DEPARTMENT OF COMMERCE AND LABOR

CIRCULAR

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 6

FEES FOR ELECTRIC, MAGNETIC, AND PHOTOMETRIC TESTING

[4th Edition]
Issued July 1, 1911

WASHINGTON
GOVERNMENT PRINTING OFFICE
1911

DEPARTMENT OF COMMERCE AND LABOR

CIRCULAR

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 6

FEES FOR ELECTRIC, MAGNETIC, AND PHOTOMETRIC TESTING

[4th Edition]
Issued July 1, 1911

WASHINGTON
GOVERNMENT PRINTING OFFICE
1911

FEES FOR ELECTRIC, MAGNETIC, AND PHOTOMETRIC TESTING

CONTENTS

1. INTRODUCTION

This circular gives the fees established by the Bureau of Standards for tests of electric, magnetic, and photometric standards, measuring instruments, and materials. It supersedes previous editions of Circular 6, and also supersedes the schedules of fees given in the following circulars: No. 17, "Magnetic Testing," December 1, 1910; No. 20, "Testing of Electrical Measuring Instruments," October 1, 1909; No. 21, "Precision Measurements of Resistance and Electromotive force," March 1, 1910. Future editions of the circulars just mentioned will be published without the lists of fees. They contain information regarding the classes of apparatus to which they pertain and the Bureau methods of testing. Copies of any of them will be sent to interested persons upon 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.

(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, watthour meters, phase meters, frequency meters, current and potential transformers, etc.

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

(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. Calibration of magnetic measuring instruments. Measurement of energy losses due to alternating magnetization in iron.

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

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 Normal cells. The electromotive force of the mean Weston Normal cell has recently been fixed by the International Committee on Electrical Units and Standards, in virtue of the authority delegated to it by the International Conference at London in 1908, as 1.0183 international volts at 20° C, and 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.

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.

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. The request 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. The most accurate results can be obtained and delays are avoided, only when such full information is given. 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. 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 for the test desired. 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 will 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.

(f) **Shipping Directions.**—Apparatus or test specimens should be securely packed in cases or packages which will not be broken in transpor-

tation, 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. 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."

5. SCHEDULES OF FEES, RESISTANCE AND ELECTROMOTIVE FORCE

SCHEDULE 71

Precision Resistance Standards

Maximum accuracy, 0.005 per cent

Denomination	Accuracy	I		II	III
		Number of temperatures	Fee	For each additional measurement	Measurement at 25° C only.
	Per cent				
(*a*) 1 ohm	0.005	3	$4.00	$1.25	$2.50
(*b*) 10 ohm	.005	3	4.00	1.25	2.50
(*c*) 100 ohm	.005	3	5.00	1.50	3.00
(*d*) 1000 ohm	.005	3	5.00	1.50	3.00
(*e*) 10000 ohm	.01	2	5.00	1.50	3.00
(*f*) 100000 ohm	.02	2	5.00	1.50	3.00
(*g*) 0.1 ohm	.005	3	4.00	1.25	2.50
(*h*) 0.01 ohm	.005	3	5.00	1.50	3.00
(*i*) 0.001 ohm	.01	2	5.00	1.50	3.00
(*j*) 0.0001 ohm	.01	2	6.00	2.00	3.50

(*k*) For standards having values 2, 3, 4, or 5 times any of the above, and between 1 and 100 000 ohms, the fees will be 30 per cent additional.

The additional fee of II is either for a measurement made a month or more after the I measurement, the standard remaining at the Bureau between the measurements, to determine the constancy of the standard over that interval; or, for an additional measurement with a current larger than the usual test current.

SCHEDULE 72

Precision Resistance Standards

Maximum accuracy, 0.025 per cent

(Fees for measurement at one temperature, 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

(*k*) For standards having values 2, 3, 4, or 5 times any of the above, the fees will be 30 per cent additional.

SCHEDULE 73

Resistance Standards for Current Measurement

Accuracy, 0.01 per cent

Denomination	I Measurement at room temperature with low test current	II For measurement at an additional temperature.	III For an additional measurement with test current not exceeding—
(*a*) 1. ohm	$2.50	$2.00	3 amp., $1.00
(*b*) .1 ohm	2.50	2.00	15 amp., 1.25
(*c*) .01 ohm	3.00	2.00	100 amp., 1.50
(*d*) .001 ohm	3.50	2.00	500 amp., 1.75
(*e*) .0001 ohm	4.00	2.00	1000 amp., 2.00

(*k*) For standards having values 2, 3, 4, or 5 times any of the above, the fees will be 40 per cent additional.

"Low test current" above signifies a test current so small as to produce no appreciable heating of the standard.

SCHEDULE 74

Resistance Standards for Current Measurement

Accuracy, 0.025 per cent

Denomination	I Measurement at room temperature with low test current	II For each additional measurement with test current not exceeding—
(*a*) 1. ohm	$2.00	3 amp., $0.75
(*b*) .1 ohm	2.00	15 amp., 1.00
(*c*) .01 ohm	2.50	100 amp., 1.25
(*d*) .001 ohm	3.00	500 amp., 1.50
(*e*) .0001 ohm	3.50	1000 amp., 1.75

(*k*) For standards having values 2, 3, 4, or 5 times any of the above, the fees will be 40 per cent additional.

SCHEDULE 75

Precision Resistance Apparatus

Accuracy (in general), 0.01 per cent

(*a*) Minimum fee for each piece of apparatus	$3.00
(*b*) Rheostats, bridges (excepting ratio coils), potentiometers (excepting coils for reducing range), etc., per coil	.25
(*c*) Ratio coils of bridges, per coil	.50
(*d*) Calibration of slide wire, per section	.25
(*e*) Reduction factors for potentiometers, per factor	2.00
(*f*) Cleaning contacts, per contact	.10
VOLT BOXES, FACTORS—	
(*g*) Test with low voltage, per factor	1.50
Test with service voltage (not exceeding 150 volts)—	
(*h*) factors 2, 3, 5, or 10, each	2.00
(*i*) 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*) Rheostats, bridges (excepting ratio coils), potentiometers (excepting coils for reducing range), etc., per coil	.15
(*c*) Ratio coils of bridges, per coil	.30
(*d*) Calibration of slide wire, per section	.15
(*e*) Reduction factors for potentiometers, per factor	1.00
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 measurement of resistance per unit length, total length, and mass (expressed in ohms per meter-gram)	3.00
(*c*) Volume resistivity, from measurement of resistance per unit length and cross section (expressed in microhms per centimeter cube)	4.00
(*d*) Resistivity, from measurement of resistance per unit length, total length, mass, and density (expressed both in microhms per centimeter cube and in ohms per 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 per cent conductivity will be given for all copper conductors submitted for measurement of resistivity.

SCHEDULE 79

Standard Cells

Accuracy, 0.0001 volt

(*a*) Testing standard cells at one temperature, about 25° C	$2.00

6. SCHEDULES OF FEES, 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.

In addition to the usual tests given in the following schedules, the Bureau is prepared to make tests of dielectric strength (using alternating electromotive forces) up to 20 000 volts, on samples of insulating material, insulated wire, insulating joints, etc. It is expected that this range will be considerably extended in the near future. 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

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 10 000 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,[1] will be charged one-half of the base fee as given above.[2]

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 1 500 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.
(*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,[1] will be charged one-half of the base fee as given above.[2]

When instruments falling 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 each range. The fee for the highest range will be taken from the above schedule; the remaining points will be charged for by 81 (*g*) or (*p*), using as base fee that for the highest range.

---

[1] 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.

[2] 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.

SCHEDULE 82

A.—Alternating-Current Ammeters

Test at five points:

(*a*) Not exceeding 50 amperes, tested at one frequency and one temperature, using currents of approximately sine wave form $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 [3] at which a test is made at five points, the additional fee will be one-half of the above rates.
(*g*) For each additional wave form [3] at which a test is made at five points, the additional fee will be equal to fee named above for the original test.
(*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. Where instruments are to be used in water-power plants, or other places where low temperatures are likely to prevail, or in engine rooms at relatively high temperatures, they may be tested at temperatures outside this range anywhere between 0° and 50° C.
(*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,[4] will be charged one-half of the base fee as given above.[5]

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 usually has springs or other elements subject to change with time. When transformer and ammeter are tested separately, it is thereafter sufficient to test the ammeter alone, at suitable intervals.

---

[3] These fees are based on a moderate range of frequency and wave form, and a moderate degree of approximation to the customer's specifications for the wave form. Extreme frequencies, unusual wave forms, or the necessity for closely following specifications for the wave form, will be subject to a special extra fee. Such tests should always be arranged for in advance of shipment of the apparatus.

[4] 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.

[5] 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.

SCHEDULE 82—Continued

B.—Alternating-Current Voltmeters

Test at five points:

(*m*)	Not exceeding 300 volts, tested at one frequency and one temperature, using electromotive forces of approximately sine wave form	$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, tested as 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[6] at which a test is made at five points, the additional fee will be one-half the base fee as given above.	
(*v*)	For each additional wave form[6] the additional fee will be equal to 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[7]	. 50
(*z*)	Each additional instrument after the first, to be tested at the same time and through the same range,[8] will be charged one-half the base fee as given above.[9]	

When alternating voltmeters are used with potential 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 usually has springs or other elements subject to change with time. When transformer and voltmeter are tested separately, it is thereafter sufficient to test the voltmeter alone at suitable intervals.

When instruments falling under Schedule 82 are submitted for test, without specific instructions, sinusoidal alternating current or voltage will be used, of 60 cycles frequency, unless some other frequency is clearly marked on the instrument. 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.

---

[6] These fees are based on a moderate range of frequency and wave form, and a moderate degree of approximation to the customer's specifications for the wave form. Extreme frequencies, unusual wave forms, or the necessity for closely following specifications for the latter will be subject to a special extra fee. Such tests should always be arranged for in advance of shipment of the apparatus.

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

[8] 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.

[9] This one-half rate applies only to the five-point test; additional points above five, at the additional frequency or wave form, will each be charged for at one-tenth of the base fee.

SCHEDULE 83

Wattmeters

A.—*Tested with direct current*

Test at five points:

(*a*)	Not exceeding 5 kilowatts, at one temperature	$2.00
(*b*)	Exceeding 5 kilowatts, not exceeding 25 kilowatts, at one temperature	3.00
(*c*)	Exceeding 25 kilowatts, not exceeding 100 kilowatts, at one temperature	5.00
(*d*)	Exceeding 100 kilowatts, not exceeding 250 kilowatts, at one temperature	6.00
(*e*)	Exceeding 250 kilowatts, not exceeding 500 kilowatts, at one temperature	8.00
(*f*)	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,[10] will be charged one-half the base fee as given above.[11]	

B.—*Tested with alternating current*

Test at five points, at one frequency and one temperature, with unity power factor and approximately sine wave form:

(*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[12] 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.	
(*s*)	For each additional wave form[12] the additional fee will be equal to 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,[10] will be charged one-half the base fee as given above.[11]	

When instruments falling 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.

---

[10] 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.

[11] 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.

[12] These fees are based on a moderate range of frequency and wave form, and a moderate degree of approximation to the customer's specifications for the wave form. Extreme frequencies, unusual wave forms, or the necessity for closely following specifications for the latter, will be subject to a special extra fee. Such tests should always be arranged for in advance of shipment of the apparatus.

Wattmeters nominally for 150 volts will be tested at 110 volts; suitable values 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 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:

(*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*) 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.	
(*h*) 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.[13] (This does not apply to meters tested in position, for which no discount is made for additional meters after the first.)	

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

Test at one frequency, unity power factor, rated voltage, and approximately sine wave form on five different loads, viz, 10 per cent, 25 per cent, 50 per cent, full load, and 50 per cent overload, unless otherwise ordered:

(*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 [14] 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.	
(*q*) For each additional voltage at which a test is made at five loads, the additional fee will be one-half the base fee.	
(*r*) For each additional wave form [14] at which a test is made at five loads, the additional fee will be equal to 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.[13] (This does not apply to meters tested in position, for which no discount is made for additional meters after the first.)	

[13] 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.

C.—*Polyphase watthour meters*

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

Instruments falling 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 [14] and one load, using approximately sine wave form	$5.00
(*b*) Each additional test at five points for other frequencies or other loads	2.50
(*c*) Frequency meters, at one voltage, using approximately sine wave form	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.	
(*f*) For each additional wave form [14] the additional fee will be equal to 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.[15]	

Instruments falling 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 five values of primary current, viz, 10 per cent, 20 per cent, 40 per cent, 60 per cent, and full load, unless otherwise ordered; secondary full-load current not exceeding 10 amperes:

(*a*) Primary current not exceeding 50 amperes, tested at one frequency, using currents of approximately sine wave form	$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
(*d*) Exceeding 500 amperes and not exceeding 1000 amperes, tested as above	8.00
(*e*) Each additional current above five will be charged one-tenth of the base fee.	

[14] These fees are based on a moderate range of frequency and wave form, and a moderate degree of approximation to the specifications for the wave form. Unusual frequencies or wave forms, or the necessity for closely following specifications for the latter, will be subject to a special extra fee. Such tests should always be arranged for in advance of shipment of the apparatus.

[15] 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.

SCHEDULE 86—Continued

(*f*) For each additional frequency [16] at which a test is made at five 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 five 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 five values of primary current as above, the additional fee will be one-half 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 base fee as given above.[17]

B.—*Potential 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,[18] approximately 20 per cent power factor, unless otherwise ordered:

(*a*) Primary voltage not exceeding 300 volts, tested at one frequency, using electromotive forces of approximately sine wave form	$3. 00
(*b*) Exceeding 300 volts and not exceeding 750, tested as above	4. 00
(*c*) Exceeding 750 volts and not exceeding 1500, tested as above	5. 00
(*d*) Exceeding 1500 volts and not exceeding 3000, tested as above	7. 00
(*e*) Exceeding 3000 volts and not exceeding 7000, tested as above	10. 00
(*f*) Exceeding 7000 volts and not exceeding 12000, tested as above	15. 00
(*g*) Exceeding 12 000 volts and not exceeding 17 000, tested as above	20. 00

(*h*) Each additional load above five will be charged one-tenth of the base fee.
(*i*) For each additional frequency[16] at which a test is made at five loads, the additional fee will be one-half of the base fee.
(*j*) 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.
(*k*) 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-half 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.[19]

---

[16] 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.

[17] This one-half rate applies only to the regular test with five values of primary current; each additional current above five, for the additional transformer, will be charged one-tenth of the base fee as given in the schedules.

[18] 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.

[19] 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. SCHEDULES OF FEES, 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

B.—*Direct-current tests*

(*m*)	Measurement of the cyclic [20] 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 [21] 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 3,000 cycles per second, for a single inductance	3.00

[20] 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.

[21] 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—Continued

(*d*) Each additional coil tested as in (*c*)..... $1.50
(*e*) Measurement of a coil at a second frequency, with a maximum of 3,000 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 [22] 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.

8. SCHEDULES OF FEES, MAGNETISM

SCHEDULE 90

Short Ballistic Test

Including normal data for the following inductions: 5000, 10 000, 15 000, 20 000, or any four values produced by forces under 300 gausses; and hysteresis data for a maximum induction of 10 000 gausses, giving the residual induction under no magnetizing force, and the coercive force, or force necessary to reduce the induction to zero.

The test specimens shall be of the form specified in schedule 91.

(*a*) Normal induction and permeability..... $3.00
(*b*) Hysteresis data..... 3.00
(*c*) Normal and hysteresis data..... 5.00
(*d*) Curve (extra)..... .50
(*e*) If the specimens to be tested are in the form of bars, and data are required for both bars of each pair, the fee for the second bar is one-half that specified in the above schedule.

SCHEDULE 91

Complete Ballistic Test

Including normal data for every 2000 gausses up to 20 000, produced by forces under 300 gausses; and hysteresis data for a maximum induction of 10 000 gausses, including the following 10 points of the loop: 0, ±2000, ±4000, ±6000, ±8000, and 10 000.

Form of specimen.—(1) *Bars:* Two bars of the same material are required, one to be tested and the second to be used as an auxiliary. The minimum length of the test piece is 25 cm (10 inches). A length of 35 cm (14 inches), however, is preferred, as more precise measurements can be made on the longer specimens. Round rods may be 1 cm or 1.27 cm (½ inch) or 0.95 cm (⅜ inch) in diameter. Specimens of any uniform section which have one pair of parallel sides and will pass through a round hole 1.27 cm (½ inch) in diameter may be submitted. (2) *Sheet metal:* For sheet metal, the test material consists of four strips 5 cm (2 inches) wide, two cut parallel and two perpendicular to the direction of rolling. The material submitted should be chosen from different parts of the sheet,

[22] 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.

and of sufficient size to permit the final cutting to size being done at this laboratory. For this purpose, four strips, 7.5 cm by 40 cm (3 inches by 16 inches), are satisfactory. Crayon lines should be drawn on each specimen parallel to the direction of rolling.

(*a*) Normal induction and permeability	$6.00
(*b*) Hysteresis data	6.00
(*c*) Normal and hysteresis data	10.00
(*d*) Curve (extra)	.75

(*e*) If the specimens to be tested are in the form of bars, and data are required for both bars of each pair, the fee for the second bar is one-half that specified in the above schedule.

SCHEDULE 92

Standard Bars

These bars, of length 35 cm, are carefully aged and supplied with a certificate containing the data of the test of Schedule 91.

Material.	Diameter of section.
Annealed wrought iron (round)	0.95 cm ($\frac{3}{8}$ inch) 1.00 cm 1.27 cm ($\frac{1}{2}$ inch)
Low carbon steel (round)	0.95 cm ($\frac{3}{8}$ inch) 1.00 cm 1.27 cm ($\frac{1}{2}$ inch)

One bar

(*a*) Normal data	$7.00
(*b*) Hysteresis data	7.00
(*c*) Normal and hysteresis data	11.00
(*d*) Standard bar without certificate	2.00

Two bars

(*h*) Normal data	11.00
(*i*) Hysteresis data	11.00
(*j*) Normal and hysteresis data	17.00

SCHEDULE 93

Wattmeter Measurements

The material submitted for test shall consist of ten small sheets approximately 30 cm (12 inches) square. These are cut at the Bureau into strips 5 by 25.4 cm and tested in this form.

(*a*) For test of energy loss, one frequency and one flux density	$4.00
(*b*) For each additional flux density	.50
(*c*) For each additional frequency	1.00
(*d*) For values of wattless component of magnetizing current (extra), each	.50
(*e*) When not otherwise specified, test will be made at 30 cycles and 60 cycles for a flux density of 10 000 gausses, fee	5.00
(*h*) Aging test, two weeks at 90°–100° C, with repetition of test (*a*)	8.00

SCHEDULE 94

Miscellaneous

(*a*) For tests not enumerated above reasonable fees will be charged.

9. SCHEDULES OF FEES, PHOTOMETRY

ELECTRIC INCANDESCENT LAMPS

A normal carbon filament incandescent lamp when operated at constant voltage increases slightly in candlepower for the first fifty 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, tungsten, or Mazda. 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 over voltage, 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

A.—Standardizing Electric Incandescent Lamps

Standardizing lamps which have been properly seasoned; horizontal candlepower, stationary or rotating; or mean spherical candlepower.

(*a*)	Carbon or metallized carbon filament lamps:	
	One lamp	$2.00
(*b*)	Two or more lamps, each	1.50
(*c*)	Tantalum filament lamps:	
	One lamp	2.00
(*d*)	Two or more lamps, each	1.50
(*e*)	Tungsten filament or Mazda lamps:	
	One lamp	2.50
(*f*)	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*) Tantalum filament lamps:
One lamp 4.00
(*p*) Two or more lamps, each 3.00
(*q*) Tungsten filament or Mazda lamps:
One lamp 5.00
(*r*) 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, which can be furnished at the prices below. Lamps of unusual voltage or candlepower, which have to be seasoned and standardized to 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*) Tantalum filament lamps:
One lamp 3.00
(*d*) Two or more lamps, each 2.50
(*e*) Tungsten filament or Mazda lamps:
One lamp 4.00
(*f*) Two or more lamps, each 3.50
(*g*) Carbon filament lamps of approximately 16 candlepower 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
(*h*) Two or more, each 5.00

SCHEDULE 97

Commercial Tests

(*a*) When the highest accuracy is not required, electric incandescent lamps are measured for candlepower, voltage, and watts:
Ten lamps or less $1.00
(*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
(*d*) Above 60 watts 2.50
(*e*) Tantalum or tungsten filament or Mazda lamps:
40 watts and below 2.50
(*f*) Above 40 watts 3.00

The Bureau does this kind of work 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 candlepower. 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

Standardization of 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 signal lamps, locomotive headlights, the calibration of illuminometers and other photometrical apparatus, color absorbing screens, etc., will be made, the fees for which will be furnished upon application.

The Bureau is not at present equipped for the testing of electric arc lamps.

S. W. Stratton,
Director.

Approved:
Benj. S. Cable,
Acting Secretary.