

DEPARTMENT OF COMMERCE

CIRCULAR

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 24

PUBLICATIONS OF THE BUREAU OF STANDARDS

[4th Edition]

Issued July 1, 1913



WASHINGTON
GOVERNMENT PRINTING OFFICE

1913

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(A) INTRODUCTION

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 is given a classified descriptive list of these papers. The papers are issued in two separate series—(1) Scientific Papers, (2) Technologic Papers. The latter series will cover the more distinctly technologic work of the Bureau. 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. The papers will be sent upon request and may be designated by the numbers which precede the titles in the list. This list will be revised from time to time, and subsequent issues will be sent to those who request it. It is assumed that individuals generally are interested in a particular class of work; hence this method of distribution has been adopted in order that each may secure the particular information desired.

The regulations under which tests and comparisons are made by the Bureau and other general information concerning its work are issued in the form of circulars, which are sent upon request.

S. W. STRATTON,
Director.

(B) LIST OF SCIENTIFIC PAPERS ISSUED BY THE BUREAU OF STANDARDS

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1. Recomparison of the United States Prototype Meter (pp. 5-19).....*L. A. Fischer*
2. A Study of the Silver Voltmeter (pp. 21-37).....*K. E. Guthe*
3. The So-called International Electrical Units (pp. 39-76)..*Frank A. Wolff*
4. The Spectra of Mixed Gases (pp. 77-81).....*P. G. Nutting*
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7. On Fibers resembling Fused Quartz in their Elastic Properties (pp. 101-107).....*K. E. Guthe*
8. On the Temperature of the Arc (pp. 109-124).....
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14. Measurement of Inductance by Anderson's Method, using Alternating Currents and a Vibration Galvanometer (pp. 291-336).....*E. B. Rosa and F. W. Grover*
15. Use of Serpentine in Standards of Inductance (pp. 337-348).....*E. B. Rosa and F. W. Grover*
16. The Silver Coulometer (pp. 349-364).....*K. E. Guthe*
17. History of the Standard Weights and Measures of the United States (pp. 365-381).....*L. A. Fischer*

¹ The page numbers after each title refer to the volume of the Bulletin in which the paper appeared. Those who wish to obtain an article to which citation has been made only by volume and page number may request a copy by using the reprint number which precedes the title.

18. Wattmeter Methods of Measuring Power Expended upon Condensers and Circuits of Low Power Factor (pp. 383-397) *Edward B. Rosa*
19. The Relative Intensities of Metal and Gas Spectra from Electrically Conducting Gases (pp. 399-416) *P. G. Nutting*
20. The Use of White Walls in a Photometric Laboratory (pp. 417-420) *Edward P. Hyde*
21. Influence of Wave Form on the Rate of Integrating Induction Wattmeters (pp. 421-434)
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22. Detector for Very Small Alternating Currents and Electrical Waves (pp. 435-438) *L. W. Austin*
23. The Positive Charges Carried by the Canal Rays (pp. 439-441) *L. W. Austin*
24. Radiation from Platinum at High Temperatures (pp. 443-447) *G. K. Burgess*
25. A Five-Thousand Volt Generator Set (pp. 449-451) *P. G. Nutting*

1906. (THE BULLETIN, VOLUME 2)

26. Talbot's Law as Applied to the Rotating Sected Disk (pp. 1-32) *Edward P. Hyde*
27. A New Determination of the Electromotive Force of Weston and Clark Standard Cells by an Absolute Electrodynamicometer (pp. 33-70) *K. E. Guthe*
28. The Gray Absolute Electrodynamicometer (pp. 71-86) *Edward B. Rosa*
29. Construction and Calculation of Absolute Standards of Inductance (pp. 87-143) *J. G. Coffin*
30. An Efficiency Meter for Electric Incandescent Lamps (pp. 145-160) *E. P. Hyde and H. B. Brooks*
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38. Experiments on the Heusler Magnetic Alloys (pp. 297-316) *K. E. Guthe and L. W. Austin*
39. A Pocket Spectrophotometer (pp. 317-318) *P. G. Nutting*

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The first nine volumes of the bulletin comprise 203 scientific papers, giving the results of investigations in electricity, photometry, heat measurements, optics, weights and measures, and chemistry.

ELECTRICITY

The 99 papers in electricity describe:

(1) Researches upon fundamental electrical standards, e. g., determinations of the ampere and the ohm in absolute measure; a determination of v (the ratio of the electromagnetic to the electrostatic unit of electricity); investigations of standard cells used in establishing the international volt; researches in the determination of the ampere; and studies of the principles and history of international electrical units.

(2) Electrical instruments and methods of measurement developed or investigated at the bureau, e. g., electro-dynamometers for the measurement of wide ranges of current and of power; sealed resistance standards; deflection potentiometers; current and potential transformers; switchboard voltmeters and ammeters; mica and paper

condensers; vibration galvanometers; and generators and detectors for radiotelegraphy. Fifty papers treat of the theory and methods of measurement, e. g., effect of wave form upon electric instruments and upon magnetic hysteresis; resistance of 4-terminal conductors; precise methods of inductance and capacity measurement; calculation of inductance of almost every kind of electric circuit; magnetic testing of straight and of circular specimens; coupled circuits, and various quantitative experiments in radiotelegraphy.

(3) **Electric and magnetic properties of materials.**—The resistivity and temperature coefficient of copper, energy losses in steels and dielectrics, and the properties of the Heusler alloys, are treated.

PHOTOMETRY

The investigations in photometry are contained in 17 papers and include: Theory of photometric units and nomenclature; rotating lamp method; comparison of electric candlepower standards with those of other countries; various photometers and observing devices; and studies of illuminants.

HEAT

The work in heat measurements is included in 28 papers and comprises the following subjects:

(1) **Heat theory.**—The thermodynamic scale; definition of the ideal gas; on Wien's and Planck's laws; gas liquefiers; steam turbines.

(2) **High temperatures.**—The temperature of the arc; optical pyrometry; the melting points of and the radiation from platinum and palladium; the radiation from copper and copper oxide; melting points of metals; platinum resistance thermometry; methods of obtaining curves; and micropyrometry.

(3) **Thermometry.**—Testing of clinical thermometers; heat treatment of mercurial thermometers; calorimetric resistance thermometers; standard scale of temperature; sulphur boiling point; corrections for emergent stem of mercurial thermometers; thermometric lag.

OPTICS

The investigations in optics are contained in 39 papers and include:

(1) **Optical theory.**—Luminous equivalent of radiation; Fechner's law; polarimetric sensibility.

(2) **Instruments and methods of optics.**—Spectrophotometers; polariscopes; instruments and methods of radiometry, monochromatic light sources; resolving power of objectives; uses of interference bands; calorimetry.

(3) **Optical data.**—Gas spectra; optical rotation; wave lengths of neon; infra-red absorption and reflection spectra; selective radiation and absorption; radiation constants and the reflecting power of metals.

WEIGHTS AND MEASURES

Under the subject of weights and measures are four papers, as follows: A recomparison of the United States prototype meter; a history of the standard weights and measures of the United States; the testing of glass volumetric apparatus; and the density and thermal expansion of ethyl alcohol and its mixtures with water.

CHEMISTRY

The 15 papers in chemistry include: Analytic determination of iron, vanadium, manganese, and sulphur; methods of preparing sulphocyanic and chloroplatinic acids; use of sodium oxalate, potassium permanganate, and benzoic acid as chemical standards; action of light, air, and heat on oils; and atomic weights of hydrogen, chlorine, and bromine.

(A complete list of the papers, with brief abstracts, is given in the Circular of the Bureau of Standards, No. 24, a copy of which will be furnished on application to that bureau.)

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162. On the Computation of the Constant C_2 of Planck's Equation by an Extension of Paschen's Method of Equal Ordinates (pp. 393-406).....*Edgar Buckingham and J. H. Dellinger*
163. A Comparison of American Direct Current Switchboard Voltmeters and Ammeters (pp. 407-422).....*T. T. Fitch and C. J. Huber*
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169. Formulas and Tables for the Calculation of Mutual and Self Induction (2d edition, revised and enlarged) (pp. 1-237) *E. B. Rosa and Frederick W. Grover*
170. The Correction for Emergent Stem of a Mercurial Thermometer (pp. 239-267) *Edgar Buckingham*
171. A Determination of the International Ampere in Absolute Measure (pp. 269-393) *E. B. Rosa, N. E. Dorsey, and J. M. Miller*
172. Deflection Potentiometers for Current and Voltage Measurements (pp. 395-417) *H. B. Brooks*
173. Outline of Design of Deflection Potentiometers, with Notes on the Design of Moving-Coil Galvanometers (pp. 419-444) *H. B. Brooks*
174. The Determination of Total Sulphur in India Rubber (pp. 445-453) *C. E. Waters and J. B. Tuttle*
175. The Measurement of the Inducances of Resistance Coils (pp. 455-485) *Frederick W. Grover and Harvey L. Curtis*
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179. Wave-lengths of Neon (pp. 539-544) *I. G. Priest*
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181. The Fourth-Terminal Conductor and the Thomson Bridge (pp. 559-610) *Frank Wenner*
182. The Standardization of Potassium Permanganate Solution by Sodium Oxalate (pp. 611-642) *R. S. McBride*
183. Benzoic Acid as an Acidimetric Standard (pp. 643-650) *G. W. Morey*
184. A Tubular Electrodynamometer for heavy currents (pp. 651-658) *P. G. Agnew*
185. Thermometric Lag (pp. 659-714) *D. R. Harper, 3d*
186. Determination of Manganese as Sulphate and by the Sodium Bismuthate Method (pp. 715-740) *William Blum*

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187. A New Precision Calorimeter (pp. 1-5) *P. G. Nutting*
188. Instruments and Methods used in Radiometry, II (pp. 7-63) *W. W. Coblenz*
189. Antenna Resistance (pp. 65-72) *L. W. Austin*
190. Energy Losses in Some Condensers Used in High-Frequency Circuits (pp. 73-80) *L. W. Austin*
191. Selective Radiation from Various Substances, IV (pp. 81-117) *W. W. Coblenz*

192. On a Modified Form of Stability Test for Smokeless Powder and Similar Materials (pp. 119-129).....*H. C. P. Weber*
193. Atomic Weight of Bromine (pp. 131-150).....*H. C. P. Weber*
194. The Silver Voltameter—Part I. First Series of Quantitative Experiments (pp. 151-207).....
.....*E. B. Rosa, G. W. Vinal, and A. S. McDaniel*
195. The Silver Voltameter—Part II. The Chemistry of the Filter-Paper Voltameter and the Explanation of Striations (pp. 202-282)..*E. B. Rosa, G. W. Vinal, and A. S. McDaniel*
196. The Diffuse Reflecting Power of Various Substances (pp. 283-325).....*W. W. Coblenz*
197. Density and Thermal Expansion of Ethyl Alcohol and of Its Mixtures with Water (pp. 327-474).....
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198. A Micropyrometer (pp. 475-479).....*G. K. Burgess*
199. A Simplified Formula for the Change in Order of Interference Due to Changes in Temperature and Pressure of Air (pp. 479-481).....*I. G. Priest*
200. New Calorimetric Resistance Thermometers (pp. 483-492).....
.....*H. C. Dickinson and E. F. Mueller*
201. The Silver Voltameter—Part III. Second Series of Testing of Silver Nitrate (pp. 493-551).....
.....*E. B. Rosa, G. W. Vinal, and A. S. McDaniel*
202. Note on Cold-Junction Corrections for Thermocouples (pp. 553-565).....*P. D. Foote*
203. The Analysis of Alternating Current Waves by the Method of Fourier, with Special Reference to Methods of Facilitating the Computations.....*F. W. Grover*
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204. The Constants of Spectral Radiation of a Uniformly Heated Enclosure or So-Called Black Body, Part I.....*W. W. Coblenz*
205. Melting Points of the Refractory Elements. I—Elements of Atomic Weight from 48 to 59 (pp. 1-114).....
.....*G. K. Burgess and R. G. Waltenberg*

(C) LIST OF TECHNOLOGIC PAPERS ISSUED BY THE BUREAU OF STANDARDS

1911

1. The Effect of Preliminary Heat Treatment upon the Drying of Clays (53 pp.) *A. V. Bleininger*
2. The Strength of Reenforced Concrete Beams. Results of Tests of 333 Beams (first series) (200 pp.)
. *R. L. Humphrey and L. H. Losse*
3. Tests of Absorptive and Permeable Properties of Portland Cement Mortars and Concretes, Together with Tests of Damp Proofing and Waterproofing Compounds and Materials (127 pp.) *Rudolph J. Wig*
4. The Effect of Added Fatty and Other Oils upon the Carbonization of Mineral Lubricating Oils (14 pp.) *C. E. Waters*
5. The Effect of High-Pressure Steam on the Crushing Strength of Portland Cement Mortar and Concrete (25 pp.) *R. J. Wig*
6. The Determination of Chromium and its Separation from Vanadium, In Steels (6 pp.) *J. R. Cain*
7. The Testing of Clay Refractories, With Special Reference to Their Load Carrying Capacity at Furnace Temperatures (78 pp.) *A. V. Bleininger and G. H. Brown*
8. A Rapid Method for the Determination of Vanadium in Steels, Ores, etc., Based on Its Quantitative Inclusion by the Phosphomolybdate Precipitate (20 pp.) . . *J. R. Cain and J. C. Hostetter*

1912

9. The Density and Thermal Expansion of Linseed Oil and Turpentine (27 pp.) *H. W. Bearce*
10. The Melting Points of Fire Bricks (17 pp.) *C. W. Kanolt*
11. Comparison of Five Methods Used to Measure Hardness (27 pp.) *Ralph P. Devries*
12. Action of the Salts in Alkali Water and Sea Water on Cements (157 pp.) *P. H. Bates, A. J. Philips, and Rudolph J. Wig*

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1913.

13. The Evaporation Test for Mineral Lubricating and Transformer Oils (13 pp.) *C. E. Waters*
14. Legal Specifications for Illuminating Gas (31 pp.)
 *E. B. Rosa and R. S. McBride*
15. Surface Insulation of Pipes *Burton McCollum and O. S. Peters*
16. The Manufacture of Lime (130 pp.) *W. E. Emley*
17. The Function of Time in the Vitrification of Clays (26 pp.) .
 *G. H. Brown and G. A. Murray*
18. Electrolysis in Concrete. . *E. B. Rosa, Burton McCollum, and O. S. Peters*
19. Physical Testing of Cotton Yarns (31 pp.) *W. S. Lewis*
20. Determination of Sulphur in Illuminating Gas (46 pp.)
 *R. S. McBride and E. R. Weaver*
21. The Dehydration of Clays (23 pp.) . *G. H. Brown and E. T. Montgomery*
22. The Effect of Overfiring Upon the Structure of Clays (23 pp.) .
 *A. V. Bleininger and E. T. Montgomery*
23. The Technical Control of the Colloidal Matter of Clays
(118 pp.) *H. E. Ashley*
24. The Determination of Phosphorus in Steels Containing Vanadium (11 pp.) *J. R. Cain and F. H. Tucker*
25. Electrolytic Corrosion of Iron in Soils. . *Burton McCollum and K. H. Logan*

(D) DESCRIPTIVE LIST OF SCIENTIFIC PAPERS

I. ELECTRICITY

2. A Study of the Silver Voltmeter *K. E. Guthe*
A description of the various forms of silver coulometers 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.
3. 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 No. 102.)
6. 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. (Aug. 1, 1904.) 6 pp.
9. 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.
10. 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.
14. 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.

- 15. Use of Surpentine 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 paraffine are quite satisfactory. (Aug. 15, 1905.) 12 pp.

- 16. 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. (Sept. 1, 1905.) 16 pp.

- 18. 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.

- 21. Influence of Wave Form on the Rate of Integrating Induc-
tion 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.

- 22. 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.

- 23. 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.

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

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

- 27. A New Determination of the Electromotive Force of Weston
and Clark Standard Cells by an Absolute Electrody-
namometer *K. E. Guthe*

An account of the construction and determination of the constant of a Gray absolute electrodymanometer and work done with the same in determining the absolute value of the electromotive force of standard cells, assuming the international ohm. (Jan. 15, 1906.) 38 pp.

- 28. The Gray Absolute Electrodymanometer *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.

- 29. 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.

31. 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 formulæ used in their calculation all assume that the current flows in a continuous sheet over the cylindrical surface. In the paper formulæ 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.
33. 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. (Mar. 30, 1906.) 17 pp.
36. 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.
37. The 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.
38. 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.
41. 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.
42. The Mutual Inductance of Two Circular Coaxial Coils of Rectangular Section
 *E. B. Rosa and Louis Cohen*
 Various formulæ for calculating the mutual inductance of coaxial circles and coaxial circular coils of rectangular section are investigated, and some new formulæ derived. The best formulæ for particular cases are indicated; it is shown where some formulæ fail, and numerous examples are given to illustrate the formulæ. (Sept. 1, 1906.) 56 pp.
47. 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 formulæ 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.

48. The Compensated Two-Circuit Electro-dynamometer. . . *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.
56. The Mutual Inductance of a Circle and a Coaxial Single-Layer Coil. The Lorenz Apparatus and the Ayrton-Jones Absolute Electro-dynamometer. *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.
58. 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.
59. The Mutual Inductance of Coaxial Solenoids.
 *E. B. Rosa and Louis Cohen*
 A critical examination of various formulæ for calculating the mutual inductance of coaxial solenoids, with numerical examples to test and illustrate the formulæ. (Mar. 30, 1907.) 20 pp.
60. 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.
64. 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.
65. 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 obtained for the ratio of the units is 2.9963×10^{10} . (May 20, 1907.) 170 pp.
66. 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 25, 1907.) 18 pp.
67. 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 Paper No. 70.) (Aug. 16, 1907.) 18 pp.

70. 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.

71. 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.

73. 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.

74. On the Self-Inductance of a Torodial 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 is given. (Aug. 10, 1907.) 7 pp.

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

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

76. 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 formulæ 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.

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

An experimental investigation to determine a method of freezing 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 is investigated. A method of procedure for a complete ballistic test is outlined. (Sept. 3, 1907.) 70 pp.

79. 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. (Oct. 11, 1907.) 26 pp.

80. 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 formulæ are derived independently and some approximate formulæ made more accurate. (Sept. 15, 1907.) 44 pp.

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

The formulæ 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.

84. The Self-Inductance of a Solenoid of any Number of Layers..... *Louis Coken*

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.

87. 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.

88. 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.

90. 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.

93. 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 formulæ 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 formulæ and formulæ assuming a uniform distribution of current over the section of a coil to the actual cases of current flowing in insulated wires. The formulæ have all been tested in actual practice, and formulæ 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 formulæ. In an appendix fourteen tables of functions and constants are given which are useful in the calculation of inductances. (Oct. 1, 1907.) 132 pp.

94. 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.

95. A Method of 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.

96. 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 high 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.

100. 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.

101. 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.

102. 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 coulometer 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.

104. 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 since been adopted by the London International Electrical Conference.) (Sept. 3, 1908.) 28 pp.
106. 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.
107. 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.
108. Errors in Magnetic Testing with Ring Specimens. *Morton G. Lloyd*
 Discussion of the errors which may 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.
109. 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 kilograms 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.
111. 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.
112. 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.

114. 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.

116. 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.

117. 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.

119. 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.

126. 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.

127. 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.

129. 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.

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

A full 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.

- 134. 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.

- 137. 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 are 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.

- 138. 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, numerical examples are given to illustrate the use of the formula. (Feb. 1, 1910.) 14 pp.

- 139. 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 electrodyonometer 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.

- 140. 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.
 The Fleming Vacuum Detector. (Mar. 1, 1910.) 16 pp.

145. 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.

147. 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 per meter-gram at 20° C.) Expressed otherwise, the change of resistivity per degree C of any sample of copper is 0.000598 ohm per meter-gram or 0.00681 microhm per centimeter cube.

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.

148. 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 per 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 per meter-gram are set forth. The desirability of an international agreement on copper conductivity standards is urged. (Aug. 1, 1910.) 24 pp.

157. 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.

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

The author measures the currents 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.

159. Some Quantitative Experiments in Long Distance Radio-telegraphy *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 1,000 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 3,750 meters, and distances up to 1,000 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.
163. 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.
164. A Study of the Current Transformer with Particular Reference to Iron Loss *P. G. Aqnew*
 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.
165. Thermodynamics of Concentration Cells *Henry S. Carhart*
 This paper discusses the equation $A = H + T \cdot dA/dT$ as a general expression of the laws of thermodynamics, and particularly in the specific form of the Helmholtz equation $E = H/nF + T \cdot dE/dT$.
 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 or 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.
166. 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° , with alternating current of frequencies of from 33 to 1,000 cycles per second. The 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.

169. 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 (this bulletin, vol. 5, 1907). 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. (Jan. 1, 1911.) 237 pp.

171. 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 semi-absolute 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 voltmeters, 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.

172. Deflection Potentiometers for Current and Voltage Measure-

ments *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 Papers Nos. 33 and 79, 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 liability of error. (June 23, 1911.) 23 pp.

173. 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.

175. 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 seconds, 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.

177. 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 resistances 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.

181. 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 of Standards 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.

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

The instrument described has a capacity of 5 000 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.

189. 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 wavelength, for wavelengths less than twice the fundamental of the antenna. Above this the resistance increases in proportion to the wavelength. 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 "artificial 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.

190. The 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 4 000 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.

194. The Silver Voltmeter—Part I. First Series of Quantita-
 tive Experiments . . . *E. B. Rosa, G. W. Vinal, and A. S. McDaniel*

This paper reviews briefly the large amount of material that has been previously published on the silver voltmeter 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 voltmeters 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. (Aug. 1, 1912.) 57 pp.

195. 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 causes 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. (Oct. 1, 1912.) 74 pp.

201. 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. (Jan. 1, 1913.) 59 pp.

203. The 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. Range 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. (Feb. —, 1913.) — pp.

See also (on p. 53) Circulars 6, 20, 21, 22, 23, 31, 34, and 36.

Ia. PHOTOMETRY

12. 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.

20. 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.

26. Talbot's Law as Applied to the Rotating Sectorcd Disk *Edward P. Hyde*
 The apparent intensity of a source, before which a sectorcd disk is rotating rapidly, is found to be proportional to the total angular opening of the sectorcd disk for all angles between 288° and 10° . (Mar. 1, 1906.) 32 pp.
30. An Efficiency Meter for Electric Incandescent Lamps *E. P. Hyde and H. B. Brooks*
 By means of a variable resistance in series with the pressure 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.
43. 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.
50. 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.
51. 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.
61. 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.
63. 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.
72. 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.

113. 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.

115. 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.

125. 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.

128. 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 one 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. Illuminants 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.

132. 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 a 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 were 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.) 16 pp.

141. 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.

144. A New Form of Direct-Reading Candle-Power 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.

See also (on p. 53) Circulars 13, 15, and 32.

II. WEIGHTS AND MEASURES

- I. 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.

17. 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.

92. The Testing of Glass Volumetric Apparatus.
 *H. S. Osbourne 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 use in determination of capacity. (Apr. 10, 1908.) 49 pp.

197. Density and Thermal Expansion of Ethyl Alcohol and of Its Mixtures with Water.
 *N. S. Osborne, E. C. Mc Kelvy, 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.

See also (on p. 53) Circulars 2, 3, 4, 9, 10, 16, 18, 19, and 22.

III. THERMOMETRY, PYROMETRY, AND HEAT MEASUREMENTS

8. 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.

11. 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 radiat. on 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.

13. 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.
24. 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.
32. Heat Treatment of High-Temperature Mercurial Thermometers
 *Herbert 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.
40. 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.
55. 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.
57. 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.
62. 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.
68. 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. (June 21, 1907.) 21 pp.
69. 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.

99. 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 curve 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.

120. The Thermoelectric Properties of Tantalum and Tungsten. *W. W. Coblenz*

This paper gives an account of an examination of the thermoelectric behavior of tantalum, tungsten, and constantan through the temperature between -190° to $+270^{\circ}$ C. (Jan. 15, 1909.) 4 pp.

121. 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.

123. 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.

124. Platinum Resistance Thermometry at High Temperatures. *G. 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.

133. 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 is 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.

135. Specific Heat of some Calcium Chloride Solutions. *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 chloride solutions of various densities at temperatures from -35° to $+20^{\circ}$ C determined by these two methods. (Nov. 4, 1909.) 30 pp.

136. 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.

143. 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.

<i>Freezing points.</i>			<i>Boiling points.</i>	
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.

149. 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 ohm and with thermocouples. When the latter are homogeneous, both methods give consistent results showing the temperatures within the radiation shield to be constant to within 0.05° Cover 27 of 30 cm of S vapor column. (Dec. 6, 1910) 4 pp.

162. 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 black-body 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.

167. 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.

170. 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.

180. 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 rigor. (Feb. 28, 1911.) 13 pp.

185. 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 thermometers, 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.

198. A Micropyrometer. *G. K. Burgess*

An incandescent lamp is mounted within the Huggens 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 H₂, 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.

200. 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.

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

This article is written with the hope of impressing upon the technical man the necessity of using some caution in the matter of the cold-junction temperature of thermocouples. That such information is needed is evidenced by the fact that one of the largest pyrometry companies in the United States (according to a person connected with the company) is correcting for the cold-junction temperature by simply adding this value to the indicated temperature of the hot junction. Such a method may involve an error as great as 50° C. The following points are discussed:

- Derivation of slope correction (3 forms).
- Magnitude of cold-junction corrections.
- Errors in slope corrections for certain typical couples.
- Applicability of slope corrections.
- Slope correction when couple is calibrated with the cold junction at a temperature other than 0° C.
- Reduction to Fahrenheit scale.
- Conversion of thermoelectric scale to standard temperature scale.
- Devices for the elimination of the cold-junction corrections. (March 19, 1913.) 13 pp.

205. 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
Co	1478 ± 5
Fe	1530 ± 5
Mn	1260 ± 20
Cr	1520 to > Fe?
Va	1720 ± 20
Ti	1794 ± 12.

(April 25, 1913.) 14 pp.

See also (on p. 53) Circulars 5, 7, 8, 11, and 35.

IV. OPTICS

4. 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.

5. 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.

6. 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.

19. 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.

34. Spectrum Lines as Light Sources in Polariscope 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.

35. 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.

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

A description of a modified spectrophotometer on the plan of a pocket spectrocope. (July 15, 1906.) 3 pp.

44. 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.

45. 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.
46. 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.
49. 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.
52. 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.
85. Instruments and Methods used in Radiometry *W. W. Coblentz*
 Experimental investigation of sensibility 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 sensibility. (Oct. 1, 1907.) 70 pp.
86. A Quartz Compensating Polariscopes with Adjustable Sensibility *Frederick Bates*
 The theory and description of a new type of quartz-wedge polariscopes which gives the maximum theoretical sensibility, whatever the character of the substance polarized. (Oct. 15, 1907.) 6 pp.
89. 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.
91. 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.
97. Selective Radiation from Various Solids. I *W. W. Coblentz*
 A spectrophotometric 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.

98. Remarks on the Quartz Compensating Polariscopes 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.

103. 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.

105. Radiation Constants of Metals *W. W. Coblenz*

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

110. 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. The precision attained was, for 30 determinations, average error, 0.21 per cent; and probable error of mean, about ± 0.03 per cent. (Mar. 18, 1909.) 15 pp.

122. 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.

131. Selective Radiation from Various Solids. II. *W. W. Coblenz*

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.

132. Luminous Efficiency of the Firefly. . *Herbert E. Ives and W. W. Coblenz*

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.

133. 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.) 9 pp.

142. 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.

146. 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.

150. Note on Oscillatory Interference Bands and Some of Their Practical Applications.....*G. O. Squier and A. C. Crehore*
(Sept. 1, 1910.) 12 pp.152. The Reflecting Power of Various Metals.....*W. W. Coblenz*

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 thermo-electric power of molybdenum-copper, comments on the radiation laws of metals, etc. (Dec. 6, 1911.) 53 pp.

154. 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.

155. 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.

156. Selective Radiation from Various Substances. III. . . . *W. W. Coblenz*

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.

168. Radiometric Investigation of Water of Crystallization,
Light Filters, and Standard Absorption Bands . . . *W. W. Coblenz*

The present paper contains further contributions (see No. 45) 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 0.67μ and transmits 80 per cent in the green and blue. Standard spectral lines are given for calibrating prisms. (May 16, 1911.) 45 pp.

176. 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.

179. 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 one part in 10 000 000, and the values are considered accurate to within about one or two parts in 6 000 000. (Nov. 23, 1911.) 6 pp.

187. 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.

188. Instruments and Methods Used in Radiometry—II. . . . *W. W. Coblenz*

The paper gives an account of the attainments in spectroradiometry since 1907. (See No. 85.) This includes air and vacuum bolometers, thermopiles, and radiomicrometers; linear and surface thermopiles of bismuth and silver; new combinations of instruments; and (Note I) the Callendar radio-balance. (Dec. 8, 1911.) 57 pp.

191. Selective Radiation from Various Substances, IV. *W. W. Coblenz*

The present paper contains further contributions to the study of the radiating properties of various substances. (See Nos. 91, 97, 131, 156.) This includes a determination of (I) the radiation constants of platinum (see No. 105), (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 enclosing walls, (VI) standard spectral energy curves (Note I), light filters which absorb all the infra-red (see No. 168), and (Note II) transmission of prism material. (June 5, 1912.) 37 pp.

196. The Diffuse Reflecting Power of Various Substances . . . *W. W. Coblenz*

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 24. The substances examined include lampblack, platinum 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.

199. 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 therefore 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.

204. The Constants of Spectral Radiation of a Uniformly Heated Enclosure or So-called Black Body, Part I.

W. W. Coblenz

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. The numerical values of the constants are: $A = 2911 \pm 1$, $C = 14456 \pm 4$ Mikron, degree. (Jan. 15, 1913.) — pp.

See also (on p. 53) Circulars 12, 27, and 28.

V. CHEMISTRY

53. 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 sulphocyanide. (Jan. 20, 1907.) 42 pp.

54. 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.

77. 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.
81. 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.
82. 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.
153. 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 oxygen. (Sept. 29, 1910.) 8 pp.
160. 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.
161. 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.
174. 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.

178. 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.

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

The effect 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 was determined and the necessary end-point corrections fixed. Loss of oxygen during titration is probably responsible for the observed variations, but none of these exceed 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 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.

See also (on p. 53) Circulars 14, 19, 25, and 26.

183. 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 with benzoic acid, then both sodium and barium hydroxide. The results show that benzoic acid is accurate, and that fact, combined with other advantages, makes benzoic acid an excellent material for an acidimetric standard. (May 4, 1912.) 8 pp.

186. 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 secure 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.

192. 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.

193. 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 bromoplatinate. The hydrobromic acid formed is also weighed. From ten determinations twenty values are obtained giving the ratio H: Br equal to 1: 79.306⁶ with a probable error of $\pm .0014$. Taking the atomic weight of hydrogen as 1.00779 ($\sigma=16$) the atomic weight of bromine is 79.924. (Nov. 1, 1912.) 20 pp.

195. 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 causes 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 liquids. (Oct. 1, 1912.) 74 pp.

197. 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.

(E) DESCRIPTIVE LIST OF TECHNOLOGIC PAPERS

1. Effect of Preliminary Heat Treatment upon the Drying of Clays *A. V. Bleiningger*

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.

2. 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 per cent 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 is 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.

3. Tests of the Absorptive and Permeable Properties of Portland Cement Mortars and Concretes, Together with Tests of Damp-proofing and Water-proofing 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 "water-proofing" 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 water-proofing 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.

4. 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 also caused an increase. 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.

5. 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.

6. 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.

7. The Testing of Clay Refractories, With Special Reference to Their Load Carrying Ability at Furnace Temperatures.

NATURE OF TESTS.—General consideration of the refractoriness of fire-clay 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.

8. 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.

9. 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.

10. 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 arc electric vacuum furnace. Temperatures were measured with an optical pyrometer. An improved method of calibrating optical pyrometers is described.

11. 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; (2) that the dynamic tests for hardness do not agree in general with the results of static tests. (July 22, 1912.) 27 pp.

12. 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.

13. 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.

14. 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 now under consideration for Circular No. 32 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. (Jan. 10, 1913.) 31 pp.

16. 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.

17. 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 of the present work followed was that of Bleining 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.

18. 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 recommendation. (Mar. 19, 1913.) — pp.

19. Physical Testing of Cotton Yarns. *W. S. Lewis*

PURPOSE.—Investigation of the desirability of improving the technical regulations of the trade, and of developing cotton yarn specifications, and to improve methods of testing.

NATURE OF TESTS.—General consideration of single and 2-ply yarns as to variations in size, twist, and tensile strength of yarns 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 "2-ply" yarns. Under usual atmospheric changes the size of a cotton yarn can be increased as much as 5 counts, or over 6 per cent, and its yardage to the extent of 3,500 yards per pound with "singles," and 2,000 yards per pound with 2-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 "2-ply" yarns 16 per cent by increasing the relative atmospheric humidity from 45 to 85 per cent. (Apr. 1, 1913.) 31 pp.

20. 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 procedure were used; all of these are satisfactory, but some better adapted for certain circumstances than the others. (Mar. 7, 1913.) 46 pp.

21. 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—which 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.

22. 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 proven 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.

23. 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 colloid, in so far as it pertains to the subject in hand, and by necessary definitions and brief discussions of certain physico-chemical 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.

24. 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.

25. 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.) — pp.

(F) BUREAU CIRCULARS

1. Verification of Standards and Measuring Instruments.
2. Measurements of Length and Area, including Thermal Expansion.
3. Verification of Standards of Mass.
4. Verification of Standards of Capacity.
5. Testing of Clinical Thermometers.
6. Fees for Electric, Magnetic, and Photometric Testing.
7. Pyrometer Testing and Heat Measurements.
8. Testing of Thermometers.
9. Testing of Glass Volumetric Apparatus.
10. Legal Weights (in pounds) per Bushel of Various Commodities.
11. The Standardization of Bomb Calorimeters.
12. Verification of Polariscope Apparatus.
13. Standard Specifications for the Purchase of Incandescent Electric Lamps.
14. Samples of Analyzed Irons and Steels.—Methods of Analysis.
15. The International Unit of Light.
16. The Testing of Hydrometers.
17. Magnetic Testing.
18. Standard Sheet Metal Gage.
19. Standard Density and Volumetric Tables.
20. Testing of Electrical Measuring Instruments.
21. Precision Measurements of Resistance and Electromotive Force.
22. Standard Specifications for Transformers, Oil-immersed, Self-cooled 60-cycle, 2200 volts.
23. Standardization of Electrical Practice in Mines.
24. Publications of the Bureau of Standards.
25. Standard Analyzed Samples.—General Information.
26. Analyzed Iron and Manganese Ores.—Methods of Analysis.
27. The Testing and Properties of Optical Instruments.
28. The Determination of the Optical Properties of Materials.
29. Announcement of a Change in the Value of the International Volt.
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31. Copper Wire Tables.
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33. United States Government Specifications for Portland Cement.
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35. Melting Points of Chemical Elements.
36. The Testing and Properties of Electric Condensers.
37. Electric Wire and Cable Terminology.
38. The Testing of Mechanical Rubber Goods.
39. Specifications for and Measurement of Standard Sieves.
40. Sodium Oxalate as A Standard in Volumetric Analysis.
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