

ELECTRICAL INDICATING INSTRUMENTS AND METERS
MOUNTED IN POWER PLANTS

1. GENERAL

1.01 This section covers apparatus requirements and adjusting procedures for electrical indicating instruments, both switchboard and panel types, and meters, mounted in power plants.

1.02 It is reissued to include instruments of the A, B, D, G, H, J, S, and AA types, manufactured by the Western Electric Company. It has been so completely rewritten in being brought up to date that the use of arrows to indicate changes is impractical.

1.03 This section is divided as follows:

1. GENERAL

2. REQUIREMENTS

3. ADJUSTING PROCEDURES

- 3.01 General Requirements
- 3.02 Zero Indication
- 3.03 Freedom of Movement
- 3.04 Accuracy

(1) D-C Voltmeters.

(19) A-C Voltmeters.

(31) D-C Milliammeters.

(44) A-C Milliammeters.

(57) D-C Ammeters Having Ranges of 5 Amperes or Less and Having No External Shunts

(66) A-C Ammeters Having Ranges of 5 Amperes or Less and Having No Current Transformers.

(75) D-C Ammeters Having Ranges from 5 to 75 Amperes and Having No External Shunts.

(81) A-C Ammeters Having Ranges from 5 to 75 Amperes and Having No Current Transformers.

(89) D-C Ammeters Having External Shunts

(100) A-C Ammeters Having Current Transformers.

(103) Wattmeters.

3.05 Power Factor Meters

3.06 Frequency Meters

3.07 A-C Watthour Meters

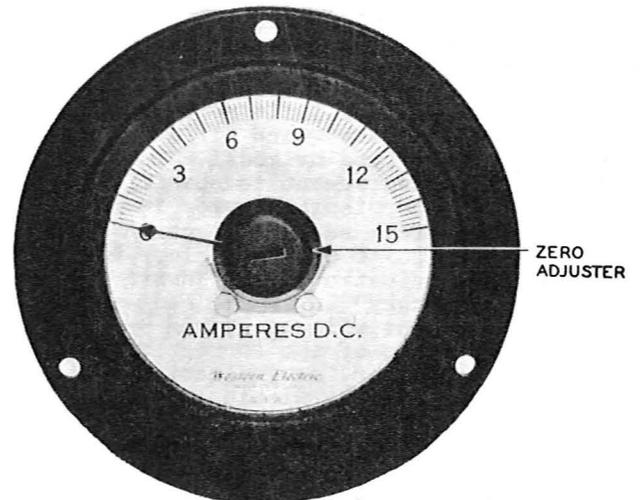


Fig. 1 - Typical Western Electric Company Instrument

1.04 Reference shall be made to Section A400.001 covering General Requirements and Definitions for additional information necessary for the proper application of the requirements listed herein.

1.05 Requirements and associated procedures marked with a number sign (#) need not be checked for by the installer unless it is thought that the requirement is not being met or performance indicates that such a check is advisable.

1.06 Requirements and associated procedures marked with an asterisk (*) need not be checked for during maintenance unless the apparatus or part is made accessible for other reasons or its performance indicates that such a check is advisable.

1.07 The checks of accuracy in this section are based on the use of the

KS-8039 volt-milliammeter or its electrical equivalent as a secondary standard for checking the other instruments. The detailed procedures are based on the use of this instrument although they are, in general, applicable where equivalent instruments are used.

1.08 Reference shall be made to section A702.017 for a description of the KS-8039 instrument.

1.09 New instruments should be examined when unpacked and if there is evidence of rough handling, as indicated by damaged shipping containers or otherwise, they should be checked and, if defective, returned for repair.

1.10 Any instrument known to have been subjected to overload should be checked.

1.11 Instruments are built to meet accuracy limits which differ according to the type or model. The accuracy of an instrument is specified as the maximum permissible error in percentage of the full scale deflection and applies at any point on the scale. For example, the indication of an instrument having an "accuracy" of ± 1 per cent and 75 scale divisions will be within $3/4$ of one scale division of the correct value. If it is a voltmeter, an indication on the 150 volt range will be within 1.5 volts.

1.12 Instruments as received from the manufacturer are usually well within their accuracy limits. In general, the limits given in the table in this section are sufficiently close to indicate whether the instrument has been damaged during shipment or otherwise. They will also indicate when, during life, the instrument should be referred through regular channels for recalibration.

1.13 In general, instruments are checked for zero indication, freedom of movement, and accuracy. In some cases, instructions call for the use of the zero adjuster to adjust an instrument to a high degree of accuracy at a given point on the scale. In this case the accuracy at other points of the scale may be reduced and the zero current requirement is waived. This procedure is not recommended for a-c instruments, nor for instruments used at more than one point on the scale.

1.14 With the exception of adjustments covered in this section, no attempt should be made to correct defects on the job. For the correction of sluggish motion, bent pointers or breakage, as well as the recalibration of instruments which cannot be made to meet the requirements by means of the zero adjuster, the instrument

shall be handled in accordance with authorized local practice.

1.15 Ammeter shunts should not be touched with the fingers, since, in ordinary operation, they may reach temperatures too high for safe contact. The design permits a maximum of 248F (120C) at the hottest point. Temperatures in excess of this, provided that the current rating of the shunt is not being exceeded, indicate poor connections at the shunt or in close proximity to it.

1.16 Reference shall be made to Bell System Practices for Apparatus Requirements and Adjusting Procedures as follows:

D-C Watthour Meters - Sect. A401.560
D-C Ampere-hour Meters - Sect. A401.561
Portable Instruments - Sect. A438.923

2. REQUIREMENTS

Indicating Instruments

2.01 General: Instruments shall be checked in place on their respective panels, without being removed.

2.02 Zero Indication: Except on suppressed-zero instruments and those which have been adjusted to indicate with a high degree of accuracy at one point on the scale, with no current flowing in the instrument, the pointer shall indicate zero on the scale Gauge by eye.

2.03 Freedom of Movement: When current through the instrument is gradually increased or decreased, the pointer shall follow the change smoothly, without sticking. Center zero instruments shall be checked on both sides of zero. Gauge by eye.

2.04 Accuracy

(a) The indication of a voltmeter used for floating a battery, when compared with the standard, shall be within ± 0.2 volt for voltmeters used for floating 24- and 48-volt batteries and within ± 0.5 volt for those on 130 volts or more. These limits apply at any point in the floating range. Gauge by eye.

(b) The indication of voltmeters (other than those used for battery floating) and of milliammeters, ammeters, and wattmeters, when compared with the standard, shall be within the permissible error shown in Table 1. Gauge by eye.

(c) Column 4 of the table shall be applied for all new instruments, for ammeters used for measuring trickle

charge, and for other instruments in service, with the following exceptions, for which column 5 shall be applied.

- (1) Ammeters used for measuring the output of charging generators.
- (2) Ammeters and wattmeters used for measuring the output of alternators.

Note: Permissible error as expressed in scale divisions varies with the accuracy being maintained and with the number of divisions which

appear on the scale of the particular instrument. The information in column 4 of the table is based on the rated accuracy and that in column 5 on the minimum acceptable accuracy in service. A margin has been included to allow for errors of observation. The maximum permissible number of scale divisions of difference between the indication of the standard and that of the instrument under check is given for each of the commonly used arrangements of instrument scales.

Table 1

Rated Accuracy and Service (1)	Manufacturer and Model or Type (2)	Divisions on Scale (3)	Maximum Permissible Error In Scale Divisions	
			(4)	(5)
1% Direct Current	Weston, Model 11, 24, 57, 269, 271, 273 Western Electric, Type S Type D Voltmeters	40	1/2	2-1/4
		50	3/4	2-1/2
		60	3/4	3-1/4
		75	1	4
		100	1-1/4	5-1/2
		150	2	8
2% Direct Current	Weston, Model 301 Western Electric, Type A, B, G, H, J, AA Type D Ammeters	30	3/4	1-3/4
		40	1	2-1/4
		50	1-1/4	3
		60	1-1/2	3-1/4
		65	1-1/2	3-1/2
		75	2	4
		80	2	4-1/4
		100	2-1/2	5-1/2
1% Alternating Current	Weston, Model 151, 156, 216, 260, 261, 429, 578, 610, 641, 642, 744 Westinghouse, Type DY Roller-Smith, Type FA	25	1/2	1-1/2
		30	1/2	1-3/4
		40	1/2	2-1/4
		50	3/4	2-1/2
		60	3/4	3-1/4
		65	1	3-1/2
		75	1	4
2% Alternating Current	Weston, Model 476	25	3/4	1-1/2
		30	3/4	1-3/4
		40	1	2-1/4
		50	1-1/4	2-3/4
5% Alternating Current Rectifier Type	Weston, Model 301 Western Electric, Type C, D, G, H, J, S, and AA	50	2-3/4	2-3/4
		75	4	4

Note: On engine-alternator sets, instruments resembling the Weston Model 301 in appearance, but of other manufacture, are currently being supplied. They should be checked under the requirements applying to the Weston Model 476.

#*2.05 Power Factor Meters: The error of the Weston Model 356 power factor meter shall be
Maximum - ± 0.01

Note: The pointer of a power factor meter does not return to zero when current is removed from the instrument.

#*2.06 Frequency Meters

(a) The error of the Weston Model 214 frequency meter shall be
Maximum ± 0.3 cycles

Note: The pointer of a frequency meter does not return to zero when current is removed from the instrument.

Meters

#*2.07 A-C Watthour Meters: The error of General Electric a-c watthour meters shall be
Maximum $\pm 2\%$

3. ADJUSTING PROCEDURES

3.001 List of Tools, Gauges, Materials, and Test Apparatus (Equivalents may be substituted if desired).

Tools

Screwdriver, watchmaker's No. 3
Screwdriver, as required to fit zero adjusters

Gauges, Materials, and Test Apparatus

For all instruments (except wattmeters)
Volt-milliammeter, KS-8039, and associated connection leads

For d-c and a-c voltmeters and d-c ammeters having external shunts
Cord, 2W17A (2 required)
Spade terminal, No. 364 tool (3 required)
Test Set, 35-type

For d-c and a-c milliammeters
Cord, 2W17A
Spade terminal, No. 364 tool (2 required)
Test Set, 35-type

For d-c ammeters, having no external shunts and a-c ammeters, having no current transformers, and checked at values between 0.75 and 3 amperes
Reversing Switch, Graybar Cat.

(for a-c instruments only)
Rheostat, Allen Bradley 438198 Bulletin 410, Size 1/2, Form WM
Storage Battery (one cell is sufficient)
Wire, as required

For d-c ammeters, having no external shunts, and a-c ammeters, having no current transformers, and checked at values between 3 and 50 amperes

Portable Testing Shunt, 60 amperes, 100 millivolts
Reversing Switch, Graybar Cat. (for a-c instruments only)
Rheostat, Allen Bradley 438197 Bulletin 410, Size 5, Form WM
Storage Battery (one cell is sufficient)
Wire, as required

For single-phase wattmeters
Weston Model 310, range as required
Wire, as required

For polyphase wattmeters
Weston Model 329 (or two Model 310), range as required.
Wire, as required

3.002 General Procedure

(1) It is recommended that instruments, except d-c voltmeters, be disconnected from the circuit for testing. They shall be left in place on the panels and temporary leads shall be run from a suitable source of power. Within its capacity, the 35-type test set should be used as the means for controlling the voltage or current applied to the instrument under test. Where the power requirements exceed the capacity of the test set, rheostats of suitable characteristics should be obtained. In any case, a KS-8039 instrument, or equivalent, with a shunt, if required, should be used as a standard.

(2) If disconnecting an ammeter would interrupt service which must be maintained, bridge the terminals of the ammeter before disconnecting, making the connections at the most convenient points in the circuit, other than the terminals of the instrument. Use wire of adequate size to avoid overheating.

Caution: Never open the secondary of a current transformer while the primary is connected to power.

(3) In determining the number of scale divisions on a center zero instrument, total the number on each side of the zero. In the case of a suppressed zero instrument, determine the number of divisions there would be if the scale were extended back to zero. For example, such a voltmeter, with a scale marked for 20 to 30 volts and having 50 scale divisions should be considered as having 150 divisions. In determining the number of scale

divisions on an a-c instrument, include in the total the small subdivisions which have been omitted near the zero.

(4) Center zero instruments should be checked on both sides of the zero. In general, instruments should be checked at a point near the middle of the range over which they are used. However, those used over a wide range should be checked at two or three points in the range. Multirange instruments should be checked on each range.

(5) After adjusting a zero adjuster, it is desirable to seal it by means of a piece of scotch tape or masking tape to discourage unauthorized adjustments.

(6) In the absence of vibration such as is produced by rotating machines or by transformers operating nearby, the standard and the instrument under test should be gently tapped with the finger or the end of a lead pencil as the current through them is brought to the value selected for checking the accuracy.

Indicating Instruments

3.01 General Requirements (Rq.2.01)

(No procedure)

3.02 Zero Indication (Rq.2.02)

(1) If the instrument is equipped with a zero adjuster, with a suitable screwdriver, turn the adjuster as required. In making this adjustment it will be noticed that there is considerable slack motion between the adjuster and the pointer. When the pointer has been brought to the correct indication, the adjuster should be backed off slightly before making the final check.

(2) If the instrument is not equipped with a zero adjuster it will be necessary to remove the cover. This procedure should be referred to the supervisor.

3.03 Freedom of Movement (Rq.2.03)

3.04 Accuracy (Rq.2.04)

D-C Voltmeters

Suppressed Zero Type

(1) Connect the standard, with the VOLTS switch on the appropriate point, in parallel with the instrument being checked. Adjust the regulator of the associated charging source until the pointer of the standard falls on the nearest scale line. Adjust the instrument to indicate as nearly as

possible, the same value. Observe the pointer for freedom of movement.

(2) Suppressed zero voltmeters manufactured by Weston usually have zero adjusters appearing on the outside of the cover, but without connection to the abutment lever by means of which the indication of the instrument is adjusted. In such a case, remove the cover and shift the abutment lever manually as required. See Fig. 2. In some older models, no zero adjuster appears on the outside of the cover and a straight lever is provided within, for adjusting the indication. After the cover has been removed, loosen the two clamping screws and shift the lever manually, as required. Tighten the screws firmly before replacing the cover. See Fig. 3. Suppressed zero voltmeters manufactured by Western Electric are without the zero adjuster. To adjust the indication it will be necessary to remove the cover and shift the member to which the spring is attached. It is held by friction and is not clamped.

(3) While the cover is removed make sure that there is no lint or other foreign matter in the airgap. Replace the cover before checking the adjustment.

Side Zero Type

(4) Check as outlined above for suppressed zero voltmeters or remove potential from the voltmeter being checked by disconnecting all wiring at the terminals or by removing fuses as required, and proceed as outlined below.

(5) Set the MILLIAMPERES switch on the standard instrument at the SHORT position and set the VOLTS switch at the OPEN position.

(6) Connect the (-) binding post of the standard instrument to the T terminal of the 35-type test set and connect the VOLTS-MILLIAMPERES binding post of the standard instrument to the R terminal of the 35-type test set. See Fig. 4.

(7) On the 35-type test set operate the BAT & GRD CO key. Move the red sliders 1, 2, and 3 and black slider 4 to the extreme right and move the black sliders 1 and 3 to the center of the rheostat. Move the black slider 2 to the extreme left of the rheostat. Insert the plug of a 2W17A cord into the 4W jack of the test set and connect the ring conductor by means of a No. 364 tool, to the GRD terminal of the test set. See Fig. 4

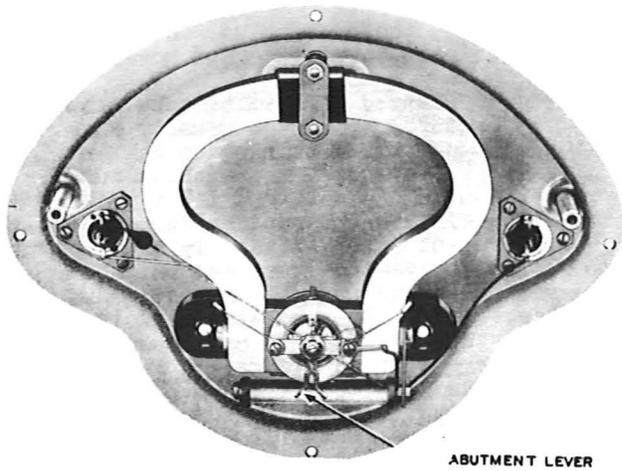


Fig. 2 - Weston Model 273 Voltmeter

(8) Connect the positive side of the testing battery (potential not more than 150 volts) to the GRD terminal of the test set or connect the positive side of the central office battery to the tip of a 2W17A cord, with the plug inserted in the BAT & GRD jack of the test set. Connect the negative side of the testing battery to the BAT terminal of the test set or connect the negative side of the central office battery to the ring of the cord in the BAT & GRD jack. Use No. 364 tools in the cord tips at the end opposite the plug. See Fig. 4.

(9) Release the BAT & GRD CO key and operate and lock telegraph key 2 of the test set. The milliammeter in the test set will indicate the current flowing.

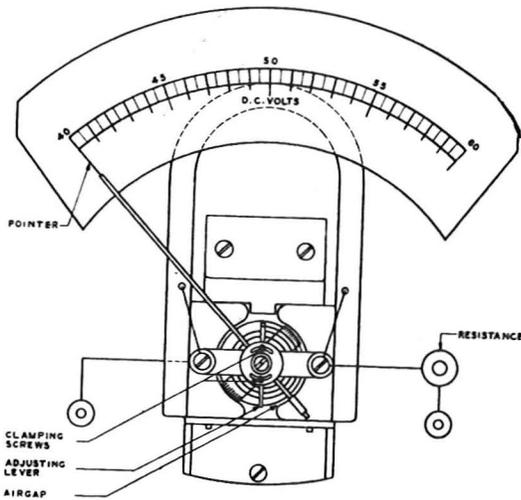


Fig. 3 - Weston Voltmeter - Old Model

(10) Select the potential at which the voltmeter is to be checked. This potential should be some value both near the middle of the range over which the voltmeter is used and also where both the voltmeter and the standard instrument are calibrated with a line on the scale. If the voltmeter is to be adjusted for high accuracy at a given point on the scale, select this value.

(11) Turn the VOLTS switch on the standard instrument in a counter-clockwise direction to the position at which the selected checking potential is in the upper two-thirds of the scale.

(12) Operate the BAT & GRD CO key. Connect the negative terminal of the voltmeter being checked to the (-) binding post of the standard instrument. Connect the positive terminal of the voltmeter to the VOLTS-MILLIAMPERES binding post of the standard instrument. Do not remove connections from the standard instrument to the 35-type test set. See Fig. 4.

(13) Restore the BAT & GRD CO key to normal. Adjust the red 2 slider of the rheostat until the standard instrument indicates a value slightly higher than the selected checking value. Gradually decrease and then increase the current through the instruments, using the black 2 slider of the

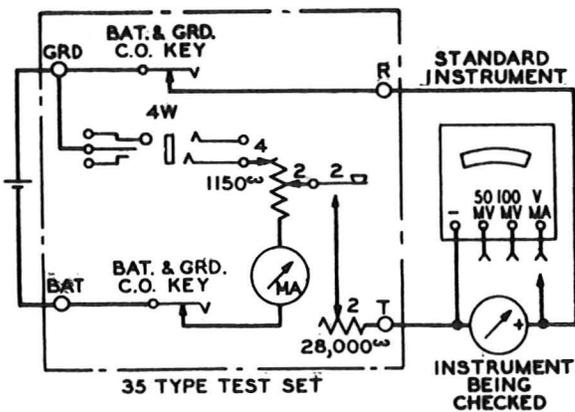


Fig. 4 - Checking Circuit for Voltmeters and Millivoltmeters

rheostat, and check to see that requirement 2.03 is met. Adjust the black 2 slider of the rheostat until the standard instrument indicates the selected checking value.

Caution: If a potential greater than 60 volts is used take care not to touch the metal portions of the rheostat while using the test set.

(14) Check to see that the indication of the voltmeter does not differ from that of the standard instrument by more than the permissible error specified in 2.04.

(15) If the voltmeter is to be adjusted for high accuracy at a given point on the scale, readjust the zero adjuster so that the indication of the voltmeter agrees with that of the standard instrument.

(16) If the voltmeter is to be checked at more than one point on the scale, select another checking potential as covered in (10) and adjust the black 2 slider and the red 2 slider, if required, until the standard instrument indicates the selected checking value. Proceed as covered in (14).

(17) If the voltmeter is calibrated with more than one range that can be checked at less than 150 volts, select one checking potential in each of the other ranges as covered in (10). Operate the BAT & GRD CO key, change the connections at the voltmeter, or the range changing switch on the voltmeter, to include the desired range and repeat the procedures covered in (11), (13), and (14).

(18) Operate the BAT & GRD CO key on the 35-type test set and remove all test connections. Restore all keys and switches to normal and if circuit wiring has been removed, restore this wiring.

A-C Voltmeters

(19) Disconnect from power and apply the test set as covered in (4) to (9) inclusive.

(20) Select the potential at which the voltmeter is to be checked. This potential should be some value near the middle of the range over which the voltmeter is used. In checking other than rectifier-type voltmeters, select a potential that is indicated by a scale line on both the standard instrument

and the voltmeter under test. The error of the voltmeter can then readily be determined in scale divisions. In checking rectifier-type voltmeters, select a potential indicated by a scale line on the standard instrument and, if possible, of such a value that when multiplied by 1.11 it is also indicated by a scale line on the voltmeter under test. For example 50 volts on the standard instrument and 50×1.11 or 55.5 volts on the voltmeter under test might both be indicated by scale lines. The error of the voltmeter can then readily be determined in scale divisions.

(21) Proceed as covered in (11), (12), and (13).

(22) Note the indication of the voltmeter under test. Operate the BAT & GRD CO key and reverse the leads to the voltmeter under test. Restore the BAT & GRD CO key and again note the indication of the voltmeter. The average of these two readings should be used for the accuracy check.

(23) For other than rectifier-type voltmeters, check to see that the average of the two indications obtained by (22) does not differ from that of the standard instrument by more than the requirements specified in 2.04. For rectifier-type voltmeters, multiply the indication of the standard instrument by 1.11. Then check to see that the average of the two readings obtained in (22) does not differ from this new value by more than the permissible error specified in 2.04. Multiplying by 1.11 accounts for the different indication of rectifier-type instruments when measuring a direct current.

(24) If the voltmeter is to be checked at more than one point on the scale, select another checking potential as covered in (20), adjust the black 2 slider and the red 2 slider, if required, until the standard instrument indicates the selected checking value.

(25) Proceed as covered in (22) and (23).

(26) If the voltmeter is calibrated with more than one range that can be checked at less than 150 volts, select one checking potential in each of the other ranges as covered in (20). Operate the BAT & GRD CO key, change the connections at the voltmeter or operate the range changing switch on the voltmeter to include the desired range.

(27) Turn the VOLTS switch on the standard instrument in a counter-clockwise direction to the position at which the selected checking potential is in the upper two-thirds of the scale.

(28) Restore the BAT & GRD CO key to normal. Adjust the red 2 slider of the rheostat until the standard instrument indicates a value slightly higher than the selected checking value. Adjust the black 2 slider of the rheostat until the standard instrument indicates the selected checking value.

Caution: If a potential greater than 60 volts is used, take care not to touch the metal portions of the rheostat while using the test set.

(29) Proceed as covered in (22) and (23).

(30) Operate the BAT & GRD CO key on the 35-type test set and remove all test connections. Restore all keys and switches to normal and if circuit wiring has been removed, restore this wiring.

D-C Milliammeters

(31) Remove current from the milliammeter being checked and disconnect all wiring at the milliammeter terminals.

(32) Set the VOLTS switch on the standard instrument at the MA position and set the MILLIAMPERES switch at the SHORT position. Move all red and black sliders on the test set to the extreme right.

(33) Connect the VOLTS-MILLIAMPERES binding post of the standard instrument to the R terminal of the 35-type test set, connect the (-) binding post of the standard instrument to the positive terminal of the milliammeter being checked, and connect the negative terminal of the milliammeter being checked to the T terminal of the test set. See Fig. 5.

(34) Operate the BAT & GRD CO key of the test set. Connect the positive side of the testing battery (potential not more than 60 volts) to the GRD terminal of the test set or connect the positive side of the central office battery to the tip of a 2W17A cord, with the plug inserted in the BAT & GRD jack of the test set. Connect the negative side of the testing battery to the BAT terminal of the test set or connect the negative side of the central office battery to the

ring of the cord in the BAT & GRD jack. Use No. 346 tools in the cord tips at the end opposite the plug. See Fig. 5. Restore the BAT & GRD CO key of the test set to normal.

(35) Select the current at which the milliammeter is to be checked. This current should be some value both near the middle of the range over which the milliammeter is used and also where both the milliammeter and the standard instrument are calibrated with a line on the scale. If the milliammeter is to be adjusted for high accuracy at a given point on the scale, select this value.

(36) Set the MILLIAMPERES switch on the standard instrument to the position at which the selected checking current is in the upper two-thirds of the scale.

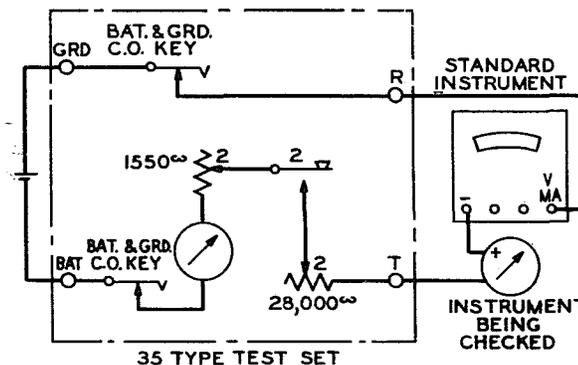


Fig. 5 - Checking Circuit for Milliammeters

(37) Operate and lock telegraph key 2 of the test set. Move the red and black sliders 2 of the test set to gradually increase and then decrease the current through the instrument and check to see that requirement 2.03 is met. Adjust the red and black sliders 2 of the test set so that the standard instrument indicates the selected checking value. Check to see that the indication of the milliammeter does not differ from that of the standard instrument by more than the permissible error specified in 2.04.

(38) If the milliammeter is to be adjusted to be highly accurate at a given point on the scale, readjust the zero adjuster so that the indication of the milliammeter agrees with that of the standard instrument.

(39) If the milliammeter is to be checked at more than one point on the scale select another checking current as covered in (35) and repeat the procedures covered in (36) and (37).

(40) If the milliammeter is calibrated with more than one range that can be checked at less than 750 milliamperes, select one checking current in each of the other ranges as covered in (35). Operate the BAT & GRD CO key, change the connections at the milliammeter or operate the range changing switch on the milliammeter to include the desired range.

(41) Set the MILLIAMPERES switch on the standard instrument at the position where the selected checking current is in the upper two-thirds of the scale.

(42) Restore the BAT & GRD CO key to normal and adjust the red and black sliders 2 of the test set so that the standard instrument indicates the selected checking value. Check to see that the indication of the milliammeter does not differ from that of the standard instrument by more than the permissible error specified in 2.04.

(43) Operate the BAT & GRD CO key on the 35-type test set and remove all checking connections. Restore all keys and switches to normal and replace all circuit wiring.

A-C Milliammeters

(44) Repeat procedures (31) and (34) inclusive.

(45) Select the current at which the milliammeter is to be checked. This current should be some value near the middle of the range over which the milliammeter is used. In checking other than rectifier-type milliammeters, select a current that is indicated by a scale line on both the standard instrument and the milliammeter under test. The error of the milliammeter can then readily be determined in scale divisions. In checking rectifier-type milliammeters, select a current indicated by a scale line on the standard instrument and of such a value that when multiplied by 1.11 it is also indicated by a scale line on the milliammeter under test. For example 500 milliamperes on the standard instrument and 500×1.11 or 555 milliamperes on the milliammeter under test might both be indicated by scale lines. The error of the milliammeter can then readily be determined in scale divisions.

(46) Set the MILLIAMPERES switch on the standard instrument at the position where the selected checking current is in the upper two-thirds of the scale.

(47) Operate and lock telegraph key 2 of the test set. Move the red

and black sliders 2 of the test set to gradually increase and then decrease the current through the instrument and check to see that requirement 2.03 is met. Adjust the red and black sliders 2 of the test set so that the standard instrument indicates the selected checking value.

(48) Note the indication of the milliammeter under test. Operate the BAT & GRD CO key and reverse the leads to the milliammeter under test. Restore the BAT & GRD CO key to normal and again note the indication of the milliammeter under test. The average of these two readings should be used for the accuracy check.

(49) For other than rectifier-type milliammeters, check to see that the average of the two readings obtained by (48) does not differ from the indication of the standard instrument by more than the permissible error specified in 2.04. For rectifier-type milliammeters, multiply the indication of the standard instrument by 1.11. Then check to see that the average of the two readings of (48) does not differ from this new value by more than the permissible error specified in 2.04. Multiplying by 1.11 accounts for the different indication of rectifier-type instruments when measuring a direct current.

(50) If the milliammeter is to be checked at more than one point on the scale, select another checking current as covered in (45), adjust the black and red sliders 2 until the standard instrument indicates the selected checking value.

(51) Proceed as covered in (48) and (49).

(52) If the milliammeter is calibrated with more than one range that can be checked at less than 750 milliamperes, select one checking current in each of the other ranges as covered in (45). Operate the BAT & GRD CO key, change the connections at the milliammeter or operate the range changing switch on the milliammeter to include the desired range.

(53) Set the MILLIAMPERES switch on the standard instrument at the position where the selected checking current is in the upper two-thirds of the scale.

(54) Restore the BAT & GRD CO key to normal and adjust the red and black sliders 2 of the test set so that the standard instrument indicates the selected checking value.

(55) Proceed as covered in (48) and (49).

(56) Operate the BAT & GRD CO key on the 35-type test set and remove all checking connections. Restore all keys and switches to normal and replace all circuit wiring.

D-C Ammeters Having Ranges of 5 Amperes or Less and Having No External Shunts

(57) Remove current from the ammeter being checked and disconnect all wiring at the ammeter terminals.

(58) Set the VOLTS switch on the standard instrument at the MA position and set the MILLIAMPERES switch at the SHORT position.

(59) Connect the standard instrument in series with the ammeter, a suitable rheostat, and a source of d-c potential that will deflect the ammeter to the desired point on the scale. Use wire capable of carrying the necessary current without undue heating. See Fig. 6.

Caution: Before connecting current to the instruments make sure that the rheostat is adjusted so that the current flow will not damage the instruments.

(60) Select the current at which the ammeter is to be checked. This current should be some value both near the middle of the range over which the ammeter is used and also where both the ammeter and the standard instrument are calibrated with a line on the scale. If the ammeter is to be adjusted for high accuracy at a given point on the scale, select this value.

(61) Turn the MILLIAMPERES switch on the standard instrument, in a counterclockwise direction, to the position at which the selected checking current is in the upper two-thirds of the scale.

(62) Move the slider of the rheostat to gradually increase and then decrease the current through the ammeter

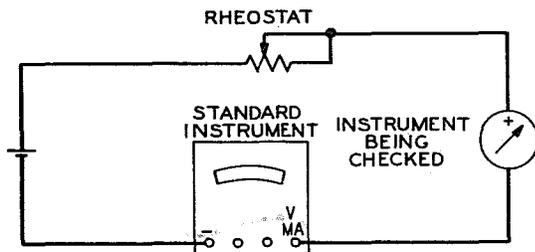


Fig. 6 - Checking Circuit for D-c Ammeters, Having No External Shunts, and Checked at Values Between 0.75 and 3 Amperes

and check to see that requirement 2.03 is met. Adjust the rheostat so that the standard instrument indicates the selected checking value. Check to see that the indication of the ammeter does not differ from that of the standard instrument by more than the permissible error specified in 2.04.

(63) If the ammeter is to be adjusted to be highly accurate at a given point on the scale, readjust the zero adjuster so that the indication of the ammeter agrees with that of the standard instrument.

(64) If the ammeter is to be checked at more than one point on the scale, select another checking current as covered in (60) and repeat the procedures covered in (61) and (62).

(65) Remove current from the ammeter being checked and remove all checking connections. Restore the connections removed in order to check the ammeter.

A-C Ammeters Having Ranges of 5 Amperes or Less and Having No Current Transformers

(66) Remove current from the ammeter being checked and disconnect all wiring at the ammeter terminals.

(67) Set the VOLTS switch on the standard instrument at the MA position and set the MILLIAMPERES switch at the SHORT position.

(68) Connect the ammeter in series with the standard instrument through a reversing switch. Wire the reversing switch so that current through the ammeter is reversed by the operation of the switch. Include a suitable rheostat and a source of d-c potential that will deflect the ammeter to the desired point on the scale. Use wire capable of carrying the current without undue heating. See Fig. 7.

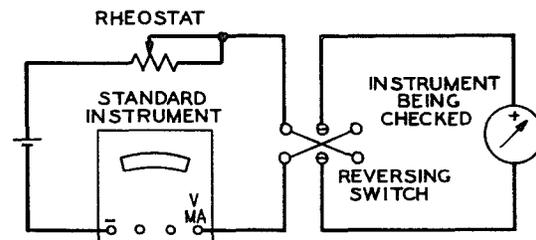


Fig. 7 - Checking Circuit of A-c Ammeters, Having No Current Transformers, and Checked at Values Between 0.75 and 3 Amperes

Caution: Before connecting current to the instruments make sure that the rheostat is adjusted so that the current flow will not damage the instruments.

- (69) Select the current at which the ammeter is to be checked. This current should be some value both near the middle of the range over which the ammeter is used and also indicated by a scale line on both the standard instrument and the ammeter under test. The error of the ammeter can then readily be determined in scale divisions.
- (70) Set the MILLIAMPERES switch on the standard instrument at the position where the selected checking current is in the upper two-thirds of the scale.
- (71) Close the reversing switch and move the slider of the rheostat to gradually increase and then decrease the current through the ammeter and check to see that requirement 2.03 is met. Adjust the rheostat so that the standard instrument indicates the selected checking current and note the indication of the ammeter. Operate the reversing switch to the other position and again note the indication of the ammeter. Use the average of these two readings for determining the accuracy.
- (72) Check to see that the average of the two readings obtained by the procedures in paragraph (71) does not differ from the indication of the standard instrument by more than the permissible error specified in 2.04.
- (73) If the ammeter is to be checked at more than one point on the scale, select another checking current as covered in (69) and proceed as covered in (70), (71), and (72).

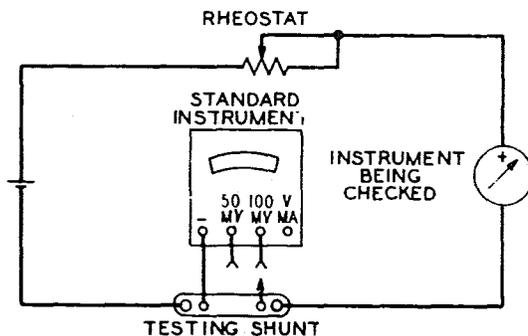


Fig. 8 - Checking Circuit for D-c Ammeters, Having No External Shunts, and Checked at Values Between 3 and 50 Amperes

- (74) Remove current from the ammeter being checked and remove all checking connections. Restore the connections removed in order to check the ammeter.

D-C Ammeters Having Ranges from 5 to 75 Amperes and Having No External Shunts

- (75) Remove current from the ammeter being checked and disconnect all wiring at the ammeter terminals.
- (76) Connect the 60-ampere, 100-millivolt portable testing shunt in series with the ammeter. See Fig. 8. Using the cords furnished with the standard instrument, connect the (-) binding post of the standard instrument to the negatively connected terminal of the testing shunt and connect either the 50 MILLIVOLTS or the 100 MILLIVOLTS binding post of the standard instrument to the other terminal of the testing shunt. The 50 MILLIVOLTS binding post is used for checking current of 3 to 30 amperes and the 100 MILLIVOLTS binding post is used for checking currents of 30 to 60 amperes.
- (77) Connect the ammeter, and the associated testing shunt and standard instrument through a suitable rheostat to any available source of direct current potential that will deflect the ammeter to the desired checking point. See Fig. 8. Use wire capable of carrying the current without undue heating. Adjust the rheostat to obtain the proper checking current.

Caution: Before connecting current to the instruments, make sure that the rheostat is adjusted so that the current flow will not damage the instruments.

- (78) Proceed as covered in (60), (61), (62), and (63).

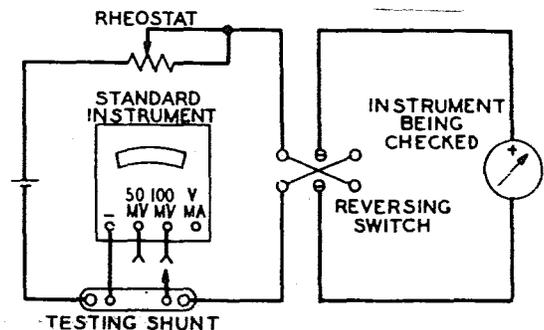


Fig. 9 - Checking Circuit for A-c Ammeters, Having No External Shunts, and Checked at Values Between 3 and 50 Amperes

(79) If the ammeter is to be checked at more than one point on the scale, select another checking current as covered in (60) and repeat (61) and (62).

(80) Remove current from the ammeter being checked and remove all checking connections. Restore the connections removed in order to check the ammeter.

A-C Ammeters Having Ranges from 5 to 75 Amperes and Having No Current Transformers

(81) Remove current from the ammeter being checked and disconnect all wiring at the ammeter terminals.

(82) Connect the ammeter in series with the 60-ampere, 100-millivolt portable testing shunt through a reversing switch. See Fig. 9. Exercise care in selecting a reversing switch that will carry the current used in checking and that will break the current without excessive arcing at the contacts. Wire the reversing switch so that the current through the ammeter is reversed by the operation of the switch. Use wire capable of carrying the current without undue heating. Using the cords furnished with the standard instrument, connect the (-) binding post and either the 50 MILLIVOLTS or the 100 MILLIVOLTS binding post of the standard instrument to the instrument terminals of the testing shunt. The 50 MILLIVOLTS binding post is used for checking currents of 3 to 30 amperes and the 100 MILLIVOLTS binding post is used for checking currents of 30 to 60 amperes. See Fig. 9.

(83) Wire the standard instrument, portable testing shunt, reversing switch, and the ammeter through a suitable rheostat to any available source of direct current potential that will deflect the ammeter to the desired checking point. In making these connections check to see that the negative binding post of the testing shunt is connected to the negative side of the source of potential. See Fig. 9. Adjust the rheostat to obtain the proper testing current.

Caution: Before connecting current to the instruments make sure that the rheostat is adjusted so that the current flow will not damage the instruments.

(84) Select the current at which the ammeter is to be checked. This current should be some value both near the middle of the range over which the ammeter is used and also indicated by a

scale line on both the standard instrument and the ammeter under check. The error of the ammeter can then readily be determined in scale divisions.

(85) Close the reversing switch and move the slider of the rheostat to gradually increase and decrease the current through the ammeter and check to see that requirement 2.03 is met. Adjust the rheostat so that the standard instrument indicates the selected checking current and note the indication of the ammeter. Operate the reversing switch to the other position and again note the indication of the ammeter. Use the average of these two readings for determining the accuracy.

(86) Check to see that the average of the two readings obtained by the procedures in paragraph (85) above does not differ from the indication of the standard instrument by more than the permissible error specified in 2.04.

(87) If the ammeter is to be checked at more than one point on the scale, select another checking current as covered in (84) and proceed as covered in (85) and (86).

(88) Remove current from the ammeter being checked and remove all checking connections. Restore the connections removed in order to check the ammeter.

D-C Ammeters Having External Shunts

(89) Remove current from the associated shunt and disconnect the shunt leads at the shunt. Current may be restored to the shunt after the leads have been disconnected.

(90) Using the leads supplied with the standard instrument connect its (-) binding post to the T terminal of the 35-type test set and its 50 MILLIVOLTS binding post to the R terminal. See Fig. 4.

Note: If the millivoltmeter (ammeter without its external shunt) is associated with a shunt rated 100 millivolts, connect the standard instrument at the 100 MILLIVOLT binding post, instead of the 50 MILLIVOLT binding post.

(91) Move the red sliders 1, 2, and 3 and black slider 4 to the extreme right and move the black sliders 1 and 3 to the center of the rheostat. Move the black slider 2 to the extreme left of the rheostat. Insert the plug of a 2W17A cord into the 4W jack of the test

set and connect the ring conductor, by means of a No. 364 tool, to the GRD terminal of the test set. See Fig. 4.

(92) Operate the BAT & GRD CO key and connect the positive side of a dry cell to the GRD terminal of the test set. Connect the negative side of the dry cell to the BAT terminal of the test set.

(93) Select the potential at which the millivoltmeter is to be checked. This should be some value that will cause a deflection of the millivoltmeter pointer to a scale line near the middle of the range over which the instrument is used. It should also deflect the pointer of the standard instrument to a scale line. If the millivoltmeter is to be adjusted for high accuracy at a given point on the scale, select a value that will cause a deflection to that point.

Note: If connection is made to the 50 MILLIVOLTS binding post of the standard instrument, a full-scale deflection is 50 millivolts. If connection is made to the 100 MILLIVOLTS binding post, a full-scale deflection is 100 millivolts. Proportionate deflections of the millivoltmeter under check and the standard instrument will indicate the accuracy of the millivoltmeter, that is, if the millivoltmeter under check is normally used with a 50-millivolt shunt, a deflection of 25 millivolts on the standard instrument should cause a half-scale deflection of the millivoltmeter under check; likewise a 40-millivolt deflection on the standard instrument should cause a four-fifths scale deflection of the millivoltmeter under check.

(94) Using the shunt leads, connect the negative binding post of the millivoltmeter to the T terminal of the test set and the positive binding post to the R terminal. See Fig. 4.

(95) Restore the BAT & GRD CO key to normal and operate and lock the telegraph key 2 of the test set. Adjust the red 2 slider of the rheostat until the standard instrument indicates a value slightly higher than the selected checking value. Gradually decrease and then increase the current through the instruments, using the black 2 slider of the rheostat, and check to see that requirement 2.03 is met. Adjust the black 2 slider of the

rheostat until the standard instrument indicates the selected checking value.

(96) Check to see that the indication of the millivoltmeter being checked does not differ from its calculated value, based on the indication of the standard instrument, by more than the permissible error specified in 2.04.

(97) If the millivoltmeter is to be adjusted for high accuracy at a given point on the scale, readjust the zero adjuster so that the indication of the millivoltmeter agrees with that of the standard instrument.

(98) If the millivoltmeter is to be checked at more than one point on the scale, select another checking potential as covered in (93) and adjust the black 2 slider and the red 2 slider, if required, until the standard instrument indicates the selected checking value. Proceed as covered in (96).

(99) Operate the BAT & GRD CO key on the 35-type test set and remove all checking connections to the millivoltmeter. Reconnect the shunt to the instrument checked.

A-C Ammeters Having Current Transformers

(100) Remove current from the primary circuit of the associated current transformer. Disconnect the ammeter from the transformer and short-circuit the secondary terminals of the transformer. Current may be restored to the transformer so long as its secondary terminals remain short-circuited.

Caution: Never allow current to flow in the primary of a current transformer while its secondary circuit is open.

(101) Proceed to check the ammeter in accordance with (82) to (87), inclusive. In this case full-scale deflection is produced by a current of 5 amperes. Smaller currents will produce smaller deflections, in direct proportion.

(102) Remove current from the ammeter being checked and remove all checking connections. Check that no current is flowing in the current transformer primary, remove the short circuit from its secondary terminals and restore the ammeter connections.

Wattmeters

(103) Remove current from the associated circuit. If a single-phase wattmeter is being checked, connect a Weston Model 310, or equivalent,

wattmeter with the potential element in parallel, and the series element in series, with the respective elements of the instrument under check. Similarly, when checking a polyphase wattmeter, connect a Weston Model 329 (or two of Model 310). If current transformers are involved be sure that the secondary circuit of each one is closed before restoring power to the circuit.

(104) Restore power to the circuit and check to see that the indication of the wattmeter, at any available load within the usual range for the particular office, does not differ from that of the standard instrument (or from the sum of the indications of the two standard instruments) by more than the permissible error specified in 2.04.

(105) Remove power from the circuit. Restore the original connections, being sure that the secondary circuits of any current transformers are closed.

#*3.05 Power Factor Meters (Rq.2.05)

(1) If the instrument is thought to be in error, it is recommended that arrangements be made, in accordance with authorized local practice, to have the local power company or some other, well equipped organization make the check.

#*3.06 Frequency Meters (Rq.2.06)

(1) If the accuracy of the instrument is in doubt, it may be checked by being connected to a source of known frequency.

Meters

#*3.07 A-C Watthour Meters (Rq.2.07)

(1) When a check of one of these meters is required, it is recommended that arrangements be made, in accordance with authorized local practice, to have the local power company or some other, well equipped organization do the work.

Bell Telephone Laboratories, Inc.