

## ELECTRICAL INDICATING INSTRUMENTS REQUIREMENTS AND ADJUSTING PROCEDURES

### 1. GENERAL

1.01 This section covers the requirements and adjusting procedures for the following portable and mounted electrical indicating instruments used in central offices.

AC and DC Ammeters	Ohmmeters
AC and DC Voltmeters	Power Factor Meters
AC and DC Wattmeters	Frequency Meters AC Watthour Meters

This section does not cover instruments with non-linear arbitrary scales, that is, electrically operated instruments which have scales that are marked in terms of a designated unit, such as DB.

1.02 This section is reissued to add ohmmeters; to bring the section up-to-date and to include the electrical indicating instruments previously covered in Section 102-510-701. This section replaces Section 102-510-701, Issue 3-D. Since this issue covers a general revision, the arrows ordinarily used to indicate changes have been omitted.

1.03 Reference shall be made to Section 020-010-711 covering general requirements and definitions for additional information necessary for the proper application of the requirements listed herein.

1.04 *Asterisk (\*)*: Requirements are marked with an asterisk when to check for them would necessitate dismantling or dismounting of apparatus, or would affect the adjustment involved, or other adjustments. No check need be made for these requirements unless the apparatus or part is made accessible for other reasons, or its performance indicates that such a check is advisable.

1.05 *Instrument Types and Accessories*: Electrical indicating instruments, used in ac and dc circuits, which are covered in this section belong to three general types as follows.

Permanent-Magnet Moving Coil  
Electrodynamometer  
Electromagnetic (moving-vane)

Various accessories are necessary for use with the instruments to extend their current and voltage ranges. These accessories are of the following types.

Multipliers (Resistors)  
Shunts  
Current Transformers  
Potential Transformers

1.06 *Permanent-Magnet Moving Coil*: In this type of instrument a coil which is arranged to turn in jewel bearings is mounted in the field of a permanent magnet. Coil motion is restrained by two flat coiled springs which also serve to conduct current to the coil. Current through the coil produces a magnetic field causing the coil to turn in the permanent magnet field. This movement may be used to measure either direct current or voltage. When a rectifier is added in series with the coil, this type of instrument may be used in alternating current circuits. AC and dc scales on such an instrument are not the same, since accuracy on alternating current with the rectifier is quite a bit less than the accuracy of the movement alone on direct current. With the addition of a thermal converter element in the circuit, the permanent-magnet moving coil instrument may be used for accurate measurements of alternating currents practically independent of frequency and wave form. With the addition of suitable batteries and resistors in the circuit the permanent-magnet moving coil instrument, working as a dc voltmeter, can be used as an ohmmeter to measure resistance.

**1.07 *Electrodynamometer:*** This type of instrument has a fixed coil and a pivoted coil, both of which carry current when connected in a circuit. The magnetic fields set up cause the pivoted coil to move. When both coils are connected in series as in a voltmeter or ammeter, pointer deflection is proportional to the square of the current. Consequently, the scale is not linear and is quite compressed at the lower end. A wattmeter is an instrument of this type with fixed coils energized by circuit current and movable coils energized by circuit voltage. Instruments of this type may be used to measure ac or dc current, voltage, or power.

**1.08 *Electromagnetic (moving-vane):*** In this type of instrument, a pivoted iron vane or tube to which the pointer is attached is mounted within a fixed coil. The magnetic field set up in the coil by circuit current or voltage causes the iron vane or tube to turn. This type of instrument is rarely used in dc circuits but is widely used to measure ac current or voltage. Instruments having various ac ranges up to 750 volts and 50 amperes are self-contained. For measuring larger voltages and current in higher ranges, external instrument transformers are used with the instrument.

**1.09 *Multipliers (resistors):*** Instrument moving coils have very low resistance and would burn out if connected to voltages higher than about 0.1 volt. A resistor is added in series with the coil to allow higher voltages to be measured and in many instances is mounted inside the instrument case. When the resistor (multiplier) is external, it bears the same serial number as the instrument and the connecting leads together with the resistor are included in the calibration of the instrument.

**1.10 *Shunts:*** Only currents up to about 0.050 (50 milliamperes) can be taken into a moving coil through the springs. For direct current instruments with ranges in excess of 50 ma, it is necessary to bypass most of the current, allowing only the current necessary for operation of the instrument to pass through it. For instruments measuring up to 50 amperes, the shunt may be in the instrument case. Otherwise the shunt is mounted externally and is connected to the instrument by a pair of leads which together with the shunt are included in the calibration of the instrument. The maximum safe

working temperature for large shunts is 190° F. A temperature in excess of 190° F (provided that the current rating of the shunt is not being exceeded) indicates poor connections at the shunt or in close proximity to it. Temporary overloads will result in higher temperatures which, if continued, will damage the shunt.

**1.11 *Current Transformers:*** The ranges of ac ammeters and wattmeters are extended with the use of current transformers which are designed for various current ratios and which provide a means of insulating the indicating instrument from the line. *For safe operating procedures, and for the protection of the current transformer, the secondary winding should always be shorted or connected to the ammeter and never allowed to operate into an open circuit.*

**1.12 *Potential Transformers:*** Potential transformers are used to step down line voltage and to provide a means of insulating the instrument from the line.

**1.13** The detailed procedures for checking ammeters and voltmeters are based on using the KS-8039 volt-milliammeter which has a rated accuracy of 1/4 of 1 per cent, although the general methods are applicable to other equivalent instruments. 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 used in the test circuit. In any case a KS-8039 instrument, or equivalent, with a shunt if required, should be used as a standard in conjunction with the test set for checking other instruments.

**1.14** The ammeters and voltmeters which should be checked for accuracy limits using the KS-8039 volt-milliammeter as a standard, are listed in Tables A through D. Instruments manufactured by the Western Electric Co. are covered in Tables C and D. Instruments not manufactured by the Western Electric Co., including instruments having KS- specification numbers, are covered in Tables A and B. With the exception of KS- specification instruments having special accuracy requirements, the KS number is not referred to in the tables, since on KS instruments the KS number as well as the manufacturer's name and model or type number

appears on the scale plate of the instrument. The model number appearing on the scale plate of some instruments also includes an additional number (for example 301-57). Only the basic model numbers are listed in Tables A and B.

1.15 Instruments as received from the manufacturer are usually well within their accuracy limits. 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. In general, the limits 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.

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

1.17 Instruments of various types have different accuracy limits. The limits for accuracy, as referred to in the tables in this section, are based on the accuracy guaranteed by the manufacturer plus the accuracy limits of the standard instrument. Except for microammeters, the accuracy requirements are expressed as a tolerance in scale divisions and apply at any point on the scale. For microammeters, the accuracy requirements are specified as a voltage tolerance which is read on the standard instrument. For the purpose of this section, a scale division may be defined as the smallest subdivision into which the scale is divided by lines. The indication of an instrument having an "accuracy" of  $\pm 1$  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.

1.18 In general, instruments are checked for proper zero indication, freedom of pointer movement, and accuracy. In some cases the zero adjuster screw may be used to adjust an instrument to be highly accurate at a given point on the scale provided greater leniency is allowed at all other points on the scale. In this case, the zero indication requirement is waived. This pro-

cedure is not recommended for alternating current instruments nor for instruments used at more than one point on the scale.

1.19 The checking procedures for requirements 2.02 (Freedom of Pointer Movement) and 2.03 (Electrical Requirements) are covered under the following headings.

<b>Instruments Listed in the Tables</b>	<b>Page</b>
DC Voltmeters — 150 Volts or Less ..	15
DC Voltmeters — Used In Power Plants .....	16
AC Voltmeters — 150 Volts or Less ..	16
DC Milliammeter on 35-Type Test Set .....	17
DC Microammeters — Less than 1000 Microamperes .....	18
DC Milliammeters — Less than 750 Milliamperes .....	18
AC Milliammeters — Less than 750 Milliamperes .....	19
DC Ammeters — Between $3/4$ And 3 Amperes .....	20
AC Ammeters — Between $3/4$ And 3 Amperes .....	21
DC Ammeters — Between 3 And 50 Amperes — No External Shunts ....	21
AC Ammeters — Between 3 And 50 Amperes — No Current Transformers	22
DC Ammeters Having External Shunts .....	22
AC Ammeters Having Current Transformers .....	23
Wattmeters .....	23
 <b>Instruments Not Listed in the Tables</b>	
Ohmmeters .....	24
Power Factor Meters .....	24
Frequency Meters .....	24
AC Watthour Meters .....	24

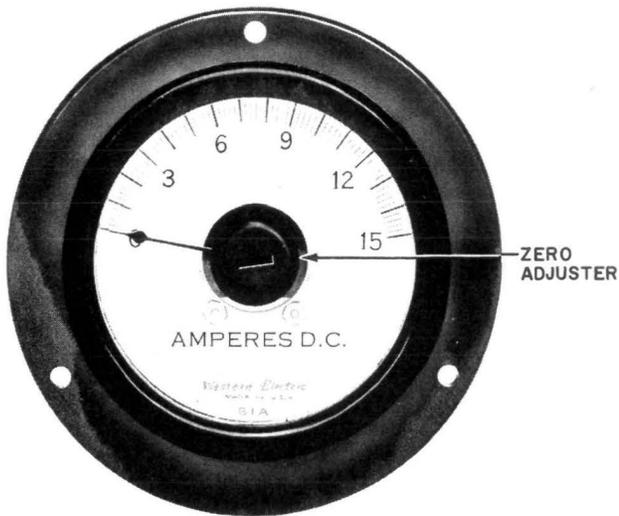


Fig. 1 – Western Electric G1A DC Ammeter (flush-mounting case)

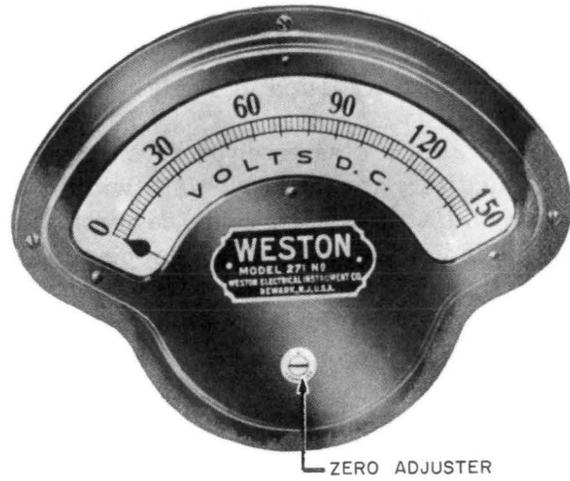


Fig. 3 – Weston Model 271 DC Voltmeter (surface-mounting case)

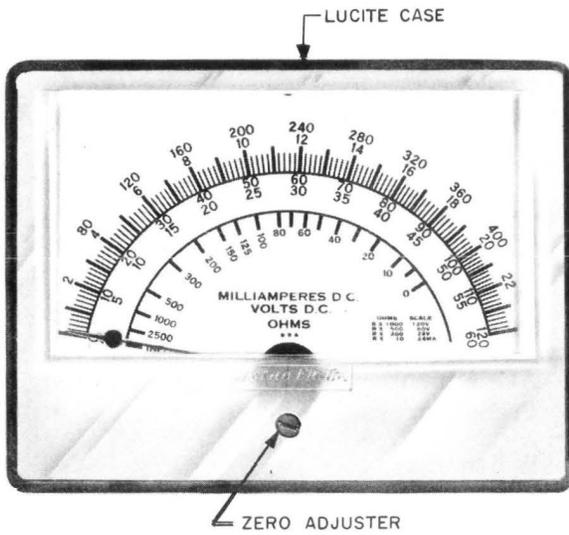


Fig. 2 – Western Electric S9A Volt-Ohm-Milliammeter (surface-mounting case)

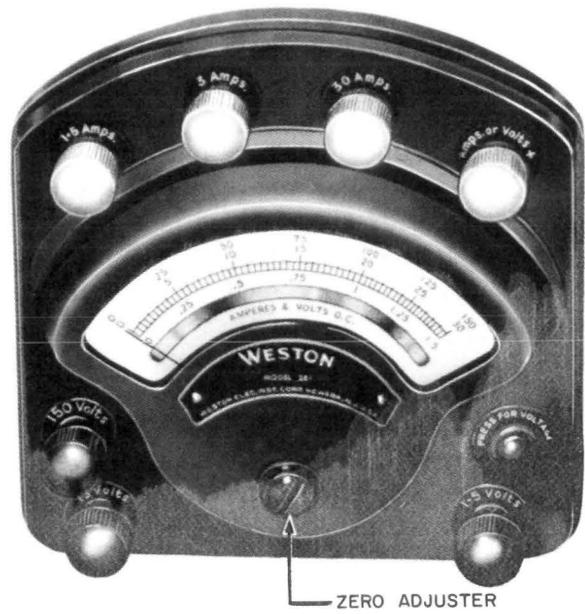


Fig. 4 – Weston Model 281 DC Volt-Ammeter (portable)

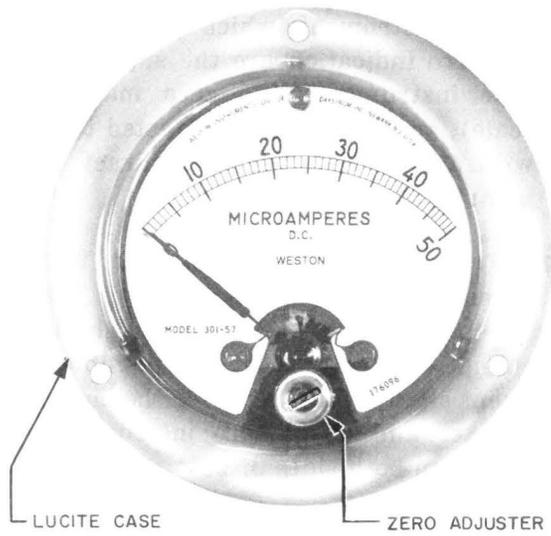


Fig. 5 – Weston Model 301 DC Microammeter (flush-mounting case)

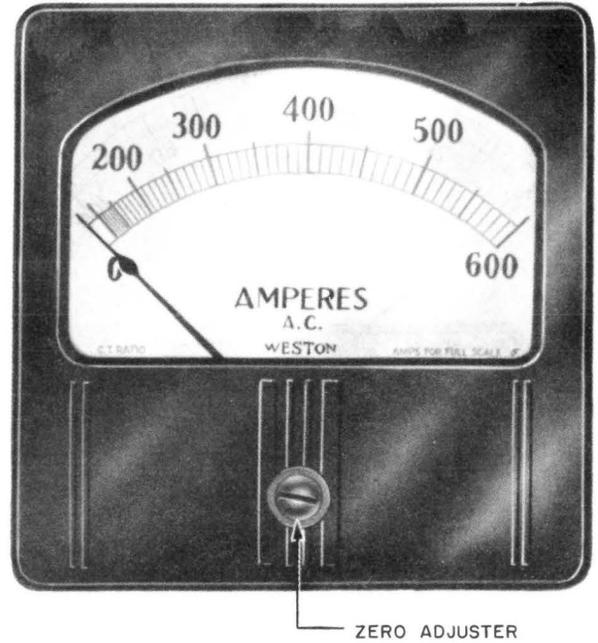


Fig. 7 – Weston Model 734 AC Ammeter — Used With Transformer (flush-mounting case)

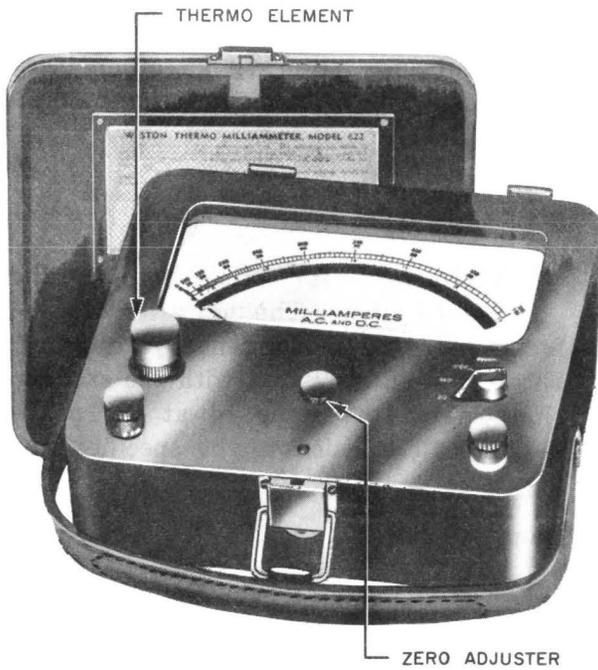


Fig. 6 – Weston Model 622 AC-DC Thermo Milliammeter (portable)

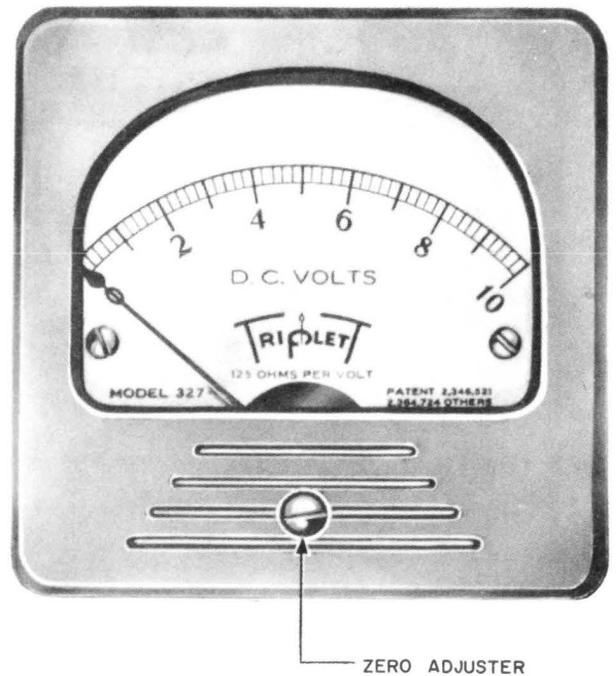


Fig. 8 – Triplett Model 327 DC Voltmeter (flush-mounting case)

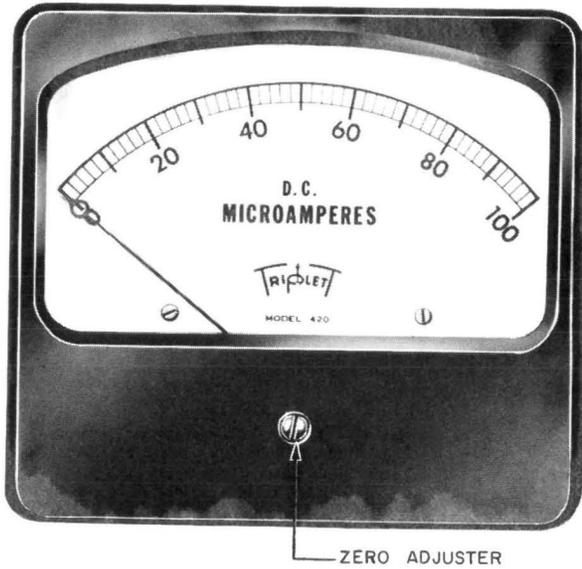


Fig. 9 – Triplet Model 420 DC Microammeter (flush-mounting case)

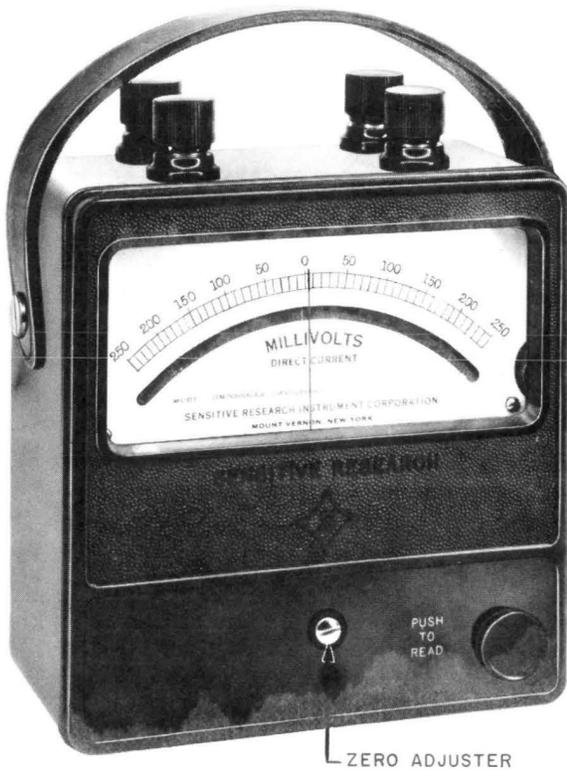


Fig. 10 – Sensitive Research Inst Corp. DC Millivoltmeter (portable)

2. REQUIREMENTS

2.01 **Zero Indication:** With no current flowing through the instrument, the pointer shall indicate zero on the scale.

Gauge by eye.

**Note:** Instruments which cannot be checked for zero indication are the suppressed zero type instruments (no zero mark on the scale), and instruments adjusted to indicate with a certain degree of accuracy at some point on the scale.

2.02 **Freedom of Pointer Movement:** When current through the instrument is gradually decreased or increased, the pointer shall follow this change smoothly. Whenever possible this requirement shall be checked over the entire scale. Zero center and offset zero instruments shall be checked on both sides of zero.

Gauge by eye.

2.03 **Electrical Requirements (accuracy)**

(a) **General:** Unless otherwise specified in the tables in this section, the circuit requirement tables, or other job information, KS specification instruments shall meet the same requirements for accuracy as other instruments bearing the same manufacturer's model or type number.

(b) **Instruments Covered in Tables A through D**

(1) **Voltmeters for Measuring Battery Float Voltage:** The indication of a voltmeter used for showing float voltage of a battery, when compared with the standard, shall match the standard at the nearest minor scale division to the specified floating value.

Gauge by eye.

(2) **Microammeters:** The accuracy of microammeters when compared to the standard instrument shall be within the limits shown in Column 4 of Table D.

Gauge by eye.

- (3) **Ammeters for Measuring Output of Charging Generators:** The accuracy of these ammeters, when compared to the standard instrument, shall be within the limits shown in Column 5 of Tables A, B, and C.  
Gauge by eye.
- (4) **Ammeters and Wattmeters for Measuring Output of Alternators:** The accuracy of these instruments, when compared to the standard instrument, shall be within the limits shown in Column 5 of Tables A, B, and C.  
Gauge by eye.
- (5) **All Other Instruments:** The accuracy of these instruments, when compared to the standard instrument, shall be within the limits shown in Column 4 of Tables A, B, and C.  
Gauge by eye.
- (c) **Ohmmeters:** With the pointer of the ohmmeter at midpoint position on the scale, the reading on the standard decade resistor setting shall be within  $\pm 10$  per cent of the

numerical resistance value indicated by the pointer.

**Note:** Ohmmeters having more than a single range shall be checked at the midpoint position on each range.

- \* (d) **Weston Model 356 Power Factor Meter:**  
The error of this instrument shall be  
Max  $\pm 0.01$   
Gauge by eye.  
**Note:** The pointer of a power factor meter does not return to zero when current is removed from the instrument.
- \* (e) **Weston Model 214 Frequency Meter:** The error of this instrument shall be  
Max  $\pm 0.03$  cycles  
Gauge by eye.  
**Note:** The pointer of a frequency meter does not return to zero when current is removed from the instrument.
- \* (f) **General Electric AC Watthour Meter:**  
The error of this instrument shall be  
Max  $\pm 2\%$   
Gauge by eye.

**TABLE A — ACCURACY REQUIREMENTS**  
**DIRECT CURRENT INSTRUMENTS**  
**EXCLUSIVE OF WESTERN ELECTRIC TYPES**

RATED ACCURACY OF INSTRUMENT (see note 1)	MANUFACTURER AND MODEL OR KS NUMBER (see notes 2, 3, and 4)	NUMBER OF SCALE DIVISIONS	ALLOWABLE DEVIATION IN SCALE DIVISIONS AT ANY POINT ON THE SCALE	
			COLUMN 4	COLUMN 5
COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5
1/4 of 1 per cent	Weston Model 1 KS-7361 (see note 5)	100 or less	1/4	—
	KS-8039 (see note 6) KS-8589 (see note 7)	100-200	1/2	—
1/2 of 1 per cent	Weston Models 45, 322, 508, 622, 901, 931 (see note 8)	100 or less	1/2	—
	Sensitive Research Instrument Corp., Model "BELLUD" (see note 9)	101-150	3/4	—
	KS-8529 (see note 10)	151-200	1	—
1 per cent	Weston Models 11, 24, 57, 264, 267, 269, 271, 273, 280, 281, 319, 431, 456, 502, 643, 741  Triplett Model 420 Ammeters KS-14644 (see note 11) KS-19137, L1 (see note 12)	50 or less	1/2	2-1/2
		51-75	3/4	3-1/2
		76-100	1	4
		101-125	1-1/4	5-1/2
		126-150	1-1/2	8
2 per cent	Weston Models 301, 489, 506, 564, 600, 697, 731, 801, 1301, 1331, 1531, 1941  Triplett Models 321, 324, 327, and 420 Voltmeters KS-14510, L1 and L5 (see note 13) KS-14559, KS-14625 (see note 14) KS-16943, L1 (see note 15)	25 or less	1/2	1-3/4
		26-35	3/4	2-1/4
		36-50	1	3
		51-60	1-1/4	3-1/4
		61-75	1-1/2	4
		76-80	1-3/4	4-1/4
		81-100	2	5-1/2
101-150	3-1/2	8		

**Notes for Table A**

1. Unless otherwise noted, the rated accuracy is specified in per cent of full-scale deflection at any point on the scale.
2. Instruments of other manufacturer's than those listed, which have rated accuracies as specified in the table, may be checked using the requirements in the table.
3. Instruments of other manufacturer's than those listed, furnished on engine-alternator sets, should be checked using the requirements specified in the table for the Weston Model 801.
4. Microammeters bearing the model numbers of the listed instruments in Column 2 should be checked for accuracy following the procedures specified for similar microammeters listed in Table D.
5. Special Weston Model 1 milliammeter having a full-scale sensitivity of 12 milliamperes with the zero at the right end of the scale.
6. Special Weston Model 622 volt-milliammeter.
7. Special Weston Model 25 milliammeter.
8. Weston Model 622 AC-DC Thermo instruments are accurate to within  $\pm 1$  per cent of full-scale deflection for all dc ranges and to within  $\pm 0.5$  per cent of full-scale deflection for all ac ranges.
9. Sensitive Research Instrument Corp, zero center portable millivoltmeter and it should be checked on both sides of zero.
10. Special Weston Model 430 milliammeter having a step type scale and a full-scale sensitivity of 31.5 milliamperes. The allowable deviation in scale divisions at any point on the scale is  $1/4$  of a step.
11. Special Weston Model 741 microammeter having a full-scale sensitivity of 500 microamperes. To check the accuracy, follow the procedures specified for Western Electric microammeters (Table D). Use a 15,000 ohm series resistor and read the 7.5 volts scale on the standard instrument to check the allowable deviation in scale divisions in Column 4.
12. Special Weston Model 1941 voltmeter having a rated accuracy of  $\pm 1$  per cent of full-scale deflection at any point on the scale except at the 21-volt point where the accuracy is  $\pm 0.5$  per cent of full-scale deflection.
13. Special Triplett Model 630 volt-ohm-milliammeter having a full-scale sensitivity of 50 microamperes dc. The accuracy of all dc ranges is  $\pm 2$  per cent of full-scale deflection for both list numbers except that at the 0.275-volt point on the 0.3 dc volt range of the List 5 meter, the accuracy is  $\pm 0.5$  per cent of full-scale deflection when the instrument is used in a horizontal position.
14. Special Weston Model 301 or Triplett Model 321 milliammeter having a full-scale sensitivity of one milliammeter.
15. Special Weston Model 1531 zero center microammeter and it should be checked on both sides of zero. To check the accuracy, follow the procedure for a similar microammeter listed in Table D.

**TABLE B — ACCURACY REQUIREMENTS  
ALTERNATING CURRENT INSTRUMENTS  
EXCLUSIVE OF WESTERN ELECTRIC TYPES**

RATED ACCURACY OF INSTRUMENT (see note 1)	MANUFACTURER AND MODEL, TYPE OR KS NUMBER (see notes 2 and 3)	NUMBER OF SCALE DIVISIONS	ALLOWABLE DEVIATION IN SCALE DIVISIONS AT ANY POINT ON THE SCALE	
			COLUMN 4	COLUMN 5
COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5
1/2 of 1 per cent	Weston Models 155, 412, 622, 904 (see note 4)	100 or less	1/2	—
		101-150	3/4	—
1 per cent	Weston Models 151, 156, 216, 260, 261, 330, 429, 578, 610, 641, 642, 743, 744 Westinghouse Type DY Roller-Smith Type FA	25 or less	1/4	1-1/2
		26-50	1/2	2
		51-75	3/4	3-1/2
2 per cent	Weston Models 476, 507, 517, 528, 733, 734, 964 G.E. Type AO-22	25 or less	1/2	1-1/2
		26-30	3/4	1-3/4
		31-50	1	2-1/4
		51-60	1-1/4	2-3/4
		61-75	1-1/2	3
3 per cent	Weston Model 1302 KS-14472 (see note 5)	40 or less	1-3/4	—
		41-50	2	—
4 per cent	Weston Models 643, 742	51-60	2-1/2	—
		61-75	3	—
5 per cent	Weston Models 301, 506, 600, 697, 732 KS-14510, L1 and L5 (see note 6) KS-14646 (see note 7)	20 or less	1	—
		21-25	1-1/4	—
		26-30	1-1/2	—
		31-40	2	—
		41-50	2-1/2	—
		51-60	3	3
		61-75	3-3/4	4

**Notes for Table B**

1. Unless otherwise noted, the rated accuracy is specified in per cent of full-scale deflection at any point on the scale.
2. Instruments of other manufacturer's than those listed, which have rated accuracies as specified in the table, may be checked using the requirements in the table.
3. Instruments of other manufacturer's than those listed, furnished on engine-alternator sets, should be checked using the requirements specified in the table for the Weston Model 476.

4. Weston Model 622 AC-DC Thermo instruments are accurate to within  $\pm 0.5$  per cent of full-scale deflection for all ac ranges and to within  $\pm 1$  per cent of full-scale deflection for all dc ranges.
5. Special Weston Model 476 ammeter.
6. Special Triplet Model 630 volt-ohm-milliammeter. The accuracy for all ac ranges is  $\pm 5$  per cent of full-scale deflection.
7. Special Weston Model 741 voltmeter.

**TABLE C — ACCURACY REQUIREMENTS**  
**DIRECT AND ALTERNATING CURRENT INSTRUMENTS**  
**WESTERN ELECTRIC CODED TYPES**  
**EXCLUSIVE OF MICROAMMETERS**

*INSTRUMENT RATED ACCURACY AND SERVICE	CODE OR D- SPEC. NUMBER	NUMBER OF SCALE DIVISIONS	ALLOWABLE DEVIATION IN SCALE DIVISIONS AT ANY POINT ON THE SCALE	
COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5
1 per cent DC	B4H, B4J, B4K, C2C, C2J, C4B, C9A, C9B, D2D, D4B, D4C, D4D, D4E, D9A, G2AA, G9D, H4H, H4J, H4K, AA9A, and S type	50 or less	1/2	2-1/2
		51-75	3/4	3
		76-80	1	4
		81-120	1-1/4	5
		121-150	1-1/2	8
	D-165982, D-165983	60 or less	3/4	—
1-1/2 per cent DC	C8A, D8A	60 or less	1	—
2 per cent DC	A, B, C, D, G, H, J, M, and AA types (except specific code numbers listed above)	30 or less	3/4	1-1/2
		31-50	1	2
		51-60	1-1/4	2-1/2
		61-75	1-1/2	3-1/2
		76-80	1-3/4	4
		81-100	2	—
	D-167232, D-167689, D167765, D-167788, D-167790, D-167791, D-168908, D-169318, D-169883, D-171654, D-171655, D-171656, D-175507, D-175533, D-178396	50 or less	1	—
		51-60	1-1/4	—
		61-75	1-1/2	—
		—	—	—
5 per cent AC	C, G, M, and AA types	30 or less	1-1/2	—
		31-37	2	—
		38-50	2-1/2	2-3/4
		51-75	3	4

\* The rated accuracy is specified in per cent of full-scale deflection at any point on the scale unless otherwise noted.

TABLE D — ACCURACY REQUIREMENTS (see notes 1 and 2)

## DIRECT CURRENT MICROAMMETERS

## WESTERN ELECTRIC CODED TYPES

CODE OR D-SPEC. NUMBER	SERIES RESISTANCE (OHMS $\pm 1\%$ )	CHECKING POINTS ON MICROAMMETER	VOLTAGE TOLERANCE ON STANDARD INSTRUMENT	VOLTAGE SCALE ON STANDARD INSTRUMENT
COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5
G3D	300,000	50	13.7 -16.3	75
		75	21.1 -23.9	
		100	28.7 -31.5	
G3H	150,000	50	6.8 - 8.2	30
		100	14.2 -15.8	
		150	21.6 -23.4	
G3J (see note 3)	300,000	10	2.5 - 3.5	7.5
		20	5.5 - 6.5	
G3K	300,000	15	4.1 - 4.9	15
		25	7.1 - 7.9	
		35	10.1 -10.9	
G3L	300,000	5	1.3 - 1.7	7.5
		10	2.8 - 3.2	
		15	4.35- 4.75	
G3N	150,000	25	3.4 - 4.2	15
		50	7.0 - 8.0	
		75	10.8 -11.8	
AA3A	300,000	1.0	5.55- 6.55	15
		1.5	8.55- 9.55	
		2.0	11.55-12.55	
AA3B	300,000	50	13.7 -16.3	75
		75	21.1 -23.9	
		100	28.7 -31.5	
AA3F	150,000	50	6.75- 8.3	30
		100	14.2 -15.95	
		150	21.7 -23.6	
D-171653	300,000	15	4.0 - 5.0	15
		25	7.0 - 8.0	
		35	10.0 -11.0	
D-171654	300,000	25	7.0 - 8.0	15
	15,000	500	7.2 - 7.8	

**Notes for Table D**

1. The microammeters listed in Table D have a rated accuracy of 2 per cent of full-scale deflection at any point on the scale.
2. When checking the microammeter as a voltmeter, use the series resistor as specified in Table D.
3. The G3J microammeter is a zero center instrument and should be checked on both sides of zero.

**3. ADJUSTING PROCEDURES**

**3.001 List of Tools, Materials, and Test Apparatus**

CODE OR SPEC. NO.	DESCRIPTION
<b>TOOLS</b>	
KS-6854	3-1/2 Inch Screwdriver
R-1005	Jewelers Screwdriver
—	3-Inch C Screwdriver
<b>MATERIALS</b>	
KS-2423	Cloth
—	Anstac 2-M Antistatic Solution (Chemical Development Corp.)
<b>TEST APPARATUS</b>	
35 Type	Test Set
KS-8039	Weston Model 622 Volt-Milliammeter and Associated Connecting Leads, or Equivalent
KS-9442,L21	Portable Testing Shunt
—	Weston Model 310 Single-Phase Portable Wattmeter or Equivalent
—	Weston Model 329 Poly-Phase Portable Wattmeter, or Equivalent
—	General Radio Type 1432-M Decade Resistor, or Equivalent
—	IRC-Type WW4 Wire-Wound Resistors (1 per cent accuracy) or the Equivalent Values as Specified in Table D (resistances of the required values are also included in the KS-8295 volt-ohmmeter, where available, and may be obtained as follows)

RESISTANCE OHMS	CONNECT TO PIN JACKS	OPERATE SWITCH
15,000	15V & 30V	—
150,000	150V & 300V	—
300,000	— & 300V	DC

CODE OR SPEC. NO.

DESCRIPTION

TEST APPARATUS

—	IRC-Type WW4 Wire-Wound Resistors (1 per cent accuracy) or the Equivalent Values as Specified in Table F
—	Rheostat of Adequate Rating, Capable of Carrying the Current, as Required
—	Reversing Switch Capable of Carrying the Current, as Required

**3.002** Before making any adjustment on the instrument, determine that the trouble is not with the connecting circuits. No adjustments, other than those covered in this section, should be made by the regular maintenance forces. It is assumed that all other adjustments will be made in a central instrument bureau, or repair center, or by authorized instrument repair personnel.

**3.003** Instruments arranged for mounting on metal panels should be checked on their respective panels. They should be left in place and temporary leads run from a suitable source of power. Portable instruments should be checked in the position in which they are to be used. Nonshielded instruments should be checked in a place where they will not be affected by outside influences such as iron, steel, magnetic fields, and other instruments.

**Caution:** When disconnecting the instrument, unsolder all soldered connections. Do not cut the wires.

**3.004 Disconnecting Current Measuring Instruments**

- (1) When removing an ac or dc current measuring instrument from a circuit, bridge around it before disconnecting the wires from the instrument terminals.

(2) Before disconnecting a dc ammeter from a circuit, determine whether it has an external shunt. *An external shunt must be left in the circuit and the instrument disconnected by removing the small instrument leads at the shunt.* If there is no external shunt, the circuit will be opened as soon as the instrument is disconnected, causing a hazardous condition as well as a possible service interruption, and it will be necessary to bridge around the instrument before disconnecting it. Make the connections at the most convenient points in the circuit, other than the terminals of the instrument, using wire of adequate size to avoid overheating.

*Caution: Ammeter shunts should not be touched with the fingers, since, in ordinary operation, they may reach temperatures too high for safe contact.*

(3) Current transformers are used with many ac ammeters and wattmeters. The secondary winding of each current transformer *must* be shorted before disconnecting an associated instrument.

*Caution: If the winding of a current transformer is left open (not shorted) and the primary carries current, high voltages and high temperatures will occur in the winding. This can cause severe shock to personnel, or fire, or other damage to equipment.*

**3.005** In general, instruments should be checked for accuracy at some point near the middle of the range over which they are used. Instruments used over a wide range shall be checked at two or three points on the scale, except multiscale instruments.

**3.006** Multiscale instruments should be checked at one point on each scale except when the voltage or current required for any scale is too high to make the check conveniently, as for instance when the voltage is more than 150 volts or the current is more than 3/4 ampere. In such cases, when two or more scales are checked, a check of a single point on each of these scales will be considered satisfactory. When only one scale is checked, it should be checked at two or three points.

**3.007** Zero center and offset zero instruments should be checked on the scales both sides of zero. In determining the number of scale divisions on a zero center 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 ac instrument, include in the total the small subdivisions which have been omitted near the zero point.

**3.008** In this section direct current is used for convenience in checking alternating current instruments for accuracy. To do this, the current through the ac instrument is reversed and the average of the two readings is used to determine the accuracy. In checking rectifier type ac instruments on dc, the reading on the dc instrument must be multiplied by a factor of 1.11 in order to get the equivalent reading on the ac instrument.

**3.009** Whenever possible, set the deflection of the standard instrument, by means of the rheostat, to a reading where both the standard instrument and the instrument being checked are calibrated so that a scale line on each instrument represents the same reading. The error of the instrument being checked can then readily be determined in scale divisions.

**3.010** 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 eraser end of a lead pencil as the current through them is brought to the value selected for checking the accuracy.

**3.011** 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.

### **3.01 Zero Indication (Reqt 2.01)**

(1) If the instrument is equipped with a zero adjuster screw, using a screwdriver to fit the screw slot, turn the screw until the requirement is met. If this requirement is not

met after current has been applied, check for freedom of pointer movement.

**Caution:** *The zero adjuster screw should turn freely. Do not attempt to turn the screw after resistance is met, as the adjusting mechanism may be seriously damaged. In making this adjustment, observe that there is considerable slack motion in the zero adjuster screw. When the position of the pointer has been changed, back off the screw slightly before the final check.*

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

**3.02 Freedom of Pointer Movement** (Req't 2.02)

**3.03 Electrical Requirements (accuracy)**  
(Req't 2.03)

**Static Charges on Meter Cases Made of Lucite (Methyl Methacrylate):**

(1) During cleaning operations, static surface charges of sufficient intensity to interfere with the proper movement of the pointer in the meter, may be produced on a Lucite meter case. This static charge problem may be generally overcome by wiping the meter face with a clean KS-2423 cloth slightly moistened with Anstac 2-M antistatic solution. Allow the moistened surface to dry and then wipe with a dry, clean KS-2423 cloth. Further applications of the antistatic solution should be made as required to overcome any static charges. Occasionally, this procedure may not be entirely effective for Western Electric S-type meters. When this condition exists, apply Anstac 2-M antistatic solution in the same manner as covered above to the inside and outside of the entire S-type meter case. To do this, remove the meter from service and, if necessary, draw it forward sufficiently to provide access to the case mounting screws. Use the KS-6854 screwdriver to remove the four flathead machine screws which hold the case to the base of the meter. Care must be exercised so as not to damage the screw slots and the bushings which mount under the screw heads. After the antistatic solution has been applied to the inside of the cover, remount the cover and make sure that the four mounting screws are in place before returning the meter to service.

**DC Voltmeters — 150 Volts or Less**

(2) **Preparation:** To check whether the instrument meets the requirements, use the 35-type test set and the KS-8039 volt-milliammeter, covered in Section 100-515-101, as the standard instrument.

(3) Remove potentials from the instrument to be checked and disconnect all wiring at the terminals.

**Caution:** *When disconnecting the instrument, unsolder all soldered connections. Do not cut the wires.*

(4) **35-Type Test Set Application:** Connect the voltmeter to be checked and the standard instrument, used as a voltmeter, across the T and R terminals of the test set using B/G/V application as covered in Section 100-101-101. In this application, when using the 35D or 35F test set, the VM key should be normal.

**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.*

(5) **Checking Voltage**

(a) Select the voltage at which the voltmeter is to be checked. This voltage should be some value near the middle of the range where the voltmeter is used and 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 voltage.

(b) Turn the VOLTS switch on the standard instrument to the scale position so that the selected checking voltage is in the upper two thirds of the scale.

(6) **Freedom of Pointer Movement:** Adjust the sliders of the test set, as required, until the standard instrument indicates a value slightly higher than the starting value as covered in (5). Gradually decrease and then increase the current through the instrument being tested using the sliders, as required, and check that the requirement is met.

(7) **Accuracy:** Adjust the sliders of the test set, as required, until the standard instrument indicates the selected checking voltage. Check that the indication on the voltmeter does

not differ from that on the standard instrument by more than that specified in requirement 2.03.

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

(9) If the voltmeter is to be checked at more than one point on the scale, select another checking voltage as covered in (5) and proceed as covered in (7).

(10) If the voltmeter is calibrated with more than one scale that can be checked at less than 150 volts, select one checking voltage in each of the other scales as covered in (5) and repeat the procedure covered in (7).

(11) If the voltmeter to be checked is a suppressed zero instrument, select the checking voltage as covered in (5) and proceed as covered in (6), (7), and (12).

(12) Using a suitable screwdriver, adjust the zero adjuster of the voltmeter under test to indicate exactly, or as nearly as possible, the same value as shown on the standard instrument. The accuracy with which the instrument is set depends on its use.

(13) **Caution:** *The zero adjuster screw should turn freely. Do not attempt to turn the screw after resistance is met, as the adjusting mechanism may be seriously damaged. In making this adjustment, observe that there is considerable slack motion in the zero adjuster screw. When the position of the pointer has been changed, back off the screw slightly before the final check.*

(14) After completing the tests, remove all test connections and restore all wiring to the voltmeter.

#### (15) DC Voltmeters Used in Power Plants

(a) Suppressed zero voltmeters manufactured by Western Electric and some Weston models are not equipped with zero adjusters. Other suppressed zero instruments are equipped with dummy zero adjusters without connection to the pointer adjusting mechanism. In such a case, it will

be necessary to remove the cover and adjust the torsion spring tension. For Western Electric instruments, shift the adjusting arm, as required, to adjust the pointer indication. The arm is held by friction and is not clamped. For Weston instruments, it is necessary to loosen the adjusting arm clamping screws before moving the arm. After making the adjustments, as required, make sure that the clamping screws are tightened securely. Remount the cover before checking the suppressed zero instrument as covered in (5) through (7). Then proceed as covered in (14).

**Note:** While the cover of the instrument is removed, make sure there is no lint or other foreign matter inside the case or in the air gap.

(b) In some cases it may be possible to check the instrument in the circuit where it is used, when it is practicable to use the plant voltage for testing. To do this proceed as follows. Set the VOLTS switch on the standard instrument to the range position appropriate for the voltmeter being checked and connect the standard in the circuit in parallel with the voltmeter. Adjust the regulator of the associated charging source until the pointer of the standard falls on the nearest scale line of the voltage selected for checking.

**Note:** The plant voltage adjustment procedure may be complicated or the nature of load variations may cause an unsteady voltage. Therefore it is usually undesirable or impossible to check the accuracy of the instrument in the circuit.

#### AC Voltmeters — 150 Volts or Less

(16) **Preparation:** Proceed as covered in (2) and (3).

(17) **35-Type Test Set Application:** Proceed as covered in (4).

#### (18) Checking Voltage

(a) Select the voltage at which the voltmeter is to be checked. This voltage 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 voltage 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 voltage 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  $50 \times 1.11$  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.

(b) Turn the VOLTS switch on the standard instrument to the scale position so that the selected checking voltage is in the upper two thirds of the scale.

(19) **Freedom of Pointer Movement:** Adjust the sliders of the test set, as required, until the standard instrument indicates a value slightly higher than the starting value as covered in (18). Gradually decrease and then increase the current through the instrument being tested using the sliders, as required, and check that the requirement is met.

(20) **Accuracy**

(a) **Other Than Rectifier Type Voltmeters:** Adjust the sliders of the test set, as required, until the standard instrument indicates the selected checking voltage. Note the indication on the instrument being tested. Operate the BAT & GRD CO key on the test set. Reverse the connections from the instrument being tested to the test set. **Do not change the connections from the standard instrument to the test set.** Restore the BAT & GRD CO key and again note the indication on the instrument being tested. Calculate the average of the two readings so obtained and check that this value does not differ from that indicated on the standard instrument by more than that specified in requirement 2.03.

(b) **Rectifier Type Voltmeters:** Proceed as covered in (a) to obtain the average value of the two readings on the instrument being checked. Multiply the selected check-

ing value indicated on the standard instrument by 1.11. Then check that the average value does not differ from the new computed checking value by more than that specified in requirement 2.03.

**Note:** Multiplying by 1.11 accounts for the different reading of rectifier type instruments when indicating a direct current.

(21) If the voltmeter is to be checked at more than one point on the scale, select another checking voltage as covered in (18) and proceed as covered in (20).

(22) If the voltmeter is calibrated with more than one scale that can be checked at less than 150 volts, select one checking voltage in each of the other scales as covered in (18) and proceed as covered in (20) for each of the scales.

(23) After completing the tests, remove all test connections and restore all wiring to the voltmeter.

**DC Milliammeter on 35 Type Test Set**

(24) **Preparation:** Connect the KS-8039 voltmilliammeter, covered in Section 100-515-101, as a milliammeter across the T and R terminals of the test set using B/G/V application as covered in Section 100-101-101. In this application when checking the milliammeter on the 35D or 35F test set, the VM key should be normal.

**Caution:** *The battery potential used for checking the test set should not exceed 60 volts.*

(25) **Accuracy and Freedom of Pointer Movement:** Table E lists the allowable deviation in milliamperes for the checking points on the scales of the test set milliammeter. For the positions of the test set key and the standard instrument switch, as specified, adjust the sliders of the test set, as required, to check that the scales of the test set meter are within the allowable limits. While making any one of the scale accuracy checks, adjust the sliders, as required, to gradually decrease and then increase the current through the test set meter and check that requirement 2.02 is met.

**TABLE E— MILLIAMMETER CHECKING POINTS —  
35-TYPE TEST SET**

TEST SET		STANDARD INSTRUMENT	
MIL AMPS KEY POSITION	ALLOWABLE DEVIATION ON MILLIAMMETER	MILLI-AMPERES SWITCH POSITION	MILLI-AMMETER CHECKING POINT
15	2.8 to 3.2 ma	7.5	3 ma
15	9.8 to 30.2 ma	15	10 ma
15	12.8 to 13.2 ma	15	13 ma
75	39 to 41 ma	75	40 ma
750	390 to 410 ma	750	400 ma
(see note)	1.96 to 2.04 ma	7.5	2 ma

*Note:* To check the 3 milliampere scale on the 35D and 35F test sets, it is necessary to operate and hold the MIL AMPS 15(3) and the 3MA keys.

(26) After completing the tests remove all test connections.

**DC Microammeters — Less than 1000 Microamperes (see 3.004)**

(27) *Preparation:* Proceed as covered in (2) and (3).

(28) *35-Type Test Set Application:* Using B/G/V application of the test set as covered in Section 100-101-101, make the following connections to the set.

(a) Connect the standard instrument used as a voltmeter across the T and R terminals.

(b) With the series resistor, specified in Column 2 of Table D, in one leg of the circuit, connect the microammeter to be checked across the T and R terminals.

*Note 1:* In this application, when using the 35D or 35F test set, the VM key should be normal.

*Note 2:* The current flowing in the test circuit is indicated on the milliammeter of the test set.

(29) *Checking Voltage:* Turn the VOLTS switch on the standard instrument to the scale position specified in Column 5 of Table D for the microammeter to be checked.

(30) *Freedom of Pointer Movement:* On the test set adjust the sliders, as required, until the microammeter being checked indicates a value near the middle of the scale. Gradually decrease and then increase the current through the microammeter, by adjusting the sliders, as required, and check that requirement 2.02 is met.

(31) *Accuracy:* Adjust the sliders, as required, on the test set until the microammeter being checked indicates one of the checking point values in Column 3 of Table D. Check to see that the corresponding voltage reading of the standard instrument is within the limits specified in Column 4 of Table D.

(32) If the microammeter is to be checked at more than one point on the scale, select another checking point value from the table and repeat the procedure in (31).

(33) After completing the tests, remove all test connections and restore all wiring to the microammeter.

**DC Milliammeters — Less than 750 Milliampere (see 3.004)**

(34) *Preparation:* Proceed as covered in (2) and (3).

(35) *35-Type Test Set Application:* Connect the milliammeter to be checked in series with the standard instrument, used as a milliammeter, across the T and R terminals of the test set using B/G/V application as covered in Section 100-101-101. In this application when using the 35D or 35F test set, the VM key should be normal.

**(36) Checking Current**

(a) Select the current at which the milliammeter is to be checked. This current should be some value near the middle of the range where the milliammeter is used and also some value 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.

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

(37) **Freedom of Pointer Movement:** Adjust the sliders of the test set, as required, until the standard instrument indicates a value slightly higher than the starting value as covered in (36). Gradually decrease then increase the current through the instrument being tested using the sliders, as required, and check that the requirement is met.

(38) **Accuracy:** Adjust the sliders of the test set, as required, until the standard instrument indicates the selected checking current. Check that the indication on the milliammeter does not differ from that on the standard instrument by more than that specified in requirement 2.03.

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

(40) If the milliammeter is to be checked at more than one point on the scale, select another checking current as covered in (36) and proceed as covered in (38).

(41) If the milliammeter is calibrated with more than one scale that can be checked at less than 750 milliamperes, select one checking current in each of the other scales as covered in (36) and repeat the procedure covered in (38).

(42) After completing the tests, remove all test connections and restore all wiring to the milliammeter.

**AC Milliammeters — Less than 750 Milliamperes**  
(see 3.004)

(43) **Preparation:** Proceed as covered in (2) and (3).

(44) **35 Type Test Set Application:** Proceed as covered in (35).

(45) **Checking Current**

(a) 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 if possible 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  $500 \times 1.11$  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.

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

(46) **Freedom of Pointer Movement:** Adjust the sliders of the test set, as required, until the standard instrument indicates a value slightly higher than the starting value as covered in (45). Gradually decrease and then increase the current through the instrument being tested using the sliders, as required, and check that the requirement is met.

(47) **Accuracy**

(a) **Other Than Rectifier Type Milliammeters:** Adjust the sliders of the test set, as required, until the standard instrument indicates the selected checking current. Note the indication on the instrument being tested. Operate the BAT & GRD CO key on the test set. Reverse the connections from the instrument being tested to the test set. **Do not change the connections from the standard instrument to the test set.** Restore the BAT & GRD CO key and again note the indication on the instrument being tested. Calculate the average of the two readings so obtained and check that this value does not differ from that indicated on the standard instrument by more than that specified in requirement 2.03.

(b) **Rectifier Type Milliammeters:** Proceed as covered in (a) to obtain the average value of the two readings on the instrument being checked. Multiply the selected checking value indicated on the standard instrument by 1.11. Then check that the average

value does not differ from the new computed checking value by more than that specified in requirement 2.03.

**Note:** Multiplying by 1.11, accounts for the different reading of rectifier type instruments when indicating a direct current.

(48) If the milliammeter is to be checked at more than one point on the scale, select another checking current as covered in (45) and proceed as covered in (47).

(49) 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), and proceed as covered in (47) for each of the scales.

(50) After completing the tests, remove all test connections and restore all wiring to the milliammeter.

#### DC Ammeters — Between 3/4 and 3 Amperes (see 3.004)

(51) **Preparation:** To check whether the ammeter meets the requirements use the KS-8039 volt-milliammeter as a standard covered in Section 100-515-101, and a rheostat suitable for obtaining the proper testing current.

(52) Remove potentials from the ammeter to be checked and connect it in series with the standard instrument. To do this, remove the connection to the negative terminal of the ammeter and connect it to the negative binding post on the standard instrument. Connect the VOLTS MILLIAMPERES binding post of the standard instrument to the negative terminal of the ammeter. If the leads furnished with the standard instrument are not used for these connections, check the current-carrying capacity of the conductors used to make sure that they will safely carry the necessary current.

**Caution:** When disconnecting the ammeter, unsolder all soldered connections. Do not cut the wires. Before connecting current to the instruments, make sure that the rheostat or other protective resistance is adjusted so that the current flow will not damage the instruments.

(53) Restore current to the ammeter. If the ammeter is not wired in a circuit containing a source of potential, connect it and the standard instrument in the testing circuit Fig. 11.

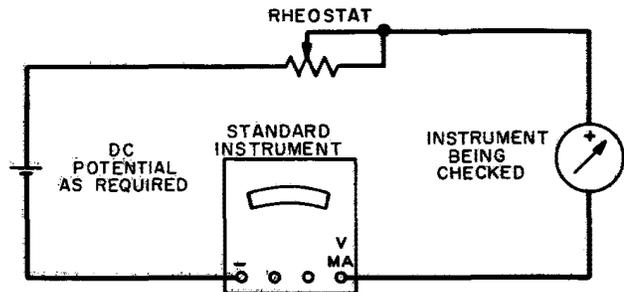


Fig. 11 — Testing Circuit for DC Ammeters Checked at Values Between 3/4 Ampere and 3 Amperes

#### (54) Checking Current

(a) 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.

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

(55) **Freedom of Pointer Movement:** Adjust the rheostat, as required, to gradually increase and then decrease the current through the ammeter and check to see that the requirement is met.

(56) **Accuracy:** Adjust the rheostat, as required, until the standard instrument indicates the selected checking current. Check that the indication on the ammeter does not differ from that on the standard instrument by more than that specified in requirement 2.03.

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

(58) If the ammeter is to be checked at more than one point on the scale, select another checking current as covered in (54) and proceed as covered in (56).

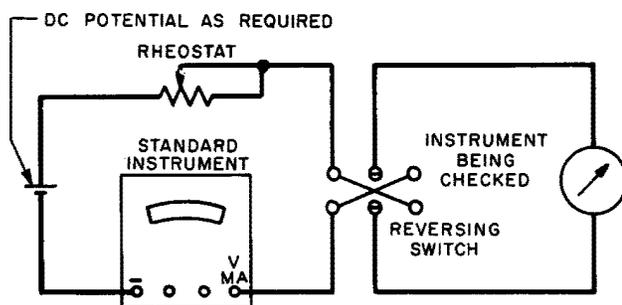
(59) After completing the tests, remove all test connections and restore all wiring to the ammeter.

**AC Ammeters — Between 3/4 and 3 Amperes**  
(see 3.004)

(60) **Preparation:** To check whether the ammeter meets the requirements, use the KS-8039 voltmilliammeter as a standard covered in Section 100-515-101, a reversing switch, and a rheostat suitable for obtaining the proper testing current.

(61) Remove potentials from the ammeter to be checked and connect it in series with the standard instrument through a reversing switch in the testing circuit Fig. 12. Wire the reversing switch so that current through the ammeter is reversed by the operation of the switch.

**Caution:** When disconnecting the ammeter, unsolder all soldered connections. Do not cut the wires. Before connecting current to the instruments, make sure that the rheostat is adjusted so that the current flow will not damage the instruments.



**Fig. 12 — Testing Circuit for AC Ammeters Checked at Values Between 3/4 Ampere and 3 Amperes**

**(62) Checking Current**

(a) Select the current at which the ammeter is to be checked. This current should be some value near the middle of the range where the ammeter is used and also a value that is indicated by a scale line on both the standard instrument and the ammeter being tested. The error of the ammeter can then readily be determined in scale divisions.

(b) Turn the MILLIAMPERES switch on the standard instrument to the scale position where the selected checking current is in the upper two-thirds of the scale.

(63) **Freedom of Pointer Movement:** Close the reversing switch and adjust the rheostat to gradually increase and then decrease the current through the ammeter and check to see that the requirement is met.

(64) **Accuracy:** Adjust the rheostat, as required, until the standard instrument indicates the selected checking current. Note the indication on the instrument being tested. Operate the reversing switch to the other position and again note the indication on the ammeter. Calculate the average of the two readings so obtained and check that this value does not differ from that indicated on the standard instrument by more than that specified in requirement 2.03.

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

(66) Proceed as covered in (59).

**DC Ammeters — Between 3 and 50 Amperes — No External Shunts (see 3.004)**

(67) **Preparation:** To check whether the ammeter meets the requirements, use the KS-8039 volt-milliammeter as a standard covered in Section 100-515-101, the KS-9442, L21 shunt, and a rheostat suitable for obtaining the proper testing current.

(68) Remove potentials from the ammeter to be checked and connect it in series with the KS-9442, L21 shunt in the testing circuit Fig. 13.

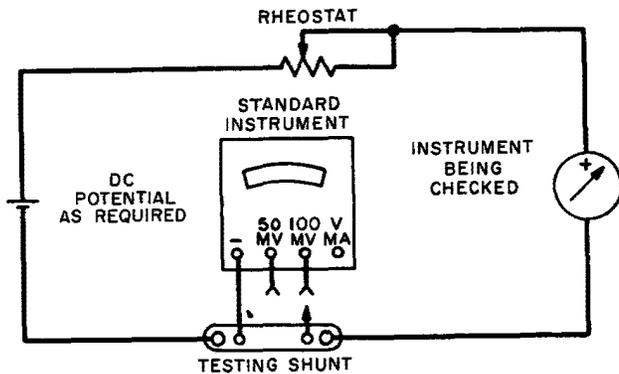


Fig. 13 - Testing Circuit for DC Ammeters Checked At Values Between 3 and 50 Amperes

**Caution:** When disconnecting the ammeter, unsolder all soldered connections. Do not cut the wires. Before connecting current to the instruments, make sure that the rheostat is adjusted so that the current flow will not damage the instruments.

- (69) **Checking Current:** Proceed as covered in (54).
- (70) **Freedom of Pointer Movement:** Proceed as covered in (55).
- (71) **Accuracy:** Proceed as covered in (56), (57), and (58).
- (72) Proceed as covered in (59).

**AC Ammeters — Between 3 and 50 Amperes — No Current Transformers (see 3.004)**

(73) **Preparation:** To check whether the ammeter meets the requirements, use the KS-8039 volt-milliammeter as a standard covered in Section 100-315-101, the KS-9442, L21 shunt, a reversing switch, and a rheostat suitable for obtaining the proper testing current.

(74) Remove potentials from the ammeter to be checked and connect it in series with the KS-9442, L21 shunt in the testing circuit Fig. 14. Exercise care in selecting a reversing switch that will carry the current used in testing and a type 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.

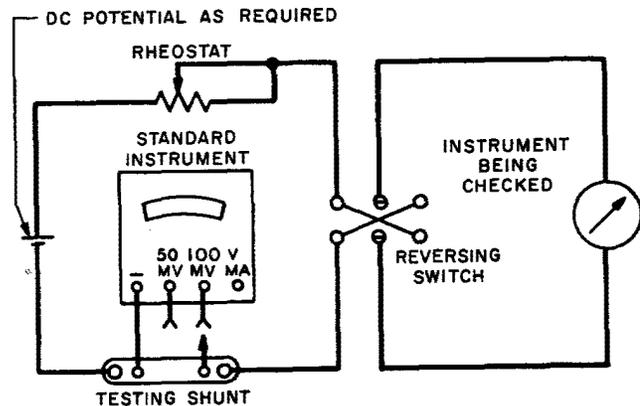


Fig. 14 - Testing Circuit for AC Ammeters Checked at Values Between 3 and 50 Amperes

**Caution:** When disconnecting the ammeter, unsolder all soldered connections. Do not cut the wires. Before connecting current to the instruments, make sure that the rheostat is adjusted so that the current flow will not damage the instruments.

- (75) **Checking Current:** Proceed as covered in (62).
- (76) **Freedom of Pointer Movement:** Proceed as covered in (63).
- (77) **Accuracy:** Proceed as covered in (64) and (65).
- (78) Proceed as covered in (59).

**DC Ammeters Having External Shunts (see 3.004)**

(79) **Preparation:** To check whether the ammeter meets the requirements, use the 35-type test set and the KS-8039 volt-milliammeter covered in Section 100-515-101 as the standard instrument.

(80) Remove current from the shunt associated with the ammeter to be tested and disconnect the shunt leads at the shunt.

(81) **35-Type Test Set Application:** Connect the ammeter (millivoltmeter) to be checked and the standard instrument, used as a millivoltmeter, across the T and R terminals of the test set using the B/G/V application as covered in Section 100-101-101. In this application when using the 35D or 35F test set, the VM key should be normal.

(82) **Checking Voltage:** Select the potential at which the ammeter (millivoltmeter) is to be checked. This potential should be some value that will cause a deflection of the ammeter pointer to a point near the middle of the range in which the instrument is used and also a value that will cause a deflection to a scale line on both the ammeter and the standard instrument. If the ammeter 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 ammeter (millivoltmeter) under test and the standard instrument will indicate the accuracy of the ammeter, that is, if the ammeter under test 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 ammeter under test; likewise a 40-millivolt deflection of the standard instrument should cause a 4/5-scale deflection of the ammeter under test.

(83) **Freedom of Pointer Movement:** Adjust the sliders of the test set, as required, until the standard instrument indicates a value slightly higher than the starting value as covered in (82). Gradually decrease and then increase the current through the instrument being tested using the sliders, as required, and check that the requirement is met.

(84) **Accuracy:** Adjust the sliders of the test set, as required, until the standard instrument indicates the selected checking value. Check to see that the pointer deflection of the ammeter (millivoltmeter) being checked does not differ from its calculated deflection, based on the standard instrument reading, by more than that specified in requirement 2.03.

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

(86) If the ammeter (millivoltmeter) is to be checked at more than one point on the scale, select another checking voltage as covered in (82) and proceed as covered in (84).

(87) After completing the tests, remove all test connections and restore all wiring to the ammeter and shunt.

#### AC Ammeters Having Current Transformers (see 3.004)

(88) **Preparation:** Proceed as covered in (73).

(89) 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. Connect the ammeter to be checked in the testing circuit Fig. 14.

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

**Note:** The basic instrument range of an ac ammeter used with a current transformer is 5 amperes.

(90) **Checking Current:** Proceed as covered in (62).

(91) **Freedom of Pointer Movement:** Proceed as covered in (63).

(92) **Accuracy:** Proceed as covered in (64) and (65).

(93) After completing the tests, remove all test connections. Check that no current is flowing in the current transformer primary and remove the short circuit from the secondary terminals. Then restore the ammeter connections.

#### Wattmeters (see 3.004)

(94) **Preparation:** To check whether the wattmeter meets the requirements, use the standard instrument as follows.

(a) **Single-Phase Wattmeters:** For checking, use the Weston Model 310 Portable Single-Phase Wattmeter as the standard instrument (accuracy 1/4 of 1 per cent).

(b) **Polyphase Wattmeters:** For checking, use the Weston Model 329 Portable Polyphase Wattmeter as the standard instrument (accuracy 1/2 of 1 per cent).

**Note:** Two model 310 wattmeters may be used in place of the Model 329 wattmeter.

(95) Remove power 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.

(96) 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 deviation specified in requirement 2.03.

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

**Ohmmeters**

(98) **Preparation:** To check whether the ohmmeter meets the requirements, use the General Radio Type 1432-M Decade Resistor as a standard instrument. See Table F.

(99) Set the pointer of the ohmmeter to be tested to "0" ohms. To do this proceed as follows. With the test leads connected to the instrument, short-circuit the test prods and adjust the ohms control knob on the instrument until the pointer indicates "0" ohms on the scale. If the ohmmeter is intended for measuring more than one range of resistance, the pointer must be set to "0" ohms on the scale for each range before making the resistance check.

**Note:** Some ohmmeters intended for measuring more than one range on the scale are equipped with a range multiplier switch.

Operate the switch, as required, for each range to set the pointer to "0" ohms.

(100) **Accuracy:** Connect the ohmmeter leads across the General Radio Type 1432-M Decade Resistor. Adjust the knob of the decade resistor until the pointer of the ohmmeter indicates midpoint on the scale and check that the requirement is met. Repeat the procedure for each range of resistance, as required. If the midpoint reading on the scale of the ohmmeter being tested is 200,000 ohms or more refer to Table F for the proper resistor to be wired in series with the decade resistor when checking the accuracy requirement.

**Note:** The total resistance that may be obtained through the General Radio Type 1432-M Decade Resistor is 111,110 ohms.

OHMMETER MIDPOINT READING (ohms)	IRC TYPE WW4 RESISTOR (ohms ± 1%)
200,000	100,000
300,000	200,000
400,000	300,000
500,000	400,000

**Power Factor Meters**

(101) 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.

**Frequency Meters**

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

**AC Watthour Meters**

(103) 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.