavior of lattice bars, pin plates, diaphragms, etc. The causes and effects of initial strain from riveting and fabrication were discussed. (June 27, 1918.) 139 pp. Price, 30 cents.

T102. The Properties of Portland Cement having a High Magnesia Content.....*P. H. Bates*

A series of cements have been burned in the experimental rotary kiln of the Bureau in which the limestone used in the raw material was replaced in part or in whole by dolomite. Cements were thus obtained in which the magnesia content varied from 1.77 to 25.53 per cent. The clinker produced was examined petrographically to determine the constituents present, their amount, and the character of their formation. The clinker was also ground and the usual physical properties of the resulting cement determined. The results obtained show that cements when containing not more than approximately 8 per cent magnesia will produce concretes with satisfactory strength at the end of one and one-half years. At this amount of magnesia, monticellite, and spinel (constituents not present in cement of lower magnesia content) appear; and these cements seem to hydrate with a large increase in volume. (Jan. 19, 1918.) 42 pp. Price, 15 cents.

T103. Typical Cases of the Deterioration of Muntz Metal (60 : 40 Brass) by Selective Corrosion....*H. S. Rawdon*

T104. The Effect of the Size of Grog in Fire-Clay Bodies.. .....*F. A. Kirkpatrick*

The size of grain has considerable influence upon the properties of mortars, concretes, fire-clay refractories, and other materials. The present investigation establishes the effect of the size of the calcined portion, or grog upon the properties of fire-clay bodies within a field of practical sizes. Strength of the raw bodies depended upon a number of factors and did not vary directly with the size of the grog. Strength of burned bodies increased directly with decrease of the size of grog. Other properties determined were resistance to temperature change, porosity, and volume shrinkage. Methods are suggested for proper proportioning of grog for glass pots, saggers, and similar bodies. (Mar. 12, 1918.) 39 pp. Price, 10 cents.

T105. Comparative Tests of Porcelain Laboratory Ware... .....*C. E. Waters*

Comparative tests of two American, two German, and one Japanese ware showed that only the last and one German make stood up well when suddenly heated or cooled. Cracks in the glaze formed under the tongs when hot pieces were picked up. At times the dishes broke. The solubilities in various reagents showed that all kinds were about equally resistant. The stains caused by ignition with ferric oxide are superficial and do not depend upon the formation of easily soluble silicates. (Dec. 10, 1917.) 8 pp. Price, 5 cents.

T106. Stabilized-Platform Weighing Scale of Novel Design.....*F. J. Schlink*

Treating of the theory and design of a new type of check-stabilized weighing scale in which the usual stabilizing element is replaced by a flexible elastic connector, to the end of eliminating practically all of the friction inherent in early stabilizing mechanisms, with the result that the total frictional resistances in the scale are sensibly independent of the position of the load on the platform. By this expedient, the utilization of check-stabilized scales is broadened and the accuracy of this type of weighing device is much increased.

The earlier types of stabilizing elements are illustrated and the limitations of each explained. The paper includes a discussion of the effects of static friction on the indications of scales and the manner in which the elimination of this increases the accuracy of weighing. (Mar. 12, 1918.) 28 pp. Price, 5 cents.

T107. Comparative Tests of Chemical Glassware..... .....*Percy H. Walker and F. W. Smither*

Composition, coefficient of expansion, refractive indices, condition of strain, effects of heat and mechanical shock, and resistance to various chemical reagents were determined on seven kinds of glassware, which bear permanent manufacturers' trade-marks, and which are offered for sale

on the American market. Two of these kinds of glass were of foreign manufacture. The tests, which were intended to furnish information as to the relative values of the different makes of glass for laboratory operations, show that the five kinds of American-made ware are distinctly superior to one of the foreign brands and at least equal to the other foreign brand. (Apr. 5, 1918.) 23 pp. Price, 10 cents.

T108. Ground Connections for Electrical Systems . . . . *O. S. Peters*

An investigation to determine the best methods of grounding electrical systems for the purpose of promoting safety to life, and also to determine the effectiveness of the methods in common use. The ground covered includes laboratory work at the Bureau and field work in cities in different parts of the United States. The main conclusion reached is that for the best degree of safety water pipes should be used for grounding wherever they are available. Where water pipes can not be reached a common ground wire connected to earth at many points offers the next best means of reducing danger from electrical systems. Except in certain favored localities to obtain a good degree of safety by the use of a single driven pipe or plate on an electrical circuit is impracticable. (June 20, 1918.) 224 pp. Price, 30 cents.

T109. Conservation of Tin in Bearing Metals, Bronzes, and Solders . . . . . *G. K. Burgess and R. W. Woodward*

Recommendations are made for means of conserving tin in bearing metals, bronzes, and solders by substitution of other alloys or constituents of the alloys. Tables are also given showing the properties of the substituted alloys. (In press.)

T110. The Influence of Quality of Gas and Other Factors upon the Efficiency of Gas-Mantle Lamps . . . . . *R. S. McBride, W. A. Dunkley, E. C. Crittenden, and A. H. Taylor*

The paper discusses the various conditions such as gas quality, gas pressure, gas adjustment, and air adjustment which affect the operation of mantle lamps, and describes the methods and apparatus employed to control these variables and study their separate effects. The results obtained are given and their application to practical operation is touched upon. The work of other investigators upon variouse phases of the same problem is briefly summarized. (Oct. 25, 1918.) 49 pp. Price, 15 cents.

T111. The Compressive Strength of Large Brick Piers. *J. G. Bragg*

The paper comprises the final report on an investigation of the strength of large brick piers, which was conducted in the Pittsburgh laboratory of the Bureau in cooperation with the National Brick Manufacturers' Association. Tests were made on 46 piers 30 inches by 30 inches by 10 feet high, and 4 supplementary piers of the same cross-sectional dimensions by 5 feet high. Transverse, compression, and absorption tests were made on each lot of bricks used. The bricks used were representative of four districts east of Mississippi River. Two or more grades of brick were obtained from each district. Three kinds of mortar were used in the beginning and three grades of bond and workmanship employed throughout the investigation. (Sept. 20, 1918.) 39 pp. Price, 10 cents.

T112. Standardization of the Saybolt Universal Viscosimeter . . . . . *Winslow H. Herschel*

A disadvantage of the Saybolt Universal Viscosimeter, in comparison with the Engler instrument, was that it had not been standardized with respect to its dimensions. The work herein described removes this objection. An equation for calculating viscosity from time of flow has also been derived, by the method described in T100. (June 27, 1918.) 25 pp. Price, 10 cents. (2d Edition in press.)

T113. Determination of Permeability of Balloon Fabrics. . . . . *Junius David Edwards*

The paper presents the results of an investigation of methods for determining the permeability of balloon fabrics to hydrogen. (July 2, 1918.) 31 pp. Price, 10 cents.

T114. A Portable Cubic-Foot Standard for Gas...*M. H. Stillman*

The paper treats of a new type of cubic-foot standard for measuring gas which because of its combined portability, accuracy, and ease of operation possesses decided advantages over the apparatus of this type commonly in use at the present time. The standard is especially well adapted to the needs of traveling inspectors of gas-meter testing apparatus.

The use of the standard in testing meter provers is much facilitated by a new auxiliary meter-prover scale which may be quickly applied to any prover.

The author was granted a patent, dedicated to the public, on the cubic-foot standard described. (Jan. 28, 1919.) 13 pp. Price, 5 cents.

T115. New Baumé Scale for Sugar Solutions.....
.....*Frederick Bates and H. W. Bearce*

Many different Baumé scales have been proposed and used in the past. At the present time there are still in use in the United States three different scales for liquids heavier than water. Two of these, namely, the Holland scale and the Gerlach scale, are used in sugar work. Neither is adapted to modern requirements. The new table lies between the Holland and Gerlach scales and has three important advantages which should commend it for general use. They are: (1) It is based upon the specific gravity values of Plato, which are considered the most reliable of any available; (2) it is based on 20° C, the most convenient and widely accepted temperature for sugar work; and (3) it is based on the modulus 145, which has already been adopted by the Manufacturing Chemists' Association of the United States, by the Bureau, and by all American manufacturers of hydrometers. (Oct. 30, 1918.) 11 pp. Price, 5 cents.

T116. Silica Refractories—Factors Affecting Their Quality and Methods of Testing the Raw Materials and Finished Ware.....*Donald W. Ross*

This paper consists chiefly of data obtained in research work on silica refractories (raw materials and finished ware). The experimental work consists of heating tests on silica materials, conducted to determine amount, speed and nature of volume, porosity, and specific gravity changes, occasioned in such materials by various heat treatments. Specific gravity determinations on leading varieties of commercial bricks, screen analyses of raw commercial brick mixes, petrographic examinations, and minor tests were also conducted.

Available data relating to manufacture of ware and geology of raw materials have been included. This work is largely a concentration of existing information, but whenever possible, original data have been obtained. In conclusion, a tentative set of specifications, developed from presented data, for the testing of silica refractories is given.

T117. Toluol Recovery.....
....*R. S. McBride, C. E. Reinicker, and W. A. Dunkley*

This paper gives a description of toluol plant construction and operation, a discussion of the various results which can be obtained, and a brief outline of the cost of carrying out this recovery. A discussion of the relation of toluol recovery to standards for gas service is also given. Typical forms of contracts which the Ordnance Department has used in contracting for the construction and operation of Government owned toluol recovery plants in connection with city gas works are also given. (Dec. 19, 1918.) 60 pp. Price, 10 cents.

T118. A Critical Study of the Ledebur Method for Determining Oxygen in Iron and Steel.
.....*J. R. Cain and E. Pettijohn*

Various sources of error in the Ledebur method, hitherto unrecognized, are described and means for avoiding these are given. Special forms of apparatus and a special procedure are described. The reducibility of oxides likely to be present in steels and irons is investigated. The limited practical use of the Ledebur method is discussed. (Jan. 11, 1919.) 33 pp. Price, 5 cents.

T119. The Ultra-Violet and Visible Transmission of Eye-Protective Glasses..... *K. S. Gibson and H. J. McNicholas*

Eighty-two samples of eye-protective glass have been studied in regard to their transmission of ultra-violet and visible radiations. For each specimen is given the trade name, dealers, color, thickness, per cent transmission curve from 230 to 700 mu, and the total transmission factor for visible radiations.

Previous work is outlined, methods and agreements discussed, and comparisons made of the various glasses as regards their protection against ultra-violet radiations.

T120. Tests of Hollow Building Tiles.
..... *Bernard D. Hathcock and Edward Skillman*

The principal tests discussed are those of compression and absorption which together total about 250. Strain readings were taken upon some of these with an 8-inch Berry strain gage for determining the limit of proportionality and the moduli of elasticity. Besides the compressive strengths and moduli of the tiles, the results show the relationships existing between the moduli of elasticity and the compressive strengths, the color of the tiles and their compressive strengths, the colors of the tiles and their moduli of elasticity, the percentages of absorption and the compressive strengths, and the percentages of absorption and the colors of the tiles. (Feb. 8, 1919.) 29 pp. Price, 5 cents.

T121. Strength and Other Properties of Wire Rope.
..... *J. H. Griffith and J. G. Bragg*

The paper presents the results of tensile tests upon 275 wire-rope specimens selected under the specifications of the Isthmian Canal Commission. The specimens ranged in diameter from one-fourth inch to three and one-fourth inches and comprised five of the more common classes used in engineering practice. The laws of construction of the specimens were determined and were used as the basis of the analysis of their physical behaviors under stress. Numerous comparative physical and chemical tests were presented of the wires, fibers, and lubricants used in wire rope construction.

T122. Tests of Eighteen Concrete Columns Reinforced with Cast Iron..... *John Tucker, jr., and J. G. Bragg*

The paper deals with data obtained from tests of concrete columns of unusual design which were made by Mr. L. J. Mensch, contracting engineer, of Chicago, and tested in the Pittsburgh laboratory of the Bureau of Standards. Tests were made on 18 columns of 13 inches cross section, the lengths varying from 6 to 14 feet. Tests were also made on samples of cast-iron reinforcement and concrete used in their construction. The construction details, methods of testing, and results obtained are fully discussed with a view to ascertaining the suitability of cast iron as a reinforcing material. A formula for variation of strength with length is given.

T123. Physical and Chemical Tests of the Commercial Marbles of the United States..... *Daniel W. Kessler*

An examination of masonry buildings and monuments which were constructed a few decades ago will readily show a great difference in the durability of various types of stone. Many important monuments which were expected to stand for centuries show marked signs of disintegration before one century has passed. Hence a study of the properties of the different deposits of stone is important in order to determine their relative value for use in commerce and in the arts. The relation between the physical properties of stone and its serviceability is not well understood. This investigation is the first step in an extensive program to establish more definitely by laboratory methods the relative value of different deposits of stone for building purposes.

CIRCULARS

[For publications in following list that are out of print or procurable only from Superintendent of Documents, Government Printing Office, Washington, D. C., and also dates of last editions, see the supplement to this Circular.]

C1. (Now in preparation. Will cover the organization, functions, and work of the Bureau.)

C2. Measurements of Length and Area, Including Thermal Expansion.

Gives the regulations under which length and area measuring apparatus, such as engineers' tapes, yard and meter standards, end standards, machine-shop gages, precision screws, and calipers are tested by the Bureau, shipping directions, schedule of fees, etc. The fundamental standards of length are described, the inter-relationship of the various units of length is given, and the methods of comparisons of length standards are outlined. 21 pp. Price, 5 cents.

C3. Design and Test of Standards of Mass.

Contains general information on the fundamental standards of mass; a classification of weights into groups according to use (industrial or scientific); tolerances, and specifications for the construction of weights in each class; a discussion of the several methods of testing and adjusting weights; tables and formulas for correction of weighings for the buoyancy of the air, etc. The regulations governing the testing of weights by the Bureau of Standards and a schedule of fees for such testing are included. 89 pp. Price, 15 cents.

C4. Verification of Standards of Capacity.

Gives shipping directions and a schedule of fees for metal capacity measures tested by the Bureau of Standards. 2 pp.

C5. Testing of Clinical Thermometers.

The edition of July 16, 1917, is considerably revised to announce new regulations, effective July 1, 1917, governing the certification of clinical thermometers. Past practice was to issue certificate in the form of a table of corrections at four points, 96°, 100°, 104°, and 108° F; the new certificate will be issued only for thermometers correct within 0.1° F at normal and 0.2° F at 104 and will contain the statement that the thermometer is correct within these tolerances.

The Circular contains a full description of the method of testing clinical thermometers and considerable matter of general interest concerning these instruments. 57 pp. Price, 5 cents.

C6. Fees for Electric, Magnetic, and Photometric Testing.

States the kinds of tests performed and gives the fees established by the Bureau for tests of electric, magnetic, and photometric standards, measuring instruments, and materials. It supersedes the schedules of fees given in older editions of the various circulars upon these subjects, editions of which have been published since 1913 without the lists of fees. The fundamental units used as the basis of measurement are summarized. Specific instructions are given as to arranging for tests and shipping apparatus. 30 pp. Price, 5 cents.

C7. Pyrometer Testing and Heat Measurements.

Information is given concerning the high-temperature scale, including a list of melting and boiling points suitable for calibration of pyrometers. Descriptions, precautions in use, and the methods of calibration of the various types of pyrometers are given, including thermoelectric, electrical resistance, optical, and radiation instruments. There is also given a list of the tests in heat measurements that the Bureau is equipped to carry out. 19 pp. Price, 5 cents.

C8. Testing of Thermometers.

A brief textbook on precision thermometers. After a brief explanation of test requirements and general conditions of test, the methods used in testing various classes of thermometers are briefly described. Considerable space is devoted to a consideration of the methods of using thermometers, the errors to which they are liable, and the precautions to be observed in their use. The principal types of laboratory thermometers, such as primary standard, laboratory and special, calorimetric and Beckmann low-temperature and high-temperature, etc., are considered in some detail, and also a few topics of general interest to users of thermometers. Electric resistance and thermoelectric thermometers are briefly described. General instructions to applicants for tests and fee schedules 31, 32, 33, 34, and 35 complete the circular. 52 pp. Price, 10 cents.

C9. Testing of Glass Volumetric Apparatus.

Contains standard specifications for glass volumetric apparatus, describes the methods of test employed at the Bureau, and gives directions for submitting apparatus for test. The Circular also includes a schedule of fees for testing volumetric apparatus. 32 pp. Price, 10 cents.

C10. Legal Weights (in pounds) per Bushel of Various Commodities.

Shows the legal weights per bushel of various commodities, as fixed by national legislation mainly for customs purposes and by the State legislatures for purposes of commerce within the States. 10 pp. Price, 5 cents.

C11. Standardization of Bomb Calorimeters.

Primarily intended to accompany the standard heat samples which are sold by the Bureau. It contains a brief discussion of some of the principles underlying the construction and use of bomb calorimeters, also information as to the manipulation of such calorimeters and the computation of results. The schedule of fees for standard heat samples and for the testing of bomb calorimeters is included. 17 pp. Price, 5 cents.

C12. Verification of Polariscopic Apparatus.

This Circular gives list of polariscopic tests, schedule and fees, and regulations concerning testing of polariscopic apparatus. (July 16, 1906.) 7 pp. [Superseded by C44.]

C13. Standard Specifications for Incandescent Electric Lamps.

These are the specifications under which tungsten and carbon filament incandescent electric lamps are purchased by the Federal Government. They describe in detail (1) the requirements as to the mechanical and physical characteristics of lamps, (2) the method of initial inspection and the selection of representative samples, and (3) the conditions under which these samples are tested for life at specified efficiencies. Although prepared primarily for use of the Government departments, these specifications are recognized as standard by the manufacturers and are used in contracts by many other purchasers of lamps. Only those thoroughly instructed in the art of lamp manufacture and in the science of photometry should undertake to determine the acceptability of lamps under the terms specified. 14 pp. Price, 10 cents.

C14. Analyzed Irons and Steels—Methods of Analysis.

Outlines methods used by chemists of the Bureau for determining C in steels and irons (direct combustion method), Si, Ti (in irons), P, S, Mn, Cu, Mo (small amounts), Ni, Cr, V, and W. 17 pp. Price, 10 cents.

C15. The International Unit of Light.

As a result of comparisons between the unit of light maintained at the Bureau of Standards, Washington; at the Laboratoire Central d'Électricité, Paris; at the National Physical Laboratory, London; and at the Physikalish-Technische Reichsanstalt, Berlin, an agreement was reached whereby a common unit, to be called the international candle, was adopted by the first three laboratories mentioned, and the simple ratio of nine-

tenths was adopted for the ratio of the German Hefner unit to the international candle.

This Circular contains the announcement which was made simultaneously in America, France, and England relative to the new unit. It contains also statements concerning (1) the different standards in use by the gas and the electrical industries; (2) the indorsement which various engineering bodies in this country and England gave to the movement for a common unit; and (3) the accuracy with which the light unit is maintained by means of incandescent electric lamps. 7 pp. Price, 5 cents.

C16. The Testing of Hydrometers.

Contains standard specifications for hydrometers, the basis of certain arbitrary scales, and the methods employed at the Bureau in the testing of hydrometers. The Circular also includes directions for submitting apparatus for test and a schedule of fees for the testing of hydrometers. 16 pp. Price, 5 cents.

C17. Magnetic Testing.

Deals with the fundamental magnetic quantities, with empirical formulas giving the relations between these quantities, with typical data of magnetic materials, and with the methods of magnetic measurements employed at the Bureau of Standards. 50 pp. Price, 15 cents.

C18. Standard Gage for Sheet and Plate Iron and Steel.

A statement of the law establishing this standard; giving the thicknesses and weights per unit area corresponding to the various gage sizes. 4 pp. Price, 5 cents.

C19. Standard Density and Volumetric Tables.

Contains standard density tables and others of a similar nature most often required in physical and chemical laboratories. For example, the density of water at all temperatures from 0° to 102° C; the density of various percentages of ethyl alcohol at various temperatures; temperature corrections to the indications of hydrometers in alcohol, sugar, and sulphuric-acid solutions; tables showing the relation between specific gravity and degrees Baumé for both heavy and light liquids; tables for determining the capacities of glass vessels from the weight of water contained or delivered; master scales for the graduation of hydrometers to indicate percentages of ethyl alcohol by weight or by volume or percentages of proof spirit. 67 pp. Price, 15 cents.

C20. Electrical Measuring Instruments.

The object of this Circular is to present briefly the fundamental principles involved in the construction and operation of commercial electrical measuring instruments, together with such information concerning the advantages and limitations of the various types of instrument as will assist the user in the determination of the general type best suited to a given purpose. The question of sources of error has been treated in some detail, with a threefold purpose—first, to suggest how some errors can be avoided; second, how corrections may be made for known sources of error; third, to furnish suggestions which will assist those who have to specify instrument performance or to select instruments.

Some space has been given to a discussion of apparatus for use in the precision testing of electrical instruments in the laboratories of central stations, public-service commissions, and colleges. Some important points in regard to the design of electrical instruments are briefly discussed. 57 pp. Price, 15 cents.

C21. Precision Measurements of Resistance and Electromotive Force.

Contains information concerning measurements and standards of resistance and electromotive force. The tests made by the Bureau of Standards of resistance standards, resistance apparatus, standard cells, and the electrical properties of conductors are described, and the specifications which such apparatus and material must meet in order to be accepted for test are included. General instructions are given for those who wish to submit

apparatus or material to the Bureau of Standards for any of the tests described.

In the testing, information has been collected concerning the behavior of resistance apparatus, and some of this, which may be of interest to the users or intending purchasers of such apparatus, is given. 30 pp. Price, 5 cents.

C22. Standard Specifications for Transformers, Oil-Immersed, Self-Cooled, 60-Cycle, 2200 Volts.

These specifications provide a standard for the purchase of transformers of the type most frequently used by Government departments and by other purchasers. They have been drawn with the cooperation of Government engineers and of representatives of leading manufacturers, with the purpose of securing the most serviceable apparatus on the market, and at the same time to admit the regular product of leading manufacturers. 12 pp.

C23. Standardization of Electrical Practice in Mines.

A committee was appointed by the American Mining Congress in 1909 to investigate the electrical practice in mines and to make recommendations for standardizing it. The Bureau of Standards was represented on this committee, and undertook a study of electrical mining laws and practice in conjunction with the committee. This Circular contains the preliminary report of the committee and the results of the Bureau's study. Proposed rules for the installation and use of electricity in mines are given together with explanatory statements and suggestions for avoiding the particular dangers due to the electric wires in mines. About half of the circular is devoted to the electrical mining laws in effect in the several States and foreign countries.

This Circular has not been revised because this work, undertaken before the Bureau of Mines was established, has since been taken over by that bureau. Inquiries for further information of this character should be addressed to the Bureau of Mines, Washington, D. C. 93 pp. Price, 15 cents.

C24. Publications of the Bureau of Standards.

Gives titles of all four series—scientific papers, technologic papers, circulars, and miscellaneous publications. The list is numerically arranged in each series and each title is accompanied by an abstract. A full index facilitates reference to publications on specific subjects. 149 pp.

C25. Standard Samples—General Information.

Describes the functions and methods of preparing standard samples for use in analysis and gives summarized tables of analyses of the samples now being issued, together with prices and directions for ordering. 16 pp. Price, 5 cents.

C26. Analyzed Iron and Manganese Ores—Methods of Analysis.

The essential details of the methods employed at the Bureau of Standards in the analysis of the standard analyzed samples of iron and manganese ores are described and a brief statement of the methods used by the other analysts cooperating in this work is given. The following determinations are considered, viz, SiO_2, P, S, Al_2O_3, Ti, V, Fe (total and ferrous), available O, Mn, CaO, MgO, Na_2O, K_2O, H_2O, and CO_2. 20 pp. Price, 5 cents.

C27. The Testing and Properties of Optical Instruments.

The properties of optical instruments are discussed. The principal errors in uncorrected lenses are enumerated and the methods of correcting these errors are outlined. The testing of lenses and optical instruments is described, and the fees for optical tests, including refractive index, are stated. 15 pp. 41 pp. Price, 10 cents.

C28. The Determination of the Optical Properties of Materials.

This Circular treats briefly: (1) The fundamental laws of the reflection, absorption, and transmission of light; (2) the fundamental data or visual sensibility; (3) the specifications of color; (4) the characteristics and the testing of absorption and diffusion screens, such as colored spectacle glasses, photographic "ray filters," signal glasses, white matt surfaces, etc.; and (5) refractometry. 19 pp. Price, 5 cents. [Out of print. Not to be reprinted. Withdrawn from circulation and to be superseded by future publications.]

C29. Announcement of a Change in the Value of the International Volt.

The international volt was for many years defined in terms of the electromotive force of the Clark cell. It was found that the Weston cell was superior to the Clark as a standard, and at the London International Electrical Congress of 1908 the Weston normal cell was adopted to replace the Clark cell as the international standard, and a special international committee was authorized to determine the value to be assigned as the electromotive force of the Weston normal cell. Accordingly, a joint investigation was undertaken at this Bureau by representatives of the national laboratories of England, France, Germany, and the United States.

The number decided upon as the electromotive force of the Weston normal cell was 1.0183 international volts at 20° C. This value was announced as effective on January 1, 1911. The unit is maintained by intercomparisons of standard cells by the national laboratories. 13 pp. [Superseded by C60 and will not be reprinted.]

C30. Lime: Its Properties and Uses.

A brief description of the manufacture and properties of lime, and a discussion of the suitability of different kinds of lime for the various building and chemical industries. 22 pp. Price, 5 cents.

C31. Copper Wire Tables.

These tables are in terms of the international standard values for the resistivity, temperature coefficient, and density of copper, which were adopted in 1913 by the International Electrotechnical Commission and were based on experimental investigations made at this Bureau. A historical discussion of standard values is given.

It was found necessary, in preparing the tables, to give considerable attention to the subject of wire gages. A history of wire gages and an account of the trend of present practice is given, together with a detailed consideration of the American wire gage.

The tables are comprehensive. Besides numerous tables giving the relations of resistance, length, and mass for standard sizes, there are tables of standard resistivities and temperature coefficients, wire gages, cables, and aluminum wire. The tables are duplicated in English and metric units.

Certain auxiliary questions are treated in appendices. These include: (1) The expression of the various kinds of resistivity and units thereof; (2) calculation of the constant connecting the change of resistivity with the temperature from the known law of proportionality between temperature coefficient and conductivity; (3) data on the density of copper; (4) calculation of the resistance and mass of cables; (5) international standard of resistance for copper. This Circular is a very complete compendium. Persons who desire only a wire table for working purposes should apply for the Copper Wire Table Card, listed on page 107, under "Miscellaneous." 76 pp. Price, 20 cents.

C32. Standards for Gas Service.

This Circular is intended as an impartial and, as nearly as may be, an accurate summary of the facts which must be considered in connection with regulations affecting quality of gas and gas service. It has been prepared with the cooperation of many engineers and inspectors. It is, therefore, believed to reflect the opinion of the industry as well as to give the findings and recommendations of the Bureau.

A form is proposed for a model city gas ordinance, and rules are suggested for adoption of State public-service commissions. The technical matters involved are fully discussed, and a summary is given of all regulations in force in cities larger than 25 000 and in all States. 197 pp. Price, 35 cents.

C33. United States Government Specification for Portland Cement.

Gives in detail the Government specification for Portland cement and describes the standard methods of testing. Additional sections are devoted to methods of chemical analysis and to interpretation of results of tests. There are included, also, the auxiliary specifications for testing sieves and specific-gravity flasks. 43 pp. Price, 10 cents.

C34. The Relation of the Horsepower to the Kilowatt.

Various values have been given for the number of watts in a horsepower. The uncertainty of this equivalent arises from the fact that the value of the horsepower was originally expressed in gravitational units. As ordinarily used, the magnitudes of such units as the pound force, the foot-pound, etc., vary from place to place because of the variation of gravity. James Watt defined the horsepower as 550 foot-pounds per second. Using the value of the acceleration of gravity at the place where the experiments upon which the definition was based were made, this equals 746 watts. This value has the authority of long usage, is a convenient round number, and is the value which was recommended by the British Association Committee on Units in 1873. Using this value of 746 watts, the variation from place to place of the number of local foot-pounds per second in a horsepower is shown in the circular by tables. The "continental horsepower," which is used on the continent of Europe, is equal to 736 watts. It is thus over 1 per cent different from the horsepower used in the United States and Great Britain. Modern practice tends more and more toward the universal use of the kilowatt and the disuse of the horsepower. This practice is recommended by the Bureau. 16 pp. Price, 5 cents.

C35. Melting Points of Chemical Elements, and Other Standard Temperatures.

Contains a complete list of the melting points in centigrade and Fahrenheit degrees of all the chemical elements and the boiling points of materials used as thermometric standards, as determined at the Bureau and elsewhere. 2 pp. Price, 5 cents.

C36. The Testing and Properties of Electric Condensers.

In this circular the properties of the various types of condensers are discussed and tests are indicated by which the important properties of a condenser may be determined. Especial attention is given to mica condensers, but in addition air, paper, compressed gas, oil, and glass condensers are considered. The important constants of representative condensers of each class are given, and the characteristics of a good condenser of each type are stated. 26 pp. Price, 5 cents.

C37. Electric Wire and Cable Terminology.

The Bureau, in cooperation with the Standards Committee of the American Institute of Electrical Engineers, investigated the confused terminology of electric wires and cables in 1912. Numerous persons and companies submitted their ideas and practices, and from them a standard set of definitions was evolved. These definitions are now accepted as standard in the industry. The circular gives standard definitions of "strand," "cable," and fifteen other principal terms. Each definition is accompanied by explanatory remarks, and in most cases is illustrated with a picture of the kind of conductor defined. The technical definitions of the terms are not far from the original common meanings of the words. A discussion of stranded conductors is included, giving the standard stranding for conductors of stock sizes. 13 pp. Price, 5 cents.

C38. The Testing of Rubber Goods.

Gives the methods in use at the Bureau of Standards in the testing of rubber goods. The various physical tests commonly employed are described in detail, and the machines used for this purpose, many of which were designed at the Bureau, are illustrated and described in detail. Data are given showing the effect of various factors on the tensile properties of rubber. Special attention is given to the effect of temperature on the physical tests. The circular also contains a brief outline of the methods of collecting crude rubber and the processes used in the manufacture of various rubber articles.

The methods used in the chemical analysis are given, together with an explanation of the reasons for making these tests and their significance.

The methods of analysis and specification of the Joint Rubber Insulation Committee for 30 per cent Hevea insulation are given.

Regulations are given concerning the conditions under which tests are made for State and municipal governments and private parties. 89 pp. Price, 15 cents.

C39. Specifications for and Measurement of Standard Sieves.

Discusses the methods of weaving the cloth used in such sieves, especially as they affect the question of tolerances to be allowed. Methods of use of the sieves, particularly in fineness tests of cement, are also given.

The specifications for standard sieves of 100, 200, 20, and 30 meshes per linear inch prepared by this Bureau and adopted by the Departmental Conference on Portland Cement Specifications are given. Methods of test and the forms of certificates and reports which this Bureau will issue are described, together with general instructions to applicants for tests. Later revised specifications for the 200-mesh sieve will be found in Technologic Paper No. 42.

It is expected that this Circular No. 39 will be revised soon to include specifications for the standard screen scale recently adopted by a conference of representatives of various engineering and technical societies, Government bureaus, and private firms. This screen scale covers the range of openings from 8 mm to 0.044 mm and is intended to meet the needs of all industries using sieves for testing purposes. 14 pp. Price, 5 cents.

C40. Sodium Oxalate as a Standard in Volumetric Analysis.

The considerations leading to the choice of sodium oxalate as a primary standard, especially for oxidimetry, are discussed. The methods for the purification and testing of sodium oxalate are described and its stability and hygroscopic properties are considered. Methods for using sodium oxalate as an oxidimetric and acidimetric standard are described, together with a consideration of the accuracy thereby attainable. 13 pp. Price, 5 cents.

C41. Testing and Properties of Textile Materials.

Gives an outline of the procedure used at the Bureau of Standards for determining the identity, average length, percentage of moisture, percentage of oil, and other foreign matter of unspun fiber; the length, tensile strength and elongation, yarn number, twist, percentages of loading, sizing, and coloring material, and fiber composition of yarn, thread, and twine; and the weight, tensile strength and elongation, fiber composition, number of threads per inch, yarn number, folding endurance, and fastness of color of fabrics.

There are also given instructions regarding applications for test and shipment of samples and a schedule of the usual fees payable for tests. 26 pp. Price, 10 cents.

C42. Metallographic Testing.

The following subjects are discussed: (1) Scope of the science of metallography; (2) thermal analysis; (3) microscopic analysis; (4) chemical and mechanical testing of metals as auxiliaries to metallographic examination.

Metals are tested to determine their structure, including homogenity; previous history, including heat and mechanical treatments; suitability for specific uses and in fulfillment of specifications, and for the determination of causes of failure. The apparatus and methods used by the Bureau in metallographic testing are briefly described. 16 pp. Price, 5 cents.

C43. The Metric Carat.

Announces the change from the use of the old carat weight for weighing precious stones to that of the metric carat of 200 milligrams, adopted as a standard July 1, 1913, by the dealers in precious stones in this country and by the United States Government. Tables of the relation of the old and the new metric carat are given, together with precautions and requirements for the accurate weighing of gems. 12 pp. Price, 5 cents.

C44. Polarimetry.

Gives the basic principles of modern polarimetry, including a resumé of the work done at this Bureau and elsewhere in this field. It consists of 196 pages with 35 pages of conveniently arranged tables and is adequately illustrated. Detailed descriptions of the more common types of polariscopes, saccharimeters, and apparatus are given, together with

methods of use, testing, etc. Considerable space is devoted to methods of sugar analysis, together with numerous tables. The preparation and testing of pure sucrose and dextrose is discussed. The United States Treasury Department sugar regulations are given. The results of recent researches are fully discussed, including the basis of standardization of the modern saccharimeter. The circular is of particular interest to the scientific investigator as well as persons engaged in the sugar industries. 196 pp.

C45. The Testing of Materials.

Describes the Bureau's work of testing structural and miscellaneous materials. A section is devoted to each principal class of materials, describing the sources, properties, uses, and methods of tests. The introduction treats of the theory of the testing of materials as leading to the development of standards of quality; regulations governing testing and fees are also given. 89 pp. Price, 10 cents.

C46. The Testing of Barometers.

This circular, which is equally concerned with aneroid and mercurial barometers, is written for the guidance of persons who are already familiar with the normal operation of such instruments and desire them standardized at the Bureau. A brief enumeration of the defects and errors to be guarded against is followed by a schedule of fees for the various tests. 12 pp. Price, 5 cents.

C47. Units of Weight and Measure; Definitions and Tables of Equivalents.

Supersedes the previous publication "Tables of Equivalents of United States Customary and Metric Weights and Measures" and in its new form includes definitions of the various units, with recognized multiples and subdivisions, the spelling and abbreviations adopted by the Bureau, as well as tables of equivalents from 1 to 999 units of the units of length, area, volume, capacity, and mass in the customary and metric systems. 68 pp. Price, 15 cents.

C48. Standard Methods of Gas Testing.

Contains suggestions as to the location and equipment of gas-testing laboratories, a description of some of the accepted forms of apparatus, directions for the making of the various tests, and recommendations as to the interpretation of experimental results. It applies to work to be done in the official inspection of gas quality and gas service, especially that relating to heating value, candlepower, purity, and specific gravity of the gas and the pressure at which it is supplied. 202 pp. Price, 40 cents.

C49. Safety Rules to be Observed in the Operation of Electrical Equipment and Lines.

A set of suggested rules to govern employers of workmen engaged in work on or about electrical equipment or lines and to govern the employees in their work. The two sections addressed to employers deal with requirements resting upon the operating organization, choice of employees, training, and like questions, including the provision of means by which employees can comply with the rules addressed directly to them.

The rules for employees comprise general precautions, the division of responsibility, specific rules for handling live parts, and procedures for the protection of employees working near live and moving parts.

Under special sections are included rules addressed to various classes of electrical workmen, including operators in stations, on lines overhead and underground, arc-lamp inspectors or trimmers, testing-room employees, meter workers, signal-line employees, and workers in tunnels or subways.

The purpose of the rules is to place before employers and employees alike, in convenient form, rules which have been found to promote safety in the operation of electrical equipment and lines. 50 pp. Price, 10 cents. [Superseded by C54.]

C50. National Standard Hose Couplings and Fittings for Public Fire Service.

The Boston fire of 1872 and the Baltimore fire of 1904 emphasized the dangers of nonuniformity in fire-hose couplings. In spite of much agitation of the subject, little was done toward introducing an adopted standard until 1904. This circular gives the history of the movement, which culminated in the adoption of the national standard specifications by some dozen organizations. Couplings made according to these specifications have been put into service in 897 cities and towns. The specifications for the standard coupling are given and the method to be followed during transition from old to national standard. 34 pp. Price, 5 cents.

C51. Measurement of Time and Tests of Timepieces.

Gives the regulations under which tests of timepieces are carried out at the Bureau of Standards, particularly tests of high-grade adjusted watches. The methods of test are described, and suggestions are given on the use and care of a watch. The sources of reliable standard time for the comparison of a watch are enumerated, and a table of the points of change of time in going from one standard-time section to another in the United States is given. The circular also gives the necessary directions for the submission of watches for test and a schedule of the fees charged. 39 pp. Price, 15 cents.

C52. Regulation of Electrotyping Solutions.

This circular has been entirely rewritten and enlarged. The technical matter relates principally to the operation of copper electrotyping baths. The definitions of electrical terms and tables of equivalents and useful electrochemical data are of interest to electroplaters as well as electrotypers. 13 pp. Price, 10 cents.

C53. The Composition, Properties, and Testing of Printing Inks.

A circular of general information on the subject of printing inks. The composition of some of the more common types of ink is given, together with a brief description of the constituents which are usually present. The processes in use for the manufacture of printing inks are described, the requisites for a good ink are discussed, and tests are given for determining the quality of an ink.

The circular also includes an abstract of the procedure for the analysis of printing inks already published by the Bureau. 35 pp. Price, 10 cents.

C54. National Electrical Safety Code.

A code of rules for electrical construction and operation, to safeguard electrical practice. The code is divided into four parts. Part I, on electrical supply stations, requires safe surroundings for station equipment, the proper isolation or guarding of live parts, according to voltage and use, the suitable grounding of machine frames, and the provision of adequate working spaces. Part 2, on electrical line construction, requires certain specified clearances and separations for supply and signal lines and certain strength, according to climatic conditions, to preserve these clearances. For underground lines the necessary spacing and accessibility are required. Part 3, on electrical utilization equipment, contains accident-prevention requirements for the electrical wiring and equipment of factories and homes. Part 4, on electrical operation, includes operating safety rules addressed to employers and employees concerned in electrical work. A supplementary section gives rules for grounding equipment and lines. Each part is accompanied by an explanatory discussion of its requirements. All the interested national electrical associations, commissions, and many other organizations have cooperated in its preparation and criticism, and the code may fairly be stated to be the most complete and satisfactory electrical safety code yet prepared. It will be revised from time to time by the Bureau to keep it abreast of practice. 323 pp. Price, 20 cents.

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C55. Measurements for the Household.

The purpose of this circular is (1) to give information as to units, methods, and instruments of measurement useful in household activities, (2) to describe available means of assuring correct quantity in articles bought by weight and measure, and (3) to give other facts of interest which would awaken an appreciation of the rôle of measurement in daily life.

This circular gives general information concerning the various kinds of measurement involved in household activities, such as measurement of purchases, measurements of heat, light, electricity, water, gas, humidity, density, pressure, and time. Emphasis is laid upon the practical application of this information. The broader aspect of measurement is considered as related to efficiency in household management. While trade weights and measures is an important part of the circular, in view of the growing interest in domestic science the other sections will prove of particular interest and value. 149 pp. Price, 15 cents.

C56. Standards for Electric Service.

The factors determining the adequacy and safety of electric service are discussed in connection with the regulation of such service by State public-service commissions. Regulatory rules for State adoption and ordinances for cities are proposed. All electric-service rules now enforced by public-service commissions and municipalities are collected and compared, and a specification for the acceptance of types of electricity meters is proposed for adoption by such commissions. 262 pp. Price, 45 cents.

C57. United States Standard Tables for Petroleum Oils.

Consists of tables for the use of those engaged in the oil industry. Tables 1, 2, and 3 give the specific gravity, degrees Baumé, and the volume of oil at 60° F from the values of these quantities observed at other temperatures. Tables 4 and 5 give the relations between specific gravity, degrees Baumé, and pounds per gallon. 64 pp. Price, 15 cents.

C58. Invar and Related Nickel Steels.

This circular is mainly a composition from many sources of the properties of nickel steels, with particular reference to the properties of invar. There are chapters on magnetic, electrical, thermal, and mechanical properties, applications, sources, with brief statements on microstructure and constitution. 68 pp. Price, 10 cents.

C59. United States Standard Baumé Hydrometer Scales.

Gives the origin, history, and present status of the Baumé scales in use in the United States, with special reference to the Baumé scale for petroleum oils. It is intended to counteract the misleading statements recently published outside the Bureau in regard to the Baumé scale. 13 pp. Price, 5 cents.

C60. Electric Units and Standards.

A unified treatment is given of the principal units and standards in electricity and magnetism, the available information on which has hitherto been scattered over an extensive literature. This circular takes the place of various previous publications of the Bureau dealing with fragments of the subject. The circular includes a historical treatment, a classification of the units and systems of units, a discussion of the status of the magnetic units, a description of the fundamental electrical standards, the laws on electric units, conversion factors, and a bibliography. 68 pp. Price, 15 cents.

C61. Specifications and Tolerances for Weights and Measures and Weighing and Measuring Devices.

These specifications and tolerances for weights and measures and weighing and measuring devices are designed to eliminate weights and measures which are false, without prejudice to such as conform as closely as is mechanically possible to the standards, and those which are of such construction that they are faulty, are not reasonably permanent in their indication or adjustment, or are designed to or may be used to facilitate the

perpetration of fraud. They were first adopted in 1913, and from time to time additions and amendments have been made until the present edition includes proper requirements for nearly all kinds of devices found in commercial use.

The classes of apparatus treated are linear measures; capacity measures, including glass graduates; measuring pumps; scales of all types; and weights. 44 pp. Price, 10 cents.

C62. Specifications for and Methods of Testing Soaps.

A brief description of the general nature of soap is followed by recommended specifications for several commonly used varieties. The specifications contain methods of sampling and testing, which are made a part of each specification. 25 pp. Price, 5 cents.

C63. Specification and Tests for the Transparency of Paper and Tracing Cloth.

Comprises an elementary explanation of the method used at the Bureau, a detailed description of the apparatus and experimental methods, a discussion of accuracy, a standard formula for the specification, some general information relative to transparency of tracing cloth, routine instructions to applicants for tests, and a schedule of tests and fees. 8 pp. Price, 5 cents.

C64. Rules and Regulations for Enforcement of Lime-Barrel Act.

The rules and regulations contained in this circular are those which are authorized by section 4 of the act to standardize lime barrels (Public No. 228, 64th Congress), which reads as follows: "Sec. 4. That rules and regulations for the enforcement of this act, not inconsistent with the provisions of the act, shall be made by the Director of the Bureau of Standards and approved by the Secretary of Commerce, and that such rules and regulations shall include reasonable variations or tolerances which may be allowed." The text of the act is included as an appendix. 7 pp. Price, 5 cents.

C65. Gas Calorimeter Tables.

A condensed set of operating and computing instructions for use with a flow gas calorimeter and tables of correction data. 19 pp. Price, 5 cents.

C66. Standard Samples for Thermometric Fixed Points.

Description of methods of preparation, analysis, and determination of melting points of tin, zinc, aluminum, and copper to be issued by the Bureau as standard samples for reproducing certain fixed points of the temperature scale. 13 pp. Price, 5 cents.

C67. Combined Table of Sizes in the Principal Wire Gages.

A table combining in one series the sizes in the American (B. & S.), Steel, Birmingham (Stubs'), British Standard, and Metric Wire Gages, arranged in order of diameters of wires. It gives the diameters of all the gage numbers in these five systems in mils, inches, and millimeters, also the cross sections in square mils, circular mils, square inches, and square millimeters. The table is specially useful to manufacturers who wish to determine the nearest equivalent in American or British gage sizes of wires specified in millimeters or square millimeters, or vice versa. 5 pp. Price, 5 cents.

C68. Public Utility Service Standards of Quality and Safety.

A brief outline of the public service activities of the Bureau together with lists of the publications bearing on the various subjects which are issued by the Bureau. The subheadings giving the public service activities are: Standards for Electric Service, Standards for Gas Service, Standard Methods of Gas Testing, National Electrical Safety Code, Electrolysis Mitigation, and Further Activities. 8 pp. Price, 5 cents.

C69. Paint and Varnish.

This publication is intended to give, without unnecessary detail, information which should be of value to those interested in the use of paint and varnish. After a general discussion and classification of paints and varnishes and an explanation of the process of "drying" the raw materials, including oils, driers, thinners, resins, and pigments that enter into the composition of paint or varnish, are individually described. The methods of manufacture and of testing varnishes are presented, ready-mixed or prepared paints are discussed, and somewhat detailed instructions on mixing paints and stains, on color blending, and on the application of paint and varnish to various surfaces are given. Specifications in common use for many of the materials treated, and a glossary of painters' terms also appear. 85 pp. Price, 15 cents.

C70. Materials for the Household.

Describes the more common materials used by the household, comprising paint materials, cement, clay products, lime, plasters and stucco, wood, metals, bituminous roofing, inks and dyes, adhesives, paper, textiles, rubber, leather, cleansers and preservatives, fuels, illuminants, lubricants, and a concluding chapter on quantity in the purchasing of materials. Each title is treated under the general heads of composition and definition, sources, properties, uses, tests, preservation, hints as to selection and use, and references. 259 pp. Price, 25 cents.

C71. Rules and Regulations Promulgated Under Authority of the Federal Standard Barrel Law.

Section 3 of the Federal standard barrel law (38 Stat., ch. 158, p. 1186 63d Cong., 3d sess.) reads in part as follows:

"SEC. 3. That reasonable variations shall be permitted and tolerance shall be established by rules and regulations made by the Director of the Bureau of Standards and approved by the Secretary of Commerce * * *."

This Circular contains the rules and regulations which are authorized by the quoted part of the above law. The text of the law is included as an appendix to the publication. 8 pp. Price, 5 cents.

C72. The Scope and Application of the National Electrical Safety Code.

This Circular is intended to aid those to whose attention the safety code has been called and those who are contemplating its adoption or use in acquiring the necessary familiarity with its intent and scope. The need for the code is explained and examples of personal injuries by electricity are given, most of them avoidable by observance of the rules. The method of arrangement of the code to promote its convenient use and the intended manner of application of the code by engineers and inspectors are briefly explained. A short summary is also given of the provisions of each of the four principal parts of the code.

As the code is being adopted on trial by many administrative bodies and public utility companies, it is expected that this circular will facilitate its introduction and aid in its interpretation. 84 pp. Price, 20 cents.

C73. Copper.

This Circular deals primarily with the physical properties of pure and of commercial grades of copper. The best data and values are given for the various physical characteristics and constants, together with a bibliography of the sources from which these values are taken. The effect of impurities upon the properties of copper is discussed as well as the influence of various factors in its manufacture. 103 pp. Price, 20 cents.

C74. Radio Instruments and Measurements.

This Circular is a treatise on radio measurements for use by Government officers, radio engineers, and others concerned. The Circular includes a development of the essential theory of high-frequency measurements from simple but precise low-frequency theory, the use of reactance curves in the rapid solution of problems, descriptions of radio instruments, and

formulas and data for radio work. The full treatment of fundamental principles will make this Circular serve as a foundation for later publications which may be issued by the Bureau on the general subject of radio communication. 341 pp. Price, 60 cents.

C75. Safety for the Household.

Describes the seriousness of household hazards from fire, gas, electricity, and lightning, the nature of such hazards, and the precautions which should be taken to insure safety for the household. Illustrations are given to show the dangers of short-circuiting, of spontaneous combustion and other fire risks, and of gas accidents; and methods of safeguarding against lightning. Under the headings of fire and electricity a series of brief cautions are given. 127 pp. Price, 15 cents.

C76. Aluminum and its Light Alloys.

The physical properties of aluminum and its light alloys are described and the effect of temperature, different manufacturing operations, and impurities upon these properties are discussed.

C77. The Table of Unit Displacement of Commodities.

This Circular, showing (1) the number of pounds of material per cubic foot as packed for shipment, (2) the number of cubic feet of space required for a short ton, (3) the number of cubic feet of space required for a long ton, and (4) the manner in which the it is packed, lists several hundred commercial commodities alphabetically. Appendixes give special information concerning automobiles, canned fruits and vegetables, and fresh fruits and vegetables.

This table has been prepared to meet an immediate demand for such information and will be revised and augmented from time to time as further data are obtained. The Bureau will, therefore, be pleased to receive information, criticisms, and suggestions from those interested in the table. 67 pp. Price, 10 cents.

C78. Solders for Aluminum.

The use, serviceability, method of application, and composition of solders for aluminum are discussed in the light both of special tests made at the Bureau on commercial and other compositions of solders and of general experience with them. All soldered joints are subject to rapid corrosion and disintegration and are not recommended except where protection from corrosion is provided. Suitable compositions for solders are obtained by the use of tin with addition of zinc or both zinc and aluminum within wide percentage limits. 10 pp. Price, 5 cents.

C79. Electrical Characteristics and Testing of Dry Cells.

This Circular summarizes the available information on dry cells. A brief description of the materials and methods of construction, and elementary theory of the operation of the cells is given. The various sizes and kinds of dry cells on the American market are described. The electrical characteristics of the cells and methods of testing them are discussed. In an appendix are given the proposed specifications for dry cells which have been prepared by the Bureau.

Last Edition and Date of Circulars

Circular No.	Edition.	Date.	Circular No.	Edition.	Date.	Circular No.	Edition.	Date.
1	2	(?)	28	1	Mar. 1, 1911	55	1	Aug. 28, 1915
2	5	Apr. 30, 1915	29	1	Dec. 31, 1910	56	1	July 28, 1916
3	3	Dec. 23, 1918	30	1	Apr. 15, 1911	57	2	May 11, 1916
4	2	Jan. 3, 1905	31	3	Oct. 1, 1914	58	1	Apr. 4, 1916
5	3	July 16, 1917	32	3	Mar. 10, 1915	59	1	Apr. 5, 1916
6	7	Dec. 30, 1916	33	4	Apr. 25, 1918	60	1	Sept. 25, 1916
7	5	Oct. 1, 1913	34	3	May 15, 1915	61	1	Nov. 13, 1916
8	2	June 30, 1911	35	2	Jan. 1, 1915	62	1	Dec. 16, 1916
9	9	May 2, 1918	36	1	June 30, 1912	63	1	May 17, 1917
10	3	May 9, 1918	37	2	Jan. 1, 1915	64	1	Apr. 20, 1917
11	3	June 23, 1917	38	3	July 19, 1915	65	1	July 23, 1917
12	1	July 16, 1906	39	1	Dec. 16, 1912	66	1	July 25, 1917
13	8	Apr. 13, 1918	40	2	May 15, 1913	67	1	Jan. 17, 1918
14	5	Mar. 20, 1916	41	2	Aug. 27, 1915	68	1	Oct. 6, 1917
15	3	July 1, 1911	42	1	Sept. 1, 1913	69	1	Nov. 17, 1917
16	4	Feb. 23, 1916	43	1	Nov. 1, 1913	70	1	Dec. 5, 1917
17	3	Mar. 18, 1916	44	2	Jan. 30, 1918	71	1	Sept. 18, 1917
18	2	July 1, 1911	45	1	Nov. 1, 1913	72	1	June 17, 1918
19	5	Mar. 30, 1916	46	2	July 15, 1914	73	1	June 25, 1918
20	2	May 28, 1915	47	1	July 1, 1914	74	1	Mar. 23, 1918
21	1	Mar. 1, 1910	48	2	June 10, 1916	75		Jan. 10, 1918
22	2	May 15, 1911	49	2	May 4, 1915	76	1	Mar. 10, 1919
23	1	July 15, 1910	50	2	June 8, 1917	77	1	Jan. 28, 1919
24	5	Apr. 14, 1919	51	1	Dec. 1, 1914	78	1	(*)
25	6	June 20, 1917	52	2	June 28, 1918	79	1	(*)
26	3	May 26, 1913	53	1	Mar. 29, 1915			
27	2	Aug. 9, 1918	54	2	Nov. 15, 1916			

* In press.

MISCELLANEOUS PUBLICATIONS.

[For Publications in Following List that are Out of Print or Procurable Only from Superintendent of Documents, Government Printing Office, Washington, D. C., see the supplement to this Circular.]

M1. Manual of Inspection and Information for Weights and Measures Officials.

This manual is designed primarily for official sealers and inspectors appointed to enforce weights and measures laws or ordinances, but it will also be of use to any one who has occasion to inspect and test weights and measures and weighing and measuring devices of the types ordinarily found in commercial use. It contains specifications and tolerances and complete instructions for the testing of all kinds of scales, length measures, liquid and dry capacity measures, etc.; general instructions concerning the enforcement of law; lists of standards and apparatus; a method of keeping office records, etc. Appendixes are included containing Federal weights and measures laws, with rules and regulations, the model State law in relation to weights and measures, a description of the metric system, and general tables, conversion tables, and tables of equivalents. (Nov. 14, 1918.). 246 pp.

M2. The International Metric System of Weights and Measures.

This pamphlet gives a brief historical sketch and description of the metric system, its various units and their uses, shows the methods of formation of the various tables, and closes with the statement of the legal status of the metric system in the United States and two pages of equivalents of customary and metric measures. 15 pp. Price, 10 cents.

M3. The International Metric System. (Chart.)

This graphic chart is printed in colors and shows the comparison of the customary with the metric weights and measures, including the yard, meter, avoirdupois pound, half troy pound; quart, liter, and liquid quart; foot and 3 decimeters; inch and 25 milometers. The chart is designed for use in schools, laboratories, shops, and exporting and importing offices. It gives a concise statement of the metric system and the method of forming names of the units and the tables and gives the more important equivalents between the customary and the metric measures.

M4. First Annual Conference on the Weights and Measures of the United States (1905).

Contains a record of the proceedings of the first meeting of State weights and measures officials and other delegates, which was called by the Bureau of Standards with the intention of assisting weights and measures officials so as to enable them to make a thorough and efficient inspection and test of weights and measures. A further purpose was to bring about a close cooperation between the State officials and the Bureau of Standards, with a view to obtaining the enactment of proper weights and measures laws in the States with as high a degree of uniformity among them as the varying conditions in the different States would permit, and to the end that the benefits of a proper enforcement of adequate laws on this subject might be brought to the people. A paper was read at this conference giving a short history of the standard weights and measures of the United States, tracing the source of the fundamental standards recognized in this country and including a list of the standards furnished the various States by the Federal Government, and reports were given by the delegates on the status of the weights and measures situation in their respective States. The laboratories of the Bureau were open to the delegates so that they might get information as to methods employed at the Bureau in testing weights and measures and weighing and measuring apparatus. 46 pp. Price, 10 cents.

M5. Second Annual Conference on the Weights and Measures of the United States (1906).

At this meeting reports were made by the delegates on various questions affecting weights and measures in their respective States, bringing out the extent of the organization of weights and measures work in the different States represented, and throwing light upon various ways in which fraud is perpetrated on the public; a paper was read by the secretary of the conference dealing with the weights and measures inspection services of Great Britain, Germany, France, and Austria; the question as to whether a weights and measures official should be compensated by fees or salary was discussed; and the matter of drawing up a model law was referred to the executive committee. 60 pp. Price, 15 cents.

M6. Third Annual Conference on the Weights and Measures of the United States (1907).

At this conference an address was made by the Secretary of Commerce and Labor; reports were given by the various delegates on matters of interest affecting weights and measures; a paper dealing with the kinds of weights and measures fraud encountered and various sources of loss to the public was read; and proposed national and State legislation along weights and measures lines was discussed and adopted in tentative form. 110 pp. Price, 25 cents.

M7. Fourth Annual Conference on the Weights and Measures of the United States (1908).

Contains an address by the Assistant Secretary of Commerce and Labor and by the president of the conference; an opinion of the solicitor of the Department of Commerce and Labor, approved by the Attorney General, as to the extent of the authority in the weights and measures field granted to Congress under the Constitution of the United States; reports of delegates from the various States; discussion of proposed national legislation; resolutions recommending that authority be conferred upon the Bureau of Standards to pass upon all types of weighing and measuring apparatus before they be permitted in use, urging Congress to enact a law requiring containers to be marked with their net contents, and recommending other national weights and measures legislation. 78 pp. Price, 15 cents.

M8. Fifth Annual Conference on the Weights and Measures of the United States (1910).

Contains an address by the Secretary of Commerce and Labor; report ot the secretary of the conference; reports of the delegates; short reporf on the weights and measures investigation conducted by the Bureau of Standards; paper dealing generally with the subject of weights and measures; discussion of weights and measures bills before Congress; resolutions indorsing Bureau of Standards weights and measures investigation, recommending the passage by Congress of a net-contents-of-container law, and setting forth that the high cost of living is intimately associated with weights and measures; report of committee on the formation of a full weight and measure association, and of the committee on constitution and by-laws. 123 pp. Price, 15 cents.

M9. Sixth Annual Conference on the Weights and Measures of the United States (1911).

Contains addresses by the Secretary of Commerce and Labor and the president of the conference; report of the secretary of the conference; reports of delegates; report on an investigation of the condition of weights and measures in commercial use in the United States conducted by the Bureau of Standards; paper on railroad-track scales; discussions on tolerances for weighing and measuring apparatus, legislation for uniform sizes of containers, a bill to fix sizes of certain containers, and uniform State legislation governing weights and measures; report of committee on organization of a full weight and measure league; report of the committee on State legislation; and appendix containing draft of proposed uniform law on weights and measures for adoption by the States. 158 pp. Price, 20 cents.

M10. Seventh Annual Conference on the Weights and Measures of the United States (1912).

Contains an address by the Secretary of Commerce and Labor; reports of delegates; address by the chairman of the Committee on Coinage, Weights, and Measures of the House of Representatives; report of the secretary of the conference; papers on the subjects of legislation enacted by the various States during the preceding year, method of keeping sealers' records, and platform scales; address by the State superintendent of weights and measures of New York and by the commissioner of weights and measures of New York City; discussions on the formation of a national association of weights and measures, on the net-contents-of-container law, on the changing of the date of holding the conference, and on placing weights and measures officials under civil service; reference to an inspection of weights and measures conditions throughout the United States conducted by the Bureau of Standards; review of weights and measures bills pending before Congress; report on the progress made by the committee on tolerances and specifications; resolution favoring the enactment by Congress of a law requiring all foodstuffs put up in packages to be marked in terms of standard weight or measure; answers to questions relating to the inspection of scales, double-ended measures, bottomless measures, counter tacks, wooden dishes, inspection of meters, sale of ice, sale of lard in pails, and testing scales of railroads and express companies. 186 pp. Price, 20 cents.

M11. Eighth Annual Conference on the Weights and Measures of the United States (1913).

Contains addresses by the Secretary of Commerce, the Assistant Secretary of Commerce, and the president of the conference; report by the secretary of the conference; reports by the delegates; remarks by the secretary of internal affairs of Pennsylvania; papers on the subjects of weights and measures legislation enacted by the States during the preceding year, content-of-container law, Federal regulation of weighing and measuring apparatus, testing of dry gas meters, uniformity of State laws on weights per bushel of commodities, difference in the amount of a bushel of a commodity when sold by weight and when sold by measure, testing of water meters, design and construction of scales, notes on scales, functions of a State sealer of weights and measures, testing of capacity measures, and seals and methods of sealing; discussions on proposed amendments and additions to the model State law on weights and measures, on the necessity for civil-service protection for sealers of weights and measures, on the need for inspection of scales owned by the United States, and on the place, time, and duration of sessions of the next meeting; reports of the committee on resolutions and of the committee on tolerances and specifications; resolutions indorsing a bill to establish a standard barrel, favoring the adoption of the metric carat weight, favoring civil service for weights and measures officials, and recommending that the Bureau of Standards be given authority to pass upon and authorize the use of weighing and measuring apparatus; answers to questions relating to the authority to test scales in postoffices, the weight of a gallon of milk, and the weighing of coal mined in West Virginia; and appendix containing the model State law on the subject of weights and measures. 291 pp. Price, 35 cents.

M12. Ninth Annual Conference on the Weights and Measures of the United States (1914).

Contains addresses by the Secretary of Commerce and by the president of the conference; report of the secretary of the conference; papers on the subjects of the net-weight amendment to the national food and drugs act, the metric system, creamery, prescription and jewelers' weighing and measuring appliances, glass graduates suitable for weights and measures officials, the weights and measures of Porto Rico, and the necessity of maintaining scale levers level and the lever connections plumb; announcement of an inspection and demonstration of the railroad-track scale equipment of the Bureau of Standards and of a hearing before the House Committee on Coinage, Weights, and Measures; discussions on the Tuttle-Weeks produce-barrel

bill, on tolerances and specifications, and on the place of the next meeting; reports of committee on constitution and by-laws and committees on resolutions; reports and miscellaneous papers submitted by various State and local weights and measures officials; and answers to questions relating to the size of beer barrel, proposed legislation in Virginia in relation to selling dry commodities by weight or count, and the relation of State universities to weights and measures work. 176 pp. Price, 20 cents.

M13. Tenth Annual Conference on the Weights and Measures of the United States (1915).

Contains addresses by the Secretary of Commerce and by the president of the conference; reports by delegates; report of the secretary; remarks by the collector of internal revenue of the Philippine Islands; report of railroad-track scale tests conducted by the Bureau of Standards; papers on the subjects of testing of electric meters, a method of adjusting railroad-track scales, automatic scales, weights and measures work from the standpoint of the efficiency engineer, system of keeping records, and the standard-barrel law; discussion on the Ashbrook bill; report of committee on constitution and by-laws and of committee on tolerances and specifications, and discussions thereon; resolutions relating to the appointment of a committee to investigate elevator, hopper, and grain scales, in opposition to fee system of inspection, recommending uniformity of legislation and of tolerances and specifications, for establishing a national board of examiners, inviting scale experts and manufacturers to give papers at next conference, and favoring sale of dry commodities by weight; section requiring sale of dry commodities by weight added to model law; and appendix containing the three forms of the model State law. 254 pp. Price, 50 cents.

M14. Eleventh Annual Conference on the Weights and Measures of the United States (1916).

Contains an address by the Secretary of Commerce; remarks by the president of the conference; report of the secretary; reports by the delegates; papers on the subjects of proper publicity for a weights and measures department, the selection and maintenance of apparatus in industrial plants, liquid measuring pumps, inspection and testing of track scales, installation and maintenance of track scales, recent development in heavy track-scale construction, and regulations for the weighing of coke; remarks by various manufacturers; discussion and indorsement of a bill before Congress to substitute centigrade for the Fahrenheit scale of temperature in Government publications; discussion of proper method of sale of fruits, vegetables, etc.; report of committee on tolerances and specifications and discussion thereon; reports of the committee on constitution and by-laws and of the committee on the metric system; remarks by the secretary of internal affairs of Pennsylvania; resolutions concerning the observance of a national weights and measures week, the sale of wrapped meats, the indorsement of the metric system, the appointment of a committee on public education, and the passage of Ashbrook bill; and appendix containing the specifications and tolerances for weights and measures and weighing and measuring devices, as adopted by the conference, and paper on measuring pumps. 194+44+27 pp. Price, 35 cents.

M15. Some Technical Methods of Testing Miscellaneous Supplies, Including Paints and Paint Materials, Inks, Lubricating Oils, Soaps, etc.

In this publication are assembled methods, chiefly chemical, which have been found useful in a large number of cases in testing miscellaneous materials purchased either under definite specifications or examined for prospective purchases in competition with other samples of a similar nature. As a general rule, the methods described are not original but have been compiled from a variety of sources and modifications introduced when necessary. (Nov. 15, 1916.) 68 pp. Price, 15 cents.

M16. Report to the International Committee on Electric Units and Standards.

The London conference on electric units in 1908 appointed a committee to maintain the standards and to fix the value of the Weston normal cell. The committee arranged a joint investigation of the fundamental electrical standards, which was conducted at this Bureau in 1910 by representatives of the national laboratories of England, France, Germany, and this country. Important intercomparisons were made of the resistance standards, the standard cells, and the silver voltameters of the four countries. The value finally recommended for the Weston normal cell was 1.0183 international volts at 20°C. (Jan. 1, 1912.) 207 pp. Price 30 cents.

M17. Copper-Wire Table (English and Metric).

This card gives two abbreviated copper-wire tables, in English units on one side of the card and in metric units on the other. It is of convenient size and form for use on the desk, in the shop, etc. 1914. 2 pp. For more complete information on the electrical properties of copper see Circular No. 31.

M18. National Bureau of Standards—Description of work of Bureau.

Gives brief historical sketch of the Bureau; describes the various branches of its work. The paper is descriptive and general in character. This publication is now being combined with material for a new edition of Circular No. 1.

M19. Proceedings of the Second Annual Textile Conference held at the Bureau of Standards (1917).

Gives proceedings of a textile conference at the Bureau at which representatives of the industries and the Government and textile technologists were present. A series of papers on important textile problems was given by mill superintendents, scientific investigators, and technical experts, followed in each case by pertinent discussion. The program included such topics as humidity in mills, commercial grading, nomenclature, textile laboratories, methods of testing blankets, service tests, cotton and wool, classification of silks, valuation of dies, testing of Army cloth, and the like. 87 pp.

M20. Laws Concerning the Weights and Measures of the United States (First Edition, 1904).

This work contains the weights and measures laws of the United States, of the various States, and of Alaska, the District of Columbia, Hawaii, Philippine Islands, and Porto Rico. A table giving the legal weights per bushel of commodities, as fixed by these laws, is included.

State and National Laws Concerning the Weights and Measures of the United States (Second Edition, 1912).

This work contains the weights and measures laws of the United States, of the various States, and of Alaska, the District of Columbia, Hawaii, Philippine Islands, and Porto Rico. A table giving the legal weights per bushel of commodities, as fixed by these laws, is included.

M21. "Metric Manual for Soldiers." 16 pp.

M22. Annual Report of the Director for 1902.

M23. Annual Report of the Director for 1903.

M24. Annual Report of the Director for 1904.

M25. Annual Report of the Director for 1905.

M26. Annual Report of the Director for 1906.

M27. Annual Report of the Director for 1907.
M28. Annual Report of the Director for 1908.
M29. Annual Report of the Director for 1909.
M30. Annual Report of the Director for 1910.
M31. Annual Report of the Director for 1911.
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M33. Annual Report of the Director for 1913.
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M37. Annual Report of the Director for 1917.
M38. Annual Report of the Director for 1918.

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