DEPARTMENT OF COMMERCE AND LABOR

CIRCULAR

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 24

PUBLICATIONS OF THE BUREAU OF STANDARDS

[1st Edition]
Issued June 1, 1910

WASHINGTON
GOVERNMENT PRINTING OFFICE
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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. They cover a wide range of subjects in the field of physical measurements 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.

These papers are also bound from time to time in the form of a bulletin which is sent upon request to public libraries, educational institutions, scientific societies, and other institutions where a complete file is essential, also to a limited number of persons especially concerned with the work of the Bureau as a whole.

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.

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1. Recomparison of the United States Prototype Meter (pp. 5–19) ..... *L. A. Fischer*
2. A Study of the Silver Voltameter (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*
5. On Secondary Spectra and the Conditions under which they may be Produced (pp. 83–94) ..... *P. G. Nutting*
6. Some new Rectifying Effects in Conducting Gases (pp. 95–100) ..... *P. G. Nutting*
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13. The Testing of Clinical Thermometers (pp. 275–289) ..... *C. W. Waidner and L. A. Fischer*
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*
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16. The Silver Coulometer (pp. 349–364) ..... *K. E. Guthe*

[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.

17. History of the Standard Weights and Measures of the United States (pp. 365–381) ..... *L. A. Fischer*
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21. Influence of Wave Form on the Rate of Integrating Induction Wattmeters (pp. 421–434) ..... *E. B. Rosa, M. G. Lloyd, and C. E. Reid*
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24. Radiation from Platinum at High Temperatures (pp. 443–447) ..... *G. K. Burgess*
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35. Polarimetric Sensibility and Accuracy (pp. 249–260) ..... *P. G. Nutting*
36. On the Platinum-Point Electrolytic Detector for Electrical Waves (pp. 261–274) ..... *L. W. Austin*
37. The Influence of Frequency upon the Self-Inductance of Coils (pp. 275–296) ..... *J. G. Coffin*
38. Experiments on the Heusler Magnetic Alloys (pp. 297–316) ..... *K. E. Guthe and L. W. Austin*
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40. Preliminary Measurements on Temperature and Selective Radiation of Incandescent Lamps (pp. 319–329) . . . . . *C. W. Waidner and G. K. Burgess*
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55. Radiation from and Melting Points of Palladium and Platinum (pp. 163–208) . . . . . *C. W. Waidner and G. K. Burgess*
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123. The Theory of the Hampson Liquefier (pp. 125–147) . . . . . *Edgar Buckingham*
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127. Effect of Phase of Harmonics upon Acoustic Quality (pp. 255–263) . . . . . *M. G. Lloyd and P. G. Agnew*
128. White Light from the Mercury Arc and its Complementary (pp. 265–271) . . . . . *Herbert E. Ives*

129. The Regulation of Potential Transformers and the Magnetizing Current (pp. 273–280) . . . . . *M. G. Lloyd and P. G. Agnew*
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136. On the Definition of the Ideal Gas (pp. 409–429) . . . *Edgar Buckingham*
137. Mica Condensers as Standards of Capacity . . . . . *Harvey L. Curtis*
138. The Mutual Induction of Two Parallel Coaxial Circles in Terms of Hypergeometrical Series . . . . . *Frederick W. Grover*
139. A New Method for the Absolute Measurement of Electric Quantity . . . . . *Burton McCollum*
140. The Comparative Sensitiveness of Some Common Detectors of Electrical Oscillations . . . . . *Louis W. Austin*
141. Photometric Units and Nomenclature . . . . . *E. B. Rosa*
142.[2] A Modified Method for the Determination of Relative Wave-Lengths, especially adapted to the Establishment of Secondary Standards . . . . . *Irwin G. Priest*

[2] This article completes Volume 6 of the Bulletin.

DESCRIPTIVE LIST OF TECHNICAL PAPERS CLASSIFIED BY SUBJECTS

I. ELECTRICITY

2. A Study of the Silver Voltameter . . . . . *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 Serpentine in Standards of Inductance . . . . . *E. B. Rosa and F. W. Grover*

Serpentine spools are shown to be unsuitable for standards of inductance, as the serpentine is slightly magnetic, and its permeability variable. Hence the inductance of the coil depends to some extent on how much current is passing through the coil when it is in use. Marble is nonmagnetic and therefore better. Mahogany spools saturated with 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 Induction Wattmeters . . . . . *E. B. Rosa, M. G. Lloyd, and C. E. Reid*

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

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 Electrodynamometer . . . . . *K. E. Guthe*

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

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

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

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 formulæ for the calculation of their self-inductances are derived, and several other formulæ 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 Electrodynamometer. . . *Edward B. Rosa*

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

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

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

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 freeing iron from previous magnetization preliminary to a permeability test. The influence of the frequency of reversal, the number of reversals, the upper and lower limits of the current, and the method of regulating the demagnetizing current, as well as the influence of eddy currents, temperature, and gentle vibrations, 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 Cohen*

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

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

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.

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.

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

In the methods previously used for the absolute determination of the electro-chemical 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 electrodynomometer 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.

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

Articles 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.

See also (on p. 32) Circulars 6, 20, 21, 22, 23.

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 Sectored Disk. . . . . *Edward P. Hyde*

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

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.

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 watts 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 formulæ. Photometric Nomenclature is considered and some new proposals made. Several problems are given for illustration.

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

II. WEIGHTS AND MEASURES

1. 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. Osborne and B. H. Veazey*

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

See also (on p. 32) Circulars 2, 3, 4, 9, 10, 16, 18, 19, 22, 23.

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 radiation pyrometers as to methods of calibration, sources of error, order of accuracy, and necessary precautions. Applications to the radiation from platinum and other substances. (Sept. 15, 1904.) 61 pp.

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 . . . . . *Hobert C. Dickinson*

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

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 . . . . . *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. Coblentz*

This paper gives an account of an examination of the thermoelectric behavior of tantalum, tungsten, and constantan through the temperature between −190° to +270° 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° 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.

See also (on p. 32) Circulars 5, 7, 8.

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 Polariscopic Measurements . . . . . *Frederick Bates*

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

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 spectroscope. (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 Polariscope with Adjustable Sensibility . . . . . *Frederick Bates*

The theory and description of a new type of quartz-wedge polariscope which gives the maximum theoretical sensibility, whatever the character of the substance polarized.

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

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

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

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 is 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. Coblentz*

A spectrobolometric investigation of the radiation constants of various metals, including tungsten, tantalum, osmium, and platinum; also various forms of carbon filaments. Theoretical and experimental data 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 achromatism, and (3) simplicity of observation and calculation. The prevision attained was, for 30 determinations, average error, 0.21 per cent; and probable error of mean, about ± 0.03 per cent. (Jan. 29, 1909.) 30 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. Coblentz*

The present paper is a continuation of previous work (No. 97) on this subject. Several minerals are shown to be solid solutions instead of definite chemical compounds, which suggests that this method of analysis might be of use in studying the physical condition of highly fusible oxides.

The spectral energy curves of carbon and tungsten are set to a "color match" and it is shown that the eye is incapable of detecting a difference in emissivity of 5 per cent or more in the extreme red end of the spectrum. (Aug. 14, 1909.) 18 pp.

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 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.) 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 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.) 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 spectroscopic standards.

Characteristics of the Method: (1) Use of circular spectrum 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 9,000,000. (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."

See also (on p. 32) Circular 12.

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.

BUREAU CIRCULARS

1. Verification of Standards and Measuring Instruments.
2. Verification of Metal Tapes.
3. Verification of Standards of Mass.
4. Verification of Standards of Capacity.
5. Testing of Clinical Thermometers.
6. Verification of Electrical Standards and Measuring Instruments.
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. Samples of Analyzed Irons and Steels.—General Information as to Samples.
12. Verification of Polariscopic Apparatus.
13. Standard Specifications for the Purchase of Carbon-Filament Electric Incandescent Lamps.
14. Samples of Analyzed Irons and Steels.—Methods of Analysis.
15. A Proposed International Unit of Light.
16. The Testing of Hydrometers.
17. Magnetic Testing.
18. United States Standard Sheet Metal Gauge.
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.

MISCELLANEOUS

International Metric System. (Chart.)
Table of the Equivalents of Customary and Metric Weights and Measures.
The International Metric System of Weights and Measures. (Pamphlet.)
First Conference on the Weights and Measures of the United States.
Second Annual Conference on the Weights and Measures of the United States.
Third Annual Conference on the Weights and Measures of the United States.
Fourth Annual Conference on the Weights and Measures of the United States.