

DEPARTMENT OF COMMERCE

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**CIRCULAR**  
OF THE  
**BUREAU OF STANDARDS**

S. W. STRATTON, DIRECTOR

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No. 6

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**FEES FOR ELECTRIC, MAGNETIC, AND  
PHOTOMETRIC TESTING**

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[6th Edition]

Issued October 1, 1914



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1914



## CIRCULARS ISSUED BY THE BUREAU OF STANDARDS, DEPARTMENT OF COMMERCE

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. 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 Polariscopic Apparatus.
13. Standard Specifications for the Purchase of 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. Standard Gauge for Sheet and Plate Iron and Steel.
19. Standard Density and Volumetric Tables.
20. Testing of Electrical Measuring Instruments.
21. Precision Measurements of Resistance and Electromotive Force.
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39. Specifications for and Measurement of Standard Sieves.
40. Sodium Oxalate as a Standard in Volumetric Analysis.
41. Testing and Properties of Textile Materials.
42. Metallographic Testing.
43. The Metric Carat.
44. Polarimetry.
45. The Testing of Materials.
46. Testing of Barometers.
47. Units of Weight and Measure; Definitions and Tables of Equivalents.
48. Standard Methods of Gas Testing.
49. Safety Rules to be Observed in the Operation and Maintenance of Electrical Supply Utilities.

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# FEEES FOR ELECTRIC, MAGNETIC, AND PHOTOMETRIC TESTING

## CONTENTS

|   | Page |
|---|------|
| INTRODUCTION.....   | 4    |
| 1. INFORMATION REGARDING TESTS.....                       | 4    |
| 2. RANGE OF TESTING.....                                  | 5    |
| (a) Resistance.....                                       | 5    |
| (b) Electromotive force.....                              | 5    |
| (c) Electrical measuring instruments.....                 | 5    |
| (d) Capacity.....   | 5    |
| (e) Inductance.....                                       | 5    |
| (f) Magnetism.....  | 5    |
| (g) Radium.....   | 5    |
| (h) Photometry.....                                       | 5    |
| 3. THE INTERNATIONAL UNITS.....                           | 5    |
| 4. GENERAL INSTRUCTIONS TO APPLICANTS FOR TEST.....       | 6    |
| (a) Application for test.....                             | 6    |
| (b) Nature of test.....                                   | 7    |
| (c) Special tests.....                                    | 7    |
| (d) Condition of apparatus.....                           | 7    |
| (e) Identification marks.....                             | 8    |
| (f) Shipping directions.....                              | 8    |
| (g) Address.....  | 8    |
| (h) Remittances.....                                      | 8    |
| SCHEDULES OF FEES.....                                    | 9    |
| 5. RESISTANCE AND ELECTROMOTIVE FORCE.....                | 9    |
| (71-72) Precision resistance standards.....               | 9    |
| (73-74) Resistance standards for current measurement..... | 10   |
| (75-77) Precision resistance apparatus.....               | 10   |
| (78) Electrical properties of conductors.....             | 11   |
| (79) Standard cells.....                                  | 11   |
| 6. ELECTRICAL MEASURING INSTRUMENTS.....                  | 11   |
| (81) Direct-current ammeters and voltmeters.....          | 12   |
| A. Direct current ammeters.....                           | 12   |
| B. Direct-current voltmeters and millivoltmeters.....     | 12   |
| (82) Alternating-current ammeters and voltmeters.....     | 13   |
| A. Alternating-current ammeters.....                      | 13   |
| B. Alternating-current voltmeters.....                    | 14   |
| (83) Wattmeters.....                                      | 15   |
| A. Tested with direct current.....                        | 15   |
| B. Tested with alternating current.....                   | 15   |
| (84) Watthour meters.....                                 | 16   |
| A. Direct-current meters.....                             | 16   |
| B. Alternating-current watthour meters, single phase..... | 16   |
| C. Polyphase watthour meters.....                         | 17   |



## SCHEDULES OF FEES—Continued.

|  |      |
|--|------|
| 6. ELECTRICAL MEASURING INSTRUMENTS—Continued.                     | Page |
| (85) Phase meters, power-factor meters, and frequency meters. .... | 17   |
| (86) Instrument transformers. ....                                 | 17   |
| A. Current transformers. ....                                      | 17   |
| B. Potential transformers. ....                                    | 18   |
| 7. CAPACITY AND INDUCTANCE. ....                                   | 19   |
| (88) Capacity. ....  | 19   |
| A. Alternating-current tests. ....                                 | 19   |
| B. Direct-current tests. ....                                      | 19   |
| (89) Inductance. ....  | 20   |
| (90) Wavemeters. ....  | 20   |
| 8. MAGNETISM. ....   | 21   |
| (91) Normal induction and hysteresis. ....                         | 21   |
| (93) Core loss. ....   | 22   |
| 9. RADIUM. ....  | 22   |
| (94) Radium and its emanation. ....                                | 24   |
| A. Hermetically sealed specimens of radium salts. ....             | 24   |
| B. Emanation standards and measurements. ....                      | 24   |
| 10. PHOTOMETRY. ....   | 24   |
| (95) Standardizing incandescent electric lamps. ....               | 25   |
| A. Standardizing only. ....  | 25   |
| B. Seasoning and standardizing. ....                               | 25   |
| (96) Supplying standardized lamps. ....                            | 25   |
| (97) Commercial tests. ....  | 26   |
| (98) Standardizing flame standards. ....                           | 26   |
| (99) Miscellaneous. ....   | 27   |
| 11. MISCELLANEOUS TESTS. ....                                      | 27   |

## INTRODUCTION

## 1. INFORMATION REGARDING TESTS

This Circular gives the fees established by the Bureau of Standards for tests of electric, magnetic, and photometric standards, measuring instruments, and materials. The testing of radium is also included. The schedules of fees given herein supersede those previously published. Additional information concerning these tests will be found in the following Circulars:

- No. 15. The International Unit of Light.
- 17. Magnetic Testing.
- 20. Electrical Measuring Instruments.
- 21. Precision Measurements of Resistance and Electromotive Force.
- 31. Copper Wire Tables.
- 36. The Testing and Properties of Electric Condensers.

Copies of any of these Circulars will be sent to interested persons on request.

## 2. RANGE OF TESTING

(a) **Resistance.**—Determination of resistance and temperature coefficient of resistance standards. Testing of precision rheostats, Wheatstone bridges, potentiometers, volt boxes, and other resistance apparatus. Determination of conductivity and other electrical properties of conductors and insulators.

(b) **Electromotive Force.**—Determination of electromotive force of Weston, Clark, or other standard cells.

(c) **Electrical Measuring Instruments.**—Testing of direct and alternating current measuring instruments; voltmeters, millivoltmeters, ammeters, wattmeters, watt-hour meters, phase meters, frequency meters, current and voltage transformers, etc. Standardization of wavemeters for high-frequency work.

(d) **Capacity.**—Determination of capacity of condensers by alternating and direct current; measurement of phase angle, absorption ratio, and insulation resistance. Determination of constants of cables.

(e) **Inductance.**—Testing of standards of self and mutual inductance. Measurement of the inductances of instruments. Determination of the effective inductance of resistance coils.

(f) **Magnetism.**—Permeability and hysteresis tests of magnetic materials. Standardization of magnetic measuring instruments. Measurements of energy losses due to alternating magnetization in iron.

(g) **Radium.**—Determination of the radium (element) content of hermetically sealed specimens of radium salts, and of the radium emanation content of waters. The testing and standardization of apparatus used in radium measurements.

(h) **Photometry.**—Standardization of incandescent lamps used as photometric standards, and of flame standards used for gas photometry. Testing of electric lamps. Light distribution curves.

## 3. THE INTERNATIONAL UNITS

Resistances are measured in terms of the international ohm, which is fixed concretely by international agreement among the national laboratories of England, France, Germany, and America, being based on mercury ohms which have been set up according to definite specifications. The differences between the 1-ohm reference standards of these four countries are not more than two hundred-thousandths of an ohm.

Electromotive forces are measured in terms of Weston cells. The electromotive force of the mean Weston normal cell<sup>1</sup> is fixed by the International Committee on Electrical Units and Standards as 1.0183 international volts at 20° C. Since January 1, 1911, this value has been used in all official measurements at the Bureau of Standards. The mean Weston normal cell is determined by comparisons of cells set up in the four different national laboratories, taking the mean value as the value of the mean Weston cell. The differences between the reference cells of the different national laboratories are not more than two or three hundred-thousandths of a volt.

Electric current is measured in terms of standard resistances and standard cells, and expressed in international amperes. The international ampere is defined in terms of the mass of silver deposited in the silver voltameter; but the experiments of the international committee in 1910 fixed a value for the standard cell in terms of the silver voltameter, so that it is not necessary in practice to use the latter.

Measurements of power in watts are of course also in terms of standard resistances and standard cells. Alternating current, voltage, and power are measured by instruments calibrated by direct-current instruments, and hence are in terms of the same standards.

There are no international standards in magnetism, all measurements being in terms of electric current and electromotive force.

The international radium standard is preserved in Paris. This Bureau has an approximate copy of it, prepared by the Austrian Government. Its value was certified by the International Commission on Radium Standards, after being directly compared with the radium standard at Vienna and with the international radium standard at Paris. All measurements are based upon this standard, and all estimates of precision assume that its certified value is absolutely correct.

The candlepower of photometric standards is expressed in terms of the international candle, which is the common unit of England, France, and America and is ten-ninths of the Hefner unit employed in Germany.

#### 4. GENERAL INSTRUCTIONS TO APPLICANTS FOR TESTS

(a) **Application for Test.**—All articles submitted for test should be accompanied by a written request for the test. When practicable, tests

---

<sup>1</sup> The Weston normal cell is not the Weston cell used in practice. In the former, the cadmium sulphate solution is saturated at ordinary temperatures, and the cell is not adapted to portable use. The Weston portable, or unsaturated cell ranges in emf. from 1.0182 to 1.0191 international volts.



should be arranged for by the party most concerned in the use of the apparatus. When a purchaser of new apparatus wishes it tested before acceptance (and is paying for the test), he rather than the manufacturer or his agent should make the application for the test. The request for test should enumerate the articles, giving the identification marks of each, and should state explicitly the nature of the test desired. It is suggested that a prior application be made, from two weeks to a month preceding the shipment of the apparatus, if it is desired that the test be made promptly when the apparatus is received, inasmuch as regular tests are made in the order in which the applications are received, except as this practice may be varied by grouping similar tests together. This will facilitate the work of the Bureau as well as the prompt return of the apparatus. When the test is one regularly provided for in the appended schedules the fee may be computed in advance, and should be sent at the time the apparatus is shipped.

(b) **Nature of Test.**—The application should state clearly the nature of the test desired, viz, the points at which test is to be made, and the temperature or any other conditions. It is also desirable that the conditions under which the apparatus is used and the character of the work for which it is employed be stated. Unless full information is given, additional correspondence may be required, which will necessitate delay. The classification of tests in this circular should be followed, and the schedule numbers below should be used to indicate the test desired. When apparatus is sent simply for test, without definite instructions, the Bureau will, when practicable, decide upon the nature of the test without correspondence.

(c) **Special Tests.**—The Bureau will gladly cooperate with scientific investigators, manufacturers of apparatus, and others who need higher precision than is provided in the regular tests, as far as the regular work of the Bureau will permit. Kinds of tests not at present provided for may be undertaken if the work is important and the facilities and time are available. Approved tests not provided for in the regular schedules will be considered special, and a special fee will be charged for them. The test should be arranged for by correspondence before shipment of the apparatus. The application should state fully the purpose for which the apparatus has been used or is to be used in the future, the need for the test, and the precision desired. The special fee charged will depend chiefly upon the time consumed and the amount of alteration required in the regular testing apparatus. An estimate of the fee will be given when possible.

(d) **Condition of Apparatus.**—Before submitting apparatus for test, the applicant should ascertain that it fully satisfies the requirements herein

specified for such apparatus. All apparatus must be in good working condition, the insulation must be adequate, and contacts must be clean, etc. No repair work will be done at the Bureau; if repairs are needed, they should either be made by the applicant or the apparatus should be sent to the maker before it is submitted for test. When defects are found after a test has been begun, which exclude an apparatus from receiving the usual certificate, a report will be rendered giving such information as has been found. In such cases a special fee may be charged, depending upon the time consumed. All possible care will be taken in handling apparatus, but the risk of injury or breakage in shipment or under test must be borne by the applicant.

(e) **Identification Marks.**—All packages should be plainly marked with the shipper's name and address, and, when convenient, a list of the contents. Each separate piece of apparatus or sample of material should be provided with an identification mark or number. The identification mark should be given in the application for the test. It is desired that packages containing radium be marked so as to indicate the fact.

(f) **Shipping Directions.**—Apparatus or test specimens should be securely packed in cases or packages which will not be broken in transportation, and which may be used in returning them to the owner. The shipment in both directions is at the applicant's risk. Except in the case of heavy apparatus not liable to damage in transit (e. g., transformers), it is recommended that shipment be made by express. Great care should be taken in packing. Clean, fresh excelsior is a suitable packing material in most cases. Each instrument should also be wrapped in strong paper or other covering to prevent dust and excelsior from getting into it. The tops of boxes should be put on with screws, as the jar due to nailing and the subsequent opening is liable to damage delicate parts. The tops of the shipping boxes should have the return or forwarding address on the under side. If the return or forwarding address be different from the address given on letterheads used in the correspondence, it should be definitely stated in the application for the test.

Transportation charges are payable by the party requesting the test. The charges for shipment to the Bureau must be prepaid, and unless otherwise arranged articles will be returned or forwarded by express "collect."

(g) **Address.**—Apparatus submitted for test, as well as all correspondence, should be addressed simply "Bureau of Standards, Washington, D. C."

(h) **Remittances.**—Fees should be sent when the apparatus is shipped, in accordance with the appended schedules, or promptly upon receipt of

bill. Certificates are not given, nor is apparatus returned, until the fees due thereon have been received. Remittances may be made by money order or check drawn to the order of the "Bureau of Standards."

## SCHEDULES OF FEES

### 5. RESISTANCE AND ELECTROMOTIVE FORCE

#### SCHEDULE 71.—Precision Resistance Standards

*Maximum accuracy, 0.005 per cent*

(Measurement at temperature of 25° C)

|  |         |
|--|---------|
| (a) 1 ohm (accuracy 0.005 per cent).....       | \$2. 50 |
| (b) 10 ohms (accuracy 0.005 per cent).....     | 2. 50   |
| (c) 100 ohms (accuracy 0.005 per cent).....    | 3. 00   |
| (d) 1000 ohms (accuracy 0.005 per cent).....   | 3. 00   |
| (e) 10 000 ohms (accuracy 0.01 per cent).....  | 3. 00   |
| (f) 100 000 ohms (accuracy 0.02 per cent)..... | 3. 00   |
| (g) 0.1 ohm (accuracy 0.005 per cent).....     | 2. 50   |
| (h) 0.01 ohm (accuracy 0.005 per cent).....    | 3. 00   |
| (i) 0.001 ohm (accuracy 0.01 per cent).....    | 3. 00   |
| (j) 0.0001 ohm (accuracy 0.01 per cent).....   | 3. 50   |

(k) For measurements at three temperatures, 20°, 25°, and 30° C, the fee will be twice the above. (Measurements at three temperatures are made only in case the user of the apparatus shows that the small changes in resistance resulting from necessary variations in the temperature from 25° C are of importance in the work in which the standards are used.)

For standards having values 2, 3, 4, or 5 times any of the above, the next higher fee will be charged.

#### SCHEDULE 72.—Precision Resistance Standards

*Maximum accuracy, 0.025 per cent*

(Measurement at temperature of 25° C)

|   |         |
|---|---------|
| (a) 1, 10, and 0.1 ohm standards.....                     | \$1. 50 |
| (b) 100, 1000, 10 000, 0.01, and 0.001 ohm standards..... | 2. 00   |
| (c) 100 000 and 0.0001 ohm standards.....                 | 2. 50   |

For standards having values 2, 3, 4, or 5 times any of the above, the next higher fee will be charged.



## SCHEDULE 73.—Resistance Standards for Current Measurement

*Accuracy, 0.01 per cent*

|     |   |         |
|-----|---|---------|
| (a) | 1 ohm, measured with test current not exceeding 3 amperes .....   | \$2. 50 |
| (b) | 0.1 ohm, measured with test current not exceeding 15 amperes .....  | 2. 50   |
| (c) | 0.01 ohm, measured with test current not exceeding 100 amperes .....  | 3. 00   |
| (d) | 0.001 ohm, measured with test current not exceeding 500 amperes .....   | 4. 00   |
| (e) | 0.0001 ohm, measured with test current not exceeding 1000 amperes .....   | 5. 00   |
| (f) | 0.00001 ohm, measured with test current not exceeding 1500 amperes .....  | 6. 00   |
| (g) | For an additional measurement, with test current so small as not to heat the standard appreciably, either at room temperature or approximately 10° C above room temperature, the additional fee will be half the above. |         |

For standards having values 2, 3, 4, or 5 times any of the above, the next higher fee will be charged.

## SCHEDULE 74.—Resistance Standards for Current Measurement

*Accuracy, 0.025 per cent*

|     |   |         |
|-----|---|---------|
| (a) | 1 ohm, measured with test current not exceeding 3 amperes .....                                       | \$2. 00 |
| (b) | 0.1 ohm, measured with test current not exceeding 15 amperes .....                                    | 2. 00   |
| (c) | 0.01 ohm, measured with test current not exceeding 100 amperes .....                                  | 2. 50   |
| (d) | 0.001 ohm, measured with test current not exceeding 500 amperes .....                                 | 3. 00   |
| (e) | 0.0001 ohm, measured with test current not exceeding 1000 amperes .....                               | 4. 00   |
| (f) | 0.00001 ohm, measured with test current not exceeding 1500 amperes .....                              | 5. 00   |
| (g) | For an additional measurement with a smaller test current, the additional fee will be half the above. |         |

For standards having values 2, 3, 4, or 5 times any of the above, the next higher fee will be charged.

## SCHEDULE 75.—Precision Resistance Apparatus

*Accuracy (in general), 0.01 per cent*

|                      |  |         |
|----------------------|--|---------|
| (a)                  | Minimum fee for each piece of apparatus .....        | \$3. 00 |
| (b)                  | Precision rheostats, each .....                      | 10. 00  |
| (c)                  | Miscellaneous resistance apparatus, per coil .....   | . 25    |
| (d)                  | Calorimetric bridges, each .....                     | 20. 00  |
| (e)                  | Potentiometers and bridges, each .....               | 15. 00  |
| Volt boxes, factors: |  |         |
| (f)                  | Test with low voltage, per factor .....              | 1. 50   |
|                      | Test with service voltage (not exceeding 150 volts)— |         |
| (g)                  | Factors 2, 3, 5, or 10, each .....                   | 2. 00   |
| (h)                  | Factors 20, 30, 50, or 100, each .....               | 3. 00   |

## SCHEDULE 77.—Precision Resistance Apparatus

*Accuracy (in general), 0.025 per cent*

|                      |  |         |
|----------------------|--|---------|
| (a)                  | Minimum fee for each piece of apparatus.....         | \$2. 00 |
| (b)                  | Precision rheostats, each.....                       | 6. 50   |
| (c)                  | Miscellaneous resistance apparatus, per coil.....    | . 15    |
| (d)                  | Calibration of slide wire, per section.....          | . 15    |
| (e)                  | Potentiometers and bridges, each.....                | 10. 00  |
| Volt boxes, factors: |  |         |
| (f)                  | Test with low voltage, per factor.....               | 1. 00   |
|                      | Test with service voltage (not exceeding 750 volts)— |         |
| (g)                  | Factors 2, 3, 5, or 10, each.....                    | 1. 25   |
| (h)                  | Factors 20, 30, 50, or 100, each.....                | 2. 00   |
| (i)                  | Factors 200, 300, or 500, each.....                  | 3. 00   |

## SCHEDULE 78.—Electrical Properties of Conductors

|     |  |         |
|-----|--|---------|
| (a) | Resistance per unit length.....  | \$2. 00 |
| (b) | Mass resistivity, from measurements of resistance per unit length, total length, and mass; expressed in ohms (meter, gram).....                          | 3. 00   |
| (c) | Volume resistivity, from measurements of resistance per unit length and cross section; expressed in microhm-cms.....                                     | 4. 00   |
| (d) | Resistivity, from measurements of resistance per unit length, total length, mass, and density; expressed both in microhm-cms and ohms (meter, gram)..... | 5. 00   |
| (e) | Resistance temperature formula (temperature coefficient).....  | 5. 00   |
| (f) | Calibration of standards for conductivity bridges, per section.....  | 2. 00   |
| (g) | Thermoelectromotive force against copper.....  | 2. 50   |

NOTE.—The percent conductivity will be stated for all copper conductors submitted for measurement of resistivity. The standard in terms of which the percent conductivity is expressed is the International Annealed Copper Standard, viz, 0.15328 ohm (meter, gram) at 20° C, or, 1.7241 microhm-cm at 20° C. (The standard value is fully discussed in Circular 31.)

## SCHEDULE 79.—Standard Cells

*Accuracy, 0.0001 volt*

|     |   |         |
|-----|---|---------|
| (a) | Testing standard cells at one temperature, about 25° C..... | \$2. 00 |
|-----|---|---------|

## 6. ELECTRICAL MEASURING INSTRUMENTS

The fees given in the following schedules (81–86) apply to regular commercial instruments as used in practical work; these instruments are understood to be of the deflection type, requiring no special manipulation to get a reading. It is not possible to give a general statement of the accuracy of the test, as so much depends on the type and construction of the instrument tested. Where the instruments submitted for test are of the balance type (such as Kelvin balances and other instruments on this principle), and hence require more time to secure readings, or where deflection instruments or other commercial apparatus are to be tested with a greater degree of

accuracy than would ordinarily be required, *the fees charged will be twice those stated, or more*, depending on the amount of labor involved. This applies also to instruments having any unusual characteristics which increase the difficulty or labor of making the required tests.

The alternating-current tests are regularly made with currents and voltages which closely approximate to the sine wave form. Tests at other wave forms will be made when practicable, and will be subject to special fees. Such tests should be arranged for in advance of shipment of the apparatus. Determinations may be made of the wave forms used in the alternating-current tests scheduled, or of the wave forms of small machines.

#### SCHEDULE 81.—Direct-Current Ammeters and Voltmeters

##### A. *Direct-current ammeters*

Test at five points:

- |  |         |
|--|---------|
| (a) Not exceeding 50 amperes . . . . .   | \$1. 50 |
| (b) Exceeding 50 and not exceeding 250 amperes . . . . .   | 2. 00   |
| (c) Exceeding 250 and not exceeding 500 amperes . . . . .  | 3. 00   |
| (d) Exceeding 500 and not exceeding 1000 amperes . . . . .   | 5. 00   |
| (e) Exceeding 1000 and not exceeding 5000 amperes . . . . .  | 8. 00   |
| (f) Exceeding 5000 and not exceeding 10000 amperes . . . . .   | 12. 00  |
| (g) Each additional point above five will be charged one-tenth of the base fee.  |         |
| (h) For the determination of the temperature coefficient, in addition to the corrections at five points, the total fee will be double that stated above.                                     |         |
| (i) For the determination of the effect of continued current on the readings, the additional fee will be one-half the base fee as given above.   |         |
| (z) Each additional instrument after the first, to be tested at the same time and through the same range, <sup>2</sup> will be charged one-half of the base fee as given above. <sup>3</sup> |         |

Combinations consisting of a millivoltmeter and a shunt will be tested together at the above rates. If a separate test of each is desired, with the corrections for each, the fees will be charged according to the above schedule for the shunt, and 81 B for the millivoltmeter.

##### B. *Direct-current voltmeters and millivoltmeters*

Test at five points:

- |  |         |
|--|---------|
| (m) Not exceeding 300 volts, at one temperature . . . . .  | \$1. 50 |
| (n) Exceeding 300 volts and not exceeding 750 volts . . . . .  | 2. 50   |
| (o) Exceeding 750 volts and not exceeding 1500 volts . . . . .   | 5. 00   |
| (p) Each additional point above five will be charged one-tenth of the base fee.  |         |
| (q) For the determination of the temperature coefficient, in addition to the corrections at five points, the total fee will be double that stated above. |         |

<sup>2</sup> If additional instruments are not of identically the same range, but still come within the same limits as the first instrument, each such additional instrument will be charged one-half of the fee for the first instrument.

<sup>3</sup> This one-half rate applies only to the five-point test; additional points for the additional instrument will each be charged one-tenth of the base fee as given in the schedules.



- (r) For the determination of the effect of continued current on the readings, the additional fee will be one-half the base fee as given above.
- (z) Each additional instrument after the first, to be tested at the same time and through the same range <sup>4</sup> will be charged one-half of the base fee as given above.<sup>5</sup>

When instruments under Schedule 81 are submitted for test without specific instructions, single-range instruments will be tested at five points. Multiple-range instruments will be tested at five points on one range, and at one or two points on each of the other ranges. The fee will be computed by taking as base fee that for the highest point tested.

## SCHEDULE 82.—Alternating-Current Ammeters and Voltmeters

### A. Alternating-current ammeters

#### Test at five points:

- (a) Not exceeding 50 amperes, tested at one frequency and one temperature . . . . . \$2.00
- (b) Exceeding 50 amperes and not exceeding 250 amperes, tested as above . . . . . 3.00
- (c) Exceeding 250 amperes and not exceeding 500 amperes, tested as above . . . . . 5.00
- (d) Exceeding 500 amperes and not exceeding 1000 amperes, tested as above . . . . . 8.00
- (e) Each additional point above five will be charged one-tenth of the base fee.
- (f) For each additional frequency <sup>6</sup> at which a test is made at five points, the additional fee will be one-half of the above rates.
- (h) For the determination of the temperature coefficient an extra fee will be charged equal to that given above. This involves a test at three temperatures, about 10°, 25°, and 40° C, unless otherwise specified.
- (i) When the same instrument is tested both with direct and with alternating current, the fee will be 50 per cent more than for a test with alternating current only.
- (z) Each additional instrument after the first, to be tested at the same time and through the same range,<sup>4</sup> will be charged one-half of the base fee as given above.<sup>5</sup>

When alternating ammeters are used with current transformers, they may be tested together as one apparatus at the above rates. If a separate test is required for each, they will be counted as two pieces of apparatus, and the fee will be charged accordingly. The separate test is to be preferred, as the transformer will in all probability have a very constant ratio over a long period of time, while the ammeter is more liable to change with time. When transformer and ammeter are tested separately, it is thereafter sufficient to test the ammeter alone, at suitable intervals, for a period of several years. This assumes that the transformer is well constructed and of good materials.

<sup>4</sup> If additional instruments are not of identically the same range, but still come within the same limits as the first instrument, each such additional instrument will be charged one-half of the fee for the first instrument.

<sup>5</sup> This one-half rate applies only to the five-point test; additional points for the additional instrument will each be charged one-tenth of the base fee as given in the schedules.

<sup>6</sup> This fee is based on a moderate range of frequency. Extreme frequencies will be subject to a special fee. Such tests should always be arranged for in advance of shipment of the apparatus.

## SCHEDULE 82.—Alternating-Current Ammeters and Voltmeters—Continued

B. *Alternating-current voltmeters*

Test at five points:

|  |         |
|--|---------|
| (m) Not exceeding 300 volts, tested at one frequency and one temperature . . . . .   | \$2. 00 |
| (n) Exceeding 300 volts and not exceeding 750, tested as above . . . . .   | 3. 00   |
| (o) Exceeding 750 volts and not exceeding 1500, tested as above . . . . .  | 5. 00   |
| (p) Exceeding 1500 volts and not exceeding 3000, tested as above . . . . .   | 7. 00   |
| (q) Exceeding 3000 volts and not exceeding 7000, as tested above . . . . .   | 10. 00  |
| (r) Exceeding 7000 volts and not exceeding 12 000, tested as above . . . . .   | 15. 00  |
| (s) Exceeding 12 000 volts and not exceeding 17 000, tested as above . . . . .   | 20. 00  |
| (t) Each additional point above five will be charged one-tenth of the base fee.  |         |
| (u) For each additional frequency <sup>7</sup> at which a test is made at five points, the additional fee will be one-half the base fee as given above.                                    |         |
| (w) For the determination of the temperature coefficient an extra fee will be charged equal to that given above. [See 82 (h).]   |         |
| (x) Determination of the inductance and resistance of an alternating-current voltmeter at one point of the scale . . . . .   | 2. 00   |
| (y) Determination of the inductance at additional points, each <sup>8</sup> . . . . .  | . 50    |
| (z) Each additional instrument after the first, to be tested at the same time and through the same range, <sup>9</sup> will be charged one-half the base fee as given above. <sup>10</sup> |         |

When alternating voltmeters are used with voltage transformers, they may be tested together as one apparatus at the above rates. If a separate test is required for each, they will be counted as two pieces of apparatus and the fee will be charged accordingly. The separate test is to be preferred, as the transformer will in all probability have a very constant ratio over a long period of time, while the voltmeter is more liable to change with time. When transformer and voltmeter are tested separately, it is thereafter sufficient to test the voltmeter alone at suitable intervals, for a period of several years. This assumes that the transformer is well constructed and of good materials.

When instruments under Schedule 82 are submitted for test without specific instructions, single-range instruments will be tested at five points. Multiple-range instruments will be tested at five points on one range, and at one or two points on each of the other ranges. The fee will be computed by taking as base fee that for the highest point tested. Multiple-range instruments will be tested at five points on each range. The fee for the highest range will be taken from the above schedule; the remaining points will be charged for by 82 (e), using as base fee that for the highest range.

<sup>7</sup> This fee is based on a moderate range of frequency. Extreme frequencies will be subject to a special fee. Such tests should always be arranged for in advance of shipment of the apparatus.

<sup>8</sup> This usually makes it necessary to break the seals and open the instrument.

<sup>9</sup> If additional instruments are not of identically the same range, but still come within the same limits as the first instrument, each such additional instrument will be charged one-half the fee for the first instrument.

<sup>10</sup> This one-half rate applies only to the five-point test; additional points above five, at the additional frequency or wave form, will be charged for at one-tenth of the base fee.

## SCHEDULE 83.—Wattmeters

## A. Tested with direct current

Test at five points, at one temperature:

|   |         |
|---|---------|
| (a) Not exceeding 5 kilowatts.....  | \$2. 00 |
| (b) Exceeding 5 kilowatts, not exceeding 25 kilowatts.....  | 3. 00   |
| (c) Exceeding 25 kilowatts, not exceeding 100 kilowatts.....  | 5. 00   |
| (d) Exceeding 100 kilowatts, not exceeding 250 kilowatts.....   | 6. 00   |
| (e) Exceeding 250 kilowatts, not exceeding 500 kilowatts.....   | 8. 00   |
| (f) For each additional point above five will be charged one-tenth of the base fee.   |         |
| (g) For the determination of the temperature coefficient, an additional fee equal to the above will be charged. [See 82 (h).]   |         |
| (h) For the determination of the inductance and resistance of the potential circuit of a wattmeter which is being tested, the additional fee is.....  | 2. 00   |
| (z) Each additional instrument after the first, to be tested at the same time and through the same range, <sup>11</sup> will be charged one-half the base fee as given above. <sup>12</sup> |         |

## B. Tested with alternating current

Test at five points, at one frequency and one temperature, with unity power factor:

|   |         |
|---|---------|
| (m) Not exceeding 5 kilowatts.....  | \$3. 00 |
| (n) Exceeding 5 kilowatts, not exceeding 25 kilowatts, tested as above.....   | 4. 00   |
| (o) Exceeding 25 kilowatts, not exceeding 100 kilowatts, tested as above.....   | 6. 00   |
| (p) Each additional point above five will be charged one-tenth of the base fee.   |         |
| (q) For each additional frequency <sup>13</sup> at which a test is made at five points, the additional fee will be one-half of the base fee as given above.                                 |         |
| (r) For each additional power factor the additional fee will be one-half the base fee.  |         |
| (t) For the determination of the temperature coefficient, an additional fee equal to the base fee will be charged. [See 82 (h).]  |         |
| (u) For a test at five points at each additional power factor, half of the base fee.  |         |
| (v) When the same instrument is tested both with direct and with alternating current, the fee will be 50 per cent more than for test with alternating current only.                         |         |
| (w) The above fees apply to single-phase wattmeters; the base fees for polyphase wattmeters will be twice those for single-phase.   |         |
| (z) Each additional instrument after the first, to be tested at the same time and through the same range, <sup>11</sup> will be charged one-half the base fee as given above. <sup>12</sup> |         |

When instruments under Schedule 83 are submitted for test without specific instructions, wattmeters operating equally well on direct and on alternating current will be tested with direct current at five points. Wattmeters nominally for 150 volts will be tested at 110 volts; suitable values

<sup>11</sup> If additional instruments are not of identically the same range, but still come within the same limits as the first instrument, each such additional instrument will be charged one-half of the fee for the first instrument.

<sup>12</sup> This one-half rate applies only to the five-point test; additional points for the additional instrument will each be charged one-tenth of the base fee as given in the schedules.

<sup>13</sup> These fees are based on a moderate range of frequency. Extreme frequencies will be subject to a special fee. Such tests should always be arranged for in advance of shipment of the apparatus.



of current will be used. Wattmeters operating only on alternating current (induction type) will not be tested except on receipt of detailed instructions as to voltage, frequency, power factor, and number of points at which test is to be made.

#### SCHEDULE 84.—Watthour Meters

##### A. *Direct-current watthour meters*

Test at five loads, viz, 10 per cent, 25 per cent, 50 per cent, full load, and 50 per cent overload, unless otherwise ordered. The number of kilowatts given below refers to rated capacity of meter, and not to the power used in the test:

|  |         |
|--|---------|
| (a) Not exceeding 5 kilowatts.....   | \$3. 00 |
| (b) Exceeding 5 kilowatts, not exceeding 25 kilowatts.....   | 4. 00   |
| (c) Exceeding 25 kilowatts, not exceeding 100 kilowatts.....   | 6. 00   |
| (d) Exceeding 100 kilowatts, not exceeding 250 kilowatts.....  | 8. 00   |
| (e) Exceeding 250 kilowatts, not exceeding 500 kilowatts.....  | 10. 00  |
| (f) Exceeding 500 kilowatts, not exceeding 1000 kilowatts.....   | 12. 00  |
| (g) Exceeding 1000 kilowatts, not exceeding 1500 kilowatts.....  | 15. 00  |
| (h) For the determination of the temperature coefficient, an additional fee equal to twice the base fee, as given above, will be charged. This determination will be made at one-tenth and at full load, unless otherwise ordered. |         |
| (i) Each additional load above five will be charged one-tenth of the base fee.   |         |
| (z) Each additional meter after the first, to be tested at the same time and with the same range and loads, will be charged one-half the base fee. <sup>14</sup>   |         |

##### B. *Alternating-current watthour meters, single phase*

Test at one frequency, unity power factor, and rated voltage on five different loads, viz, 10 per cent, 25 per cent, 50 per cent, full load, and 50 per cent overload, unless otherwise ordered. The number of kilowatts given below refers to rated capacity of meter, and not to the power used in the test:

|   |         |
|---|---------|
| (l) Not exceeding 5 kilowatts.....  | \$3. 00 |
| (m) Exceeding 5 kilowatts, not exceeding 25 kilowatts.....  | 4. 00   |
| (n) Exceeding 25 kilowatts, not exceeding 100 kilowatts.....  | 6. 00   |
| (o) For each additional frequency <sup>15</sup> at which a test is made at five loads, the additional fee will be one-half of the base fee. |         |
| (p) For each additional power factor at which a test is made at five loads, the additional fee will be one-half the base fee.               |         |

<sup>14</sup> This one-half rate applies only to the five-point test; additional points for the additional instrument will each be charged one-tenth of the base fee as given in the schedules.

<sup>15</sup> This fee is based on a moderate range of frequency. Unusual frequencies will be subject to a special fee. Such tests should always be arranged for in advance of shipment of the apparatus.

- (q) For each additional voltage at which a test is made at five loads, the additional fee will be one-half the base fee.
- (s) For the determination of the temperature coefficient, an additional fee equal to twice the base fee will be charged. This determination will be made at one-tenth and at full load, unity power factor, unless otherwise ordered.
- (t) Each additional load above five will be charged one-tenth of the base fee.
- (z) Each additional meter after the first, to be tested at the same time and with the same range and loads, will be charged one-half the base fee.<sup>17</sup>

### C. Polyphase watthour meters

- (v) Polyphase watthour meters will be charged *twice the foregoing rates* for single-phase meters.

Instruments under Schedule 84 must in all cases be accompanied by full instructions as to the nature of the test desired.

## SCHEDULE 85.—Phase Meters, Power-Factor Meters, and Frequency Meters

Test at five points; current ranges not over 100 amperes; voltage ranges not over 250 volts.

- (a) Phase meters and power-factor meters, at one frequency<sup>16</sup> and one load..... \$5.00
- (b) Each additional test at five points for other frequencies or other loads..... 2.50
- (c) Frequency meters, at one voltage..... 3.00
- (d) Each additional test at other voltages..... 1.50
- (e) Each additional point above five will be charged one-tenth of the base fee.
- (z) Each additional instrument after the first, to be tested at the same time and at the same points, will be charged one-half the base fee as given above.<sup>17</sup>

Instruments under Schedule 85 must in all cases be accompanied by full instructions as to the nature of the test desired.

## SCHEDULE 86.—Instrument Transformers

### A. Current transformers

Test for ratio of transformation (quotient of primary or line current divided by secondary or meter current) with a given load of instruments (or specified resistance and reactance) connected to the secondary, at six values of secondary current, viz, 0.5, 1, 2, 3, 4, and 5 amperes, unless otherwise ordered:

- (a) Primary current not exceeding 50 amperes, tested at one frequency..... \$3.00
- (b) Exceeding 50 amperes and not exceeding 250 amperes, tested as above..... 4.00
- (c) Exceeding 250 amperes and not exceeding 500 amperes, tested as above..... 5.00

<sup>16</sup> This fee is based on a moderate range of frequency. Unusual frequencies will be subject to a special fee. Such tests should always be arranged for in advance of shipment of the apparatus.

<sup>17</sup> This one-half rate applies only to the five-point test; additional points for the additional instrument will each be charged one-tenth of the base fee as given in the schedules.

- (d) Exceeding 500 amperes and not exceeding 1000 amperes, tested as above. . . . . \$8. 00
- (e) Each additional current above six will be charged one-tenth of the base fee.
- (f) For each additional frequency<sup>18</sup> at which a test is made at six currents, the additional fee will be one-half of the base fee.
- (g) For each additional secondary load (of instruments, or specified resistance and reactance) at which a test at one frequency is to be made with six values of primary current, the additional fee will be one-half the base fee.
- (h) For the determination of the phase angle between primary and secondary currents, in addition to the ratio, for six values of primary current as above, the additional fee will be one-fourth the base fee as given above.
- (i) For each additional measurement of phase angle after the first six, the additional fee will be one-twentieth of the base fee as given above.
- (j) Each additional transformer after the first, to be tested at the same time and through the same range, will be charged one-half of the base fee as given above.<sup>19</sup>

### B. *Voltage transformers*

Test for ratio of transformation (quotient of primary applied voltage divided by secondary terminal voltage) with a given primary voltage, and five values of secondary load, namely, no load, 50 per cent, and full load, unity power factor; 50 per cent and full volt-amperes,<sup>20</sup> approximately 20 per cent power factor, unless otherwise ordered:

- (m) Primary voltage not exceeding 300 volts, tested at one frequency. . . . . \$3. 00
- (n) Exceeding 300 volts and not exceeding 750, tested as above. . . . . 4. 00
- (o) Exceeding 750 volts and not exceeding 1500, tested as above. . . . . 5. 00
- (p) Exceeding 1500 volts and not exceeding 3000, tested as above. . . . . 7. 00
- (q) Exceeding 3000 volts and not exceeding 7000, tested as above. . . . . 10. 00
- (r) Exceeding 7000 volts and not exceeding 12000, tested as above. . . . . 15. 00
- (s) Exceeding 12000 volts and not exceeding 17000, tested as above. . . . . 20. 00
- (t) Each additional load above five will be charged one-tenth of the base fee.
- (u) For each additional frequency<sup>18</sup> at which a test is made at five loads, the additional fee will be one-half of the base fee.
- (v) For each additional primary voltage at which a test at one frequency is to be made with five values of secondary load, the additional fee will be one-half the base fee.
- (w) For the determination of the phase angle between primary and secondary voltages, in addition to the ratio, for five values of secondary load as above, the additional fee will be one-fourth the base fee as given above.
- (x) For each additional measurement of phase angle after the first five, the additional fee will be one-twentieth of the base fee as given above.
- (z) Each additional transformer after the first, to be tested at the same time and through the same range, will be charged one-half of the above fees.<sup>21</sup>

<sup>18</sup> These fees are based on a moderate range of frequency. Tests at extreme frequencies will be subject to a special extra charge, and should always be arranged for in advance of shipment of the apparatus.

<sup>19</sup> This one-half rate applies only to the regular test with six values of secondary current; each additional current above six, for the additional transformer, will be charged one-tenth of the base fee as given in the schedules.

<sup>20</sup> When the rated capacity of the transformer exceeds 25 watts, the test at 20 per cent power factor will be made at 12.5 and 25 volt-amperes.

<sup>21</sup> This one-half rate applies only to the regular test with five values of secondary load; each additional secondary load above five, for the additional transformer, will be charged one-tenth of the base fee as given in the schedules.



## 7. CAPACITY AND INDUCTANCE

## SCHEDULE 88.—Capacity

Unless otherwise ordered, the test of a condenser will consist of the measurement of the capacity and phase angle at 100 cycles alternating current, and the measurement of the capacity with direct current using 0.6 second charge and two different times of discharge. The fee for this test, for a single condenser, according to (a), (m), and (o), is \$5. For each additional condenser, or each additional section of a subdivided condenser, according to (b), (n), and (p), the additional fee is \$1.50.

## A. Alternating-current tests

|   |         |
|---|---------|
| (a) Capacity and phase angle of a condenser, or of one section of a subdivided condenser, measured at 100 cycles per second, at one temperature.....        | \$2. 00 |
| (b) Each additional condenser, or each additional section of a subdivided condenser, tested at the same time and at the same frequency and temperature..... | . 50    |
| (c) Measurement at each additional temperature, for a single condenser.....   | 1. 00   |
| (d) Each additional condenser, tested as in (c).....  | . 50    |
| (e) Measurement at each additional frequency, with a maximum of 3000 cycles per second, for a single condenser.....   | 2. 00   |
| (f) Each additional condenser, tested as in (e).....  | 1. 00   |
| (g) Calibration of a variable air condenser at 20 points.....   | 10. 00  |
| (h) For determination of dielectric constant, a special fee will be charged.  |         |
| (i) Capacity and phase angle of a condenser or a cable, measured at 100 cycles per second, with commercial accuracy.....                                    | 1. 00   |
| (j) Each additional measurement of capacity and phase angle on condensers or cables submitted at the same time, as in (i).....                              | . 20    |

## B. Direct-current tests

|  |         |
|--|---------|
| (m) Measurement of the cyclic <sup>22</sup> capacity of a condenser, or of one section of a subdivided condenser, with 0.2, 0.4, or 0.6 second charge and 0.1, 0.5, or 1.0 second discharge... | \$2. 00 |
| (n) Each additional condenser, or each additional section of a subdivided condenser, tested similarly and at the same time.....  | . 50    |
| (o) Measurement at each additional temperature, or, with each additional time of charge or of discharge, for a single condenser.....   | 1. 00   |
| (p) Each additional condenser, tested as in (o).....   | . 50    |
| (q) For measurement of the capacity at different times of charge and discharge than those specified in (m), a special fee will be charged.   |         |
| (r) Measurement of the insulation resistance of a condenser, or of one section of a subdivided condenser.....  | 1. 00   |
| (s) Each additional condenser, tested as in (r).....   | . 50    |
| (t) Measurement of the absorption ratio <sup>23</sup> of a condenser, or of one section of a subdivided condenser.....   | 2. 00   |
| (u) Each additional condenser, tested as in (t).....   | 1. 00   |

<sup>22</sup> See Bulletin of Bureau of Standards, vol. 6, pp. 443 and 486; 1910. The cyclic capacity measured with 0.6 second charge has been found to be very nearly equivalent to the acyclic capacity with 1 second charge.

<sup>23</sup> The absorption ratio is determined by the following method: The condenser is charged 1 second; insulated 1 second; discharged 1 second; insulated 30 seconds, and then discharged through a ballistic galvanometer; again insulated 30 seconds, and so on until five successive discharges have been measured. The sum is taken as the total residual charge, and the "absorption ratio" is defined as the ratio of the residual charge to the original charge.

## SCHEDULE 89.—Inductance

|  |         |
|--|---------|
| (a) Measurement of the self-inductance of a coil, or of the mutual inductance between two coils, by alternating current of 100 cycles per second ..... | \$2. 00 |
| (b) Each additional coil tested at the same time .....   | 1. 00   |
| (c) Measurement at any other frequency, with a maximum of 3000 cycles per second, for a single inductance .....  | 3. 00   |
| (d) Each additional coil tested as in (c) .....  | 1. 50   |
| (e) Measurement of a coil at a second frequency, with a maximum of 3000 cycles per second .....  | 2. 00   |
| (f) Each additional coil tested as in (e) .....  | 1. 00   |
| (g) Calibration of a variable self or mutual inductance at 20 points .....   | 10. 00  |
| (h) Precise determination of the effective <sup>24</sup> inductance of a resistance coil for use in an alternating-current bridge .....                | 2. 00   |
| (i) Each additional coil of the same denomination .....  | 1. 00   |
| (j) Determination of the effective inductance of a rheostat resistance coil with sufficient precision for commercial work .....                        | 1. 00   |
| (k) Each additional coil of the same denomination, tested as in (j) .....  | . 50    |
| (l) For determination of the change in the resistance of an inductance coil with the frequency, a special fee will be charged.                         |         |

## SCHEDULE 90.—Wavemeters

A wavemeter, as used in radiotelegraphy, is a combination of inductance and capacity. One or the other is variable, and the settings may be interpreted in terms of wave length or frequency.

Reduced prices are given below for the standardization of wavemeters for amateurs and young experimenters. The wave length calibration listed under (*u*) will ordinarily consist of measurements at three points of the condenser for each coil. The condenser calibration listed under (*w*) will usually consist of capacity measurements at three to five points. The Bureau will decide in which class any wavemeter is to be tested.

A. *Precision wavemeters*

|   |         |
|---|---------|
| (a) Calibration of wavemeters, per point .....          | \$0. 50 |
| (b) Calibration curves, each .....                      | . 50    |
| (c) High-frequency inductance, per coil .....           | 2. 00   |
| (d) Capacity of variable air condenser, per point ..... | . 50    |
| (e) Decrement of a circuit .....                        | 1. 50   |
| (t) Minimum fee for one wavemeter .....                 | 5. 00   |

B. *Amateur wavemeters*

|   |         |
|---|---------|
| (u) Wave length calibration of wavemeter .....  | \$2. 00 |
| (v) High-frequency inductance, per coil .....   | . 50    |
| (w) Calibration of variable air condenser ..... | 1. 00   |

<sup>24</sup> The effective inductance is defined as the quotient of the reactance of the coil at any frequency divided by  $2\pi$  times the frequency. The reactance is due to the inductance of the coil, which is in series with the resistance, and to the capacity between its windings, which is in parallel with the resistance. The effective inductance may be either positive or negative, according as the inductance or the capacity effect predominates.

## 8. MAGNETISM

## SCHEDULE 91.—Normal Induction and Hysteresis

The material should be submitted in the form specified below. If hysteresis data are required, the tip of the loop must be one of the points.

|   |         |
|---|---------|
| (a) For each bar tested; first point. ....      | \$1. 50 |
| (b) Each additional point. ....                 | . 50    |
| Heat treatment of magnet steel (when required): |         |
| For each bar treated. ....                      | 2. 50   |
| Less 25 per cent for three or more bars.        |         |

In the absence of specific instructions, steel for electromagnets, etc., will be measured for the magnetizing forces corresponding to inductions of 2000, 4000, 6000, 8000, 10 000, 12 000, 14 000, 16 000, 18 000, and 20 000 gaussess, or such values as may be obtained without exceeding a magnetizing force of 300 gaussess. The fee for one bar only is \$6.

In the absence of specific instructions, magnet steel will be measured for magnetizing force, residual induction, and coercive force corresponding to a maximum induction of 14 000 gaussess. The fee for the magnetic test is \$2.50. If the specimen must be hardened, the total fee is \$7.50.

**Form of Specimen**

*Rods and Castings.*—These shall be submitted in the form of bars. Two bars of the same material are required, usually only one of which is to be tested and the second to be used as an auxiliary bar. The minimum length of the test piece is 25 cm (10 inches). Round rods may be 0.6 cm, 0.95 cm (three-eighths inch), 1 cm, or 1.27 cm (one-half inch) in diameter. Bars of any rectangular cross section which will pass through a hole 1 cm by 5 cm may be submitted.

For material to be used for electromagnets, field cores, etc., the usual test rod is 25 cm (10 inches) long and 1.27 cm (one-half inch) in diameter. Magnet steel is usually submitted in sizes as rolled and 25 cm long. Magnet steel may be hardened either by the person submitting the test or by the Bureau.

*Sheet Metal.*—Sheet metal may be submitted in either of two forms:

1. One form consists of 5 kilograms of strips 50 cm by 3 cm, half cut parallel and half cut at right angles to the direction of rolling.
2. The second form consists of 10 small sheets approximately 30 cm (12 inches) square. These are cut at the Bureau into strips 5 cm by 25.4 cm, half parallel and half at right angles to the direction of rolling. Test material is usually submitted in this form.



The same material that is submitted for a core loss test is also suitable for normal induction and hysteresis determinations.

In addition to the above, normal induction and hysteresis tests may be made on single strips 25 cm (10 inches) by 5 cm (2 inches). For this test as in the case of rods, two strips of the same material are required. The final cutting to size may be made at the Bureau without extra charge. This single strip test is intended only for investigations in which it is desired to know the characteristics of an individual strip. Core-loss determinations are not made on the single strip sample.

#### SCHEDULE 93—Core loss

The material should be submitted in the form specified below.

- |   |         |
|---|---------|
| (a) Measurement of core loss at one frequency and one flux density.....   | \$4. 00 |
| (b) Each additional measurement on the same sample.....   | . 50    |
| (c) Aging test, consisting of initial and final measurements of core loss at one frequency and one flux density with an intervening heating at 100° C. for two weeks..... | 12. 0   |

In the absence of specific instructions the core loss will be measured at a maximum induction of 10 000 gaussses and a frequency of 60 cycles. The fee is \$4.

**Form of Specimen.**—Sheet material intended for core-loss determination may be submitted in either of two forms.

1. One form consists of 10 kilograms of strips 50 cm by 3 cm, half cut parallel to the direction of rolling and half at right angles to the direction of rolling. These strips should be cut to size by the person submitting the material for test. It may, however, be done at the Bureau. If the material is to be cut to size at the Bureau, sufficient material to allow for waste must be supplied.

2. The second form consists of 10 small sheets approximately 30 cm (12 inches) square. These are cut at the Bureau into strips 5 cm by 25.4 cm, half parallel and half at right angles to the direction of rolling. Test material is usually submitted in this form.

### 9. RADIUM

As recommended by the International Commission on Radium Standards, all determinations of the radium content of hermetically sealed specimens are based upon a comparison of the penetrating gamma radiation of the specimens with that of the standard.

This penetrating radiation proceeds not from radium itself but from radium-C, one of the disintegration products of radium. Consequently, if

the products of disintegration are entirely removed when the salt is sealed, there will at first be no penetrating radiation whatever; a measurement will give no indication of the presence of any radium in the specimen. Owing to the continual disintegration of the radium atom, the products of disintegration will at once begin to accumulate and at the end of four days radium-C and consequently its penetrating radiation will have reached about one-half of its equilibrium value; and at the end of a month it will be within a half of a per cent of its equilibrium value. After equilibrium is reached the amount of radium-C in the specimen remains constant; or, rather, to be exact, it decreases at the same rate as radium disintegrates, namely, about one-half in 2000 years.

On the other hand, if only radium emanation (a gaseous disintegration product of radium) is sealed in a tube, the amount of radium-C which is in equilibrium with the amount of emanation will be formed almost immediately, and an observation will show the presence of an intensity of the penetrating radiation which is equal to that emitted by a tube which contains a certain amount of radium and which has been sealed for over a month. That is, a tube containing *no* radium may give a penetrating radiation equal to that given by a tube containing radium.

If the tube containing only radium emanation and its disintegration products is observed again, four days later, its penetrating radiation will be found to be only one-half of what it was before; after a month the radiation will have practically disappeared.

Thus, it is evident that no conclusion as to the amount of radium in a tube can be drawn from measurements made upon a single day. The actual amount of radium may be either greater or less than that indicated by the observed intensity of the penetrating radiation.

For this reason, unless specifically instructed to the contrary, the Bureau will hold all specimens for at least a week. If equilibrium is found to exist—that is, if the radiation is found to remain constant over this period—this fact will be stated in the certificate.

If for any reason it is desired that the Bureau shall not retain the specimen for this length of time, measurements will be made upon but a single day, and the certificate, while naming the amount of radium indicated by the radiation, will state that the actual amount of radium in the specimen is unknown. The fee charged will be the same for both classes of measurements.

## SCHEDULE 94.—Radium and its Emanation

*A. Hermetically sealed specimens of radium salts*

- |  |        |
|--|--------|
| (a) One specimen not exceeding 1 mg. ....  | \$5.00 |
| (b) Excess over 1 mg, per mg. ....   | .25    |
| (c) For each additional specimen of the same size and to be measured at the same time the charge will be one-half the base fee as given above. |        |

*B. Emanation standards and measurements*

- (s) The Bureau is prepared to supply a limited number of standard radium solutions, and to make measurements of the emanation content of waters which can be shipped to the laboratory. For these reasonable fees will be charged.

## 10. PHOTOMETRY

## INCANDESCENT ELECTRIC LAMPS

A normal carbon filament incandescent lamp when operated at constant voltage increases slightly in candlepower for the first 50 hours, more or less, according to the temperature at which it is burned. A stationary period is then reached, after which there is a progressive drop in the candlepower. The initial rise in candlepower is due to a gradual decrease in the resistance of the filament, while the subsequent decrease in candlepower is due chiefly to blackening, caused by a deposit on the inside of the bulb.

This is, in general, the behavior of all incandescent filament lamps, whether carbon, metallized carbon, tantalum, or tungsten. Therefore, in order that a lamp may be useful as a photometric standard it should be carefully seasoned by a preliminary burning sufficient to bring its resistance to a steady state. In order that it may not be affected subsequently by any slight overvoltage, the lamp should be seasoned at a voltage somewhat higher than that at which it is to be used as a standard.

The Bureau is prepared to standardize incandescent filament lamps which have been properly seasoned, or to season and standardize lamps when necessary, or to furnish lamps that have been seasoned and standardized at the Bureau, the respective fees being as given in the following schedule.

When lamps are submitted for standardization it is desirable that they be accompanied by a statement as to whether they have been seasoned or not, and, if so, the voltage at which they were burned and the number of hours should also be given if known. It should be stated also whether they are to be standardized rotating or stationary and whether at a given candlepower, voltage, current, or efficiency.



## SCHEDULE 95.—Standardizing Incandescent Electric Lamps

A. *Standardizing only*

Standardizing lamps which have been properly seasoned; horizontal candlepower, stationary or rotating; or mean spherical candlepower. For lamps not seasoned, fees are given under B.

|   |         |
|---|---------|
| (a) Carbon or metallized carbon filament lamps: |         |
| One lamp.....                                   | \$2. 00 |
| (b)     Two or more lamps, each.....            | 1. 50   |
| (c) Tungsten filament lamps:                    |         |
| One lamp.....                                   | 2. 50   |
| (d)     Two or more lamps, each.....            | 2. 00   |

B. *Seasoning and standardizing*

|   |         |
|---|---------|
| (m) Carbon or metallized carbon filament lamps: |         |
| One lamp.....                                   | \$4. 00 |
| (n)     Two or more lamps, each.....            | 3. 00   |
| (o) Tungsten filament lamps:                    |         |
| One lamp.....                                   | 5. 00   |
| (p)     Two or more lamps, each.....            | 4. 00   |

## SCHEDULE 96.—Supplying Standardized Lamps

The Bureau undertakes to keep on hand a small stock of seasoned and standardized lamps of the more common voltages and candlepower, some standardized stationary, others rotating. As these lamps are standardized together in comparatively large quantities, they can be furnished at the prices below. Lamps of unusual voltages or candlepower, which have to be seasoned and standardized to order, or stock lamps which have to be restandardized to meet the requirements of an order, are furnished at prices given in Schedule 95 B.

|  |         |
|--|---------|
| (a) Carbon or metallized carbon filament lamps:  |         |
| One lamp.....  | \$3. 00 |
| (b)     Two or more lamps, each.....   | 2. 50   |
| (c) Tungsten filament lamps, 60 watts and below:   |         |
| One lamp.....  | 4. 00   |
| (d)     Two or more lamps, each.....   | 3. 50   |
| (e) Carbon filament lamps of approximately 16 candles at approximately 110 volts to be used for reference standards at 4 watts per candle, which have been especially selected and measured with greater than usual precision, with certificate of candlepower, voltage, and current, and a curve showing performance during the seasoning and standardizing period..... |         |
|  | 6. 00   |
| (f)     Two or more lamps, each.....   | 5. 00   |

## SCHEDULE 97.—Commerical Tests

- (a) When the highest accuracy is not required, electric incandescent lamps are measured for candlepower, voltage, and watts:
- |                           |        |
|---------------------------|--------|
| Ten lamps or fewer.....   | \$1.00 |
| Each additional lamp..... | .10    |
- (b) Each additional lamp..... .10
- (c) When life tests are required the lamps are measured initially, then after a period of fifty hours burning, and thereafter every one hundred hours until the candlepower has fallen to 80 per cent of its original value or until the filaments break. Carbon or metallized carbon filament lamps:
- |                         |      |
|-------------------------|------|
| 60 watts and below..... | 2.00 |
| Above 60 watts.....     | 2.50 |
- (d) Tungsten filament lamps:
- |                         |      |
|-------------------------|------|
| 40 watts and below..... | 3.50 |
| Above 40 watts.....     | 4.00 |
- (f) Above 40 watts..... 4.00

The Bureau makes commercial photometric tests only when the special circumstances make the test of more than usual importance.

## FLAME STANDARDS

**Harcourt Pentane Lamps.**—Investigation has shown that the pentane lamp is a reliable working standard, but that individual lamps can not be assumed to have the nominal value of 10 candles. The Bureau is prepared to carry out tests in which lamps submitted are compared both with electric standards and with pentane lamps calibrated here and at the National Physical Laboratory of England. The candlepower is certified to plus or minus 1 per cent.

**Hefner Amyl-Acetate Lamps.**—Hefner amyl-acetate lamps give 0.9 of an international candle when burned at the regular flame height, namely, 40 mm. They are tested to determine whether they conform to specifications in construction, and are compared photometrically both with electric standards and with Hefner lamps certified by the Physikalisch-Technische Reichsanstalt. The candlepower is certified to plus or minus 2 per cent. Such amyl-acetate lamps may be made to burn at a flame height of 45 mm, when they give 1 international candle. The lamps are tested in this way also, and the candlepower certified to plus or minus 2 per cent, if provided with suitable flame sights.

## SCHEDULE 98.—Standardizing Flame Standards

- (a) Harcourt pentane lamp, candlepower certified to plus or minus 1 per cent..... \$10.00
- (b) Hefner amyl-acetate lamp, candlepower certified to plus or minus 2 per cent..... 5.00

## SCHEDULE 99.—Miscellaneous

Tests of arc lamps, signal lamps, locomotive headlights, illuminometers, color-absorbing screens, etc., are made. Light distribution curves of reflectors and light sources are furnished. The fee for any such test will be quoted after correspondence fully setting forth the nature of the test.

## 11. MISCELLANEOUS TESTS

The Bureau is prepared to make tests upon insulating materials, insulated wire, insulating joints, etc. Tests of dielectric strength (using alternating electromotive forces) up to 100 000 volts are made. Insulation resistance is determined. Correspondence regarding such tests is invited. Reasonable fees will be charged. As far as the facilities and duties of the Bureau will permit, special tests not listed will be made when their results would be of special importance.

S. W. STRATTON,  
*Director.*

Approved:

E. F. SWEET,  
*Assistant Secretary.*





