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TECHNICAL MANUAL

for

MIDGET MEGGER® INSULATION TESTER

CATALOG NO. 21805
21805-1
21804

JAMES G. BIDDLE CO.

BLUE BELL, PA. 19422

Revised September 1981

RECORD OF CHANGES

CHANGE NO.	DATE	TITLE OR BRIEF DESCRIPTION	ENTERED BY

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SECTION 1

GENERAL INFORMATION

1-1. SCOPE.

The purpose of this technical manual is to supply information which will assist in the installation, operation and maintenance of the Midget Megger Insulation Tester (NSN 1H6625-00-376-5105TE) referred to hereafter as the ohmmeter. See figure 1-1 for the complete tester, including the unit carrying case with six foot long leads stored in a separate compartment.

The ohmmeter is comprised of a rectified hand driven generator and a selectable multiscale meter. The ohmmeter measures the resistance, in megohms, to the flow of current through and/or over the surface of electrical equipment insulation. The test results are used to detect the presence of dirt, moisture, and insulation deterioration.

Figure 1-1. Ohmmeter, Midget Megger Insulation Tester, with Leather Carrying Case

This technical manual is in effect upon receipt. Extracts from this publication may be made to facilitate the operation and maintenance of the ohmmeter by the user activity.

1-2. GENERAL DESCRIPTION.

a. The ohmmeter is portable and is enclosed in a compact, impact-resistant thermoplastic case resting on four rubber feet. The moving element assembly is mounted on one end and the generator is mounted on the other. The ohmmeter is transported in a leather carrying case. A viewing window is provided in the center of the instrument to permit reading of the ohmmeter scale. The ohmmeter has two terminals, the positive (red) and negative (black) mounted on the moving element end of the instrument.

b. The ohmmeter movement is of the permanent magnet, cross-coil and pointer type with two scales, ohms and megohms. Overall scale length is about 2-7/16 inches. It is calibrated initially so that the accuracy will be well maintained within 2.5 percent of scale length during normal service. Ohmmeter scale calibration, to be within this accuracy, must be cranked at a speed of 150-170 RPM. Ohmmeter scale ranges are as stated in paragraph 1-3.

c. The test leads supplied with the ohmmeter are 6 feet long, however, other lengths are available. DO NOT INTERCHANGE TEST LEADS WITH THOSE FROM OTHER INSTRUMENTS! The leads have been designed for use with this instrument. Any substitution may cause errors in reading or be dangerous to the operator. Use spring clips for connecting the test leads to the equipment or circuit under test.

1-3. REFERENCE DATA.

a. Physical Characteristics.

Catalog No. 21805	0.0-500 ohms 0.0-100 megohms
Catalog No. 21805-1	0.0-10,000 ohms 0.0-100 megohms
Catalog No. 21804	0.0-500 ohms 0.0-50 megohms
Length	5-1/8 in. (130 mm)
Width	3-7/8 in. (98 mm)
Height	2-3/8 in. (60 mm)
Weight	2 lb. 2 oz. (1 kg)

b. Type of Operation	Handcrank operated generator
c. Operating Temperature Range . .	5° to 45°C 41° to 113°F
d. Voltage Change (using generator)	±5% (hand-crank speed of 150 to 240 RPM)
e. Accuracy	0.035 inches (0.9 mm) maximum displacement of pointer on scale when measured against standard resistors
f. Open Circuit Voltage . . .	21804 — 275 VDC maximum 21805 — 600 VDC maximum 21805-1 — 600 VDC maximum

g. Normal Operating Voltage . . . . 21804 — 0-275 VDC
21805 — 0-600 VDC
21805-1 — 0-600 VDC

h. Short Circuit Terminal Current

21804	MΩ Range	2.5 ma
	Ω Range	4.5 ma
21805	MΩ Range	3.0 ma
	Ω Range	5.5 ma
21805-1	MΩ Range	3.0 ma
	Ω Range	4.7 ma

i. Resistance Ranges

	21804	21805	21805-1
Inner Scale (Ω)	0-500	0-500	0-10,000
Outer Scale (MΩ)	0-50	0-100	0-100

1-4. SAFETY PRECAUTIONS.

— SAFETY IS THE RESPONSIBILITY OF THE USER

— LA SEGURIDAD ES EL CARGO DEL OPERADOR

CAUTION: DO NOT INTERCHANGE TEST LEADS WITH THOSE FROM OTHER INSTRUMENTS! The leads supplied have been designed for use with this instrument. Any substitutions may cause error in reading or be dangerous to the operator.

The Test Set and the sample to which it is connected are a source of high-voltage electrical energy and all persons making or assisting in the tests must use all practical safety precautions to prevent contact with energized parts of the test equipment and associated circuits.

Persons actually engaged in the test must stand clear of all parts of the complete high-voltage circuit unless the set is de-energized and all parts of the test circuit are grounded.

Any persons not directly associated with the work must be kept away from test activities by suitable barriers, barricades or warnings.

If the set is properly operated and all grounds correctly made, no rubber gloves are necessary. As a routine safety procedure, however, some users require the use of rubber gloves, not only in making connections to the high-voltage terminals, but in manipulating the controls. The James G. Biddle Co. considers this to be an excellent safety practice.

1-5. RECEIVING INSTRUCTIONS.

Your Megger instrument has been thoroughly tested and inspected to rigid inspection specifications before being shipped and is ready for use after it is set up as indicated in the Installation section. Check the equipment received against the packing list. Notify James G. Biddle Co., Blue Bell, PA. of any shortage of materials. The Megger instrument should be examined for damage received in transit. If any damage is found, file a claim with the carrier at once and notify James G. Biddle Co. or its nearest representative giving a detailed description of the damages observed.

1-6. WARRANTY.

All products supplied by the James G. Biddle Co. are warranted against all defects in material and workmanship for a period of one year following shipment. Our liability is specifically limited to replacing or repairing, at our option, defective equipment. Equipment returned to the factory for repair will be shipped Prepaid and Insured. The warranty does not include batteries, lamps or tubes, where the original manufacturer's warranty shall apply.
WE MAKE NO OTHER WARRANTY.

The warranty is void in the event of abuse or failure by the customer to perform specified maintenance as indicated in the manual.

1-7. REPAIR.

The James G. Biddle Co. maintains a complete instrument repair service. Should this instrument ever require repairs, we recommend it be returned to the factory for repair by our instrument specialists. When returning instruments for repairs, either in or out of warranty, they should be shipped Prepaid and Insured, and marked for the attention of the Instrument Service Manager.

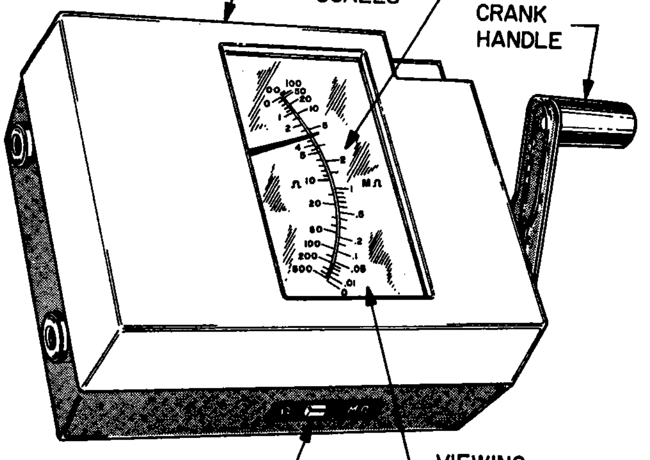


Figure 2-1. Midget Megger Insulation Tester, Front Panel View

SECTION 2

INSTALLATION

2-1. UNPACKING AND HANDLING.

To prepare the ohmmeter for use, remove outer wrapping and lift out case. Open cover and remove 6 foot leads from bottom half of case housing.

2-2. INSTALLATION.

The ohmmeter, Figure 2-1, is a portable unit used only for testing purposes and no permanent installation is necessary.

2-3. INSPECTION AND ADJUSTMENT.

Use the ohmmeter in its carrying case on a firm and fairly level base. Avoid large masses of iron and magnetic fields.

NOTE

The ohmmeter is not equipped with zeroing pointer control springs. The scale pointer will rest anywhere on the scale while ohmmeter is not in operation.

a. CHECK INFINITY. — With no connections to the terminals, check infinity by turning crank at 160 RPM, which is about 3 revolutions per second. The pointer should read infinity (∞) with selector switch set at the megohms ($M\Omega$) position.

b. CHECK ZERO. — Short circuit the terminals. Turn crank at a speed of 160 RPM minimum. Pointer should read zero.

c. CHECK TESTING LEADS. — With test leads connected to the terminals and with opposite ends separated (meter set at $M\Omega$ scale position) turn the crank at 160 RPM minimum. If the pointer indicates less than infinity there is leakage between the leads which must be removed

before ohmmeter can be used. Stop cranking, clip together the test ends of the leads. Crank to make certain, by a zero reading, that leads are not open-circuited.

2-4. PREPARATION FOR STORAGE OR RE-SHIPMENT.

To prepare for storage or long-distance shipping pack ohmmeter according to MIL-P-116C. For short distance shipment, wrap case in paper, and pack in corrugated box with adequate padding.

SECTION 3

OPERATOR'S SECTION

3-1. FUNCTIONAL OPERATION.

a. USE. — The ohmmeter is an instrument to be used in checking the insulation resistance of electrical installations and components. These tests are to be made for acceptance and test of equipment, for maintenance checks, or to determine faulty wiring.

b. CAPABILITIES AND LIMITATIONS. — The ohmmeter is designed to make insulation resistance tests. The potential applied to the apparatus under test will vary from zero to maximum voltage depending on its insulation resistance; this is caused by the voltage drop in the resistors, R4 and R5, (see figure 4-1) which is at all times in series with the positive (red) terminal.

WARNING

Do not use ohmmeter on apparatus for which the maximum test voltage is unsafe.

c. OHMMETER. — See figure 3-1. The ohmmeter is of the permanent-magnet, cross-coil and pointer type with scale lengths of about 2-7/16 inches. It is calibrated to within ±2.5 percent of scale length for normal service. Ohmmeter scale calibrations are unaffected by generator speed within limits of 150-170 RPM.

d. TEST LEADS. — Six-foot test leads are provided with ohmmeter, however, other lengths are available.

3-2. PREPARATION FOR USE

Befor using ohmmeter, check zero and infinity and check test leads. Follow procedure outlined in paragraph 2-3.

3-3. PREPARING APPARATUS TO BE TESTED

a. Shut down apparatus.

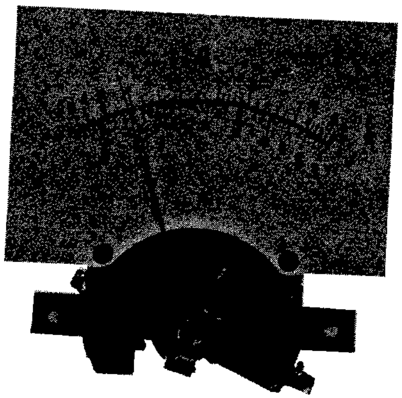


Figure 3-1. Ohmmeter Scale

b. Open all power switches.

c. Deenergize by opening circuit breakers or removing fuses.

WARNING

When taking apparatus out of service, block out disconnect switches. Apply neutral or protective (workmen's) grounds.

d. Disconnect apparatus from other equipment and circuits. Avoid removing protective grounds by disconnecting the equipment from the exposed bus or line, leaving the latter grounded.

e. If neutral or other ground connections must be disconnected, ascertain that they are not carrying current at the time, and that when disconnected no other equipment will lack necessary protection.

f. Inspect conductors which lead away from the circuit being tested to be sure that they have been disconnected properly from any source of voltage.

g. Inspect apparatus to be tested in order to determine what equipment is connected and will be included in the test. The more equipment included in the test, the lower the reading will be, and the true insulation resistance of the equipment under test may be masked by the insulation resistance of the associated equipment.

h. Ascertain that capacitance in apparatus is discharged before proceeding with test. Connect together and ground separate windings for 10 to 15 minutes immediately before a test so that insulation resistance readings are not affected by stored energy.

i. When apparatus is shut down for the insulation resistance test, make sure that the readings are not affected by leakage over or through switches or fuse blocks, etc. Such leakage may cause inaccurate test results. Inconsistent readings can be caused by current leaking from an energized line into the apparatus particularly if the live line is direct current. Such leakage can be detected by watching the ohmmeter pointer at the moment the test leads are connected to the equipment to be tested.

3-4. CONNECTIONS.

a. GENERAL. — For testing to ground, connect from the negative terminal to a conductor of the apparatus to be tested, and from the positive terminal to frame of machine, sheath cable, or to a good ground. For testing between two conductors, connect test leads to the two conductors.

In testing for leakage, various connecting procedures must be used because of differences in the electrical apparatus under test. Typical tests are described in paragraphs b through d and will serve as guides for testing insulation resistance of practically all types of apparatus and conductors.

Before the ohmmeter is connected for test, disconnect power leads, turn off circuit breaker or remove fuses. To avoid low readings on the ohmmeter, disconnect and test separately the component parts of an equipment.

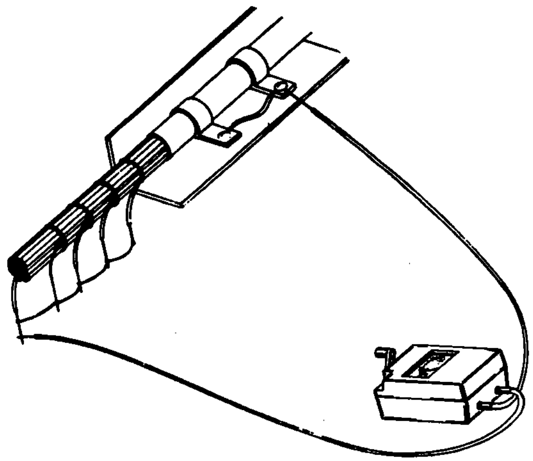


Figure 3-2. Testing Conductors to Ground

NOTE

For an initial test, connect all components together. With this information on record, it may not be necessary to separate the components for future tests unless unaccountably low readings are observed.

WARNING

Slight sparking may be encountered when attaching the test leads to equipment in which the capacitance has not been discharged completely. To remedy this condition, arrange permanently installed grounding facilties and test leads to a point where instrument connections can be made in a safe atmosphere.

b. MOTORS AND STARTING EQUIPMENT. — See figure 3-3 for connections for testing the insulation resistance of connecting lines in parallel. Disconnect the component parts and test them separately to determine where weakness exist.

WARNING

Do not use the ohmmeter in an explosive atmosphere. If necessary to test equipment located in an explosive atmosphere, arrange permanently installed grounding facilities and test leads at a point where instrument connections can be made in a safe atmosphere. Do not disconnect the test leads for at least 30 to 60 seconds following a test, so as to allow time for discharge.

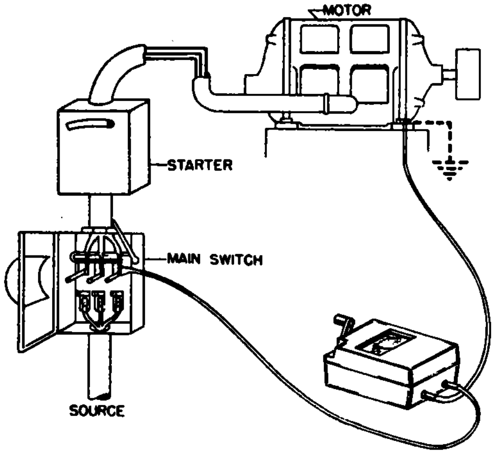


Figure 3-3. Motors and Starting Equipment, Test Connections

c. WIRING INSTALLATION. — Each circuit of a wiring installation can be tested to ground separately by working from the distribution panel. Alternately, by connecting at the main power board (figure 3-4) the entire system can be tested to ground at one time, providing all switches in the distribution panel are closed.

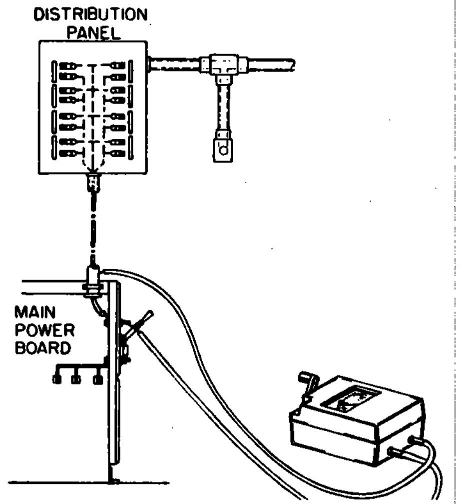


Figure 3-4. Wiring Installation, Main Power Board Test Connections

d. CONTROL, SIGNALING, AND COMMUNICATION CABLES. — To test the insulation resistance of one wire in a multiconductor cable against all other wires and sheath connected together, connect the negative terminal to one wire and the positive terminal to the sheath and the remaining wires.

3-5. TEST PROCEDURE.

After preliminary check of ohmmeter (paragraph 3-2), preparing apparatus to be tested (paragraph 3-3), and connecting the ohmmeter (paragraph 3-4), proceed with test as follows:

a. Operate ohmmeter continuously for 1 minute; then observe position of pointer on ohmmeter scale.

b. Record test results on data cards provided with ohmmeter. Put actual reading and temperature compensated reading (paragraph 3-7) on the front of the card (figure 3-5). On the reverse side of the card enter date, reading, equipment under test, base temperature correction factor, and adjusted insulation resistance.

c. Wait approximately 60 seconds for capacitance to discharge from the apparatus under test before disconnecting test leads.

d. Disconnect test leads.

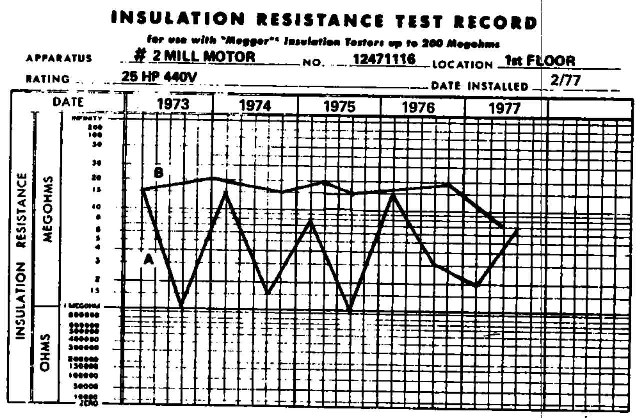


Figure 3-5. Data Card Showing Plot of Actual Readings (A) and Temperature Corrections (B)

3-6. TEST PROCEDURE DURING DRYING-OUT RUN.

To measure insulation resistance during a drying-out run, proceed as follows:

a. Prepare equipment to be tested for a drying-out run according to manufacturer's instructions.

b. Connect the ohmmeter.

c. Arrange the ohmmeter, testing leads, and thermometers so that frequent readings can be made rapidly during the drying process.

d. If external heat is applied to equipment under test, allow ohmmeter to remain connected for the duration of the heat run.

e. To avoid voltage breakdown in wet equipment, operate ohmmeter at rated speed, with a 5-megohm protective resistor between negative terminal and equipment under test. If equipment under test has a 1 megohm resistance, approximately 40 volts will be sent across it and the ohmmeter reading will be six megohms.

f. Record insulation resistance readings on plotted cross-section paper during the drying process. Readings should fall as the temperature increases during the first part of the run.

WARNING

If equipment under test is to be heated by circulating current in the windings, disconnect ohmmeter leads before circulating current is applied. Disconnect circulating current before reconnecting ohmmeter leads.

g. Continue drying-out run until both the insulation resistance and the temperature have become constant and remain so for several hours.

3-7. TEMPERATURE READINGS AND COMPENSATION.

a. TEMPERATURE CORRECTION. — Insulation resistance decreases as temperature increases. Insulation resistance readings, therefore, must be corrected to a base temperature (20°C, 68°F) so that reliable comparisons may be made of readings taken at different times.

The temperature characteristics of insulating materials and various types of electrical apparatus have their own temperature correction factors. (See table 3-1.) To make temperature corrections of insulation resistance readings, proceed as follows:

(1) Record the insulation readings as they appear on the ohmmeter scale. Assume 2 megohms at 104°F.

(2) Make corrections for temperature, using correction factors given in table 3-1, which is 4.8 (class A insulation).

(3) Record corrected values by multiplying (1) by (2). Answer, 9.6 megohms at 68°F.

Temperature correction may be omited when:

(4) A large number of units are to be tested for comparison and all are at room temperature.

(5) Periodic tests are to be made on equipment which is always at room temperature.

Table 3-1. Approximate Temperature Correction Factors for Rotating Equipment, Transformers and Cables

Temp.		Rotating Equipment		Trans. formers	Cable	
°C	°F	Class A	Class B	Oil-Filled	Code Natural	Code GR-S
0	32	0.21	0.40	0.25	0.25	0.12
5	41	0.31	0.50	0.36	0.40	0.23
10	50	0.45	0.63	0.50	0.61	0.46
15.6	60	0.71	0.81	0.74	1.00	1.00
20	68	1.00	1.00	1.00	1.47	1.83
25	77	1.48	1.25	1.40	2.27	3.67
30	86	2.20	1.58	1.98	3.52	7.32
35	95	3.24	2.00	2.80	5.45	14.60
40	104	4.80	2.50	3.95	8.45	29.20
45	113	7.10	3.15	5.60	13.10	54.00
50	122	10.45	3.98	7.85	20.00	116.00
55	131	15.50	5.00	11.20		
60	140	22.80	6.30	15.85		
65	149	34.00	7.90	22.40		
70	158	50.00	10.00	31.75		
75	167	74.00	12.60	44.70		

Table 3-1. Approximate Temperature Correction Factors for Rotaing Equipment, Transformers and Cables (Contd)

Cable					
Performance Natural	Heat Resistance Natural	Heat Resist. & Performance GR-S	Ozone Resist. Natural GR-S	Varnished Cambric	Impregnated Paper
0.47	0.42	0.22	0.14	0.10	0.28
0.60	0.56	0.37	0.26	0.20	0.43
0.76	0.73	0.58	0.49	0.43	0.64
1.00	1.00	1.00	1.00	1.00	1.00
1.24	1.28	1.53	1.75	1.94	1.43
1.58	1.68	2.48	3.29	4.08	2.17
2.00	2.24	4.03	6.20	8.62	3.20
2.55	2.93	6.53	11.65	18.2	4.77
3.26	3.85	10.70	25.00	38.5	7.15
4.15	5.08	17.10	41.40	81.0	10.70
5.29	6.72	27.85	78.00	170.00	16.00
6.72	8.83	45.00		345.00	24.00
8.58	11.62	73.00		775.00	36.00
	15.40	118.00			
	20.30	193.00			
	26.60	313.00			

b. TEST RECORDS. — Keep test records. A persistent downward trend in insulation resistance usually indicates impending trouble, even though the values may be higher than the allowed minimum values. Make allowances for equipment in service showing periodic test values lower than the allowed values so long as the values remain stable or consistent. This condition may be caused by uniformly distributed leakage of a harmless nature, and may not be the result of a dangerous localized weakness.

c. ONE-MEGOHM RULE. — One megohm is considered a fair allowable lower limit for insulation resistance of ordinary industrial equipment rated up to 1000 volts. For equipment rated above 1000 volts, 1 megohm per thousand volts is minimum. Formulas for minimum values of insulation resistance based on the kinds of insulating material used and the electrical and physical dimensions of the types of equipment under consideration are given in paragraphs d through f.

d. ROTATING MACHINERY. — Formulas for determining minimum resistance values for rotating machinery developed by the American Institute of Electrical Engineers are as follows:

(1) In the case of small AC machinery rated 999 KVA and less, use the simplified formula:

$$R_1 = KV + 1$$

where R_1 = standard insulation resistance of class A or B stator armature windings in megohms at winding temperatures up to 75°C (167°F) obtained by applying 500 volts DC to the entire winding for one minute.

KV = rated machine voltage in kilovolts.

(2) In the case of small DC machines rated 99 KVA or less, the standard insulation resistance for these armature windings should be of the order of one megohm at winding temperatures up to 75°C, obtained by applying 500 volts DC to the winding for one minute.

e. CABLE AND CONDUCTORS. — The insulation resistance of cable and conductor installations is affected by the kind of insulating material used, voltage rating,

insulation thickness and circuit length. Such circuits usually extend over great distances and may be subjected to wide variations in temperature which will affect resistance values obtained by testing. The terminals of cable and conductors also will affect test values unless they are clean, dry, or guarded. The Insulated Power Cable Engineers Association bases minimum values of insulation resistance on the following formula:

$$R = K \log_{10} \frac{D}{d}$$

where R = megohms per 100 feet of cable
K = constant for insulating material
D = outside diameter of conductor insulation
d = diameter of conductor

Refer to table 3-2.

NOTE

All dimensions must be expressed in same units. See table 3-3, Values of $\text{Log}_{10} \frac{D}{d}$.

Table 3-2. Minimum Values of K at 60°F

	Minimum Value of K (Ohms per 1,000 FT Cable)
INSULATION TYPE	
Impregnated paper	2,640
Varnished Cambric	2,640
Thermoplastic-polyethelene	50,000
NATURAL RUBBER	
Performance	10,560
Heat resistant	10,560
Ozone resistant	10,000 (Butyl)
SYNTHETIC RUBBER	
Code	950
Performance	2,000
Heat resistant	2,000
Ozone resistant	2,000
Kerite	4,000

Table 3-3. Values of $\text{Log}_{10} \frac{D}{d}$

American Wire Gauge or Circular Mils	Insulation Thickness — Inches					
	.047	.063	.078	.094	.109	.125
14 sol	.392	.470	.537	.594	.645	.691
12	.334	.405	.467	.520	.568	.611
10	.283	.348	.404	.453	.498	.538
8	.239	.296	.347	.392	.432	.470
6 str.		.225	.267	.305	.340	.373
5		.206	.245	.281	.314	.346
4		.187	.224	.257	.289	.318
3		.171	.204	.236	.265	.293
2		.155	.186	.215	.243	.269
1		.139	.168	.195	.220	.244
1/0		.126	.152	.177	.201	.223
2/0		.114	.138	.161	.183	.204
3/0		.102	.125	.146	.166	.185
4/0		.0923	.113	.132	.151	.168
250,000		.0854	.104	.123	.140	.157
300,000		.0787	.0963	.113	.130	.145
350,000		.0731	.0897	.106	.121	.136
400,000		.0688	.0845	.0995	.114	.128
500,000		.0620	.0763	.0901	.103	.116

Table 3-3. Values of $\log_{10} \frac{D}{d}$ (Continued)

Insulation Thickness — Inches						
.141	.156	.172	.188	.203	.219	.234
.732	.770	.804	.836	.866	.894	.921
.651	.686	.720	.751	.779	.806	.832
.575	.609	.641	.670	.698	.723	.748
.505	.537	.566	.594	.621	.645	.669
.403	.431	.453	.483	.506	.529	.550
.373	.401	.426	.450	.463	.495	.515
.345	.371	.395	.418	.440	.460	.480
.318	.343	.366	.388	.409	.429	.448
.293	.316	.338	.359	.379	.398	.416
.267	.288	.309	.328	.347	.365	.382
.244	.264	.284	.302	.320	.337	.354
.223	.242	.261	.278	.295	.311	.327
.204	.221	.238	.255	.271	.286	.301
.187	.202	.218	.233	.248	.262	.276
.173	.189	.204	.218	.232	.246	.259
.160	.175	.189	.203	.216	.229	.250
.150	.164	.177	.190	.203	.215	.227
.142	.155	.168	.181	.193	.204	.216
.129	.141	.153	.165	.176	.187	.198

Table 3-3. Values of $\log_{10} \frac{D}{d}$ (Continued)

American Wire Gauge or Circular Mils	Insulation Thickness — Inches					
	.047	.063	.078	.094	.109	.125
600,000			.0700	.0853	.0952	.107
700,000			.0686	.0769	.0888	.100
750,000			.0665	.0749	.0861	.0971
800,000			.0644	.0727	.0836	.0943
900,000			.0580	.0687	.0793	.0895
1,000,000			.0551	.0656	.0755	.0851
1,250,000			.0500	.0590	.0681	.0770
1,500,000			.0456	.0541	.0625	.0708
1,750,000			.0423	.0502	.0581	.0658
2,000,000			.0397	.0472	.0546	.0619
2,500,000			.0357	.0425	.0492	.0558
	Insulation Thickness — Inches					
	.250	.266	.281	.297	.313	.328
14 sol.	.945					
12	.856					
10	.771	.793	.814	.834	.853	.871
8	.691	.712	.731	.751	.770	.787
6 str.	.570	.590	.608	.626	.643	.660

Table 3-3. Values of $\log_{10} \frac{D}{d}$ (Continued)

Insulation Thickness — Inches						
.141	.156	.172	.188	.203	.219	.234
.119	.130	.141	.152	.163	.173	.183
.111	.122	.133	.143	.153	.163	.172
.108	.118	.129	.139	.148	.157	.167
.105	.115	.125	.135	.144	.154	.163
.0994	.108	.120	.128	.137	.146	.155
.0948	.104	.113	.122	.131	.140	.148
.0856	.0943	.103	.111	.119	.127	.134
.0789	.0870	.0946	.102	.110	.116	.125
.0734	.0810	.0899	.0954	.103	.110	.117
.0691	.0761	.0830	.0898	.0965	.103	.108
.0623	.0687	.0750	.0812	.0874	.0934	.0993
Insulation Thickness — Inches						
.344	.359	.375	.391	.407	.422	.438
.889	.906	.922				
.804	.821	.836	.851	.866	.880	.894
.676	.699	.706	.720	.734	.746	.760

Table 3-3. Values of $\log_{10} \frac{D}{d}$ (Continued)

American Wire Gauge or Circular Mils	Insulation Thickness — Inches					
	.250	.266	.281	.297	.313	.328
5	.535	.554	.572	.589	.606	.622
4	.500	.517	.535	.551	.568	.583
3	.466	.483	.500	.516	.532	.547
2	.433	.450	.466	.482	.497	.512
1	.399	.415	.431	.445	.461	.474
1/0	.369	.385	.399	.414	.428	.441
2/0	.342	.356	.370	.384	.397	.410
3/0	.315	.329	.342	.355	.367	.380
4/0	.289	.302	.315	.327	.339	.351
250,000	.272	.284	.296	.309	.320	.331
300,000	.254	.266	.278	.289	.300	.310
350,000	.239	.250	.262	.272	.283	.293
400,000	.227	.236	.249	.259	.269	.279
500,000	.208	.218	.228	.238	.248	.257
600,000	.193	.203	.212	.221	.230	.239
700,000	.181	.191	.199	.209	.217	.225
750,000	.176	.185	.194	.203	.211	.220
800,000	.172	.180	.189	.198	.206	.214
900,000	.164	.172	.180	.189	.196	.204

Table 3-3. Values of $\log_{10} \frac{D}{d}$ (Continued)

Insulation Thickness — Inches						
.344	.359	.375	.391	.407	.422	.438
.637	.652	.667	.680	.694	.707	.720
.598	.613	.625	.640	.653	.666	.678
.562	.576	.589	.603	.615	.628	.640
.526	.540	.553	.565	.578	.590	.602
.487	.501	.513	.525	.538	.549	.561
.454	.466	.479	.491	.502	.514	.525
.422	.435	.446	.458	.469	.480	.490
.392	.403	.414	.425	.436	.447	.457
.362	.373	.384	.395	.405	.415	.425
.342	.352	.363	.373	.383	.392	.402
.321	.331	.341	.351	.360	.369	.379
.303	.313	.323	.332	.341	.350	.359
.289	.298	.308	.317	.326	.334	.343
.266	.275	.284	.292	.301	.309	.317
.248	.256	.265	.273	.281	.289	.297
.234	.242	.250	.258	.266	.273	.281
.228	.236	.243	.251	.259	.266	.273
.222	.230	.237	.245	.252	.260	.267
.212	.219	.227	.234	.242	.249	.255

Table 3-3. Values of $\log_{10} \frac{D}{d}$ (Continued)

American Wire Gauge or Circular Mils	Insulation Thickness — Inches					
	.250	.266	.281	.297	.313	.328
1,000,000	.157	.165	.173	.181	.189	.196
1,250,000	.142	.150	.157	.165	.172	.179
1,500,000	.132	.139	.146	.153	.159	.166
1,750,000	.123	.130	.136	.143	.149	.155
2,000,000	.116	.122	.128	.135	.141	.145
2,500,000	.105	.111	.117	.122	.128	.134
Insulation Thickness — Inches						
.344	.359	.375	.391	.407	.422	.438
.203	.211	.218	.225	.232	.239	.245
.186	.192	.199	.206	.212	.219	.225
.172	.179	.185	.190	.197	.204	.210
.162	.168	.174	.180	.185	.191	.197
.153	.159	.164	.170	.176	.181	.187
.139	.144	.150	.156	..160	.165	.170

f. INSULATION BETWEEN CONDUCTORS. — The insulation resistance of one conductor of a multiconductor cable to all others and sheath is:

$$R = K \log_{10} \frac{D}{d}$$

where D = diameter over insulation of equivalent single-conductor cable = d + 2c + 2b
d = diameter of conductor (for sector cables d = diameter of round conductor of same cross section)
c = thickness of conductor insulation
b = thickness of jacket insulation

NOTE

All dimensions must be expressed in same units.

g. TRANSFORMERS. — Acceptable insulation resistance values for dry and compound-filled transformers are comparable to those for class A rotating machinery. The following formula applies:

$$R = \frac{CE}{\sqrt{KVA}}$$

where R = minimum 1 minute 500 volt DC resistance in megohms from winding to ground, or from winding to winding.
C = a constant for 20°C (68°F) measurements (see table 3-4)
E = voltage rating of winding under test
KVA = rated cap. of winding under test

For test of winding to ground with the other winding or windings grounded, the values will be much less than those given by the formula. R in this formula is based on dry, acid-free, sludge-free oil, and bushings and terminal boards which are in good condition.

The formula in table 3-4 is intended for single-phase transformers. If the transformer under test is of the three-phase type, and the three individual windings are being tested as one, then:

E = voltage rating of one of the single-phase windings (phase to phase for delta-connected units and phase to neutral for wye-connected units).

KVA= rated capacity of the complete three-phase winding under test.

Table 3-4. Values of C at 20°C (68°F)

Cycles Per Second	60	25
Tanked oil-filled type	1.5	1.0
Untanked oil-filled type	30.0	20.0
Dryer compound-filled type	30.0	20.0

SECTION 4

PRINCIPLES OF OPERATION

4-1. OVERALL FUNCTIONAL DESCRIPTION.

The ohmmeter comprises an insulation testing instrument consisting of an indicator calibrated directly in terms of ohms and megohms, a rectified alternating current generator, a gear train and fold-away crank for operating the generator, and a resistance network. The indicator used must not be confused with an ordinary ohmmeter, as it is of the cross-coil ratio type commonly called a "True Ohmmeter".

4-2. FUNCTIONAL SECTIONS.

a. INDICATING INSTRUMENT. — The indicator is of the permanent magnet cross-coil type. When current is applied to the indicator the pointer deflects a proportionate amount. The amount of deflection is determined by the circuit components and the unknown resistance.

b. GENERATOR. — The alternating current generator consists of a single stator coil and a bi-pole permanent magnet rotor. It is statically rectified to direct current through a voltage doubler rectifying circuit. The rotor runs on oilite bearings which should not require lubrication for the life of the ohmmeter. See figures 4-1 and 4-2.

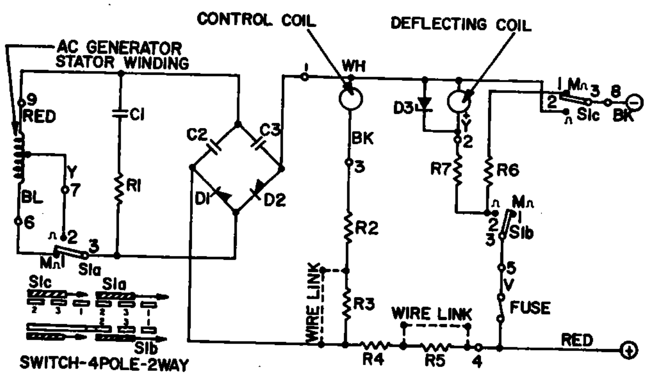


Figure 4-1. Schematic Diagram, Switch Set to Outer Scale (Megohms)

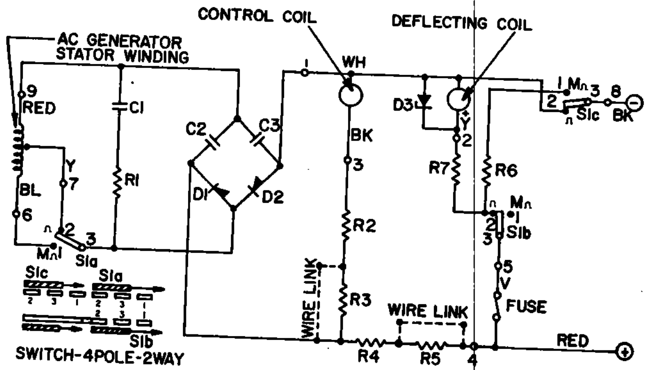


Figure 4-2. Schematic Diagram, Switch Set to Inner Scale (Ohms)

c. GEAR TRAIN. — The gear train that operates the generator is a simple spur gear drive. The gear train is lubricated by the manufacturer; no additional lubrication is required.

d. RESISTANCE NETWORK. — Figures 4-1 and 4-2 show the ohmmeter wiring diagrams.

4-3. THEORY OF OPERATION.

a. Refer to schematic diagram figure 4-1. The AC generator is used in conjunction with a stabilizing circuit and static rectifier. The stabilizing circuit consists of a capacitor connected in series with a resistor across the AC output terminals of the generator, since there is no slipping clutch to regulate the speed. As the generator speed increases, the frequency of the ouput voltage rises, the reactance of the capacitor becomes lower and more current is drawn from the generator. With a purely resistive load the voltage has to increase before the current drawn can rise. A combination of resistance and capacitance is used in the ohmmeter as the current drawn by the capacitor would otherwise be excessive at certain handle speeds.

b. The ohmmeter circuits are conventional as can be seen from the wiring diagram. The generator voltage is reduced on the continuity range by switching to a tap on the stator winding. Zener diode D3 protects the deflecting coil, with a cartridge type fuse in the circuit on the ohms range. The fuse (100 ma) provides overall protection of the deflecting circuit, while the diode provides instant protection of the deflecting coil in the event of a short duration "Accident" that could not be overcome by fuse operation.

c. The ohmmeter scale accuracy reads to within ± 0.9 mm (0.035 in.) of any marked points on the scale when measured against standard resistors.

4-4. CALIBRATION TESTS.

a. TEST EQUIPMENT. — See Table 5-1.

b. MEGOHM SCALE. — To check megohm scale, proceed as follows: (for proper cranking speed see paragraph 2-3b). Put selector switch into MΩ position.

(1) Connect 1-megohm resistor across + and – terminals.

(2) Apply voltage.

(3) Read megohm scale. Pointer should indicate 1 megohm ± 0.035 inch. Disconnect 1-megohm resistor.

(4) Repeat steps (1) through (3) using at least three resistors that cover the scale.

c. OHM SCALE. — To check ohm scale repeat procedures of the megohm scale using at least three resistors of suitable values that cover the scale range.

d. RESTORING ORIGINAL ACCURACY. — If the test results are unfavorable but consistent (for example, all readings are + 1/16 inch), compensate for the discrepancy when recording and interpreting readings. If accuracy of readings is inconsistent, return ohmmeter to repair facility for repair and/or replacement.

SECTION 5

TROUBLESHOOTING AND REPAIR

5-1. PREVENTIVE MAINTENANCE.

a. GENERAL.

(1) Inspection. - Check the ohmmeter for use in accordance with paragraph 2-3. Visually inspect the ohmmeter for a cracked or defective case and defective or broken terminals.

(2) Preventive Maintenance. - Keep the ohmmeter in a clean dry place. Handle with reasonable care. Do not attempt further preventive maintenance.

b. TEST EQUIPMENT.

NOTE

The values listed in table 5-1 can be substituted by any three known resistance values. Perform calibration when a preliminary check reveals scale error.

c. SPECIAL TOOLS. — No special tools are required.

5-2. CALIBRATION EQUIPMENT.

Table 5-1 lists calibration equipment required.

Table 5-1. Calibration Equipment Required

Nomenclature	Application	Resistance	Accuracy
Wire wound or carbon-deposit resistor	supplies known resistance	1 megohm	±1%
		10 meg-ohms	±1%
		100 meg-ohms	±1%
		10 ohms	±1%
		100 ohms	±1%
		500 ohms	±1%
		100K ohms	±1%

5-3. TROUBLESHOOTING.

Table 5-2. Troubleshooting Chart

Trouble	Probable Cause	Remedy
Pointer does not rest on infinity when cranked.	Shift of pointer suspension.	Adjust moving element infinity corrector (see figure 5-2).
Pointer does not move promptly to zero when test terminals are short circuited during zero check.	Resistor R6 high, open or Resistor R7 shorted or zener diode D3 shorted.	Remove or replace diode, resistor. (See paragraph 5-5d and figure 5-3.)

Continued . . .

Table 5-2. Troubleshooting Chart (Continued)

Trouble	Probable Cause	Remedy
	Defective moving element.	Replace moving element assembly. (See paragraph 5-5b and figure 5-1.)
Pointer indicates less than infinity when test leads are connected at terminals, with opposite ends separated, and crank is turned at normal speed.	Leakage between test leads.	Correct leakage or replace test leads.

Table 5-2. Troubleshooting Chart (Continued)

Trouble	Probable Cause	Remedy
Pointer does not indicate zero when test lead ends are touched together while ohmmeter is being cranked	Test leads open circuited	Correct open circuit or replace test leads.
Pointer indicator does not move readily.	Metallic particles collected in airgap of moving system.	Remove particles. Exercise extreme care as the moving system can be damaged in the process.
Ohmmeter does not calibrate	Resistance changes, partial short of resistors, and moving system.	Check resistance and moving system. Replace if defective. (See paragraph 5-5d and figure 5-3.)

Table 5-2. Troubleshooting Chart (Continued)

Trouble	Probable Cause	Remedy
No output voltage at + and — terminals although crank turns easily.	Defective generator or generator stator coil open.	Check generator assembly. Remove and replace if defective. (See paragraph 5-5c and figure 5-2.)
	Resistors R4, R5 or R6 open.	Check resistors and replace if defective. (See paragraph 5-5d and figure 5-3.)
	Moving system coil open.	Check coil, replace moving system if defective. (See paragraph 5-5b and figure 5-1.)

Table 5-2. Troubleshooting Chart (Continued)

Trouble	Probable Cause	Remedy
No output voltage at + and — terminals (crank does not turn easily).	Shorted capacitor C1.	Replace capacitor. (See paragraph 5-5d and figure 5-3.)
	Resistor R1 shorted.	Remove and replace resistor. (See paragraph 5-5d and figure 5-3.)
	Defective stator coil shorted	Remove and replace defective generator assembly. (See paragraph 5-5c, figure 5-2.)

Table 5-2. Troubleshooting Chart (Continued)

Trouble	Probable Cause	Remedy
Low generator voltage at terminals.	Defective stator.	Remove and replace defective generator assembly. (See paragraph 5-5c, figure 5-2.)
	Adjustable magnetic shunt out of adjustment.	Move shunt (figure 5-2) toward crank to increase voltage.
High generator voltage at terminal.	Adjustable magnetic shunt out of adjustment.	Move shunt (figure 5-2) away from crank to reduce voltage.

5-4. REMOVAL AND REASSEMBLY OF PARTS AND SUBASSEMBLIES.

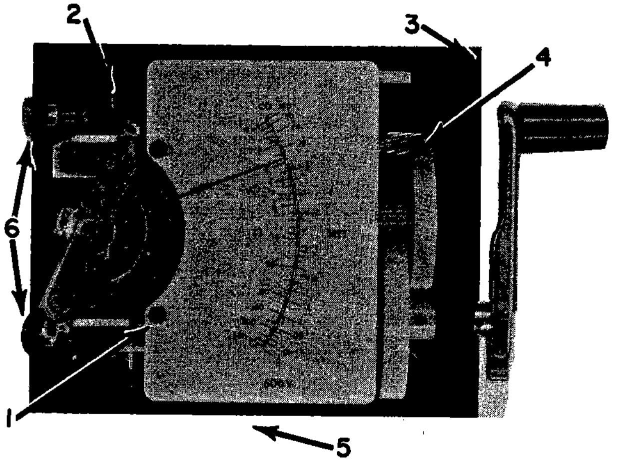
a. GENERAL. — Do not attempt to repair any part of the ohmmeter; replace the defective component.

CAUTION

In opening the ohmmeter, observe carefully how parts are removed, what they are, and in what order they are taken out. Be particularly watchful for metallic particles or slivers which may collect on the moving system magnet, thus closing the air gap and causing a sticking action of the pointer. Remove such particles of metal with a needle, but be extremely careful that the moving system is not damaged in the process.

5-5. REMOVAL OF PARTS AND SUBASSEMBLIES. (See figure 5-1.)

a. REMOVAL OF CASE COVER. — Remove instrument from its leather carrying case. Remove the four



1. **Scale Screws and Lockwashers**
2. **Mounting Screws**
3. **Case Housing Base**
4. **Generator Assembly**
5. **Scale Selector Switch (hidden on side)**
6. **Terminals**

Figure 5-1. Ohmmeter with Cover Removed

rubber feet from the base and four screws attaching cover to case. Lift off cover.

b. REMOVAL AND DISASSEMBLY OF MOVING ELEMENT ASSEMBLY WITH SCALE.

(1) Remove two screws and lockwashers (figure 5-1, item 1) attaching scale to moving element assembly. Remove scale.

CAUTION

Use extreme care not to damage the coil or the pointer.

(2) Remove two screws (2) attaching moving element assembly to chassis.

(3) Unsolder three connections (white, yellow and black leads) from terminal board.

(4) Carefully lift moving element assembly out of case.

c. REMOVAL OF GENERATOR ASSEMBLY. — Perform operations in paragraph 5-5a and b (1) thru (4) before attempting to remove generator. (See figure 5-2.)

(1) Unsolder three generator assembly connections (blue, yellow and red leads) from the terminal board.

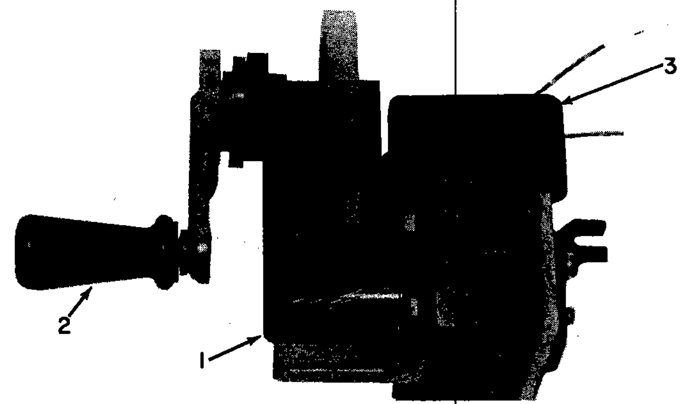
(2) Remove three screws and lockwashers holding generator to case housing. Lift generator assembly (1) out of case.

d. REMOVAL OF COMPONENT BOARD ASSEMBLY WITH COMPONENTS. — Perform operations in paragraphs 5-5a, b and c before attempting to remove the PC Board Assembly. (See figure 5-3.)

(1) Unsolder the black and red leads from the negative (black) and positive (red) terminals.

(2) Remove two-position switch cover plate at side of case. (Figure 5-1, item 5.)

(3) Remove two screws holding switch and component board assembly to case housing.



1. Generator Assembly
2. Driving Handle Assembly
3. Stator Coil Assembly

Figure 5-2. Generator Assembly

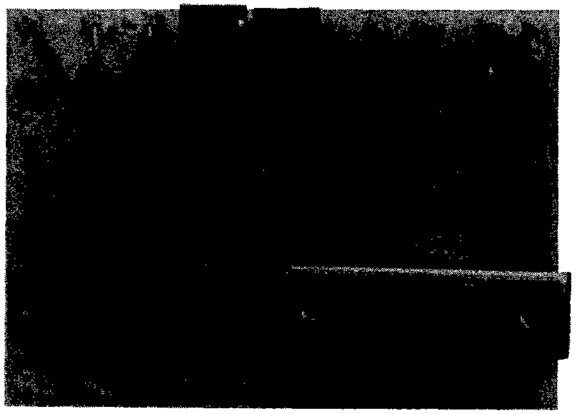


Figure 5-3. Component Board Assembly

(4) Carefully lift out complete assembly with mounted attaching parts.

(5) Unsolder defective resistors or capacitors and replace as necessary.

5-6. REASSEMBLY OF PARTS AND SUBASSEMBLIES.

a. REPLACEMENT OF COMPONENT BOARD ASSEMBLY.

(1) Carefully position board assembly into case housing and replace the two switch screws.

(2) Replace switch cover plate.

(3) Solder two binding post leads connections.

b. REPLACEMENT OF GENERATOR ASSEMBLY.

(1) Solder the three generator connections to the terminal board assembly.

(2) Carefully position the generator assembly into the case housing.

(3) Replace the three screws and lockwashers and secure the assembly to the case housing.

c. REASSEMBLY AND REPLACEMENT OF MOVING ELEMENT ASSEMBLY WITH SCALE.

(1) Carefully mount moving element assembly into case and secure in position with two screws.

(2) Solder the three connections to the terminal board assembly.

(3) Attach the scale to the moving element assembly with two screws and lockwashers.

CAUTION

Use extreme care not to damage the coil or the pointer.

d. REPLACEMENT OF CASE COVER.

(1) Carefully position the cover over the instrument base making sure the scale area is clearly visible.

(2) Replace the four base mounting screws holding the cover housing into place.

(3) Replace the four rubber feet.

SECTION 6

PARTS LIST

6-1. INTRODUCTION.

Table 6-1 lists the ohmmeter assemblies and recommended maintenance parts. Table 6-2 lists component values by reference designation for each ohmmeter.

Table 6-1. Midget Megger Insulation Tester Maintenance Parts List

Item		Part No.
Terminal		10382-3
Case Assembly		10382-1
Cover Assembly		10382-2
Feet		10382-4
Fuse 100 mA 5x20mm		2544-1
Leads		21963C
Catalog No. 21804		
Calibrated Moving System		10398-1
PC Board Assembly		10382-5
Generator		10382-8
Catalog No. 21805		
Calibrated Moving System		10398-2
PC Board Assembly		10382-6
Generator		10382-9
Catalog No. 21805-1		
Calibrated Moving System		10398-3
PC Board Assembly		10382-7
Generator		10382-9

Table 6-2. Midget Megger Insulation Tester Component Values

Reference Designation	Catalog No. 21804	Catalog No. 21805	Catalog No. 21805-1
C1	.22μ F, 400V DC	..22μF, 400V DC	.22μF, 400V DC
C2	.22μF, 250V DC	.1μF, 400V DC	.1μf, 400V DC
C3	.22μF, 250V DC	.1μF, 400V DC	.1μF, 400V DC
R1	68KΩ	100KΩ	100KΩ
R2	100KΩ	100KΩ	100KΩ
R3	Wire Link	100KΩ	100KΩ
R4	20KΩ	20KΩ	27KΩ
R5	Wire Link	20KΩ	27KΩ
R6	10KΩ	20KΩ	6.2KΩ
R7	150Ω	150Ω	910Ω