DEPARTMENT OF COMMERCE

CIRCULAR

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 6

FEES FOR ELECTRIC, MAGNETIC, AND PHOTOMETRIC TESTING

[7th Edition]
Issued December 30, 1916

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FEES FOR ELECTRIC, MAGNETIC, AND PHOTOMETRIC TESTING

CONTENTS

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; this subject is treated more in detail in a circular on radium, soon to be issued. The schedules of fees given herein supersede those previously published. A number of changes have been made in this edition, particularly in the rearrangement of Schedules 81 to 86. Additional information concerning these tests will be found in the following Circulars:

No. 13. Standard Specifications for Incandescent Electric Lamps.

No. 15. The International Unit of Light.

No. 17. Magnetic Testing.

No. 20. Electrical Measuring Instruments.

No. 21. Precision Measurements of Resistance and Electromotive Force.

No. 31. Copper Wire Tables.

No. 36. The Testing and Properties of Electric Condensers.

No. 60. Electric Units and Standards.

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 Instruments, Meters, and Transformers.**—Testing of direct and alternating current measuring instruments; voltmeters, millivoltmeters, ammeters, wattmeters, watthour meters, phase meters, frequency meters, current and voltage transformers, etc.

(d) **Capacity and Inductance.**—Determination of capacity of condensers by alternating and direct current; measurement of phase angle, absorption ratio, and insulation resistance. Determination of constants of cables. Testing of standards of self and mutual inductance; inductances of instruments; effective inductance of resistance coils.

(e) **Radio Apparatus.**—Standardization of wavemeters and high-frequency ammeters. Testing of sending and receiving sets.

(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 radioactive material, and of the radium emanation content of liquids. Testing of apparatus used in the application or measurement of radioactive material.

(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 unit is maintained by mercury standards which have been set up according to definite specifications in the national laboratories of England, France, Germany, Japan, Russia, and the United States. The 1-ohm reference standards of these countries agree within a few hundred-thousandths of an ohm. For further informa-

tion see this Bureau's Circular No. 60, "Electric Units and Standards."

Electromotive forces are measured in terms of Weston cells. The electromotive force of the mean Weston normal cell [1] is fixed by the International Committee on Electrical Units and Standards as 1.0183 international volts at 20° C. 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 reference cells of the different national laboratories agree within a few hundred-thousandths of a volt.

Electric current is measured in terms of resistance standards 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 resistance standards 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. Alternating-current instruments are used in turn to calibrate the standards used in radio measurements.

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 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.

[1] 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.

4. GENERAL INSTRUCTIONS TO APPLICANTS FOR TESTS

(a) **Application for Test.**—All articles submitted for test must be accompanied by a written request for the test. When practicable tests 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. The tests of highest precision are expensive to make, and should not be requested except for important apparatus which is of such a nature as to justify such test, as the capacity of the Bureau for such work is limited.

(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 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. Such special tests

include measurements of dielectric strength (using alternating voltage) up to 100 000 volts, and resistance of insulating materials. 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, 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 should be in good working condition, the insulation adequate, and contacts clean, etc., as apparatus which is not in good working order is not tested. If repairs or adjustments 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. When apparatus is found to be unsuitable for use in measurements as accurate as the test requested, the test will be made, if at all, according to a schedule giving appropriate accuracy. 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 first 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 in all cases where the return of the apparatus or specimens is desired. 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."

(i) **Witnessing Tests.**—Applicants for tests sometimes request that they be notified in advance when the test is to be made in order that they may come to the Bureau to witness the test. To grant such requests would not be consistent with economy and efficiency in the work of the Bureau, as on the average at least twice as much time would be consumed, and the obtaining of accurate and reliable results would be made more difficult. However, visitors who are interested in the apparatus and methods used at the Bureau are always welcome, and will be given every opportunity to obtain desired information, so far as the work on hand will permit.

5. RESISTANCE

The fees given in this section (schedules 71 to 78, inclusive) are for such tests of resistance standards, resistance apparatus, and the electrical properties of conductors as are regularly made by the Bureau.

Resistance standards of the precision type only (that is, standards made according to the best practice, adjusted very nearly to

nominal values, having amalgamated terminals, and intended for oil immersion) are accepted for test under schedule 71. For new standards certificates are not issued under this schedule until at least two months after the date of completion of manufacture.

Tests are made in accordance with schedule 71 (*k*) only when it is shown that the small changes in resistance resulting from necessary variations of the temperature from 25° C. are of importance in the work in which the standards are used.

The fees of schedule 72 apply to resistance standards of the precision type which are not of the best construction or are used in work in which the higher accuracy is not needed.

Only resistance standards (or shunts) provided with oil baths and means for water cooling are accepted for test in accordance with schedule 73.

Only resistance standards (or shunts) of the air-cooled type are accepted for test in accordance with schedule 74.

Resistance apparatus of the best quality only will be tested in accordance with schedule 75. In general, certificates are not issued for new apparatus under this schedule until at least two months after the date of completion of manufacture.

The fees of schedule 77 apply to resistance apparatus which is not of the best quality or which is not used in measurements of the highest accuracy.

The fees of schedule 78 (*a*) to (*d*), inclusive, apply only to wires between 117 and 127 cm long which are straight, clean, and practically ready for measurement. When a considerable amount of work is necessary to get the specimen in shape for test, the fee of schedule 78 (*h*) will be added to that for the determination of the electrical properties. This extra fee is charged for wire and cable from which the insulation must be removed before testing, for short or badly bent wire, and for wire which is to be annealed or drawn and annealed.

If it is desired that samples submitted for test of electrical properties be returned, it should be so stated in the request for the test.

When requested, the percent conductivity will be stated for 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 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.

For standards having values 1½, 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 1½, 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 1½, 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*) 0.000 001 ohm, measured with test current not exceeding 2500 amperes..... 7. 00
(*h*) For an additional measurement with a smaller test current, the additional fee will be half the above.

For standards having values 1½, 2, 3, 4, or 5 times any of the above, the next higher fee will be charged.

For standards having values between 1 and 10, and not 1½, 2, 3, 4, or 5, times any of the above, the second 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
(*h*)	Preparation of test specimen	2.00

6. ELECTROMOTIVE FORCE

Schedule 79.—STANDARD CELLS

[Accuracy, 0.0001 volt]

(*a*)	Determination of electromotive force of unmounted Weston normal cells or unmounted Clark cells at 20° C, each	$2.00
(*b*)	Determination of electromotive force of mounted cells at room temperature, 19° to 30° C, each	2.00
(*c*)	Determination of electromotive force of any cell at two temperatures, viz, regulating temperature of cell bath, 23° to 28° C, dependent upon season, and a higher temperature not exceeding 35° C	3.50
(*d*)	Each additional cell	2.50

(*e*) Determination of electromotive force of any cell at three temperatures, 15° to 35° C..... $5. 00
(*f*) Each additional cell..... 3. 00

NOTE.—On account of the labor involved in maintaining a fixed temperature below that of the room during April to September, the Bureau reserves the right to reject all applications for tests under 79 (*e*) during that period, except where urgent necessity can be shown.

7. ELECTRICAL INSTRUMENTS, METERS, AND INSTRUMENT TRANSFORMERS

The following points should be carefully noted before sending electrical instruments, meters, or transformers to the Bureau for test.

(a) **Plan of Fee Schedules.**—The plan of schedules 81 to 86 is to charge a "base fee" for the test of a piece of apparatus at a definite number of points (usually five); that is, at five values of current, voltage, power, etc., as the case may be. The amount of this base fee varies with the kind of apparatus and its range. Each additional point is then charged for at one-tenth of the base fee. Similarly, the fee for each additional instrument of the same kind, tested at the same time and through the same range, is one-half of the base fee. This one-half rate applies only to the five-point test; additional points beyond five for the additional instrument will each be charged one-tenth of the base fee. It will be noted that in schedules 81 to 86 the letters (*a*) to (*h*) are used for various ranges of instruments under the A sections of the schedules, and (*i*) to (*p*) for the B sections. The letters (*s*) to (*z*) have the same significance throughout, except that the scope of item (*w*) is necessarily greater in some schedules than in others. This arrangement will facilitate the use of the schedules by the Bureau and by the public.

When an instrument is submitted for test at fewer points than are called for in the base fee, the base fee will be charged. In other words, the base fee is also the minimum fee for a test of the given instrument.

The fee for a multiple-range piece of apparatus, tested on more than one range, will be computed by taking as base fee that for the highest point tested.

The fees given in schedules 81, 82, 83, and 85 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. When 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 when the instruments have any unusual characteristics which increase the difficulty of making the required tests, the fees will be greater, depending on the amount of labor required.

(b) **Wave Form and Frequency.**—The alternating-current tests are regularly made with currents and voltages which closely approximate to the sine wave form, and at frequencies not greatly exceeding the limits of the usual power and lighting frequencies. Tests at other frequencies or other wave forms will be made when practicable, and will be subject to special fees. Determinations may be made of the wave forms used in the test, or of those of small alternators. All such special tests should be arranged for in advance of shipment of the apparatus.

(c) **Alternating Current to Direct Current Transfer Tests.**—When ammeters, voltmeters, or wattmeters of the electrodynamometer type which may be operated on reversed direct current [2] and on alternating current are submitted for test on alternating current, they will first be tested on reversed direct current at the desired points, after which a determination will be made of the difference between the readings on reversed direct current and on alternating current. This "transfer test" will usually be made at one or two points.

The fee for a test made as described in the preceding paragraph will be computed as follows: The fee for the initial direct-current test at five points, with any additional direct-current tests which may be requested, such as additional points above five, temperature coefficient, etc., will be taken from the schedule of fees for direct-current tests of the given kind of instrument (ammeter, voltmeter, or wattmeter). The fee for determining the difference in the readings on direct current and on alternating current will be charged according to item (x) of the schedule of alternating-current tests for the given kind of instrument.

(d) **Points Tested.**—The points at which test is to be made should be specified in the request. However, when instruments under schedules 81 and 82 are submitted for test without specific instructions, single-range instruments, at the discretion of the

[2] The expression "reversed direct current" is used to signify the regular procedure in the use of instruments of this kind on direct current in order to avoid error caused by local magnetic field. For example, in using an electrodynamometer voltmeter on direct current, two readings are taken, the direction of current flow through the instrument being reversed before taking the second reading. The mean of the two readings gives a result independent of the local magnetic field.

Bureau, will be tested at five points; multiple-range instruments, at five points on one range and one or two points on each of the other ranges.

(e) **Millivoltmeter and Shunt.**—The combination of a millivoltmeter and a shunt will be tested as an ammeter for the fee for an ammeter of the corresponding range. If the millivoltmeter is also to be tested separately, the additional fee will be as given in schedule 81 B.

(f) **Alternating Current Ammeters.**—When alternating-current ammeters are used with current transformers, it is preferable to test ammeter and transformer separately, 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 and use. When so tested, they will be counted as two pieces of apparatus, and the fee will be charged accordingly. 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 of good materials and properly handled. The same statements apply to voltmeters used with voltage (potential) transformers.

(g) **Wattmeters.**—When single-phase wattmeters are submitted for test without specific instructions, and are of such types as may be operated on reversed direct current and on alternating current, they will be tested with reversed direct current at five points. If they have more than one range, they will be tested at five points on one range, and at one or two points on each of the other ranges. At the discretion of the Bureau, the test of other voltage ranges may be made by measurement of the resistances of the corresponding voltage circuits.

When wattmeters which may be operated on reversed direct current and on alternating current are submitted for test with alternating current, the test will be made as described under "Alternating current to direct current transfer tests," section (*c*) above.

Wattmeters operating only on alternating current (induction type) will be tested only on receipt of detailed instructions as to voltage, frequency, power factor, ranges, and points on each range at which test is to be made.

(h) **Watthour Meters, Phase Meters, etc.**, schedules 84 and 85, must in all cases be accompanied by full instructions as to the nature of the test desired. The number of kilowatts given in

schedule 84 refers to the rated capacity of the watthour meter, and not to the power used in the test. The fees for watthour meters apply alike to service meters and to portable watthour meters (so-called "rotating standards"). Since the latter are frequently made with several current and voltage ranges, it should be noted that it is not necessary to make a five-point test on each range when the different current ranges are obtained by connecting like sections of a subdivided current winding in various ways by the use of links or a controller. For example, if the meter has connection links giving ranges of 10, 20, and 40 amperes at either 110 or 220 volts, the test may be made as follows: Test the 10-ampere 110-volt range at the five values of current given in the schedule; test the 10-ampere 220-volt, 20-ampere 110-volt, and 40-ampere 110-volt ranges at 10 per cent and at 100 per cent of rated current.

(i) **Current Transformers** must be accompanied by full instructions covering the following points: Frequency at which test is to be made, resistance and reactance of secondary load, values of secondary current, and whether phase angle is desired as well as ratio. (It is necessary to know the phase angle of a transformer only when a wattmeter or a watthour meter is operated from it.) The wires used to connect the secondary instruments to the transformer should be included in the measurement of resistance and reactance. If it is not convenient to make this measurement, it will suffice for most purposes to state the maker's name, type, and serial number of each instrument, and the size and length of wire used in the secondary circuit. When the most accurate results are required, it is necessary to send the secondary instruments with the transformer. It is desirable to make the test at the particular values of secondary current given in schedule 86, *A*, and the specifying of other values within the given range should be avoided. When a current transformer has more than one primary range, a test on one range at six points and each of the other ranges at 0.5 and at 5 amperes secondary current is sufficient.

(j) **Voltage Transformers** (potential transformers) must be accompanied by full instructions covering the following points: Frequency at which test is to be made, secondary voltage (or voltages), values of secondary load, and whether phase angle is desired as well as ratio. (It is necessary to know the phase angle of a transformer only when a wattmeter or watthour meter is

operated from it.) If the transformer has more than one primary or secondary range, the application must also state with what range or ranges the test is to be made. The ratio and the phase angle of a voltage transformer change linearly as the noninductive secondary load increases, and hence, if their values are determined for two noninductive loads, values for intermediate loads may be found by interpolation. When the voltage circuits (potential circuits) of instruments operated from the transformer are practically noninductive, as is often the case, it is only necessary to measure the resistance of the voltage circuit of each instrument in order to calculate the load which it puts on the transformer. If the voltage circuits are inductive, or if doubt exists about them, the maker's name, type, and serial number of each instrument may be given, but when the most accurate results are required, it is necessary to send such secondary instruments with the transformer.

(k) **Circular No. 20** of the Bureau of Standards entitled "Electrical Measuring Instruments," contains information on the principles of operation of electrical measuring instruments, the advantages and limitations of the various types, sources of error and their avoidance, and discusses some points of design which are of interest to the user. A brief discussion of current and voltage transformers is given, and an outline of the equipment required for the precision testing of electrical instruments. A copy of this circular may be had on application to Bureau of Standards, Washington, D. C.

Schedule 81.—DIRECT-CURRENT AMMETERS AND VOLTMETERS

A. DIRECT-CURRENT AMMETERS

(*a*)	Test at five points; not exceeding 150 amperes	$1.50
(*b*)	The same, exceeding 150 and not exceeding 500 amperes	2.50
(*c*)	The same, exceeding 500 and not exceeding 1000 amperes	5.00
(*d*)	The same, exceeding 1000 and not exceeding 5000 amperes	8.00
(*e*)	The same, exceeding 5000 and not exceeding 10 000 amperes	12.00

(*s*) Each additional point above five will be charged one-tenth of the base fee.

(*t*) Each additional instrument after the first, to be tested at the same time and through the same range, will be charged one-half of the base fee.

(*u*) For the determination of the temperature coefficient a fee will be charged equal to twice the base fee.

(*v*) For the determination of the effect of continued current on the readings the additional fee will be one-half of the base fee.

(*w*) Tests on additional ranges will be charged as additional points at one-tenth of the base fee each; the first point, however, on each additional range will be counted as two points.

B. DIRECT-CURRENT VOLTMETERS AND MILLIVOLTMETERS

(*i*) Test at five points; not exceeding 300 volts..... $1. 50
(*j*) The same, exceeding 300 volts and not exceeding 750 volts..... 2. 50
(*k*) The same, exceeding 750 volts and not exceeding 1500 volts..... 5. 00
(*s*) Each additional point above five will be charged one-tenth of the base fee.
(*t*) Each additional instrument after the first, to be tested at the same time and through the same range, will be charged one-half of the base fee.
(*u*) For the determination of the temperature coefficient a fee will be charged equal to twice the base fee.
(*v*) For the determination of the effect of continued current on the readings the additional fee will be one-half of the base fee.
(*w*) Tests on additional ranges will be charged as additional points at one-tenth of the base fee each; the first point, however, on each additional range will be counted as two points.

Schedule 82.—ALTERNATING-CURRENT AMMETERS AND VOLTMETERS

A. ALTERNATING-CURRENT AMMETERS[3]

(*a*) Test at five points, at one frequency; not exceeding 150 amperes..... $2. 50
(*b*) The same, exceeding 150 amperes and not exceeding 500 amperes..... 5. 00
(*c*) The same, exceeding 500 amperes and not exceeding 1000 amperes..... 8. 00
(*s*) Each additional point above five will be charged one-tenth of the base fee.
(*t*) Each additional instrument after the first, to be tested at the same time and through the same range, will be charged one-half of the base fee.
(*u*) For the determination of the temperature coefficient a fee will be charged equal to twice the base fee.
(*v*) For the determination of the effect of continued current on the readings the additional fee will be one-half of the base fee.
(*w*) Tests on additional ranges or with other frequencies will be charged as additional points at one-tenth of the base fee each; the first point, however, under each new condition will be counted as two points.
(*x*) For the determination of the difference in the readings on direct current and on alternating current of a given frequency, in addition to an initial test with direct current, the additional fee will be one-tenth of the base fee per point tested; the first point, however, will be counted as two points. For the determination of this difference with other frequencies, or on other ranges, the fee will be one-tenth of the base fee per point tested, the first point under each new condition being counted as two points. The base fee referred to in this item is the base fee for an ammeter of the given range when tested on *alternating* current.

B. ALTERNATING-CURRENT VOLTMETERS[3]

(*i*) Test at five points, at one frequency, not exceeding 300 volts..... 2. 00
(*j*) The same, exceeding 300 volts and not exceeding 750 volts..... 4. 00
(*k*) The same, exceeding 750 volts and not exceeding 1500 volts..... 6. 00
(*l*) The same, exceeding 1500 volts and not exceeding 3000 volts..... 8. 00
(*s*) Each additional point above five will be charged one-tenth of the base fee.
(*t*) Each additional instrument after the first, to be tested at the same time and through the same range, will be charged one-half of the base fee.
(*u*) For the determination of the temperature coefficient a fee will be charged equal to twice the base fee.
(*v*) For the determination of the effect of continued current on the readings, the additional fee will be one-half of the base fee.

[3] See paragraph on "Alternating-current to direct-current transfer test" on p. 14.

(*w*) Tests on additional ranges or with other frequencies will be charged as additional points at one-tenth of the base fee each; the first point, however, under each new condition, will be counted as two points.

(*x*) For the determination of the difference in the readings on direct current and on alternating current of a given frequency, in addition to an initial test on direct current, the additional fee will be one-tenth of the base fee per point tested; the first point, however, will be counted as two points. For the determination of this difference with other frequencies, or on other ranges, the fee will be one-tenth of the base fee per point tested, the first point under each new condition being counted as two points. The base fee referred to in this item is the base fee for a voltmeter of the given range when tested on *alternating* current.

(*z*) Determination of the resistance of an alternating-current voltmeter and its inductance at one point of the scale..... $2.00

(*zs*) Determination of the inductance at additional points, each [4]..... .50

Schedule 83.—WATTMETERS

A. TESTED WITH REVERSED DIRECT CURRENT

(*a*) Test at five points; not exceeding 5 kilowatts..... $2.00

(*b*) The same, exceeding 5 kilowatts and not exceeding 25 kilowatts..... 3.00

(*c*) The same, exceeding 25 kilowatts and not exceeding 100 kilowatts..... 5.00

(*d*) The same, exceeding 100 kilowatts and not exceeding 250 kilowatts..... 8.00

(*s*) Each additional point above five will be charged one-tenth of the base fee.

(*t*) Each additional instrument after the first, to be tested at the same time and through the same range, will be charged one-half of the base fee.

(*u*) For the determination of the temperature coefficient a fee will be charged equal to twice the base fee.

(*v*) For the determination of the effect of continued current on the readings, the additional fee will be one-half of the base fee.

(*w*) Tests on additional ranges will be charged as additional points at one-tenth of the base fee each; the first point, however, on each additional range, will be counted as two points.

(*z*) Determination of the inductance and resistance of the voltage circuit of a wattmeter..... 2.00

B. TESTED WITH ALTERNATING CURRENT [5]

(*i*) Test at five points, at one frequency, one voltage, and one power factor; not exceeding 5 kilowatts..... 3.00

(*j*) The same, exceeding 5 kilowatts and not exceeding 25 kilowatts..... 4.00

(*k*) The same, exceeding 25 kilowatts and not exceeding 100 kilowatts..... 6.00

(*s*) Each additional point above five will be charged one-tenth of the base fee.

(*t*) Each additional instrument after the first, to be tested at the same time and through the same range, will be charged one-half of the base fee.

(*u*) For the determination of the temperature coefficient a fee will be charged equal to twice the base fee.

(*v*) For the determination of the effect of continued current on the readings, the additional fee will be one-half of the base fee.

(*w*) Tests on additional ranges, or with other frequencies, power factors or voltages, will be charged as additional points at one-tenth of the base fee each; the first point, however, under each new condition, will be counted as two points.

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[4] This usually makes it necessary to break the seals and open the instrument.

[5] See paragraph on "Alternating current to direct current transfer tests," on p. 14.

(*x*) For the determination of the difference in the readings on direct current and on alternating current of a given frequency and power factor, in addition to an initial test on direct current, the additional fee will be one-tenth of the base fee per point tested; the first point, however, will be counted as two points. For the determination of this difference with other conditions as to frequency and power factor, or on other ranges, the fee will be one-tenth of the base fee per point tested, the first point under each new condition being counted as two points. The base fee referred to in this item is the base fee for a wattmeter of the given range when tested on *alternating* current.

(*y*) The above fees apply to single-phase wattmeters; the base fees for polyphase wattmeters will be twice those for single phase.

Schedule 84.—WATTHOUR METERS

A. DIRECT-CURRENT WATTHOUR METERS

(*a*)	Test at one voltage on five loads, namely, 10 per cent, 25 per cent, 50 per cent, full load, and 50 per cent overload, unless otherwise ordered; not exceeding 5 kilowatts	$3. 00
(*b*)	The same, exceeding 5 kilowatts and not exceeding 25 kilowatts	4. 00
(*c*)	The same, exceeding 25 kilowatts and not exceeding 100 kilowatts	6. 00
(*d*)	The same, exceeding 100 kilowatts and not exceeding 250 kilowatts	8. 00
(*e*)	The same, exceeding 250 kilowatts and not exceeding 500 kilowatts	10. 00
(*f*)	The same, exceeding 500 kilowatts and not exceeding 1000 kilowatts	12. 00
(*g*)	The same, exceeding 1000 kilowatts and not exceeding 1500 kilowatts	15. 00

(*s*) Each additional load above five will be charged one-tenth of the base fee.

(*t*) 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 of the base fee.

(*u*) For the determination of the temperature coefficient a fee will be charged equal to twice the base fee. This determination will be made at one-tenth and at full load, unless otherwise ordered.

(*w*) Tests on additional ranges or with other voltages will be charged for as additional points at one-tenth of the base fee each; the first point, however, under each new condition, will be counted as two points.

B. ALTERNATING-CURRENT WATTHOUR METERS

(*i*)	Test at one frequency, one power factor, and one voltage, on five loads, namely, 10 per cent, 25 per cent, 50 per cent, full load, and 50 per cent overload, unless otherwise ordered; not exceeding 5 kilowatts	3. 00
(*j*)	The same, exceeding 5 kilowatts and not exceeding 25 kilowatts	4. 00
(*k*)	The same, exceeding 25 kilowatts and not exceeding 100 kilowatts	6. 00

(*s*) Each additional load above five will be charged one-tenth of the base fee.

(*t*) 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 of the base fee.

(*u*) For the determination of the temperature coefficient a fee will be charged equal to twice the base fee. This determination will be made at one-tenth and at full load, unity power factor, unless otherwise ordered.

(*w*) Tests on additional ranges, or with other frequencies, power factors, or voltages, will be charged as additional points at one-tenth of the base fee each; the first point, however, under each new condition, will be counted as two points.

(*y*) The above fees apply to single-phase watthour meters; the base fees for polyphase watthour meters will be twice those for single-phase.

Schedule 85.—PHASE METERS, POWER-FACTOR METERS, AND FREQUENCY METERS

(*a*) Phase meters and power-factor meters, test at five points; current ranges not over 100 amperes, voltage ranges not over 250 volts; at one frequency and one load $5. 00
(*b*) Frequency meters, at one voltage, test at five points 3. 00
(*s*) Each additional point above five will be charged one-tenth of the base fee.
(*t*) Each additional instrument after the first, to be tested at the same time and through the same range, will be charged one-half of the base fee.
(*u*) For the determination of the temperature coefficient, a fee will be charged equal to twice the base fee.
(*w*) Tests on additional ranges, or with (1) other frequencies or voltages in the case of phase meters and power-factor meters: (2) other voltages, in the case of frequency meters, will be charged as additional points at one-tenth of the base fee each; the first point, however, under each new condition, will be counted as two points.

Schedule 86.—INSTRUMENT TRANSFORMERS

A. CURRENT TRANSFORMERS

(*a*) Test for ratio of transformation at one frequency, with one secondary connected load, at six values of secondary current, viz., 0.5, 1, 2, 3, 4, and 5 amperes, unless otherwise ordered; primary current not exceeding 250 amperes $4. 00
(*b*) The same, exceeding 250 amperes and not exceeding 500 amperes 5. 00
(*c*) The same, exceeding 500 amperes and not exceeding 1,000 amperes 6. 00
(*q*) 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 1. 00
(*r*) For each additional measurement of phase angle after the first six, the additional fee will be ..... .20
(*s*) Each additional determination of ratio above six will be charged one-tenth of the base fee.
(*t*) Each additional transformer after the first, to be tested for ratio at the same time, through the same range, and at six values of secondary current, will be charged one-half of the base fee.
(*w*) Tests on additional ranges, or with other frequencies, or with other secondary connected loads will be charged as additional points at one-tenth of the base fee each; the first point, however, under each new condition, will be counted as two points.

B. VOLTAGE TRANSFORMERS (POTENTIAL TRANSFORMERS)

(*i*) Test for ratio of transformation, at one frequency and one secondary voltage, and with four values of secondary connected load (zero, half, and full rated noninductive load, and one inductive load approximately equivalent to the voltage circuit of an induction watthour meter, unless otherwise ordered); primary voltage not exceeding 2500 volts 4. 00
(*j*) The same, exceeding 2500 volts and not exceeding 7000 volts 6. 00
(*k*) The same, exceeding 7000 volts and not exceeding 14 000 volts 8. 00
(*l*) The same, exceeding 14 000 volts and not exceeding 17 000 volts 10. 00
(*m*) The same, exceeding 17 000 volts and not exceeding 25 000 volts 12. 00
(*q*) For the determination of the phase angle between primary and secondary voltages, in addition to the ratio, for four values of secondary load as above, the additional fee will be 1. 00

(*r*) For each additional measurement of phase angle after the first four, the additional fee will be $0.20

(*s*) Each additional load above four will be charged one-tenth of the base fee.

(*t*) Each additional transformer after the first, to be tested for ratio at the same time and through the same range, will be charged one-half of the base fee.

(*w*) Tests on additional ranges, or with other frequencies or other voltages, will be charged as additional points at one-tenth of the base fee each; the first point, however, under each new condition, will be counted as two points.

8. 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 3,000 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 [6] 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

[6] 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.

(*p*) Each additional condenser, tested as in (*o*)..... $0. 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 [7] of a condenser, or of one section of a subdivided condenser..... 2. 00
(*u*) Each additional condenser, tested as in (*t*)..... 1. 00

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 [8] 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.

9. RADIO APPARATUS

High-frequency ammeters, radio sending and receiving sets, and miscellaneous radio apparatus will be tested for a fee depending on the time necessary to make the test. Arrangements for the test of such apparatus should be made by correspondence in advance of shipment. Fees for testing wavemeters are given herewith.

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.

[7] 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.

[8] The effective inductance is defined as the quotient of the reactance of the coil at any frequency divided by 2π 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.

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*) High-frequency resistance, each	3.00
(*f*) Minimum fee for one wavemeter	5.00

B. AMATEUR WAVEMETERS

(*u*) Wave length calibration of wavemeter, for not more than two coils	$2.00
(*v*) Wave length calibration of wavemeter, each additional coil	1.00
(*w*) Calibration of variable air condenser	1.00

10. 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 gausses, or such values as may be obtained without exceeding a magnetizing force of 300 gausses. The fee for one bar only is $6.

In the absence of specific instructions, magnet steel will be measured for maximum induction, residual induction, and coercive force corresponding to a magnetizing force of 200 gausses. 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	12.00

In the absence of specific instructions the core loss will be measured at a maximum induction of 10 000 gausses 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.

11. 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 2,000 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 hermetically sealed 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.

The radium content of a preparation that is not hermetically sealed is determined either by an emanation method, or by a gamma ray measurement made after the material has been hermetically sealed for a sufficient time. The Bureau will decide in each case which is the most suitable method to be employed.

Upon the publication of a forthcoming circular devoted to radium the fees of Schedule 94A, following, may be superseded by slightly different ones, to be announced in that circular.

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 style and to be measured at the same time the charge will be one-half the base fee as given above.

B. MISCELLANEOUS.

The Bureau is prepared to supply small amounts of standard radium solutions, and, as its facilities permit, will undertake the determination of the radium content of radioactive materials and the radium emanation content of liquids, and the testing of apparatus used in the application or measurement of radioactive materials. The fee for any such test will be quoted after correspondence fully setting forth the nature of the test desired.

12. 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 they were seasoned, 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. In the certificates which are issued with standard lamps the voltage, and the corresponding current and candlepower are given. For lamps which have to be seasoned at the Bureau, 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 given 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

Schedule 97.—COMMERCIAL TESTS

A. CANDLEPOWER 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
(*b*) Each additional lamp ..... .10

B. LIFE TESTS

(*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 metalized carbon filament lamps:
60 watts and below 2.00
(*d*) Above 60 watts 2.50
(*e*) Tungsten filament lamps:
40 watts and below 3.50
(*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 desired.

S. W. STRATTON,
Director.

Approved:
WILLIAM C. REDFIELD,
Secretary.