NAVSHIPS 91704 (*Non-Registered*)

INSTRUCTION BOOK
for
BRIDGE CAPACITANCE-INDUCTANCE-RESISTANCE
ZM-11/U

THE CLOUGH-BRENGLE CO.
CHICAGO, ILL.

BUREAU OF SHIPS NAVY DEPARTMENT

Date 10 February 1953

Temporary Correction T-1 to Instruction Book for Bridge Capacitance-Inductance-Resistance ZM-11/U (NAVSHIPS 91704)

For Serial Numbers 1-970

PAGE

VII. To (INSTALLATION RECORD)

ADD

"Contract Number NObsr-49270 Date of Contract 26 June 1950"
"Contract Number NObsr-52462 Date of Contract 26 May 1951"
"Contract Number NObsr-59239 Date of Contract 25 Nov. 1951"

1-2 To (PARAGRAPH 2-b)

ADD

"Contract NObsr-49270 Dated 26 June 1950"
"Contract NObsr-52462 Dated 26 May 1951"
"Contract NObsr-59239 Dated 25 May 1951"

To (TABLE 6-1 TABLE OF REPLACEABLE PARTS)

ADD to "STANDARD NAVY STOCK NUMBER COLUMN"

PAGE	SYMBOL	STOCK NUMBER
6-5	C134	N16-C-29128-2490
6-6	C138	N16-C-29075-4678

PAGE	SYMBOL	STOCK NUMBER
6-6	E101	N17-P-69135-6825
6-6	E102	N17-P-69135-6827
6-7	E110	N16-K-700314-438
6-8	E112	N16-T-20551-1039
6-8	E116	N17-I-49510-1125
6-9	E120	N17-I-47377-6602
6-10	H101	N16-H-150001-325
6-10	H102	N16-H-150001-324
6-11	H104	N42-L-2605-6620
6-11	H108	N16-V-230001-113
6-11	H110	N16-V-230001-112
6-11	H113	N16-R-503580-251
6-12	H117	N16-S-800650-101
6-12	H119	N43-B-27099-6290
6-12	H120	N42-B-27099-6235
6-12	I 101	N17-L-6806-130
6-13	L101	N17-T-81988-9633
6-13	L102	N17-T-81891-6201
6-13	L103	N16-C-72758-1451

PAGE	SYMBOL	STOCK NUMBER
6-14	N103	N16-S-117101-735
6-14	O101	N16-M-60905-1376
6-14	O102	N17-I-77279-8201
6-15	O109	N16-B-750001-795
6-15	O110	N16-V-300087-301
6-15	O111	N17-G-157338-766
6-15	P101C	N17-C-802555-801
6-16	P101D	N17-C-802584-311
6-16	P101E	N17-S-46693-6851
6-17	R105	N16-R-88009-4261
6-17	R106	N16-R-78700-6959
6-18	R110	N16-R-79407-8759
6-19	R115	N16-R-79472-2001
6-19	R122	N16-R-50200-721
6-19	R123	N16-R-50497-391
6-20	R126	N16-R-50399-141
6-26	S105A	N17-S-91897-8910
6-27	S105D	N17-S-91897-8911
6-29	T104	N17-T-81141-6201

PAGE	SYMBOL	STOCK NUMBER
6-31	W102A	N15-W-2195-5100
6-33	XV101	N16-S-62153-1191
6-34	Z101	N16-F-44608-4081
6-13*	M101	Delete "N17-M-29374-1203 METER: arbitrary scale; panel mounted; DC round; phenolic case; style No.15 MBCA Ref Dwg Group 27; flange size 3-11/16" dia. x 3/16" thick; 2-5/32" body dia; 1-11/32" body depth from mtg surface, excluding terminals; Sun Electric Corp., Part #M-910-1" ADD "METER: arbitrary scale; panel mounted; DC round; metal case; style No. 15 MBCA Ref Dwg Group 27; flange size 2-11/16" x 3/8" thick; 2-1/16" body dia; 1-1/16" body depth from mtg. surface, excluding terminals; Burlington Instrument Co. Part No. CB-M-910-1B."

*NOTE: SNSN N17-M-29374-1203 used on Contract NObsr-43157 only. Part No. CB-M-910-1B used on Contracts NObsr-49270, NObsr-52462, and NObsr-59239 should be requested when a replacement is required on ALL contracts. Standard Navy Stock Number for Part No. CB-M-910-1B, not available at time of this publication, will be supplied by Electronic Supply Office Great Lakes, Illinois.

NAVSHIPS 91704 *(Non-Registered)*

INSTRUCTION BOOK

for

BRIDGE CAPACITANCE-INDUCTANCE-RESISTANCE ZM-11/U

THE CLOUGH-BRENGLE CO.
CHICAGO, ILL.

BUREAU OF SHIPS NAVY DEPARTMENT

Contract NObsr-43157 Approved by Bu Ships: 24 June 1952

LIST OF EFFECTIVE PAGES

PAGE NUMBERS	CHANGE IN EFFECT	PAGE NUMBERS	CHANGE IN EFFECT
Title page	Original	3-1 to 3-3	Original
A to C	Original	4-1 to 4-16	Original
i to ix	Original	5-1 to 5-50	Original
1-0 to 1-5	Original	6-1 to 6-38	Original
2-1 to 2-26	Original	i-1 to i-9	Original

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS
WASHINGTON 25, D. C.

IN REPLY REFER TO
Code 993-100
24 June 1952

From: Chief, Bureau of Ships
To: All Activities Concerned with the Installation, Operation and Maintenance of the Subject Equipment

Subj: Instruction Book for Capacitance-Inductance-Resistance Bridge ZM-11/U NAVSHIPS 91704

1. This is the instruction book for the subject equipment and is in effect upon receipt.

2. When superseded by a later edition, this publication shall be destroyed.

3. Extracts from this publication may be made to facilitate the preparation of other Department of Defense Publications.

4. All Navy requests for NAVSHIPS Electronics publications should be directed to the nearest District Publications and Printing Office. When changes or revised books are distributed, notice will be included in the Bureau of Ships Journal and in the Index of Bureau of Ships General and Electronics Publications, NAVSHIPS 250-020.

H. N. WALLIN
Chief of Bureau

RECORD OF CORRECTIONS MADE

Change No.	Date	Signature of Officer Making Correction

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT.)

Paragraph *Page*

SECTION 5—MAINTENANCE

TABLE OF CONTENTS (CONT.)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (CONT.)

LIST OF TABLES

GUARANTEE

The equipment, including all parts and spare parts, except vacuum tubes, batteries, rubber and material normally consumed in operation, is guaranteed for a period of one year from the date of delivery of the equipment to and acceptance by the Government with the understanding that all such items found to be defective as to material, workmanship or manufacture will be repaired or replaced, f.o.b. and point within the continental limits of the United States designated by the Government, without delay and at no expense to the Government; provided that such guarantee will not obligate the Contractor to make repair or replacement of any such defective items unless the defect appears within the aforementioned period and the Contractor is notified thereof in writing within a reasonable time and the defect is not the result of normal expected shelf life deterioration.

To the extent the equipment, including all parts and spare parts, as defined above, is of the Contractor's design or is of a design selected by the Contractor, it is also guaranteed, subject to the foregoing conditions, against defects in design with the understanding that if ten percent (10%) or more of any such said item, but not less than two of any such item, of the total quantity comprising such item furnished under the contract, are found to be defective as to design, such item will be conclusively presumed to be of defective design and subject to one hundred percent (100%) correction or replacement by a suitably redesigned item.

All such defective items will be subject to ultimate return to the Contractor. In view of the fact that normal activities of the Naval Service may result in the use of equipment in such remote portions of the world or under such conditions as to preclude the return of the defective items for repair or replacement without jeopardizing the integrity of Naval communications, the exigencies of the Service, therefore, may necessitate expenditious repair of such items in order to prevent extended interruption of communications. In such cases the return of the defective items for examination by the Contractor prior to repair or replacement will not be mandatory. The report of a responsible authority, including details of the conditions surrounding the failure, will be acceptable as a basis for affecting expenditious adjustment under the provisions of this contractual guarantee.

The above one year period will not include any portion of time the equipment fails to perform satisfactorily due to any defects, and any items repaired or replaced by the Contractor will guaranteed anew under this provision.

INSTALLATION RECORD

Contract Number: NObsr-43157 **Date of Contract: 9 Dec. 1948**

Serial number of equipment ....

Date of acceptance by the Navy ....

Date of delivery to contract destination ....

Date of completion of installation ....

Date placed in service ....

Blank spaces on this page shall be filled in at time of installation.

REPORT OF FAILURE

Report of failure of any part of this equipment, during its entire service life, shall be made to the Bureau of Ships in accordance with current regulations using form NAVSHIPS NBS 383 (revised). The report shall cover all details of the failure and give the date of installation of the equipment. For procedure in reporting failures see Chapter 67 of the Bureau of Ships Manual or superceding instructions.

ORDERING PARTS

All requests or requisitions for replacement material should include the following data:

1. Standard Navy stock number or, when ordering from a Marine Corps or Signal Corps supply depot, the Signal Corps stock number.

2. Name and short description of part.

If the appropriate stock number is not available the following shall be specified:

1. Equipment model or type designation, circuit symbol, and item number.

2. Name of part and complete description.

3. Manufacturer's designation.

4. Contractor's drawing and part number.

5. JAN or Navy type number.

SAFETY NOTICE

WARNING

The attention of officers and operating personnel is directed to Chapter 67 of the Bureau of Ships Manual or superseding instructions on the subject of radio-safety precautions to be observed.

This equipment employs voltage which is dangerous and may be fatal if contacted by operating personnel. Extreme caution should be exercised when working with the equipment.

While every practicable safety precaution has been incorporated in this equipment, the following rules must be strictly observed:

KEEP AWAY FROM LIVE CIRCUITS:

Operating personnel must at all time observe all safety regulations. Do not change tubes or make adjustments inside equipment with the power cord connected. Under certain conditions dangerous potentials may exist in circuits with power controls in the off position due to charges retained by capacitors. To avoid accident always remove power and discharge and ground circuits prior to touching them.

An approved poster illustrating the rules for resuscitation by the prone pressure method shall be prominently displayed in each radio, radar, or sonar enclosure. Posters may be obtained upon request to the Bureau of Medicine and Surgery.

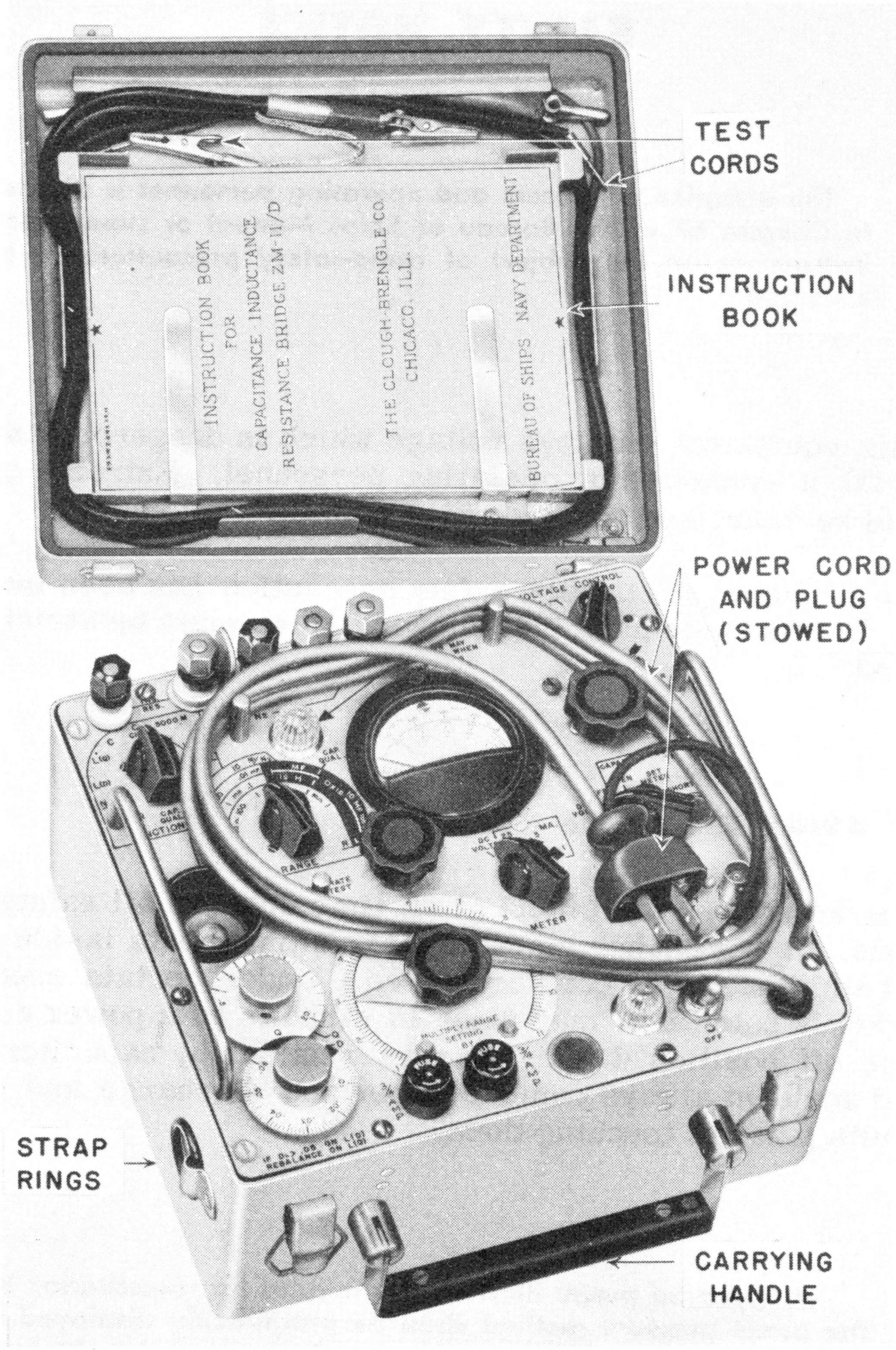


Figure 1-1. Capacitance, Inductance, Resistance Bridge, ZM-11/U

SECTION 1
GENERAL DESCRIPTION

1. GENERAL DESCRIPTION.

The Capacitance-Inductance-Resistance Bridge, Type ZM, 11/U, is contained within a portable combination case as shown completed in Figure 1-1 with lid removed, power cord stowed on suitable panel posts and test leads and instruction manual stowed, in lid. It is used to measure capacitance, inductance, resistance, transformer turn ratio, dissipation factor of inductors and capacitors, and storage factor of inductors at 1000 cycles-per-second; and insulation resistance of capacitors and other parts as well as leakage in electrolytic capacitors at direct current. General condition of many capacitors may be examined without removal from circuit using a test frequency of 10.75 Megacycles. By use of the ZM-11/U Bridge, many electronic parts such as resistors, capacitors (paper, mica, electrolytic), coils, chokes and transformers may be examined for condition and suitability for installation.

While designed primarily for service measurements, its overall accuracy is about half that usually realised by laboratory equivalents of greater bulk and complexity. It is self-contained except for a source of line power and embodies its own source of 1000 cycle bridge current together with a sensitive bridge balance indicator; an adjustable source of direct current for electrolytic capacitor and insulation resistance testing; and a meter with suitable ranges for leakage current tests on electrolytic capacitors. Additionally, a quality test for ascertaining whether a capacitor is open or shorted even though a resistance or inductance remains connected across it at the time of measurement is included. The turns ratio of an iron-cored transformer may also be determined.

The basic measurements of resistance, capacitance, inductance and turn ratio are made by suitable bridge circuits. Incidental to these, the dissipation or storage factor of capacitors and coils is balanced and read on suitable dials and this result may be applied to circuit problems with due regard for the test frequency which is 1000 cycles. Polarizing voltage may be applied to electrolytic capacitors while determining their capacitance and dissipation, and their direct current leakage may be determined either with or without the capacitance and dissipation. Insulation resistance of capacitors and other parts may be determined within the ranges and accuracies shown in Table 1-1.

2. REFERENCE DATA.

a. Nomenclature: Capacitance-Inductance-Resistance Bridge, ZM-11/U.

b. Contract: NObsr-43157 dated 9 December 1948.

c. Contractor: The Clough-Brengle Co., Chicago, Illinois.

d. Cognizant Inspector: Inspector of Naval Material, Chicago, Illinois.

e. One package per equipment. No equipment spares.

f. Cubical contents of shipment are, crated .89 cu. ft., uncrated .23 cu. ft., no equipment spares included. 14 pounds.

h. All bridge measurements are made at 1000 cycles-per-second. Capacitor quality test at 10.75 megacycles and 1000 cycles. Leakage and insulation resistance tests at direct current.

i. Line power required from single phase source of alternating current, 105 to 125 volts, 50 to 1000 cycles.

j. Input power requirements: for normal bridge operation is

TABLE 1-1. RANGE AND ACCURACIES OF MEASUREMENTS.

MEASUREMENT	RANGE	MAXIMUM ERROR REFERRED TO READING.	
(Test Current)	mmf:micromicrofarad MF:microfarad MH:millihenry H:henry meg:megohm	NORMAL CONDITIONS Temp.24°C. Pressure 14.9 PSI. Relative humidity 70%	Temperature 0-55°C. Humid.0-90% to 38°C Line 105-125 volts 50 to 1000 cycles.
Capacitance (1 kc)	10 mmf to 10 MF 1 MF to 100 MF 10 MF to 1100 MF	2% +1 scale div. 3@ +1 scale div. 5% +1 scale div.	4% +1 scale div. 6% +1 scale div. 6% +1 scale div.
Inductance (1 kc)	0.1 MH to 1 H 1 H to 10 H 10 H to 110 H	2% +1 scale div. 5% +1 scale div. 10% +1 scale div.	6% +1 scale div. 10% +1 scale div. 15% +1 scale div.
Resistance (1 kc)	1 ohm to 11 meg	2% +1 scale div.	5% +1 scale div.
Insulation Resistance Test (direct current)	200 to 500 meg 5000 to 1000 meg	3% +100 megohms 3% +200 megohms	20% +100 megohms 20% +250 megohms
Transformer Turn Ratio	0.01 to 110 (K=1)	2% +1 scale div.	5% +1 scale div.
D-C Leakage current of capacitors (d-c)	0 to 1, 5, & 25 milliamperes	3% of full scale	5% of full scale
D dissipation factor (1 kc)	0-.06(10mmf-.1MF) 0-.6(.1MF-1100MF)	20% +.02 in D	30% +.03 in D
Q storage factor (1 kc)	0.5 to 20	20%	30%
D-C applied to electrolytic capacitors	0 to 500 volts	5% of full scale	8% of full scale

29 watts; with 400 volt, 4 milliampere output from d-c power supply, 36 watts.

TABLE 1-2. EQUIPMENT SUPPLIED

Quantity per Equipment	NAME OF UNIT	OVERALL DIMENSIONS			VOLUME	WEIGHT
		Weight	Width	Depth		
1	Capacitance-Inductance-Resistance Bridge ZM-11/U	5-11/16	8-27/32	9-5/8	.23	14
1	Cable assembly, R-F (P101)	1/2	1/2	48	*	*
1	Test Lead, Red (W101)	1/2	1/2	36	*	*
1	Test Lead, Black (W102)	1/2	1/2	36	*	*
2	Instruction Books for Bridge ZM-11/U.	7	5-3/4	1/2	*	*

Dimensions are in inches, volume in cubic feet, weight in pounds.

* Denotes items normally stowed in lid and included in basic weight and volume.

TABLE 1-3. ELECTRON TUBE COMPLEMENT.

CIRCUIT APPLICATION	NUMBER OF TUBES OF TYPE INDICATED							
	6E5	6J6	6AV6	6AG5	6AL5W	6AQ5	6X4W	Total No. Of Tubes
Electron Ray Indicator for bridge balance	1							1
Power amplifier		1						1
Bridge oscillator			1					1
Electron tube voltmeter (quality test)			1					1
Amplifier, 1 kc				1				1
RF Rectifier					1			1
RF Power Oscillator						1		1
Line Power Rectifier							1	
Total Number of Each Type	1	1	2	1	1	1	1	8

SECTION 2
THEORY OF OPERATION

1. BASIC BRIDGE CIRCUIT. GENERATOR AND INDICATOR.

a. Figure 2-1 shows a bridge circuit in its most elementary form. An alternating current generator, G, passes current through two resistors, A and B, called the ratio arms and through resistors, Rx and Rs, called the unknown and standard, respectively. From consideration of the voltage drops, no current will pass through the head-telephone indicator, HT, when

$$\frac{Rx}{Rs} = \frac{A}{B} \text{ or } Rx = \frac{A}{B} Rs$$

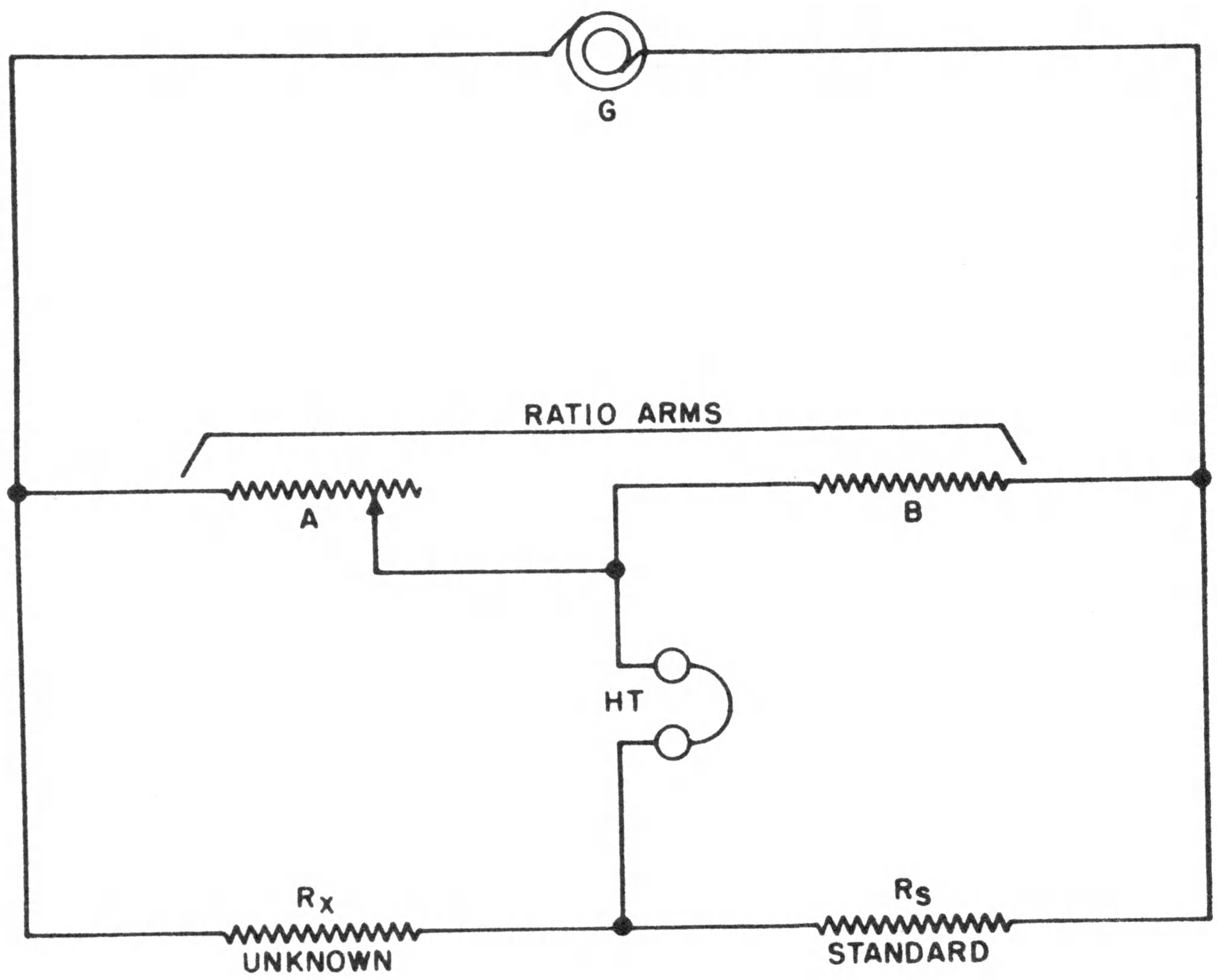


Figure 2-1. Elementary Bridge Circuit.

hence no response will be heard. If A and B are precalibrated in some convenient way, one has only to connect an unknown resistor and adjust A and B until silence is had in the head telephone; then the value of Rx may be read directly from the calibrations on A and B.

b. In practice, the generator must have special properties such as low admittance to ground, in order that the accuracy will be preserved when using high ratios of A to B. It must also have adequate output of good waveform, since, in some applications, the bridge cannot be balanced simultaneously at the fundamental and a harmonic. The method used in generating the 1000 cycle test current used in the ZM-11/U Bridge is shown in Figure 2-2. Vacuum tube V103 is the 1000 cycle oscillator, V102 amplifies the output thereof and transformer T102 connects the amplifier output to the bridge circuits.

Tube V103 is connected as an amplifier. Bias is supplied by a cathode resistor, R141 which is by passed by capacitor C103. Plate voltage is through resistor R142. The signal output is passed into a ladder network of four capacitor-resistor combinations; C122, R138; C121, R137; C120, R136 and C119, R135. Each combination shifts the phase somewhat, the proportions being such that a 1000 cycle impulse is shifted 180 degrees in passing through the four combinations. The shifted output is returned to the grid of V103 and, due to the amplifying property, sustained oscillation results. Any tendency to fly into wide swings of highly distorted waveform is effectively prevented by a slight pulse of grid current at the positive peak.

One grid of a push-pull amplifier, V102, is connected to the junction between capacitors C120 and C121. Here the phase has not been through the full 180 degree reversal but the voltage is suitable. Some of the plate signal of V103 is taken off through a capacitor C125 and fed through a two step ladder; R143, C124 and R144, C123. This ladder has shunt capacitors and series resistances while the other ladder (C122, R138 and C121, R137) has shunt resistances and series capacitors. Thus the one

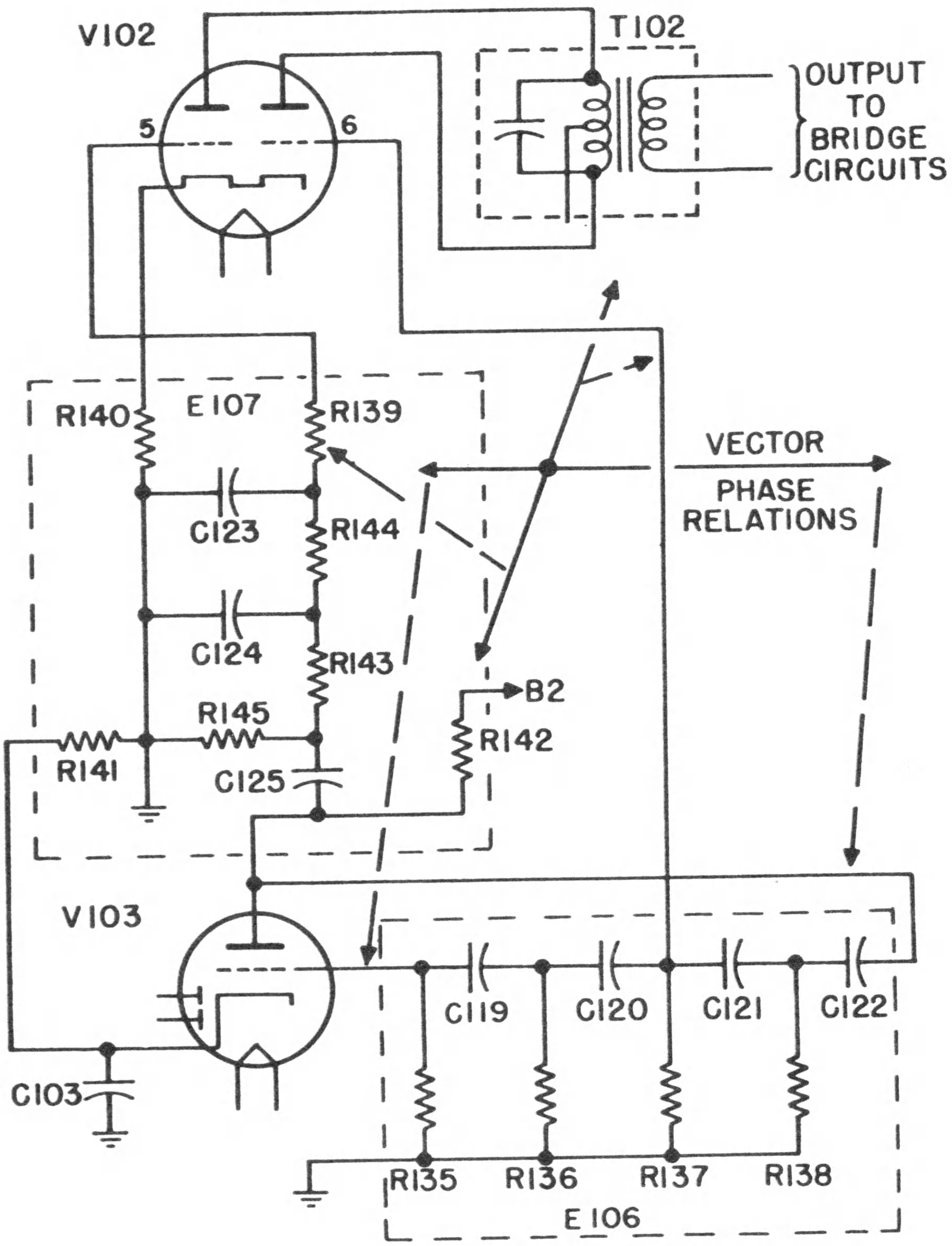


Figure 2-2. 1000 Cycle Generator.

advances the phase of the V103 plate signal while the other retards it. The various phase shifting elements are proportioned so that grid (5) is driven at the same amplitude as grid (6) but in opposite phase as required for true push-pull operation. Spurious oscillation in the amplifier is blocked by resistor R139 and resistor R145 provides a grid-leak to ground (through R139, R144, and R143).

The construction of the output transformer T102 is shown in Figure 5-9. The primary, hidden by its supporting bracket which is also the interwinding shield, is tuned to 1000 cycles for highest efficiency and to suppress harmonics in the output. The secondary is supported with a minimum of solid material to keep the capacitance and leakage to the core at a minimum. Placing of the primary and secondary at the opposite ends of the long core produces high leakage inductance and causes the output to be self regulating with respect to the connected impedance.

c. Headphones lack the necessary sensitivity for balancing and are supplanted by a balance indicator for the Bridge, ZM-11/U. It consists of an amplifier V105, together with an electron-ray tube indicator, V101. The amplifier-indicator combination is necessarily so sensitive that only a fraction of a millivolt is needed to cause an appreciable closure of the eye pattern. Normally the pattern would close entirely with only a few millivolts input, corresponding to a very small unbalance and show no further movement for greater unbalance. This would be undesirable since balance is more readily reached if the operator has some idea of the direction of the needed change, even when far from the actual balance. To make this possible a simple automatic gain control has been embodied in the amplifier; eye-pattern activity may be seen at levels as high as one volt.

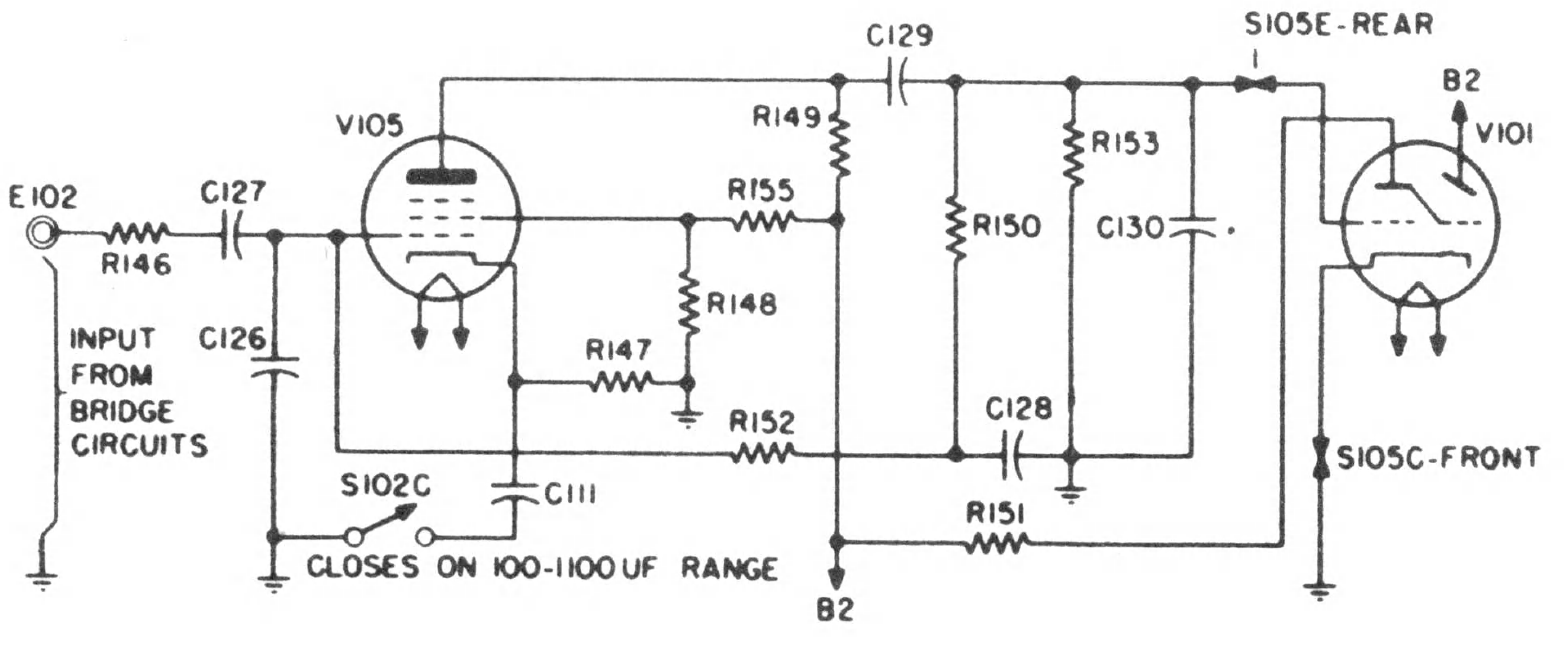


Figure 2-3. Amplifier-Indicator Circuit.

Figure 2-3 shows the connections of the amplifier-indicator for all bridge circuit positions of the Function switch. The four elements, R146, C127, C126 and R152, form a broadly resonant 1000 cycle filter to the amplifier input, V105. Cathode bias is from resistor R147 which is not bypassed except on the 100-1100 microfarad range where extra gain is required due to the large ratio employed. Screen supply is from the junction of R148-R155 while plate supply is through R149. C129 and R153 act as blocking-capacitor and grid leak, respectively, for V101, while the four elements, R149, C129, R153 and C130 form another filter broadly resonant to 1000 cycles like the one in the input. For a large signal to the amplifier, the grid of V101 rectifies and becomes negative due to the capacitor-leak action. This voltage is filtered by combination R150-C138 and is returned to the amplifier grid through R152 and the amplification is accordingly reduced. As bridge balance is approached, this automatic gain control voltage is reduced until, near balance, it becomes essentially zero; the amplifier-indicator then acts at maximum gain permitting very close balance.

The symbolic generator and the headphone indicator will continue to be used in discussion of the various bridge circuits employed in the Type ZM-11/U, it being understood that the actual counterparts described above are in use.

2. RESISTANCE BRIDGE.

a. When the FUNCTION SWITCH S105 is turned to "R" (resistance) the bridge circuit is connected as shown in Figure 2-4. Comparison of this with Figure 2-1 shows that the "A" arm is actually a potentiometer R157 which carries the MULTIPLY RANGE SETTING BY calibration 1 to 11 on the panel. (see Figure 4-1). This is swamped off at its lower end, R156, so that the panel setting of 1.0 includes exactly 1000 ohms and higher settings correspondingly higher values; also, that the "B" arm is one of four decimally related values selected by a switch. There are two values of the standard, Rs. Both switches

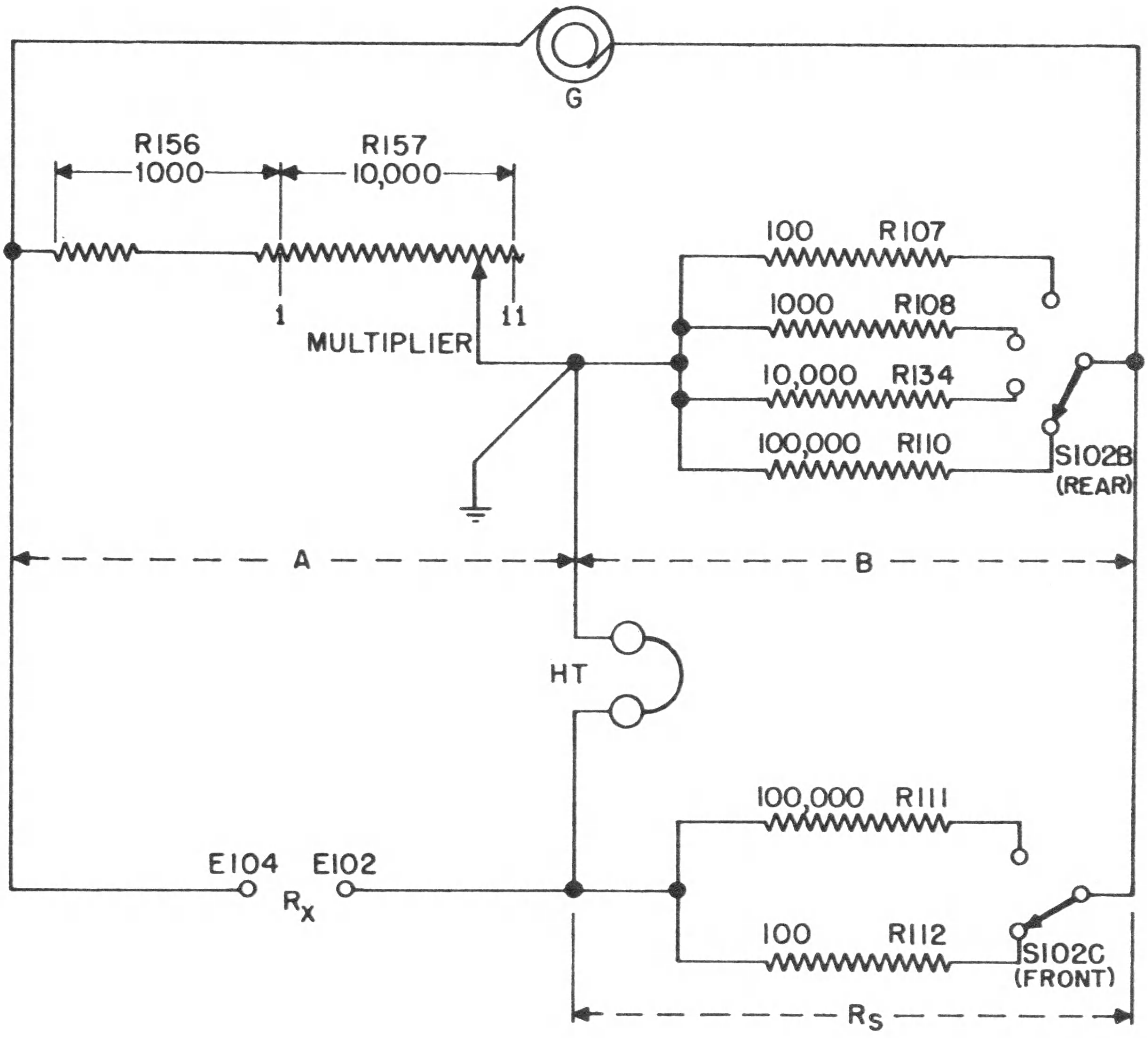


Figure 2-4. Resistance Bridge, Essential Circuits.

shown are part of the RANGE SWITCH S102.

b. If the action of the two switch parts shown are traced out in the schematic diagram, Figure 5-14, for the various positions of the RANGE switch it will be found that the seven resistance bridge ranges are formed as shown in Table 2-1.

It will be seen that the standard resistance changes after the

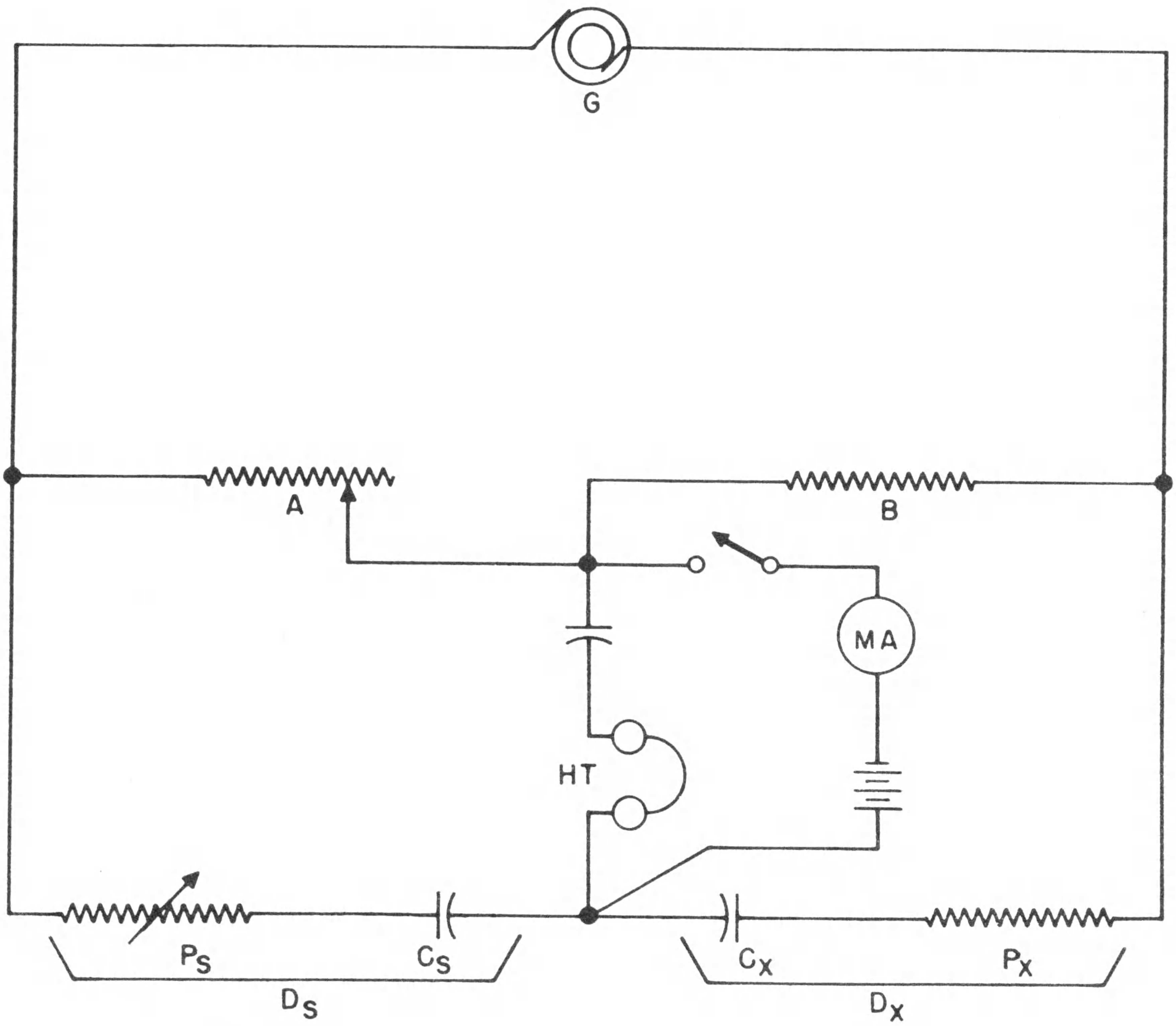
TABLE 2-1. RESISTANCE BRIDGE RANGES.

Range No.	Range Switch On	Mult. By Dial	Resis. "A"	Resis. "B"	Stand. Res. Rs	$Rx = \frac{A}{B} \times Rs$
1	1Ω	1.0	1000	100,000	100	1.0
	1Ω	11.0	11000	100,000	100	11.0
2	10Ω	1.0	1000	10,000	100	10.0
	10Ω	11.0	11000	10,000	100	110.0
3	100Ω	1.0	1000	1,000	100	100
	100Ω	11.0	11000	1,000	100	1,100
4	1 KΩ	1.0	1000	100	100	1,000
	1 KΩ	11.0	11000	100	100	11,000
5	10 KΩ	1.0	1000	10,000	100,000	10,000
	10 KΩ	11.0	11000	10,000	100,000	110,000
6	.1 MΩ	1.0	1000	1,000	100,000	100,000
	.1 MΩ	11.0	11000	1,000	100,000	1,100,000
7	1.0 MΩ	1.0	1000	100	100,000	1,000,000
	1.0 MΩ	11.0	11000	100	100,000	11,000,000

fourth range and that three of the basic ratios are re-used with the new standard in the last three ranges. This plan requires a minimum of calibrated resistors and permits a wide range of measurement without extreme ratios of A/B which would introduce undersirable complications.

3. CAPACITANCE BRIDGE.

a. Figure 2-5 shows a simplified circuit of the capacitance measurement. As the balance equation shows, it is actually the capacity-reactance rather than the capacitance which is bal-



$$\frac{A}{B} = \frac{X_S}{X_X} = \frac{\frac{1}{2\pi f C_S}}{\frac{1}{2\pi f C_X}} = \frac{C_X}{C_S}$$

ALSO $2\pi f C_S P_S = 2\pi f C_X P_X$ OR $D_S = D_X$

WHERE $X_S = \frac{1}{2\pi f C_S}$ (THE CAPACITY REACTANCE)

AND $X_X = \frac{1}{2\pi f C_X}$

Figure 2-5. Capacitance Bridge, Essential Circuits.

anced. Reversal of the positions of the standard and unknown with respect to the arms (compare with Figure 2-1) causes the A arm to retain its linear calibration. If the same relationship were used as for the resistance measurement, the A arm would have to have a new calibration which would be non-uniform corresponding to a reciprocal relationship.

b. In addition to its reactive property, the unknown capacitance will always have some loss. This loss may have the property of either a shunt or series resistance or may be, perhaps, a combination of both. Whatever its true nature it can be represented by a simple series resistance, Px, as has been done in Figure 2-5 and which can be balanced by a calibrated series resistance, Ps, in the standard side. Rather than to calibrate this control in its actual resistance it is an operational convenience to calibrate it in dissipation, D, as defined in Figure 2-5, then the control provides the means for completing the capacitance balance and its dial shows a merit figure for the capacitor under test.

c. The actual circuit arrangement for capacitance measurement is in Figure 2-6, corresponding to the "C" position of the FUNCTION switch. Note that the "A" arm is the same one used for resistance measurement as is the "B" arm with the addition of one resistor for an extreme range. Similiarly, two capacitance standards are used. With these arrangements, eight continuous and progressive ranges in capacitance are formed as shown in Table 2-2.

d. Because two values of standard capacitance are used, two values of the dissipation control must also be provided. These are gauged on one shaft which bears the "D" panel dial. Note that these controls do not bear the same ratio to each other as their respective standard capacitances. Table 2-2 shows that the 1000 mmf standard is used through the first four capacitance ranges, 10 mmf to 0.11 MF. The capacitors measured in this range are usually of mica or paper dielectric and cannot have very high dissipation before their condition is suspect. For this

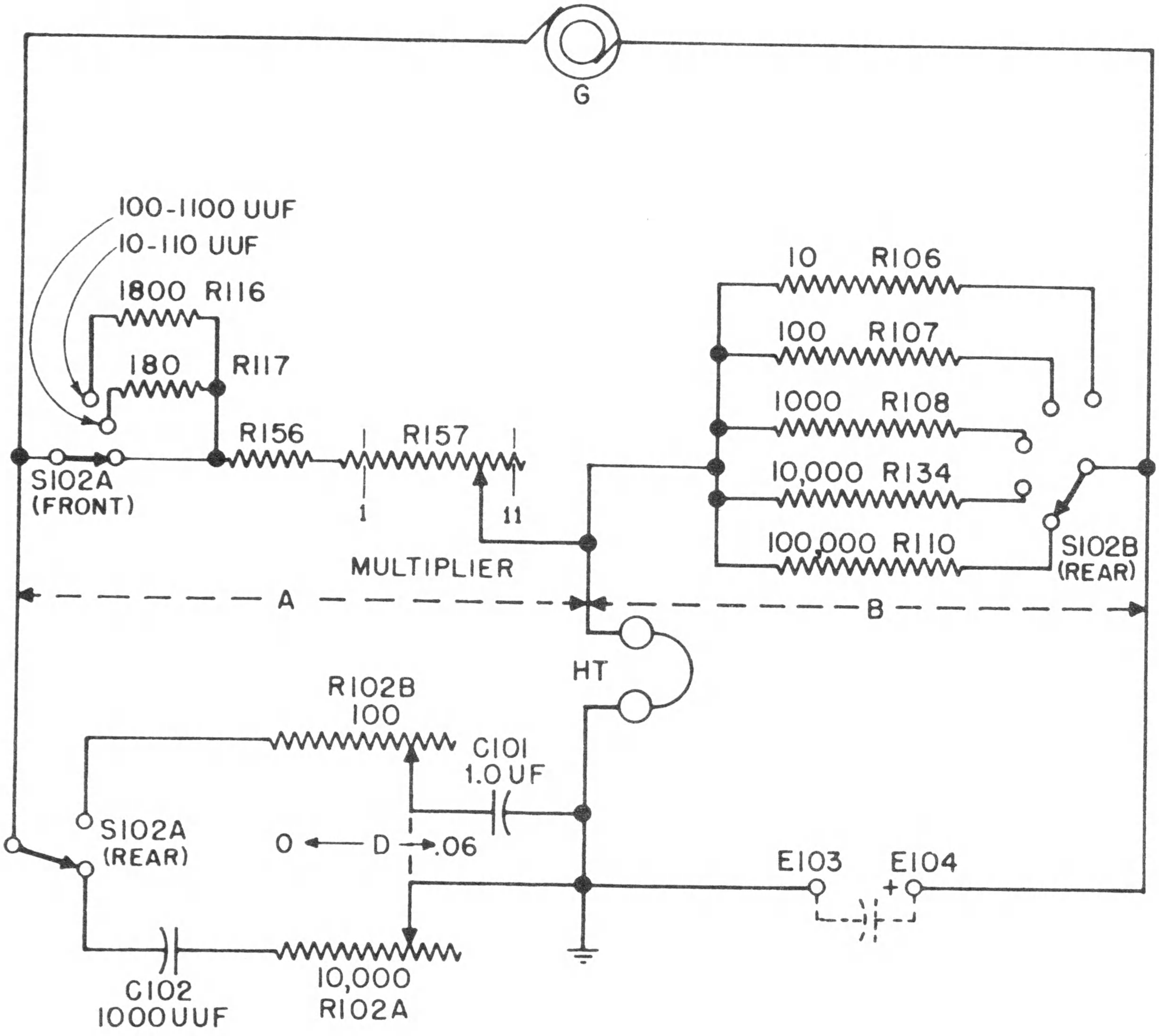


Figure 2-6. Capacitance Bridge, Measuring Circuit.

reason, a maximum range of "D" of 0.06 was selected for use with the 1000 mmf standard. This gives best readability in the region of usual interest.

The remaining four capacitance ranges cover 0.1 MF to 1100 MF. Particularly in the higher end of this range, the capacitor tested is apt to be of electrolytic construction and a wider range of "D" is required to balance acceptable units. Hence a range of 0 to 0.6 in "D" is provided in these ranges. Attention is

TABLE 2-2. CAPICITANCE BRIDGE RANGES

Range No.	Range Switch On	Mult. By Dial	Resis. "A"	Resis. "B"	Stand. Capac. Cs	$Cx = \frac{A}{B} X Cs$
1	10 mmf 10 mmf	1.0 11.0	1000 11000	100,000 100,000	1000 uuf 1000 uuf	10 uuf 110 uuf
2	100 mmf 100 mmf	1.0 11.0	1000 11000	10,000 10,000	1000 uuf 1000 uuf	100 uuf 1100 uuf
3	1000 mmf 1000 mmf	1.0 11.0	1000 11000	1,000 1,000	1000 uuf 1000 uuf	1000 uuf 11000 uuf (0.011 uf)
4	.01 MF .01 MF	1.0 11.0	1000 11000	100 100	1000 uuf 1000 uuf	.01 uf .11 uf
5	.1 MF .1 MF	1.0 11.0	1000 11000	100,000 10,000	1.0 uf 1.0 uf	.1 uf 1.1 uf
6	1.0 MF 1.0 MF	1.0 11.0	1000 11000	1,000 1,000	1.0 uf 1.0 uf	1.0 uf 11.0 uf
7	10 MF 10 MF	1.0 11.0	1000 11000	100 100	1.0 uf 1.0 uf	10.0 uf 110.0 uf
8	100 MF 100 MF	1.0 11.0	1000 11000	10 10	1.0 uf 1.0 uf	100.0 uf 1100.0 uf

called to this feature in the reverse color segment of the RANGE switch designation marked "D x 10", indicating that all "D" dial readings are to be multiplied by ten when using these ranges.

e. The capacitance between the panel binding posts, E103 and E104, together with that of the connecting wiring and switch contacts which amounts to 17 to 18 mmf is already taken care of in every capacitance measurement. This prevents possible error or neglect on the part of the operator to include this necessary correction for stray capacitance.

It will be noted that for the 10 to 110 mmf range, the resistance of the "A" arm is 100 ohms per mmf, thus for this range an 1800 ohm resistance inserted in the "A" arm has the effect of subtracting 18 mmf from the reading of the "MULTIPLY RANGE SETTING BY dial. Similiarly, insertion of 180 ohms has the effect of subtracting 18 mmf on the 100 to 1100 mmf range. These insertions of selected resistors, R116 and R117, are made automatically by suitable contacts on the FUNCTION and RANGE switches. The residual capacitance is negligible on the higher ranges and its effect is uncompensated.

4. POLARIZING CAPACITORS—D. C. SUPPLY

NOTE

Capacitors of electrolytic construction for d. c. operation often require the application of a d. c. voltage in order to exhibit the same capacitance and dissipation factor that they would in practical circuit operation. When a d. c. voltage equal or less than the marked working voltage is applied there is a sudden rush of current which falls back to a smaller steady value after 3 or 4 minutes, if the capacitor is in good condition. This steady value of current is called the leakage current. When the stable current value is reached the capacitor is said to be polarized.

a. If Cx in Figure 2-5 is electrolytic constructed, its capacitance and dissipation may be desired under simulated operating conditions and, for this, an hypothetical battery and meter are shown. A series capacitor blocks the battery from the indicator and the d-c flow will be through the "B" arm and the unknown, Cx, Px. The d-c leakage current may be read on the meter.

b. In the Model ZM-11/U the battery function is by a power supply of the RF type. Figure 2-7 shows the circuit when the OSCILLATOR switch is in the D. C. VOLTS position. V107 co-operates with transformer assembly T103 to oscillate at about 300 kilocycles. It has a secondary winding of very high Q and inductance/capacitance ratio which develops a relatively high RF voltage. This is rectified by tube V106 and smoothed by a resistance-capacitance combination, R121, C107 and C106. Plate supply to the oscillator tube is at B1 corresponding to the d-c bus of the same marking in Figure 5-14. The amplitude of

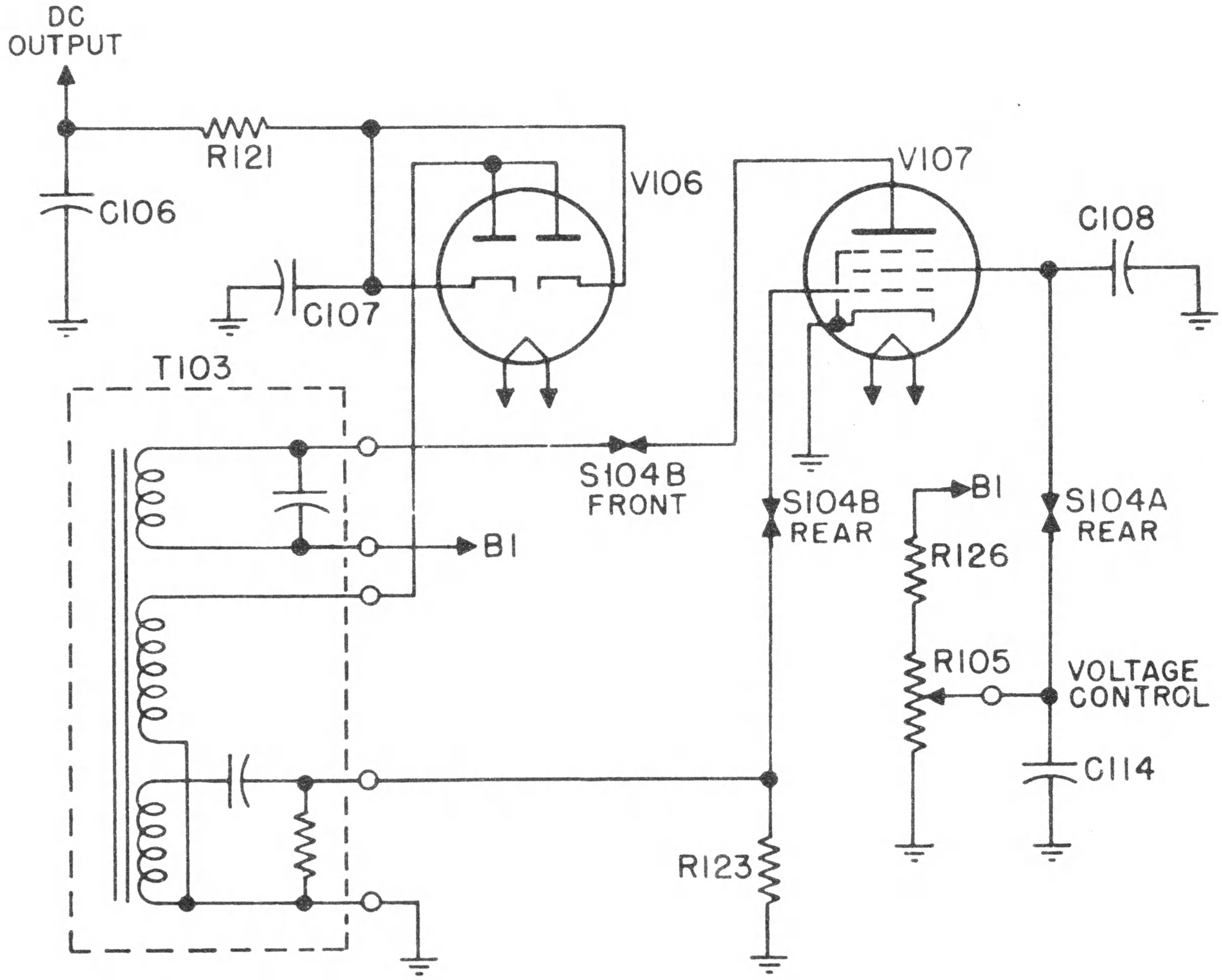


Figure 2-7. D-C Power Supply, RF Type.

the RF oscillation, and hence the d-c output, is controlled by the VOLTAGE CONTROL; R105, which controls the screen supply to the oscillating tube. With the FUNCTION switch in the C-CHG (charge) position, this d-c is connected into the bridge circuit in a manner analogous to the battery connection of Figure 2-5.

c. The advantages of an RF type supply, when compared to direct rectification and filtering of line power, are several; ease of filtering, due to the higher frequency; control by a small low wattage potentiometer; high efficiency; poor regulation at high currents, making the unit self protective for shorted capacitors and protecting the operator against high-current shocks; and manifest savings in weight and bulk of equipment.

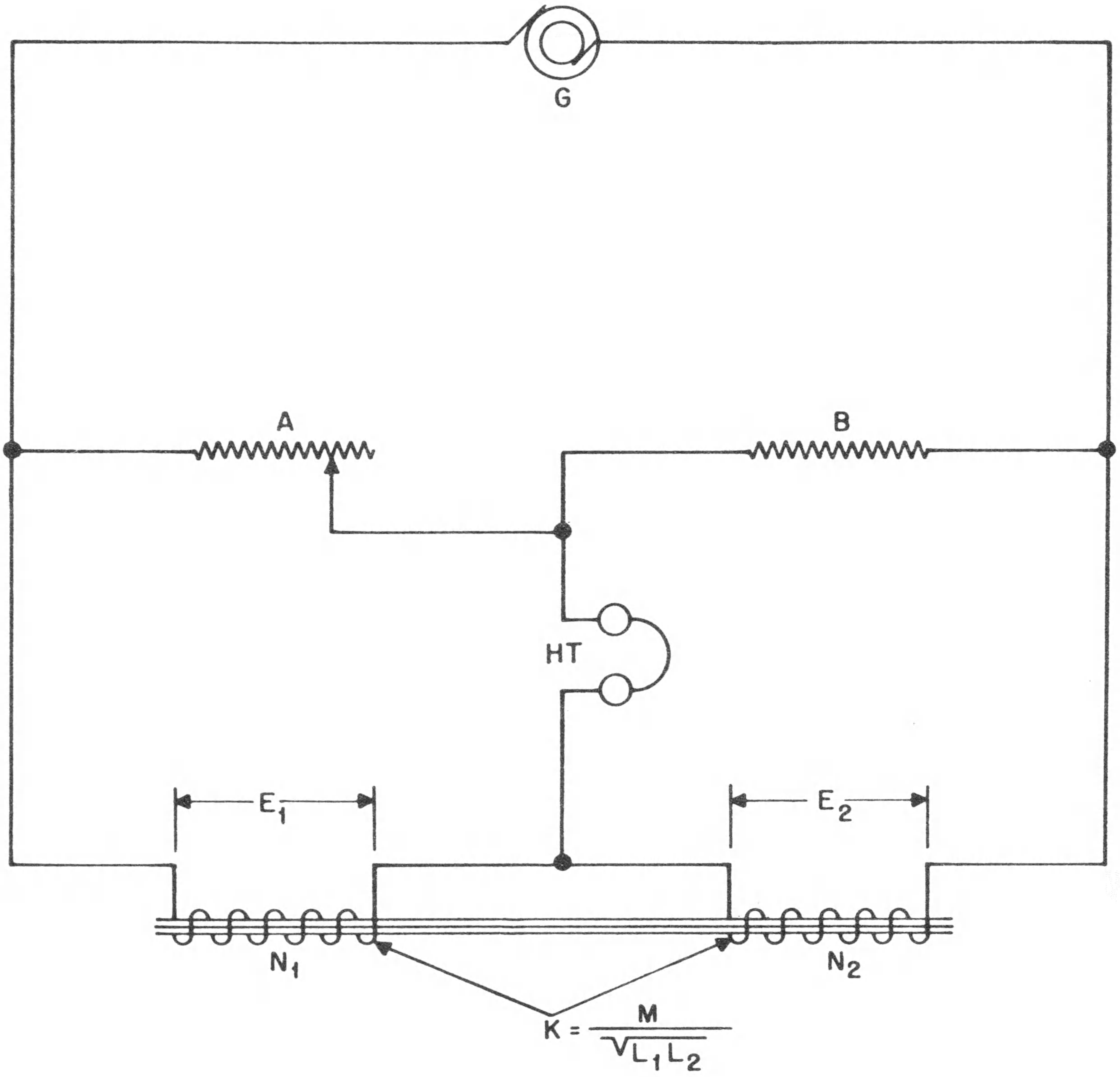
5. D-C METER CIRCUIT.

a. For control of the direct current the panel meter, M101, is normally connected as a 0-500 voltmeter so the operator can observe the potential applied to the sample. When the METER SWITCH S103 is turned to MA positions, current ranges of 25, 5 and 1 milliampere (see shunts R113, R114) are selected in turn to measure the current leakage through the connected electrolytic capacitor.

b. Attention is called to the fact that the d-c power supply and meter circuits are so arranged and connected that the normal capacitance-bridge circuits are in no way interfered with, therefore the capacitance and dissipation of the electrolytic capacitor may be measured while the capacitor is polarized to the desired extent.

6. TURN RATIO TEST FOR TRANSFORMERS.

a. If operation of the basic bridge circuit, Figure 2-1, is interpreted as a balancing of the ratio arms against the respective voltage drops across R_X and R_S, then it is apparent that the same ratio arms can be balanced against the voltage drops across two windings of a transformer. This is shown schematically in Figure 2-8. If N_1 and N_2 are the turns of two closely coupled windings connected series-aiding as shown, then the bridge current through these will cause voltages, E_1 and E_2



$$\frac{E_1}{E_2} = \frac{N_1}{N_2} = \frac{A}{B} \quad \text{WHEN } K = 1$$

Figure 2-8. Turn Ratio Test.

proportional to the respective turns. Obviously, the bridge will balance when A and B have this same ratio.

b. With the FUNCTION switch set at N_1/N_2, the connections are the same as shown in Figure 2-4 for resistance except for omission of the resistance standards. Since there are only four basic ratios (four values of the B arm) there are only four marked values of turn-ratio on the RANGE SWITCH, against which the MULTIPLY BY dial applies.

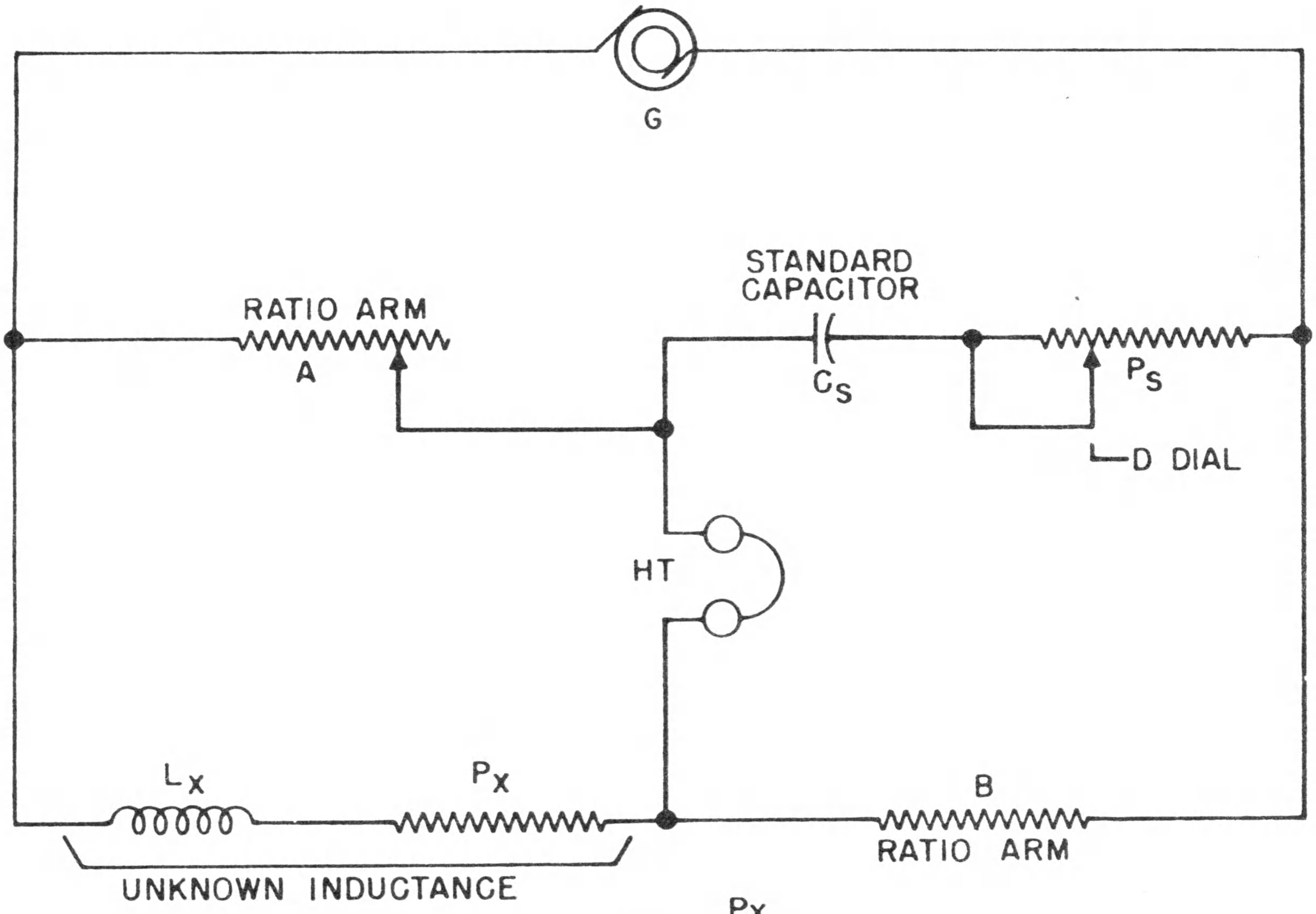
7. INDUCTANCE BRIDGE CIRCUITS.

a. These circuits employ the existing capacitance standards and loss controls so far as possible. Also, a wider range of dissipation must be provided to accommodate the practical range of inductors; powdered iron core coils designed for audio filters will show relatively low dissipation when measured at 1000 cycles while RF coils, even though of low-loss construction for their normal operating frequency, will show high dissipation when measured at 1000 cycles.

Both for reference and measurement it is convenient to introduce the storage factor, Q, which is the ratio of inductive reactance to resistance of a coil. It is also the reciprocal (1/D) of the dissipation.

In order to accommodate the large existing range in loss factors, two basic circuits are employed; the Hay bridge for coils with low losses at 1 kc (low D or high Q); and the Maxwell circuit for those having higher losses (high D, or low Q).

b. Hay's circuit, in effect when the FUNCTION SWITCH is at L(D), and its basic balance equations are shown in Figure 2-9. Equations (3) and (4) assume that D^2 may be neglected with respect to 1.0 under certain conditions. For D = 0.05, the error from so doing is 1/4%; above this, the error rises rapidly and becomes appreciable with respect to the basic accuracy of the



$$D_L = \frac{P_X}{2\pi f L_X}$$

$$L_X = \frac{ABC_S}{1+(2\pi f C_S P_S)^2} = \frac{ABC_S}{1+D^2} \quad (1)$$

$$P_X = \frac{AB(2\pi f C_S)^2 P_S}{1+(2\pi f C_S P_S)^2} = \frac{AB(2\pi f C_S)^2 P_S}{1+D^2} \quad (2)$$

BALANCE EQUATIONS MUST BE SIMULTANEOUSLY BROUGHT ABOUT TO BALANCE BRIDGE.

WHEN D^2 IS SMALL WITH RESPECT TO 1

$$L_X \approx ABC_S \quad (3)$$

$$P_X \approx AB(2\pi f C_S)^2 P_S \quad (4)$$

DIVIDING (4) BY (3) AND $2\pi f$:—

$$\frac{P_X}{2\pi f L_X} = 2\pi f C_S P_S = D \quad (5)$$

$2\pi f C_S P_S$ — BASIC CALIBRATION OF 'D' DIAL

$\frac{P_X}{2\pi f L_X}$ — THIS IS $\frac{1}{Q}$ OR D OF THE INDUCTOR.

Figure 2-9. Inductance Bridge, Hay's Circuit.

Model ZM-11/U. This limitation is expressed on the panel in abbreviated form by "IF D_L .05 ON L(D), REBALANCE ON L(Q)". In other words, if the dissipation, when using the Hay circuit exceeds 0.05, change to the Maxwell circuit, discussed in the next paragraph, and balance the loss factor of the coil in terms of the Q of the coil.

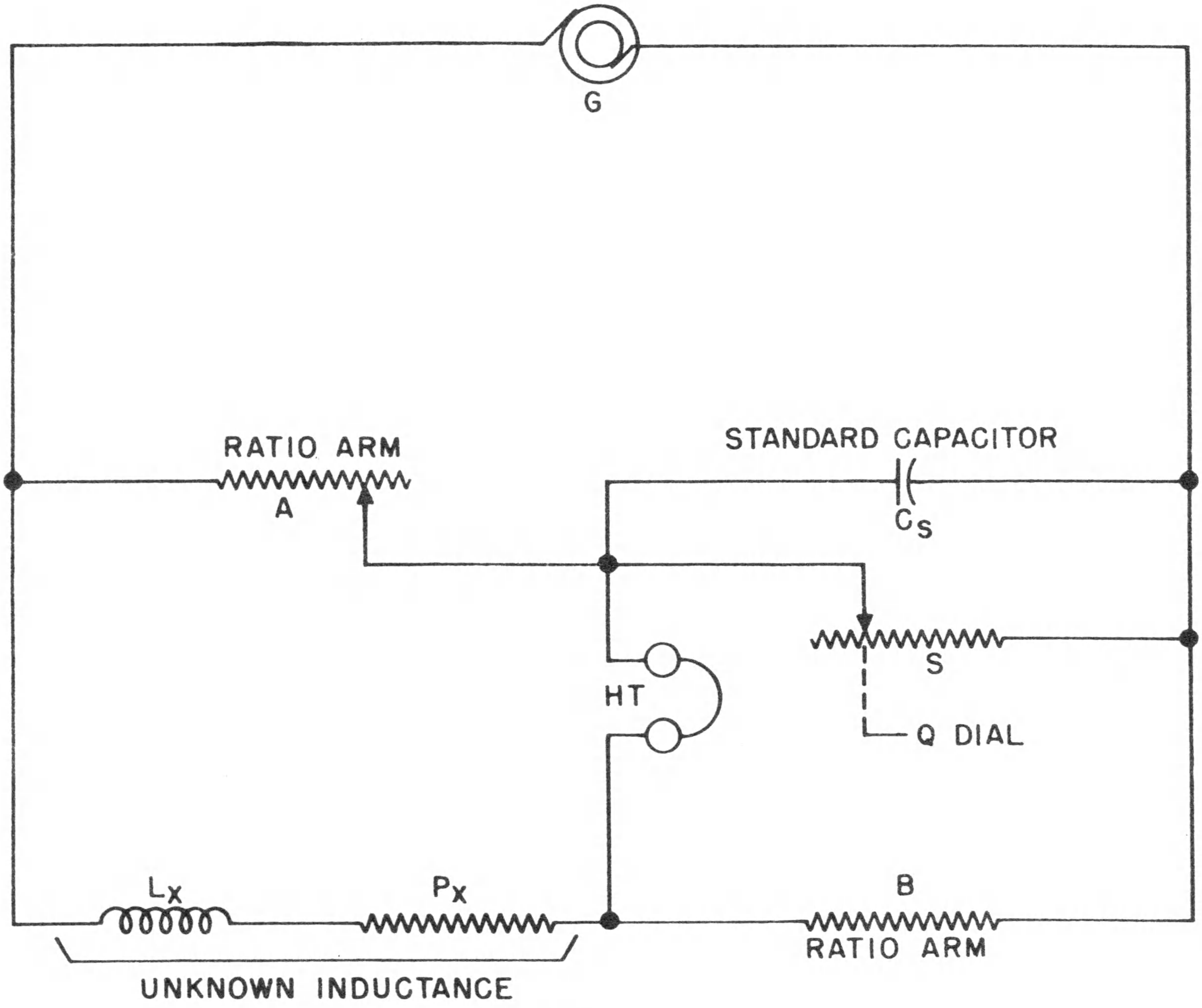
The algebra on Figure 2-9 also points out the justification for using the same dissipation control (D dial) in series with the standard capacitor which was employed in the capacitance-bridge connection, Figure 2-6.

c. Figure 2-10 shows the basic form of the bridge connection used for measuring coils having larger losses than expressed by D = .05 The only change is a new loss-control in shunt to the standard capacitor, rather than the series control used in the Hay bridge. As shown in the algebra, this control is conveniently calibrated in Q, the storage factor of the inductor measured. This requires a second loss control on the panel of the Type ZM-11/U Bridge, marked Q. This control is in effect when the FUNCTION SWITCH is turned to L(Q).

d. Comparison of equation (3) of Figure 2-9 with equation (1) of Figure 2-10 shows that the balance, for inductance, is the same for either circuit. This permits use of the same markings on the RANGE SWITCH for both the L(D) and L(Q) settings of the FUNCTION SWITCH. The simplified and combined circuit of Figure 2-11 shows that the only change is substitution of the shunt less control R103 for the series control R102. The electrical switching is completed by a mechanical interlock between the D and Q dials necessitating that either must be returned to its initial position before the other can be turned appreciably.

Note, the resistors of the B arm are arranged in the same manner with respect to the standard capacitances that was employed for the capacitance-bridge connection. The principle difference is that the measured result now depends on the product of the ratio arms, A x B, rather than on the quotient, A/B.

This accounts for the unsystematic arrangement of the inductance ranges.



$$Q_L = \frac{2\pi f L_X}{P_X}$$

$L_X = ABC_S$ (1)

$SP_X = \frac{L_X}{C_S}$ (2)

(1) and (2) MUST BE SIMULTANEOUSLY TRUE TO BALANCE BRIDGE.

SINCE $Q_L = 2\pi f \frac{L_X}{P_X}$ AND FROM (2) $\frac{L_X}{P_X} = C_S S$

$Q_L = 2\pi f C_S S$ (3)

Figure 2-10. Inductance Bridge, Maxwell's Circuit.

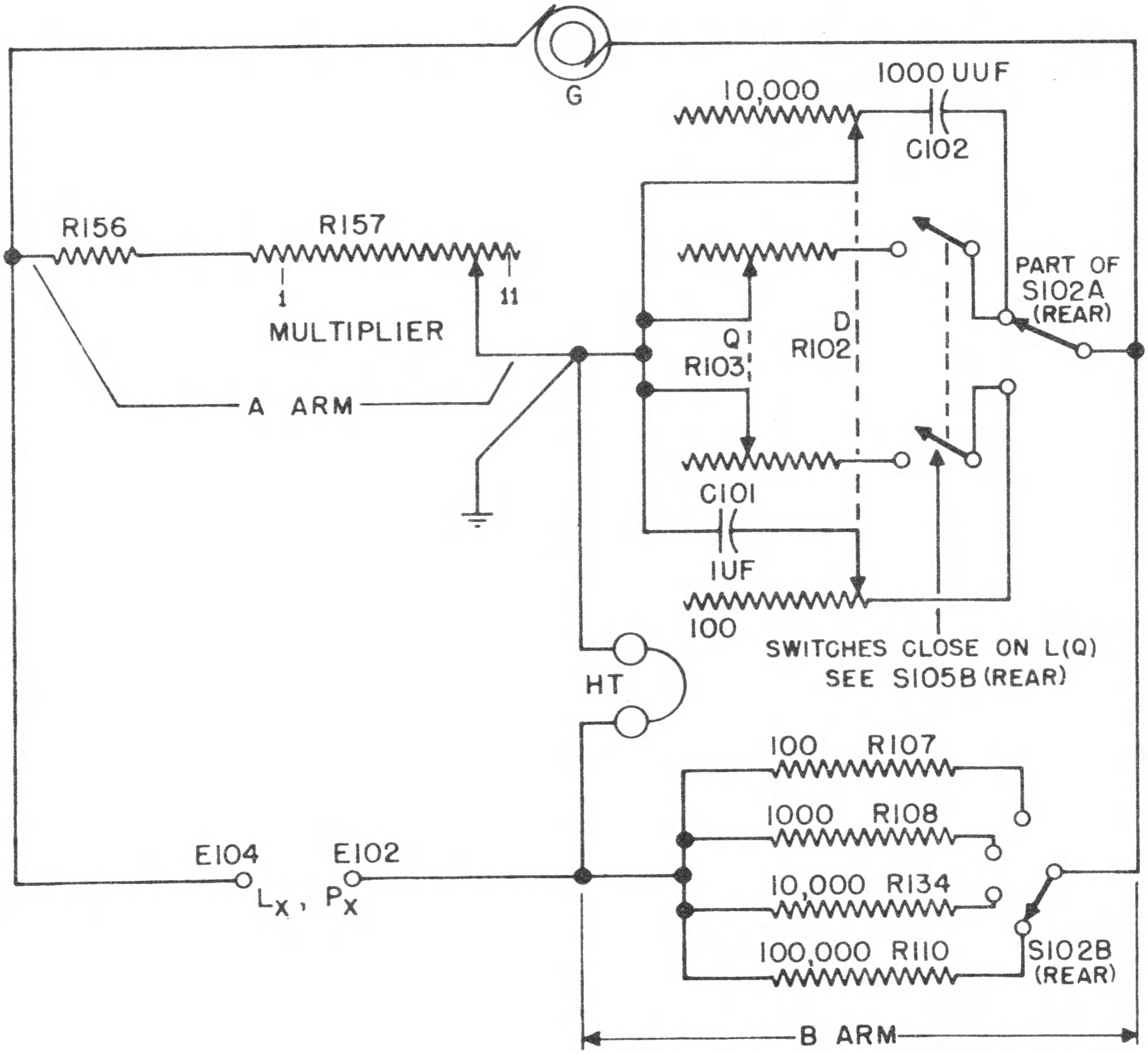


Figure 2-11. Inductance Bridge, Measuring Circuit.

8. CAPACITOR QUALITY TESTS.

a. Special testing facilities are included in the Model ZM-11/U for determining if a capacitor is either shorted or open without disconnecting it from its circuit and even though it is shunted with a resistor or inductor of not too low a value. (This limitation is fully covered in Section 4, Operation.) With the FUNCTION and RANGE switches in the required positions for this test, the essential circuits are shown in Figures 2-12 and 2-13. Both show the triode, V104, connected as an electronic voltmeter of the grid rectifying type. Figure 2-12 shows its grid grounded in the SET METER position of the CAPACITOR QUALITY TEST switch so the meter in its plate circuit may be set to full scale by potentiometer, R105, (VOLTAGE CONTROL). Recall now that the grid rectifying electronic voltmeter gives full scale deflection for zero input and deflects down-scale for appreciable applied voltage.

b. In the OPEN test connection, the electronic voltmeter is connected across the output winding of the oscillating transformer, T104. Connected in parallel to these are the impedance element, Z101, and the quality test cable, P101. The impedance element acts as terminal loading for the cable so that the combination has the qualities of a quarter-wave transmission line at a frequency of about 10.75 megacycles. It will be recalled

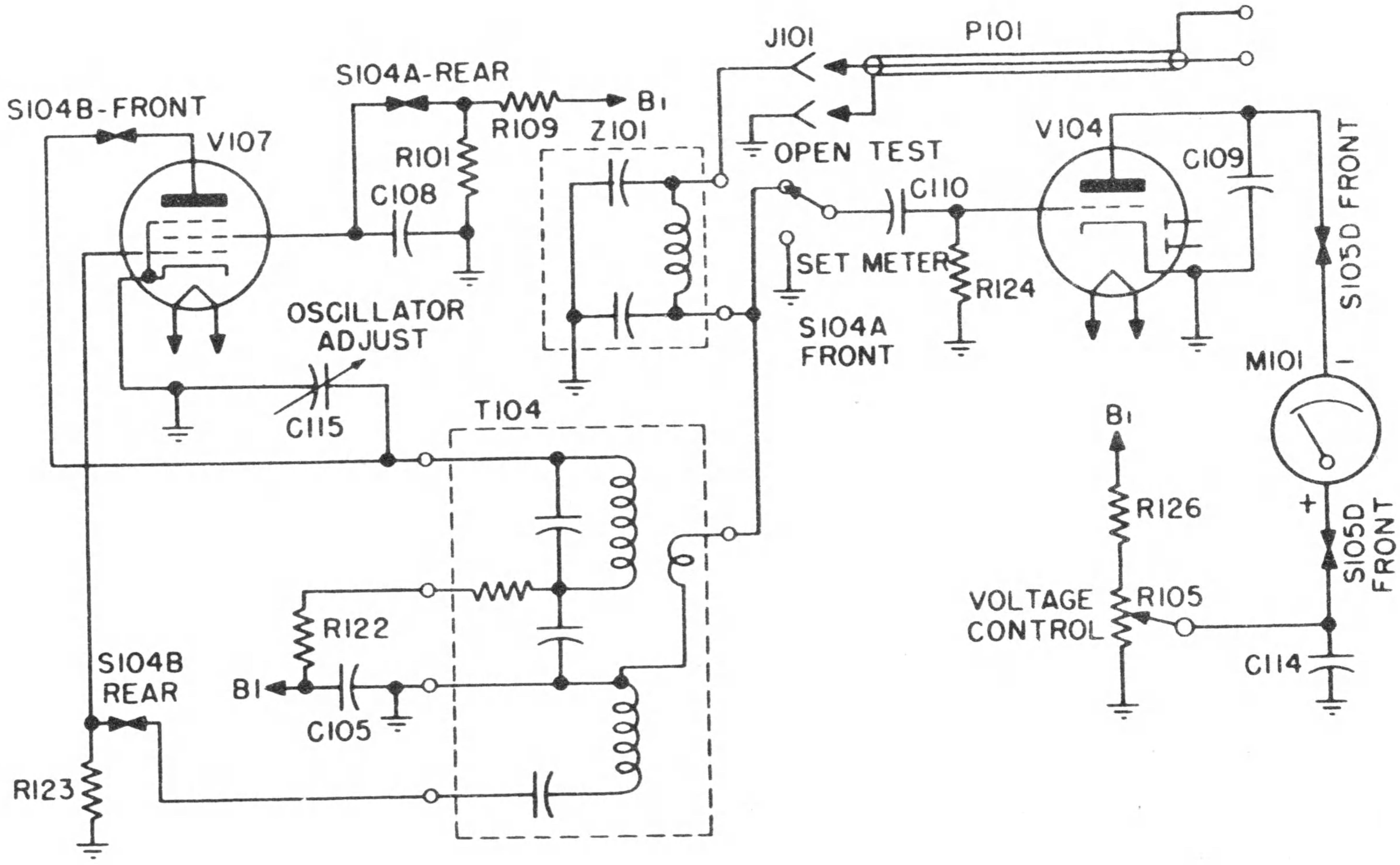


Figure 2-12. Capacitor Quality, Calibrate and Open Test.

that an impedance connected to the output end of a quarter-wave line is reflected to the sending end as the reciprocal of the connected impedance, that is, an open on the output end appears as a short on the sending end and vice-versa.

Thus, with the cable clips open, a short appears across the T104 output winding when the frequency is carefully adjusted to the quarter-wave frequency of the line by means of the panel controlled capacitor, C115. The electronic voltmeter connected in parallel to this short accordingly reads full scale, corresponding to zero voltage.

c. If the cable output is now clipped across a good capacitor, still connected in its circuit, some impedance other than zero will appear across the input of the quarter-wave combination and the voltage across the v.t.v.m. will rise causing the meter reading to drop. If the presumed capacitor is open, there will be no change in reading of meter M101.

d. The OPEN test is subject to certain limitations with respect to the size of the capacitor being examined and the relative size and kind of impedance connected across it in its own circuit.

If the capacitor is shunted by a resistor of less than 60 ohms, the reaction of the resistor alone on the quarter-wave line raises the input end impedance causing the electronic voltmeter to read down scale. This is the indication for "capacitor not open." Since the low valued resistor alone can produce the same reading the capacitor may, in fact, be open.

If the capacitor is shunted by an inductor and together they resonate to a frequency higher than the test frequency, then the parallel circuit so formed will have inductive rather than capacitive reactance at the test frequency. The condition of the capacitor is accordingly masked.

If the capacitor is 45 mmf or less it has a capacitive reactance of 500 ohms or more at the test frequency and this will be reflected to the cable input as 2.5 ohms reactance or lower. This is sufficiently close to the open end cable condition to show "open" capacitor, whereas the capacitor is merely too small to give proper indication.

Likewise, if the capacitor is between 45 and 170 mmf and is shunted by a resistor that is low relative to its reactance at the test frequency, the capacity reactance is obscured by the low resistance and false indication may result.

e. The SHORT test, Figure 2-13, employs the same electron tube voltmeter and meter setting procedure as the other test, but is supplied from the 1000 cycle generator of the Model ZM-11/U. The cable has no special electrical properties at this frequency and serves simply as a connecting means to the doubtful capacitor. Obviously, if the capacitor is shorted, the electronic voltmeter will receive no input and will remain at full scale. If the capacitor is not shorted, the meter will drop.

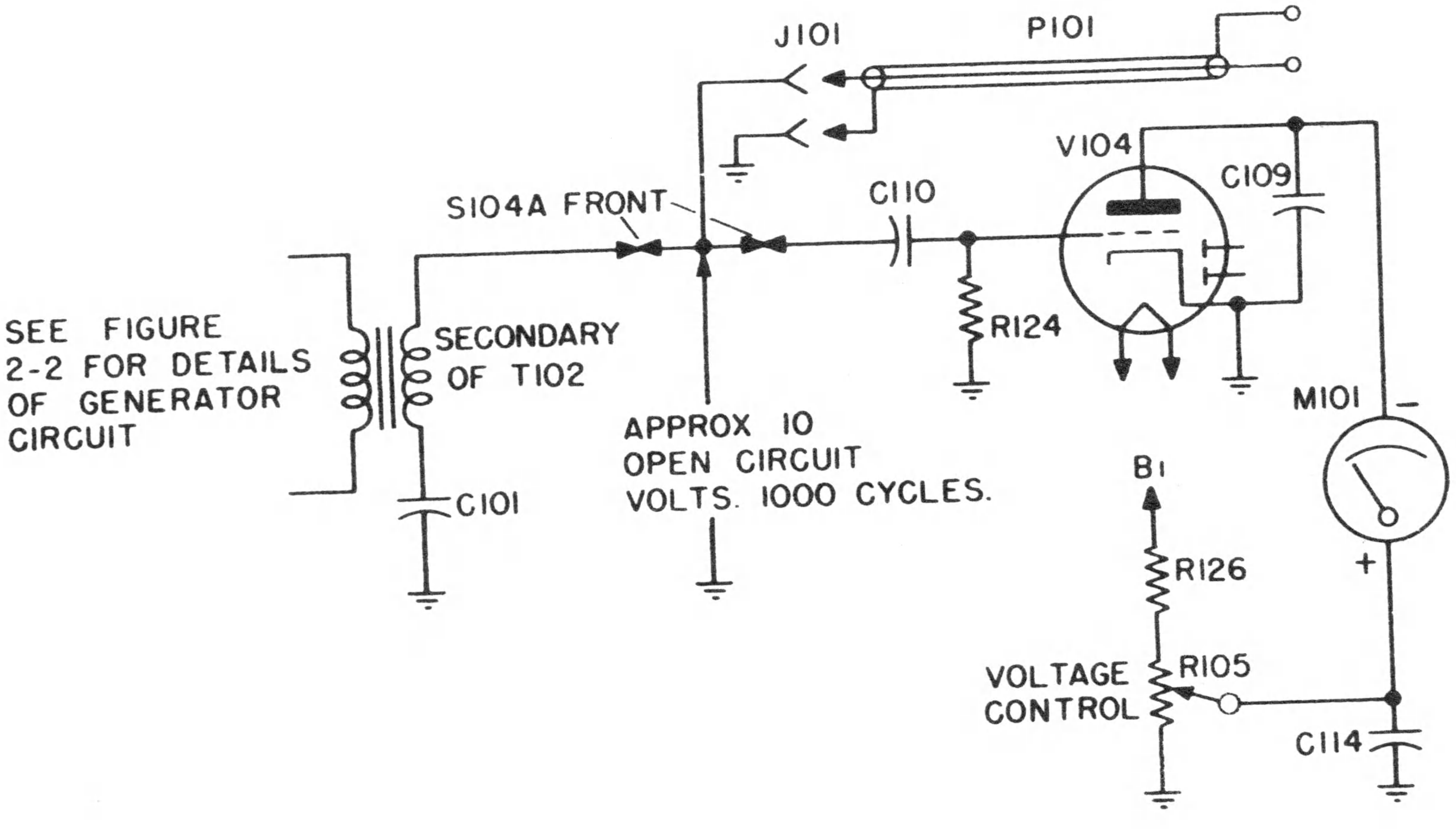


Figure 2-13. Capacitor Quality, Short Test Circuit.

If the capacitor is 50 microfarads or more it will have a capacitive reactance of 3 ohms or less at the 1000 cycle test frequency. This low value will indicate a short, whereas the capacitor is merely exhibiting its normal reactance to the test circuit.

Likewise if some smaller capacitor is shunted by a resistor of 5 ohms or less, the resistor alone will cause a short indication which may be false.

9. INSULATION RESISTANCE TEST.

a. This is for determining d-c resistance of the order of 200 to 10000 megohms such as might be found as the leakage in a paper or mica capacitor or across the contacts of a dirty switch. It is controlled by three positions of the FUNCTION switch marked INS. RES. (insulation resistance) and the principle is the voltmeter ammeter method wherein R = E/I. Figure 2-14 shows the embodiment of this principle in the Model ZM-11/U.

b. In the CAL(ibrate) INS. RES. position of the FUNCTION switch, the RF type d-c power supply and electronic voltmeter described in paragraphs 2-4 and 2-5 are connected and energized. With the meter set to full scale, exactly 1.0 milliampere flows in the meter circuit and establishes a + 3.0 volt drop across the resistor R120. This is applied to the grid of V101 through a 60 megohm resistor chain and would normally cause the eye-pattern to open fully. This is countered by an adjustable cathode bias, R104. (CALIBRATE INS. TEST on panel) so that the pattern can be made to just close, but not overlap. The applied calibrating voltage is the same as that which would be applied to the grid of V101 by a current of 0.05 microampere through the 60 megohm resistor, hence, the eye-tube has, in effect, been calibrated as an ammeter of 0.05 uA sensitivity.

c. With the FUNCTION switch in the 10000 M(egohm) position, the calibrating voltage is shorted out and the power supply with supervisory voltmeter are connected to the panel post E102.

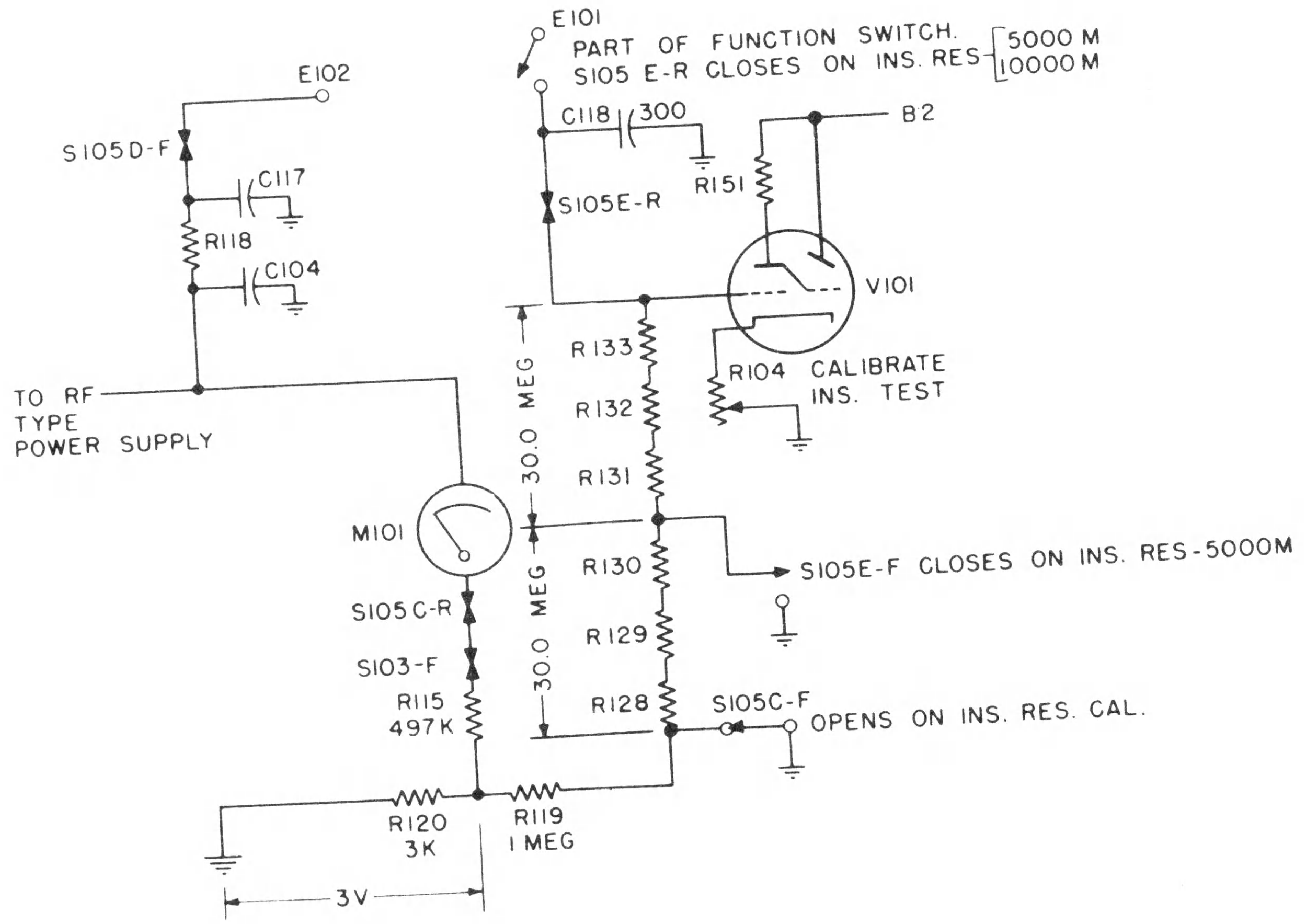


Figure 2-14. Insulation Resistance Circuit.

The grid circuit of V101 is likewise connected to the panel post E101. With the unknown connected between these two panel posts, the applied d-c voltage is adjusted until the eye-pattern again just closes, indicating that the current through the sample is just 0.05 uA. The required voltage, divided by 0.05 uA is then the resistance of the sample connected to the panel posts. As an operating convenience, this division has already been made and applied to the meter as a special calibration. It is read directly in megohms.

d. With the FUNCTION switch in the 5000 M(egohm) position, half the grid resistor of V101 is shorted out. This decreases the sensitivity of the eye-tube microammeter by one-half to 0.1 uA. The range in megohms is accordingly halved.

e. As stated in paragraph a, the method is basically the voltmeter-ammeter method where R = E/I. Thus on the 10,000 megohm range I is always 0.05 uA. At an applied voltage of 300, for example, the indicated resistance will be 300/0.05 uA or 6000 megohms. On the 5000 megohm range, I is always 0.1 uA and with, say, 250 volts applied the indicated resistance is 250/0.1 uA or 2500 megohms.

SECTION 3
INSTALLATION

1. UNPACKING.

a. The Bridge, ZM-11/U, may be received in an export packing case, domestic packing case or in its own case with the weatherproof lid secured. When new equipment is received, select a location where the equipment may be unpacked without exposure to the elements and convenient to the permanent or semi-permanent installation.

b. Figure 3-1 shows the details of the export packaging and contains numbered instructions for the unpacking procedure. Check the contents against the master packing slip.

NOTE

Save the original packing cases and containers for both export and domestic shipments, when possible. They can be used again when the equipment is repacked for storage or shipment.

2. INSTALLATION.

a. Since the ZM-11/U is a self-contained portable instrument the only installation precautions are to see that a suitable power source is conveniently available and that the instrument and items to be tested are on a substantial bench, preferably. Release the cover of the Type ZM-11/U by means of the four snap catches, revealing the front panel as shown in Figures 1-1 and 4-1. Uncoil the line supply cord from the panel posts. Most tests require a ground connection to the case. Connect the black wire coming out of the supply cord at the plug end to the electrical conduit or to a water pipe. In temporary situations a

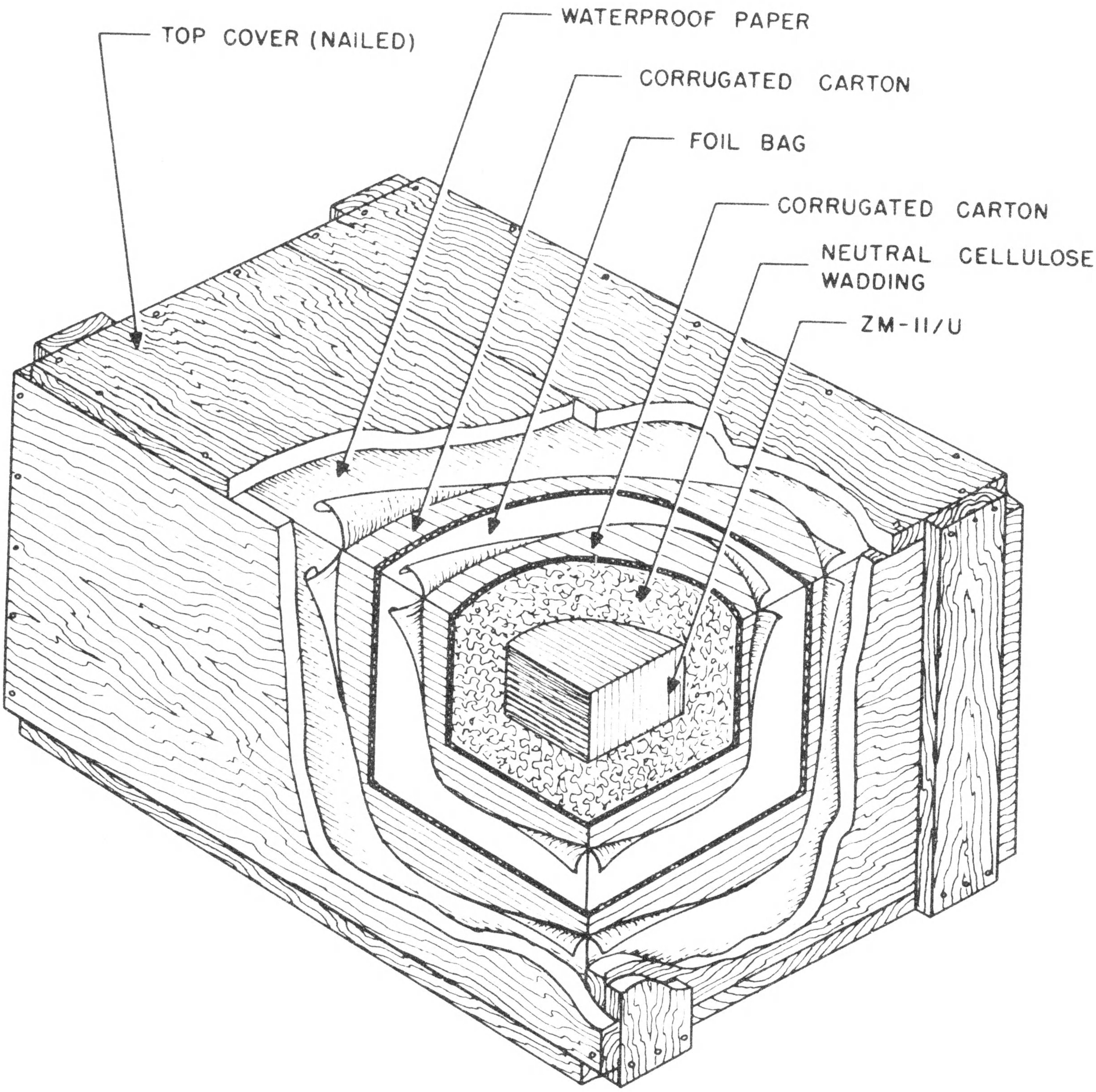


Figure 3-1. Bridge, Type ZM-11/U, Unpacking Procedure.

piece of pipe or a ground stake driven into moist earth will serve.

b. Before plugging the line cord into the power receptacle make certain that the supply voltage and frequency are within the range stated in the nameplate. Do not allow power or output cords of other devices to lay across the face of the instrument nor in the general vicinity of the binding posts.

3. INITIAL ADJUSTMENTS.

Turn the POWER switch ON. The pilot lamp to the left should light and after a minutes warm-up the greenish pattern should appear in the INDICATOR tube. The ZM-11/U is now ready for any of the numerous test and measurement operations detailed in the next Section.

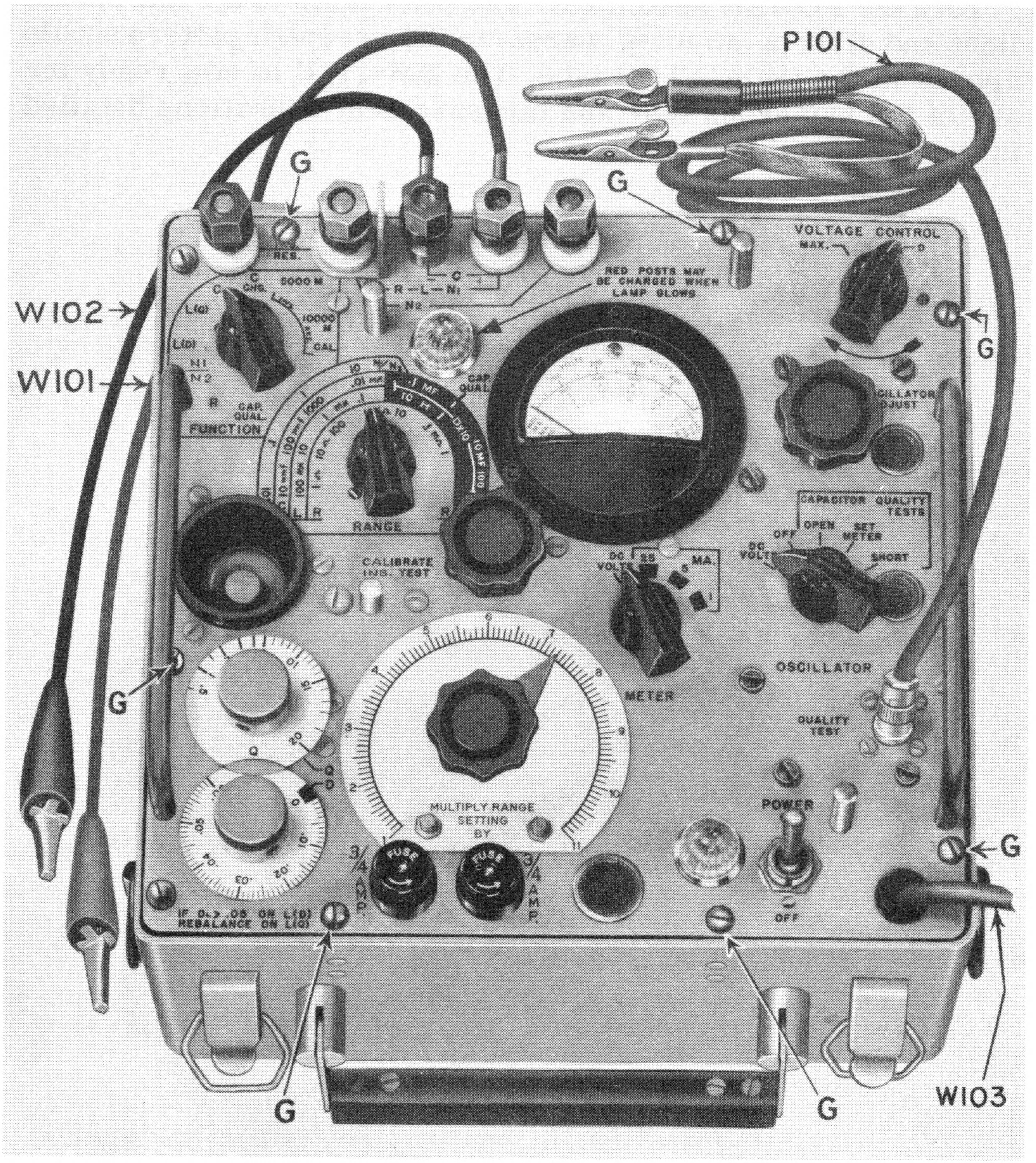


Figure 4-1. ZM/11U Bridge, Set up for Operation.

SECTION 4
OPERATION

CAUTION

The ZM-11/U Bridge has its own self contained sources of power for all tests described in this section. Before connecting the Bridge to any component in a receiver or transmitter, make certain that all sources of power to the latter, both line and battery are disconnected. Discharge all capacitors before connecting the Bridge. Failure to observe this may result in damage to the Bridge or destroying its basic accuracy.

1. INTRODUCTION.

a. The tests and measurements of which the ZM-11/U Bridge is capable are numerous and of wide range so it would be well to become as familiar as possible with the panel and control layout as early as possible. Figure 4-1 shows a view of the panel and general appearance as set up for operation. The panel designations are necessarily abbreviated in many instances, consistent with the limited panel area available. These are now amplified with brief statements on what the various controls are for.

b. Description of panel controls.

FUNCTION SWITCH—upper left, Positions named clockwise.

CAP. QUAL.	Capacitor Quality. For general condition, short or open. NOT for capacitance measurement.
R	Resistance. Bridge measurement at 1000 cycles.

$\frac{N_1}{N_2}$	Turn Ratio. Bridge measurement. Refers to number of turns of respective windings of transformer.
L(D)	Inductance. Bridge measurement. Dissipation factor balanced and read on D dial at lower left.
L(Q)	Inductance. Bridge measurement. Storage factor of coil balanced and read on Q dial, just above D dial.
C	Capacitance. Bridge measurement. Losses are balanced and read on D dial.
C CHG.	Capacitance, Charge. Same as C function but with d-c polarization applied to unknown capacitor.
INS. RES.	5000 M(egohms) 10000 M(egohms) CAL(ibrate) — Insulation Resistance test with direct current. Two ranges available as named.

RANGE SWITCH—upper left. Selects the bridge ranges.

N_1/N_2 ring	Read when making Turn Ratio measurement. Ratios .01, 1, 1 or 10 to be multiplied by the setting of the MULTIPLY RANGE SETTINGS BY dial.

C ring

10	mmf	(micromicrofarads)
100	mmf	
1000	mmf	
.01	MF	(microfarads)
.1	MF	
1	MF	Note reverse color
10	MF	Sector, these ranges.
100	MF	D x 10

L ring	100	MH (millihenries)	
	10	MH	
	1	MH	
	.1	MH	Note reverse color sector, these ranges. D x 10
	10	H (henries)	
	1	H	

R ring	1	(ohm)
	10	
	100	
	1	KΩ (kilohm or 1000's of ohms)
	10	KΩ
	.1	MΩ (megohm or 1,000,000's 0f ohms)
	1	MΩ

CAP. QUAL. — Shows position of RANGE switch for capacitance quality tests.

Q DIAL—LOWER LEFT

0-20 — Storage factor of coil. This is infinity to .05 in dissipation, hence this dial overlaps:-

D DIAL—LOWER LEFT

0 - .06 — Dissipation factor. Reads 0 - 0.6 when used on the D x 10 ranges of the L(D) and C functions.

MULTIPLY RANGE SETTING BY— Main lower dial.

1.0 - 11.0 — This is an interpolating control covering all increments between settings of the RANGE switch.

METER SWITCH— just below panel meter.

DC VOLTS	Range 0-500. Spring returns switch to this position.
25 5 MA 1	(milliampere - .001 ampere) Selects suitable range for reading leakage current.

OSCILLATOR SWITCH— right hand center.

DC VOLTS	Connects r-f type power supply so that d-c voltage is available for capacitor charging and insulation resistance tests.
OFF	Disconnects next above.
OPEN SET METER SHORT	Three positions for the CAPACITOR QUALITY TESTS.

OSCILLATOR ADJUST— to the right of the panel meter.

(No marks)	Adjusts the 10.75 mc oscillator to exact quarter wave relationship with the line for making the Open Test - Capacitor Quality.

VOLTAGE CONTROL— upper right hand.

0 - MAX	Adjusts the output from the d-c power supply. Used in connection with the Insulation Test, Capacitor Quality Tests and polarizing electrolytic capacitors.

CALIBRATE-INS. TEST— lower left of panel meter.

Calibrate Insulation Test. Controls the initial indicator pattern prior to making the insulation test.

POWER, ON-OFF— lower right

Controls line power to all internal circuits. Pilot lamp at left indicates line "ON".

2. CAPACITOR QUALITY TESTS.

a. General. These tests determine the condition of a capacitor, in a general way, without removing it from its chassis or circuit. The tests are included for quick checks of many capacitors without disconnecting each one for testing. When the quality test indicates any abnormality, one end of the capacitor should be disconnected and the capacitor checked in the usual manner.

To start the test, remove the coaxial cable (RF Cable Assembly P101) from the lid and plug it into the QUALITY TEST jack at the right.

b. OPEN test. Let the cable lay loosely to one side and make certain the clips are not touching each other. Turn the

FUNCTION switch to CAP. QUAL.
RANGE switch to CAP. QUAL.
D dial to 0.
VOLTAGE CONTROL to 0.
OSCILLATOR switch to SET METER.

Advance the VOLTAGE CONTROL until the meter reads full scale and

Turn OSCILLATOR switch to OPEN.
Set OSCILLATOR ADJUST until the meter
meter reads full scale.

Now the meter is calibrated and the oscillator is adjusted to the quarter wave frequency of the transmission line and you may connect the clips to the capacitor to be tested, connecting the ground lead of P101 to ground lead or lead nearest ground of the capacitor being tested. If the meter continues to read full scale, the capacitor is open unless:-

(1) It is shunted by a resistor of less than 60 ohms.
(2) It is shunted by an inductor which resonates it to a frequency higher than 9 megacycles.
(3) It is less than 45 micromicrofarads.
(4) It is small and shunted by a resistor less than the value shown in Table 4-1.

If the meter reads downscale, that is, at other than full scale, the capacitor is either all right or short-circuited. The actual meter reading has no importance.

Applicability of (1), (3) or (4) is determined by inspection of the circuit constants of the device in which the capacitor is installed. Likewise applicability of (2) may be determined from the tuning ranges of the device or from the product of the capacitor under test and the value of the shunting inductance. In general, if the product of the capacitor (in mmf) and the inductance (in microhenries) is less than 300, the inductor should be disconnected before testing the capacitor.

c. SHORT Test. When the OPEN test indicates that the capacitor is short-circuited or not open, it is necessary to make the SHORT test to differentiate. Turn the

OSCILLATOR switch to SHORT

and observe the meter reading. If it returns to full scale, as previously calibrated, the capacitor is short circuited. If it reads below full scale, the capacitor is not short circuited. This indication may be false if:-

(1) The capacitor is shunted by a resistance of less than 5 ohms.
(2) The capacitor has a nominal value greater than 50 microfarads.

This test is included for quick checks of many capacitors without disconnecting each one for testing. When the quality test indicates an adnormality, one end of the capacitor should be disconnected and the capacitor checked in the usual manner.

TABLE 4-1. MINIMUM SIZE SHUNTING RESISTOR BELOW WHICH OPEN QUALITY TEST IS VOID.

NOMINAL SIZE OF CAPACITOR MMF	MINIMUM SIZE OF RESISTOR OHMS	NOMINAL SIZE OF CAPACITOR MMF	MINIMUM SIZE OF RESISTOR OHMS
170	100	75	1000
140	200	60	2000
120	300	50	5000
110	400	47	10000
100	500	45	Infinite

Applicability of (1) or (2) can usually be determined from the circuit diagram and data of the device in which the capacitor is a part.

3. RESISTANCE. Range 1 ohm to 11.0 megohms.

a. Turn the FUNCTION switch to R. Connect the unknown to the R posts, second and fourth from the left. Select a suitable RANGE setting, reading from the R ring. Turn the MULTIPLY BY dial until the INDICATOR pattern shows the maximum possible opening, indicating balance. If this comes at either extreme of the dial, take the next higher or lower setting of the RANGE switch and rebalance. Multiply the RANGE setting by the MULTIPLY BY dial setting to get the resistance.

b. The resistance as determined by the bridge circuit is the 1000 cycle value. Some difficulty may be had in obtaining a sharp balance with inductive resistors. Such units may be shunted by a variable capacitance during measurement, this being varied until a sharp balance point is obtained. The resistance value read from the bridge will not be affected by this reactance neutralization.

The resistance of highly inductive units may be better determined by measuring them as inductances and computing the 1000 cycle resistance from the Q or D determination thereof. The way to do this is fully explained in paragraph 5c.

c. When non-inductive resistors of 100,000 ohms and higher are connected to the bridge with the test leads, the balance may be impaired by the capacitance between the leads. Connection of the resistor directly to the binding posts is recommended for the higher values.

4. TRANSFORMER TURN RATIO. Range 0.01 to 110.

a. Turn the FUNCTION switch to N1/N2. Connect one winding to the N1 posts, second and fourth from left, and the other winding to the N2 posts, second and fifth. At each of the four RANGE switch positions, N1/N2, run the MULTIPLY BY dial over its range while watching the INDICATOR pattern. If no balance is obtained, (balance is indicated by maximum opening of the eye tube) reverse the binding post connections to one winding and repeat. If balance is now had but is fuzzy or broad, reverse the connections to both windings to eliminate the effect of interwinding capacitance and rebalance. The turn Ratio is the setting of the RANGE switch, read in the N1/N2 ring, times the setting of the MULTIPLY BY dial.

b. Effect of Coupling Coefficient. The theory of the Turn Ratio measurement shows that the true ratio is measured only when the transformer has complete magnetic coupling between the two windings, that is, a coupling coefficient of 1.0. The possible error, otherwise, is negligible for a ratio of 1.0 but increases with the ratio. To get a working idea of this, see Table 4-2.

The stated errors are in the direction that makes the measured ratio appear higher than actual.

Well designed two-winding transformers will usually have

TABLE 4-2. ERROR IN TURN RATIO DUE TO IMPERFECT COUPLING.

RATIO	1.0	2.0	5.0	10.0	100
COUPLING COEF. K	Percent Error	Percent Error	Percent Error	Percent Error	Percent Error
1.0	0.0	0.0	0.0	0.0	0.0
.98	0.0	0.8	1.3	1.8	2.0
.95	0.0	1.8	3.5	4.2	5.0
.90	0.0	3.5	8.2	9.0	10.8

sufficiently close coupling so the errors will be negligible except for the highest ratios. The Turn Ratio test is useless on intermediate and radio frequency transformers because of the very slight coupling of such coils. For the same reason, their turn ratio is not usually of interest.

5. INDUCTANCE Range 100 microhenries to 110 henry.

a. Connect the unknown inductor to the L posts, second and fourth from left. Turn the FUNCTION switch to the L(D) or L(Q) position depending on the probable loss factor of the coil being tested. Usually coils with powdered-iron cores designed for operation in the audio range will fall within the loss range of L(D) while others, such as RF and IF coils will fall in the loss range of L(Q). If unable to guess which, attempt a balance on the L(Q) setting. Select a probable RANGE setting, L ring, and attempt a balance by rotating the MULTIPLY BY dial. If any indication of balance is had, try to perfect it by simultaneous adjustment of the Q dial. If balance is approached at either end of the MULTIPLER dial, try the next higher or lower RANGE setting and perfect the balance.

If you reach a point where you pass through a partial balance on the MULTIPLY BY dial but are unable to perfect it because of lack of range on the Q dial, the coil probably has a Q factor greater than 20 and you should shift the FUNCTION switch setting to L(D). You should now be able to perfect the balance using the D dial. Note the mechanical interlock between the D and Q dials which makes it necessary to return either one to its initial position before the other can be turned.

b. Read the RANGE setting and multiply it by the setting of the MULTIPLY BY dial. The product is the inductance of the unknown. Note the setting of the D or Q dial at which balance was had. If inductance balance was had in one of the reverse color ranges, 10 or 1 henry, the D dial setting is to be multiplied by 10. If the apparent value of D, as measured on the L(D) function is in excess of 0.05, the balance point must have been missed on the L(Q) function or should be repeated there for best accuracy in the inductance determination.

c. If the equivalent series resistance, at 1000 cycles, of the coil is desired it may be computed from

$$R = \frac{2\pi f L}{Q} \quad \frac{6280 \times L}{Q}$$

or from

$$R = 2 \quad f L D = 6280 \quad L \times D$$

In either computation, don't forget to point off three places if L is in millihenries, six if in microhenries.

Example 1: Assume a coil has been measured on the ZM-11/U and found to have an inductance of 90 millihenries and a Q of 15. Then

$$R = \frac{6280 \times 90}{15} = 37.680 \text{ ohms. for MH.}$$

Example 2: Assume a coil measured 15.0 Henries and a D of 0.03. Then

$$R = 6280 \times 15 \times .03 = 2826 \text{ ohms}$$

NOTE

Where the very highest accuracy of results is required, readings of the Q dial should be corrected in accordance with the correction curve found in the lid of the instrument under the instruction manual.

d. If the measured inductance is in excess of 10 henries and the test leads have been used for connection, eliminate or separate them as much as possible for minimum mutual capacitance where highest accuracy is needed. At 1000 cycles, sufficient capacitance may be present from bunched leads to cause the inductance to measure a little high.

6. CAPACITANCE. Range 10 micromicrofarads to 1100 microfarads.

a. Connect the unknown capacitor to the C posts, third and fourth from left. Turn the FUNCTION switch to C. Select a suitable RANGE setting, C ring. Attempt a balance with the MULTIPLY BY dial, perfecting it by simultaneous adjustment of the D dial. With complete balance, read the capacitance as the product of the RANGE setting and the MULTIPLY BY dial. Read the D dial for the loss factor. Multiply the D dial reading by ten when using any RANGE in the reverse color sector.

b. If required, the equivalent series resistance of the capacitor at 1000 cycles may be computed from

$$R = \frac{B}{2 \pi f C} = 159 \frac{D}{Cm}$$

where Cm is the measured value of the capacitor in microfarads. If C is in micromicrofarads, multiply by 1,000,000.

Example 1: Assume that a capacitor has been found to have a capacitance of 18 MF and a D of 0.3. Then

$$R = \frac{159 \times .3}{18} = 2.67 \text{ ohms.}$$

Example 2: Another capacitor has a capacitance of 120 mmf and a D of 0.04. Then

$$R = \frac{159 \times .04}{120} \times 1{,}000{,}000 = .053 \times 1{,}000{,}000 = 53{,}000$$

c. When very small capacitors are measured, readings of D somewhat different than the actual dissipation of the sample capacitor will be obtained. This is due to the losses in the binding post and switch deck insulation as well as other inevitable solid dielectric material in parallel with the capacitor while it is being measured. When the true value of dissipation is required it may be computed from

$$d = D + \frac{17}{Cmm} \times (D - .02)$$

where d is the actual dissipation
D is the reading of the D dial
Cmm is the capacitance in mmf.

Example 1: Cmm is found to be 40 mmf and D, read from the dial, is .035. Then

$$d = .035 + \frac{17}{40}(.035 - .02) = .0413$$

Example 2: Cmm is 60 mmf and D is .01. Then

$$d = .01 + \frac{17}{60}(.01 - .02)\quad .00717$$

or the value may be interpolated from the graph in Figure 4-2. For values of C higher than 100 uuf, the correction is negligible for practical purposes.

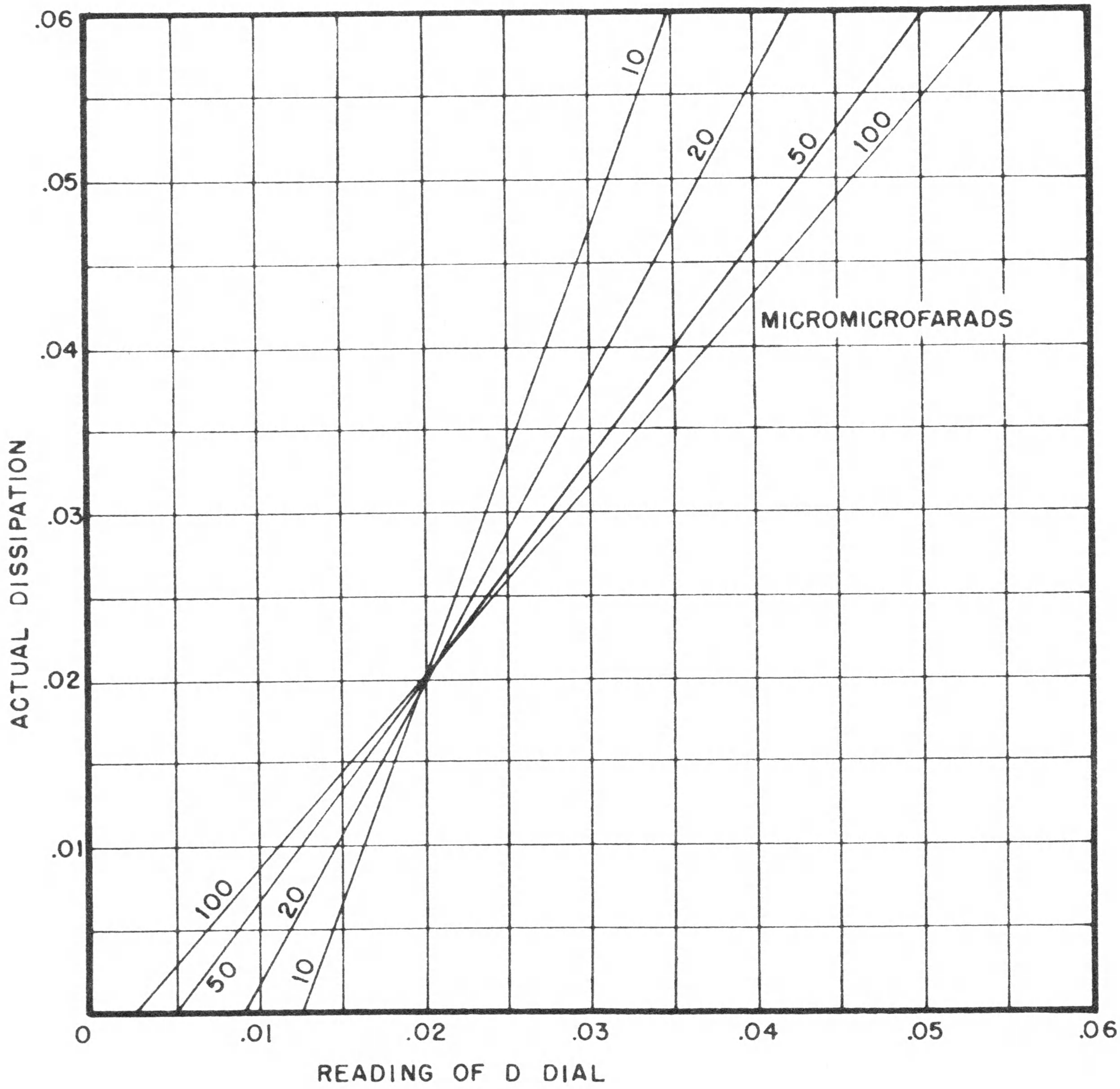


Figure 4-2. Correction Curve for D when measuring Small Capacitors.

d. Electrolytic Capacitors. Observe the polarity marks adjacent to the C binding posts when making connections to the unknown. Turn the VOLTAGE CONTROL to 0. After this, turn the FUNCTION switch to C.CHG. (charge) and the OSCILLATOR switch to D.C. VOLTS. The pilot adjacent to the meter will light indicating that the charging power supply is connected. Advance the VOLTAGE CONTROL, slowly until the meter reads capacitor voltage. Failure of the meter to respond means a shorted or excessively leaky capacitor. One which has not seen service for some time will form or polarize very slowly. Some will perhaps require current that is in excess of the power output from the ZM-11/U power supply which is capable of:-

10 milliamperes up to 100 volts
5 milliamperes up to 300 volts
3.5 milliamperes up to 450 volts

When the voltmeter reading is stable at the rated capacitor voltage or lower, if desired, proceed with measurement. Capacitance and dissipation are determined by balancing the bridge in the same manner directed for the C function. Electrolytic units often show somewhat different characteristics when polarized.[1]

WARNING

High voltages are employed in the above test. Always use the insulated clips.
~~Discharge capacitors immediately after used.~~
Turn the voltage control to 0 immediately after use. Keeping away from any metal, Discharge capacitor while it is still connected to the ZM-11/U Series Bridge. Remove the capacitor and short its terminals again to remove any reconstituted charge.

e. Direct Current Leakage. While the electrolytic capacitor is polarized as above, its direct current leakage may be determined by turning the METER switch to the 25 MA (milliampere) position. If the indicated current is less than 5 MA, turn to the 5MA range and similiarly to the 1 MA range in order to read well upscale on the meter. Do not attempt to read the leakage current until complete polarization is indicated by a stable voltage reading. Failure to observe this may result in damage to the meter.

[1] See paragraph 304C of NAVSHIPS 900,628 for additional data on recharging capacitors

7. INSULATION RESISTANCE.

Range 200 to 10,000 megohms at d-c.

a. Connect the sample to the INS. RES. posts, first and second from the left.

Turn FUNCTION switch to CALIBRATE

Turn OSCILLATOR switch to D. C. Volts.

Advance VOLTAGE CONTROL until meter reads 500 volts.

Turn CALIBRATE / INS. TEST until INDICATOR pattern just closes.

Turn FUNCTION switch to 5000 M(egohms) or 10000 M(egohms)

If the INDICATION pattern closes permanently, the resistance of the sample is in excess of the full range selected. If the pattern opens, reduce the applied voltage (VOLTAGE CONTROL) until the pattern is just closed, the same as employed in calibration. Read the insulation resistance from the meter scale.

b. It will be noted in Figure 2-14 that the sample, if a capacitor, must charge through a very large resistance. If the capacitor is large this may take a matter of minutes. This delay may be a nuisance, particularly if the line voltage fluctuates amd further delay is required for the capacitor to assume its new charge. The test will be speeded if one of the test leads is connected to the GND binding post and its tip tapped on the left hand post while making the final adjustment of the INDICATOR pattern. This provides a low resistance charging path for the large capacitor.

8. ACCURACY OF MEASUREMENTS.

The basic accuracy of the Bridge ZM-11/U as received from the factory and with the various precautions of these instructions observed is shown in Table 4-3.

TABLE 4-3. BASIC ACCURACY OF THE FUNCTIONS OF ZM-11/U BRIDGE.

MEASUREMENT	RANGE	MAXIMUM ERROR REFERRED TO READING.	
(Test Current)	mmf:micromicrofarad MF:microfarad MH:millihenry H:henry meg:megohm	NORMAL CONDITIONS Temp.24°C. Pressure 14.9 PSI. Relative humidity 70%	Temperature 0-55°C. Humid.0-90% to 38°C Line 105-125 volts 50 to 1000 cycles.
Capacitance (1 kc)	10 mmf to 10 MF 1 MF to 100 MF 10 MF to 1100 MF	2% +1 scale div. 3@ +1 scale div. 5% +1 scale div.	4% +1 scale div. 6% +1 scale div. 6% +1 scale div.
Inductance (1 kc)	0.1 MH to 1 H 1 H to 10 H 10 H to 110 H	2% +1 scale div. 5% +1 scale div. 10% +1 scale div.	6% +1 scale div. 10% +1 scale div. 15% +1 scale div.
Resistance (1 kc)	1 ohm to 11 meg	2% +1 scale div.	5% +1 scale div.
Insulation Resistance Test (direct current)	200 to 500 meg 5000 to 1000 meg	3% +100 megohms 3% +200 megohms	20% +100 megohms 20% +250 megohms
Transformer Turn Ratio	0.01 to 110 (K=1)	2% +1 scale div.	5% +1 scale div.
D-C Leakage current of capacitors (d-c)	0 to 1, 5, & 25 milliamperes	3% of full scale	5% of full scale
D dissipation factor (1 kc)	0-.06(10mmf-.1MF) 0-.6(.1MF-1100MF)	20% +.02 in D	30% +.03 in D
Q storage factor (1 kc)	0.5 to 20	20%	30%
D-C applied to electrolytic capacitors	0 to 500 volts	5% of full scale	8% of full scale

FAILURE REPORT

A failure report must be filled out for the failure of any part of the equipment whether caused by defective or worn parts, improper operation, or external influences. It should be made on Failure Report, form NBS-383, which has been designed to simplify this requirement. The card must be filled out and forwarded to BUSHIPS in the franked envelope which is provided. Full instructions are to be found on each card.

Use great care in filling the card out to make certain that it carries adequate information. For example under "Circuit Symbol" use the proper circuit identification taken from the schematic drawings, such as T803, in the case of a transformer, or R207, for a resistor. Do not substitute brevity for clarity. Use the back of the card to completely describe the cause of failure and attach an extra piece of paper, if necessary.

The purpose of this report is to inform BUSHIPS of the cause and rate of failures. The information is used by the Bureau in the design of future equipment and in the maintenance of adequate supplies to keep the present equipment going. The cards you send in, together with those from hundreds of other ships, furnish a store of information permitting the Bureau to keep in touch with the performance of the equipment of your ship and all other ships of the Navy.

This report is not a requisition. You must request the replacement of parts through your Officer-in-Charge in the usual manner.

Make certain you have a supply of Failure Report cards and envelopes on board. They may be obtained from the nearest District Printing and publications office.

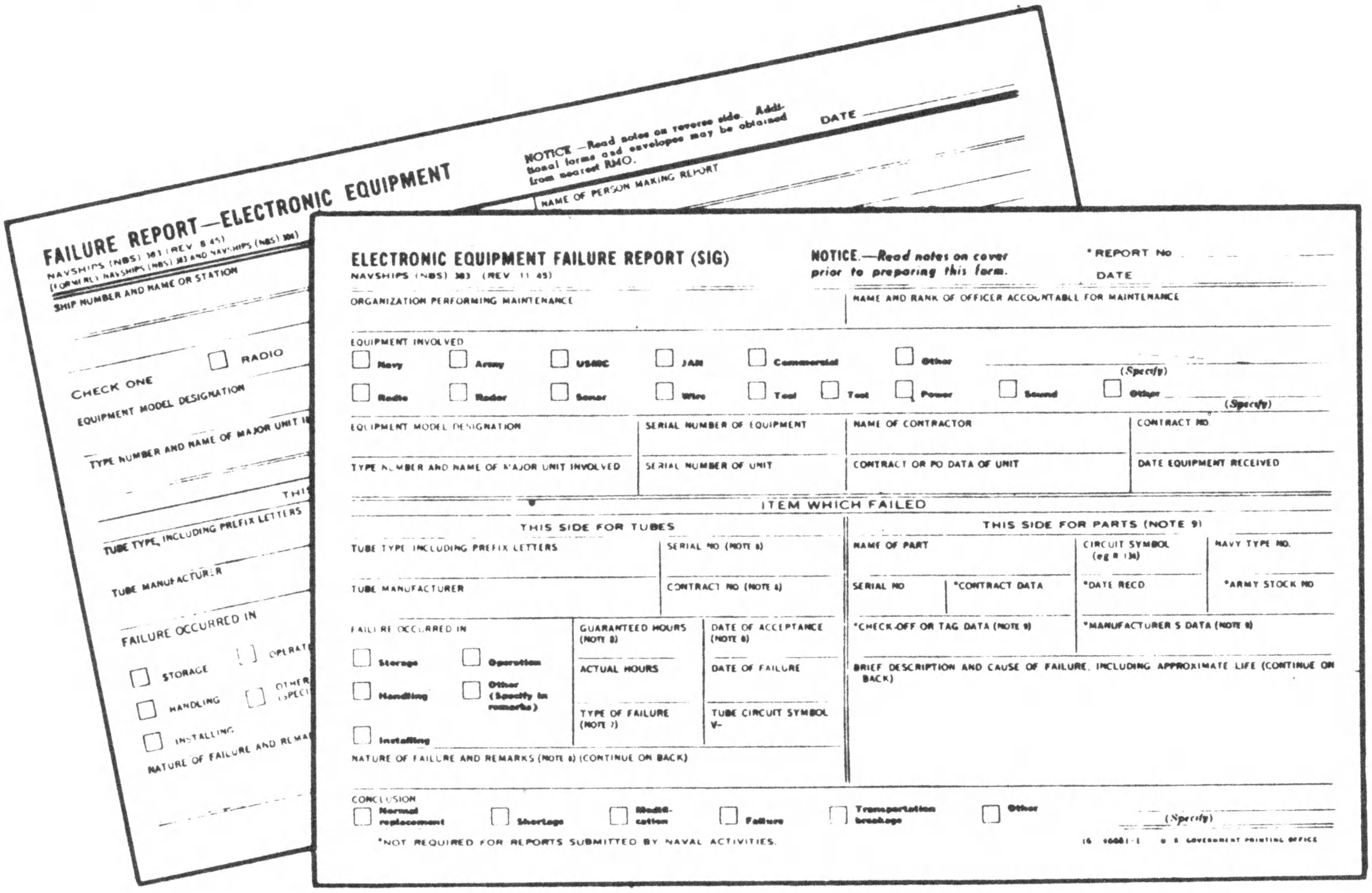
SECTION 5
MAINTENANCE

1. GENERAL.

Since C-R-L Bridge, A-N Type ZM-11/U, is essentially a maintenance instrument it may go unused for considerable periods of time but, when needed, it must be in first class operating condition and its calibrations unimpaired to be of any value whatsoever. Because of this, the value of routine checks on its operating condition cannot be overemphasized.

2. EMERGENCY MAINTENANCE.

Table 5-1 shows the indications of fuse failure. Two fuses in turn-cap mounts appear on the panel, Figure 4-1, and one is connected in each side of the power line circuit. The proper


FAILURE REPORT—ELECTRONIC EQUIPMENT
NOTICE —Read notes on reverse side. Additional forms and envelopes may be obtained from nearest RMO.
DATE
NAME OF PERSON MAKING REPORT
SHIP NUMBER AND NAME OR STATION
CHECK ONE
RADIO
EQUIPMENT MODEL DESIGNATION
TYPE NUMBER AND NAME OF MAJOR UNIT
TUBE TYPE, INCLUDING PREFIX LETTERS
TUBE MANUFACTURER
FAILURE OCCURRED IN
STORAGE
HANDLING
INSTALLING
NATURE OF FAILURE AND REMARKS

ELECTRONIC EQUIPMENT FAILURE REPORT (SIG)
NAVSHIPS (NBS) 383 (REV. 11 45)
NOTICE.—Read notes on cover prior to preparing this form.
*REPORT No
DATE
ORGANIZATION PERFORMING MAINTENANCE
NAME AND RANK OF OFFICER ACCOUNTABLE FOR MAINTENANCE
EQUIPMENT INVOLVED
Navy | Army | USMC | JAN | Commercial | Other (Specify)
Radio | Radar | Sonar | Wire | Test | Test | Power | Sound | Other (Specify)
EQUIPMENT MODEL DESIGNATION
SERIAL NUMBER OF EQUIPMENT
NAME OF CONTRACTOR
CONTRACT NO.
TYPE NUMBER AND NAME OF MAJOR UNIT INVOLVED
SERIAL NUMBER OF UNIT
CONTRACT OR PO DATA OF UNIT
DATE EQUIPMENT RECEIVED
ITEM WHICH FAILED
THIS SIDE FOR TUBES
TUBE TYPE INCLUDING PREFIX LETTERS
SERIAL NO (NOTE 8)
TUBE MANUFACTURER
CONTRACT NO (NOTE 8)
FAILURE OCCURRED IN
Storage | Operation
Handling | Other (Specify in remarks)
Installing
GUARANTEED HOURS (NOTE 8)
DATE OF ACCEPTANCE (NOTE 8)
ACTUAL HOURS
DATE OF FAILURE
TYPE OF FAILURE (NOTE 7)
TUBE CIRCUIT SYMBOL V-
NATURE OF FAILURE AND REMARKS (NOTE 8) (CONTINUE ON BACK)
THIS SIDE FOR PARTS (NOTE 9)
NAME OF PART
CIRCUIT SYMBOL (eg R 136)
NAVY TYPE NO.
SERIAL NO
*CONTRACT DATA
*DATE RECD
*ARMY STOCK NO
*CHECK-OFF OR TAG DATA (NOTE 9)
*MANUFACTURER S DATA (NOTE 9)
BRIEF DESCRIPTION AND CAUSE OF FAILURE, INCLUDING APPROXIMATE LIFE (CONTINUE ON BACK)
CONCLUSION
Normal replacement | Shortage | Modification | Failure | Transportation breakage | Other (Specify)
*NOT REQUIRED FOR REPORTS SUBMITTED BY NAVAL ACTIVITIES.
U. S. GOVERNMENT PRINTING OFFICE

Figure 5-1. Failure Report, Sample Form.

size is 3/4 ampere as marked adjacent to the fuse mounts. Access holes in the top of these mounts permit insertion of test prods for determining the condition of the fuses and the line connection. A spare fuse for emergency use is mounted in clips on the back of the panel. The location is shown in Figure 5-2. See paragraph 4a for instructions for removal of the instrument from its case.

REPLACEMENT OF FUSES

WARNING

Never replace a fuse with one of a higher rating unless continued operation is more important than probable damage. If a fuse burns out immediately after replacement, do not replace it a second time until the cause has been corrected.

Pilot lamps may be replaced from the panel side by unscrewing the jewel cap after which the lamp may be released from its receptacle by a slight twist.

Replacement of fuses and pilot lamps is the only emergency maintenance permissible during operation of the ZM-11/U Bridge.

3. PREVENTIVE MAINTENANCE.

a. GENERAL - Preventive maintenance is maintenance performed on equipment (usually when the equipment is not in use) to keep it in good working order. Preventive maintenance differs from trouble shooting and repair in that its object is to prevent the occurrence of troubles.

b. ROUTINE MAINTENANCE CHECK CHART. - The procedures listed in Table 5-1 are to be performed weekly, unless the interval is modified by the officer-in-charge.

TABLE 5-1. WEEKLY ROUTINE MAINTENANCE CHART.

WHAT TO DO	OBSERVE-CORRECT OPERATION	TROUBLE-DISPOSITION
1. Ground line cord tab, plug in line, turn POWER to ON.	Line pilot should light. After 1 minute, INDICATOR should show pattern.	If neither, check for blown fuse, broken line plug or dead power receptacle.
		If INDICATOR patterns but no pilot, check for dead pilot.
		If pilot lights but no INDICATOR, refer to Table, 5-3, Item 1.
2. Turn VOLTAGE CONTROL to 0; FUNCTION to C. CHG.; OSCILLATOR to D.C. VOLTS.	Binding post pilot should light.	If not, replace pilot. If still not, refer to Table 5-3, Item 2, NOW.
	DO NOT CONTINUE TESTS WITHOUT PILOT PROTECTION	
3. Advance VOLTAGE CONTROL slowly and watch panel meter.	Smooth adjustment to 500 volts should be had.	If adjustment erratic, refer to Table 5-3, Item 3. If no or low voltage, refer to Table 5-3, Item 4.
4. Connect 120,000 ohm resistor to C posts and repeat (3).	Smooth adjustment to 500 volts should be had.	If erratic, refer to Table 5-3, Item 3. If can't secure 500 v. refer Table 5-3, Item 4.

5. Hold (4) and 450 v. and turn METER to 25, then 5 MA.	Read 3.5 MA each range. (See tolerance Table 4-3)	If out of tolerance, see Table 5-3, Item 5.
6. Calibrate INS. RES. per Sec. 4 Par. 7.	Meter should adjust to full scale. INDICATOR pattern should appear as described.	If not refer to Table 5-3, Item 6.
7. Calibrate CAPACITOR QUALITY TEST as per Sec. 4, Par. 2a.	Meter should adjust full scale as per the instructions.	If can't adjust, electron voltmeter is defective. Refer Table 5-3, Item 7.
8. Turn OSCILLATOR to OPEN. Adjust per Sec. 4, Par. 2a. Short clips of R-F Cable, P101.	Meter remains full scale with open test clips. Meter should drop to 300 v. or less.	If not refer to Table 5-3, Item 8. Higher reading means weak r-f oscillator. See Table 5-3, Item 8.
9. Turn OSCILLATOR to SHORT. Open clips of R-F Cable, P101.	Meter remains full scale with clips shorted. Meter should drop to 250 v. or less.	If not, short in output. See Table 5-3, Item 9. If higher, 1000 cycle oscillator-amplifier may be weak. Table 5-3, Item 9.
10. Measure various spare components, standards if available, on various bridge functions.	Compare measured values with marked nominal values. (See tolerances in Table 4-3.)	If out of tolerance, chart your results and refer to Table 5-2 to isolate defective bridge element.
11. Inspect test leads.	No frays. No shorts. No opens.	Repair as required. For P101, see Par. 10a.

NOTE

The attention of maintenance personnel is invited to the requirements of Chapter 67 of the Bureau of Ships Manual, of the latest issue.

c. RE-TROPICALLIZATION. - The Bridge, Type ZM-11/U, has been moistureproofed and fungusproofed at assembly. No further treatment is required unless parts are replaced. Refer to Specification JAN-T-152, Treatment, Moisture - and Fungus-resistant, of Communications, Electronic, and Associated Electrical Equipment for the procedures to be used in re-tropicallization following parts replacement.

4. CORRECTIVE MAINTENANCE.

a. GENERAL. - Paragraphs 4 through 6 describe the symptoms produced by malfunctioning of the Type ZM-11/U circuits and the procedures for localizing and correcting the trouble. Calibration procedures are included in Paragraph 8 to permit restoration of the instrument to its original accuracy after replacement of any of the precision components. Table 5-1 covers all of the useful checks which can be made without removal of the instrument from its case.

REMOVAL FROM CASE.

NOTE

Never remove the instrument from the case without first disconnecting the line cord. Even a slight shock may cause you to involuntarily drop or throw the instrument.

Upend the case and remove the two hexagonal headed screws appearing on the bottom of the case. Back off the seven round head captive screws appearing around the edge of the panel marked G in Figure 4-1. These can be identified by their bright nickel finish. Have a helper hold the case, if necessary, while you grasp the panel handles and lift the entire unit clear of the case.

PRECAUTIONS. - Careless inspection and replacement of parts often makes new faults inevitable. Note the following points:

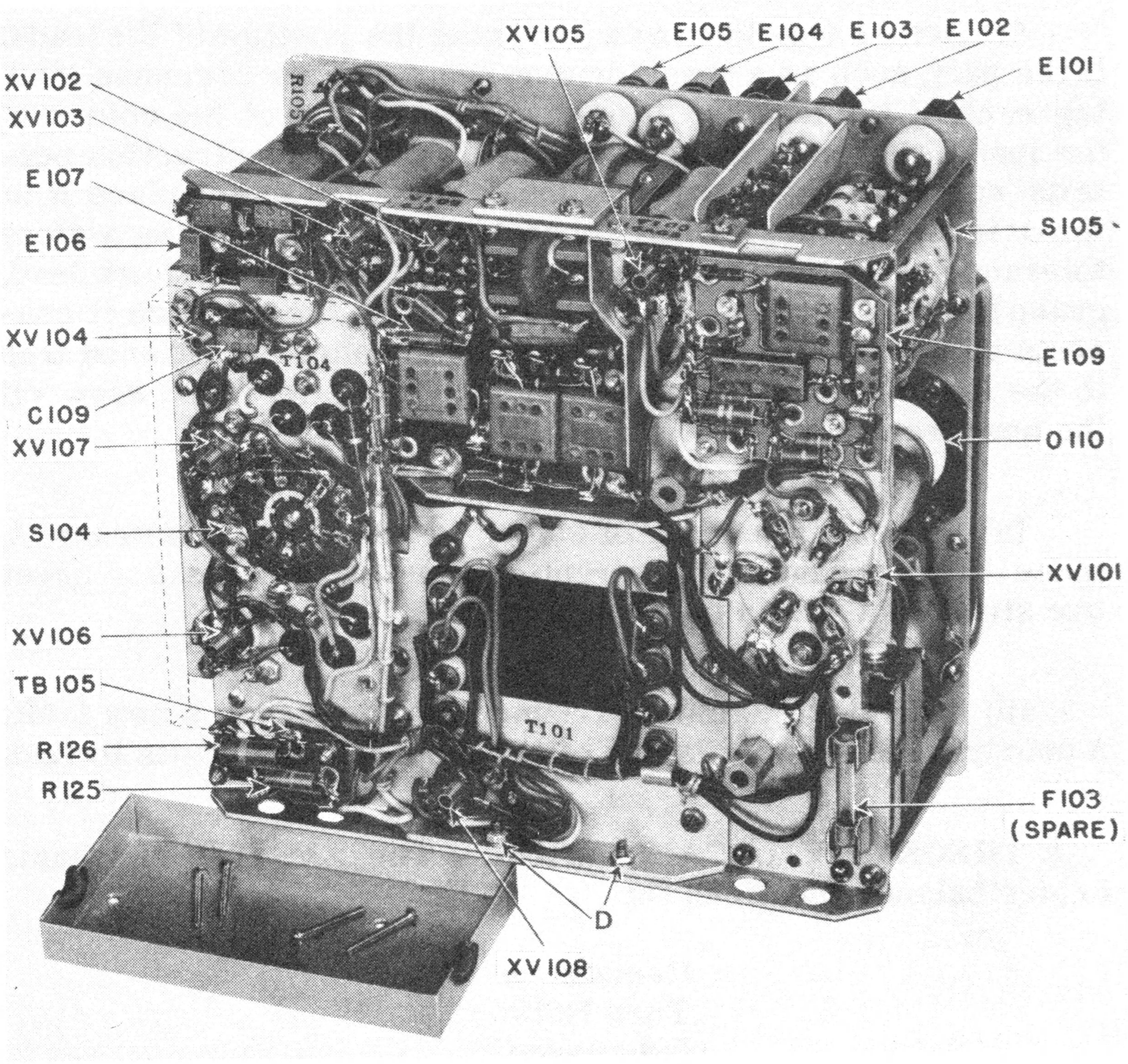


Figure 5-2. ZM-11/U Bridge, Removed from Case.

(1) Avoid pointless tampering at all times. Never release the dial screws on a panel control unless you have thoroughly considered the reasons for doing so as well as the facilities at hand for restoring the calibration of the dial when the knob is replaced.

(2) Do not needlessly push or pull on leads. This may necessitate a time consuming recalibration when only a simple replacement was required.

(3) Before unsoldering a part, note the position of the leads. If the part, such as a transformer, has a number of connections, tag each of the leads to it or make a notation of the colors of the leads. If you remove a capacitor whose construction permits reversal when replaced, mark it so you can replace it in the original manner. When connecting or disconnecting a close tolerance resistor (5 percent or less) that has a short lead, grasp the lead between the resistor and the lug to which it connects with pliers, then apply a freshly-cleaned well-tinned iron to the lug to release or apply solder. The pliers will draw off the heat from the lead.

(4) Do not allow drops of solder to fall into the instrument, since they may cause short circuits. For the same reason never use steel wool within the instrument.

(5) A carelessly soldered connection may cause a new fault. A poorly soldered joint is one of the most difficult faults to find.

b. THEORY OF LOCALIZATION. - The ZM-11/U has basic bridge balance functions for

Resistance
Turn Ratio
Inductance
Capacitance

TABLE 5-2. ACTIVE ELEMENTS OF THE BRIDGE CIRCUITS

RANGE NO.	"A" ARM	"B" ARM (Ratio)	FUNCTION	MARKED RANGE	Std. R	Std. C	D Control	Q Control	A Arm Compensation.
			N_1/N_2	.01					
	R157		C	10 mmf		C102	R102A		R116
1	R156	R110	L	100 MH		C102	R102A	R158A	
		(.1)	R	1 Ω	R112				
			N_1/N_2	.1					
	R157		C	100 mmf		C102	R102A		R117
2	R156	E112	L	10 MH		C102	R102A	R158A	
		(1.0)	R	10 Ω	R112				
			N_1/N_2	1.					
	R157		C	1000 mmf		C102	R102A		
3	R156	R108	L	1 MH		C102	R102A	R158A	
		(10)	R	100 Ω	R112				
			N_1/N_2	10.					
	R157		C	.01MF		C102	R102A		
4	R156	R107	L	.1 MH		C102	R102A	R158A	
		(100)	R	1. KΩ	R112				
			N_1/N_2						
	R157		C	.1 MF		C101	R102B		
5	R156	E112	L	10 H		C101	R102B	R158B	
		(1.0)	R	10 KΩ	R111				
			N_1/N_2						
	R157		C	1 MF		C101	R102B		
6	R156	R108	L	1 H		C101	R102B	R158B	
		(10)	R	.1 MΩ	R111				
			N_1/N_2						
	R157		C	10 MF		C101	R102B		
7	R156	R107	L						
		(100)	R	1 MΩ	R111				
			N_1/N_2						
	R157		C	100 MF		C101	R102B		
8	R156	R106	L						
		(1000)	R						
See switch sections:				(f-front of deck, r-rear of deck)					
S102	S105 A,C,D	S102 B-r	S105 Marks	S102 Marks	S102 C-f	S102 A-r		S105	S102A-f S105A-f

Auxiliary functions are

Capacitance Charging
Insulation Resistance Test
Capacitor Quality Test

The 1000 cycle oscillator-amplifier (V103, V102), the amplifier-indicator (105, V101) and the "A" ratio arm are common to all the bridge functions so failure of one of these will cause the bridge to fail to balance or to balance broadly in all functions and all ranges. Likewise, an inaccuracy in the "A" arm will be reflected as a corresponding inaccuracy in all of the ranges and functions.

The "B" arm, viewed as a resistor group, is common to all bridge functions, but defects in any one resistor of the group will be reflected only in certain ranges.

The standard resistors (R111, R112) are employed only for the resistance balance while the capacitance standards (C101, C102) are employed for both the capacitance and inductance bridge functions. In either case, which of the standards employed depends on the function and range in use.

The various combinations of ratio arms and standards used for the various functions and ranges are clarified by Table 5-2 which shows the specific element in use for each range and function by its symbol number. Additionally, the portion of the switch controlling the insertion is shown at the bottom of the table.

The internal RF type power supply is used for capacitor charging and as a source for the Insulation Resistance test. Its output is continually supervised by the panel voltmeter so its failure or weakening will ordinarily be apparent from the meter readings.

The Insulation Resistance test employs the indicator tube

(V101) of the amplifier-indicator so that broad bridge balance together with difficulty in calibrating the Insulation Test will ordinarily point to some weakness in this tube or its immediate circuit. Likewise, the 1000 cycle oscillator-amplifier circuit is common to the bridge functions and to the Short Test of the Capacitor Quality determination. The electronic voltmeter formed by the panel meter and tube V104 is employed throughout the Capacitor Quality Tests. The tube V107 functions as an RF oscillator for both the d-c charging supply and in the Open test of the Capacitor Quality circuits, so any weakness will be reflected in both operations.

Specific troubles and the methods used for tracing them are shown in Table 5-3.

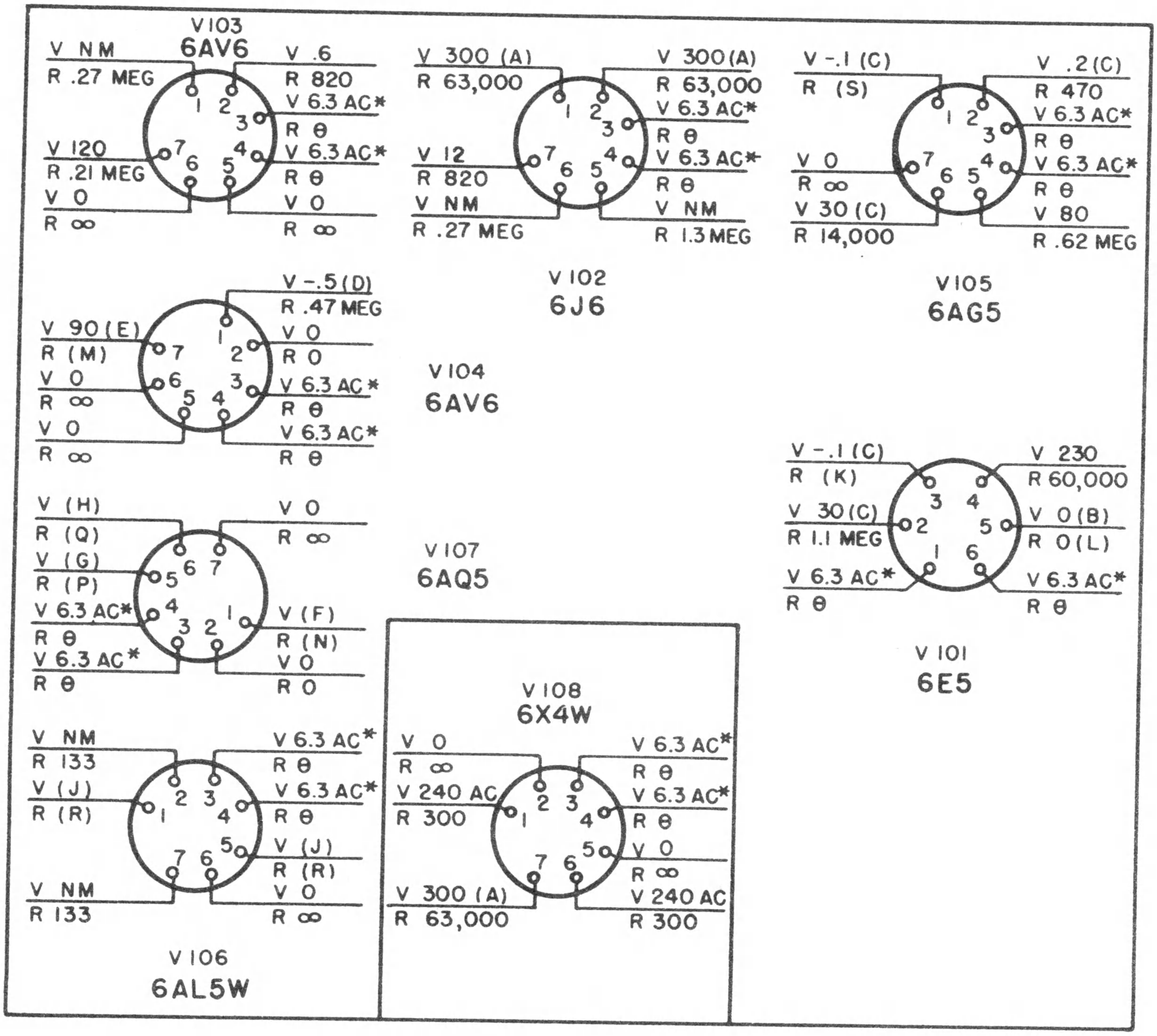
5. VOLTAGE RESISTANCE CHART.
(See Figure 5-3)

CAUTION

Withdraw the line plug from the power receptacle before measuring resistance. Failure to observe this precaution may damage the ohmmeter as well as the ZM/11U Bridge.

Magnitudes of the voltage and resistance to chassis from the base pins of all tubes are contained in the voltage-resistance chart. Observe carefully the notes calling for particular settings of the controls and switches in order to obtain the values shown. Access to the pin sides of tubes V106, V107 and V104 is had only after removal of the bottom pan shield as shown in Figure 5-2. It is secured with four binder-head screws.

Subsidiary voltage-resistance and symbol information is contained in Figures 5-4, 5-5, 5-6, and 5-7, showing the terminal boards in detail. These appear on the page in the same position as the reader views them in Figure 5-2.



NOTES:

Voltages are to chassis with 20,000 ohms-per-volt meter and are positive unless otherwise marked.

Resistances are to chassis and in ohms, unless marked MEG

** Indicates voltages between adjacent pins.

NC No connecting wire.

NM Not measured, no significance.

θ Zero, as read on ohmeter.

Figure 5-3. Voltage and Resistance Chart.

NOTES: (CONT.)

VOLTAGES: VARIATION WITH SWITCHING

(A) With output from C;CHG., as much as 10 volts lower.

(B) Except with FUNCTION at INS. RES., then depends on CALIBRATE INS. RES. setting (R104 — 0-75

(C) With R, N_2 binding post (102) shorted to chassis

(D) OSCILLATOR at SET METER;

(E) OSCILLATOR at SET METER; adjusted per Sec. 4, Par. 2a.

		(F)	(G)	(H)
(F) (G) (H)	FUNCTION at C.CHG; OSCILLATOR on D;C. VOLTS and VOLTAGE CONTROL to 500 panel meter volts	-20	285	54
	FUNCTION at CAP. QUAL; OSCILLATOR at OPEN	-4	250	40

(J) FUNCTION at C.CHG; OSCILLATOR at D.C.VOLTS. at various settings of VOLTAGE CONTROL, should agree with panel meter.

RESISTANCES: VARIATION WITH SWITCHING

(K)	FUNCTION at INS. RES. CAL., 1000 M, or CAP. QUAL.	60 MEG
	FUNCTION at 5000 MEG	30 MEG
	FUNCTION at any other position	10 MEG
(L)	Except FUNCTION at any INS. RES. depends on CALIBRATE INS. TEST (R104)	0-25,000
(M)	FUNCTION at any except CAP. QUAL.	Inf.
	FUNCTION at CAP. QUAL; OSCILLATOR at any CAP TEST depends on VOLTAGE CONTROL (R105)	0-60,000
(N)	OSCILLATOR at D.C. VOLTS	22,000
	OSCILLATOR at any other	51,000
(P)	OSCILLATOR at D.C. VOLTS	63,000
	OSCILLATOR at OFF	Inf.
	OSCILLATOR at any CAPACITOR QUALITY	70,000
(Q)	OSCILLATOR at D.C. VOLTS depends on setting of VOLTAGE CONTROL (R105)	0-60,000
	OSCILLATOR at OFF	Inf.
	OSCILLATOR at any CAPACITOR QUALITY setting	200,000
(R)	FUNCTION at C.CHG; OSCILLATOR at D.C. VOLTS	0.5 MEG
	FUNCTION at CAP. QUAL; OSCILLATOR at CAPACITOR QUAL. depends on VOLTAGE CONTROL (R105)	3000-60,000
(S)	FUNCTION at INS. RES.	3.7 MEG
	FUNCTION at any other	14. MEG

Figure 5-3. Voltage and Resistance Chart (cont.)

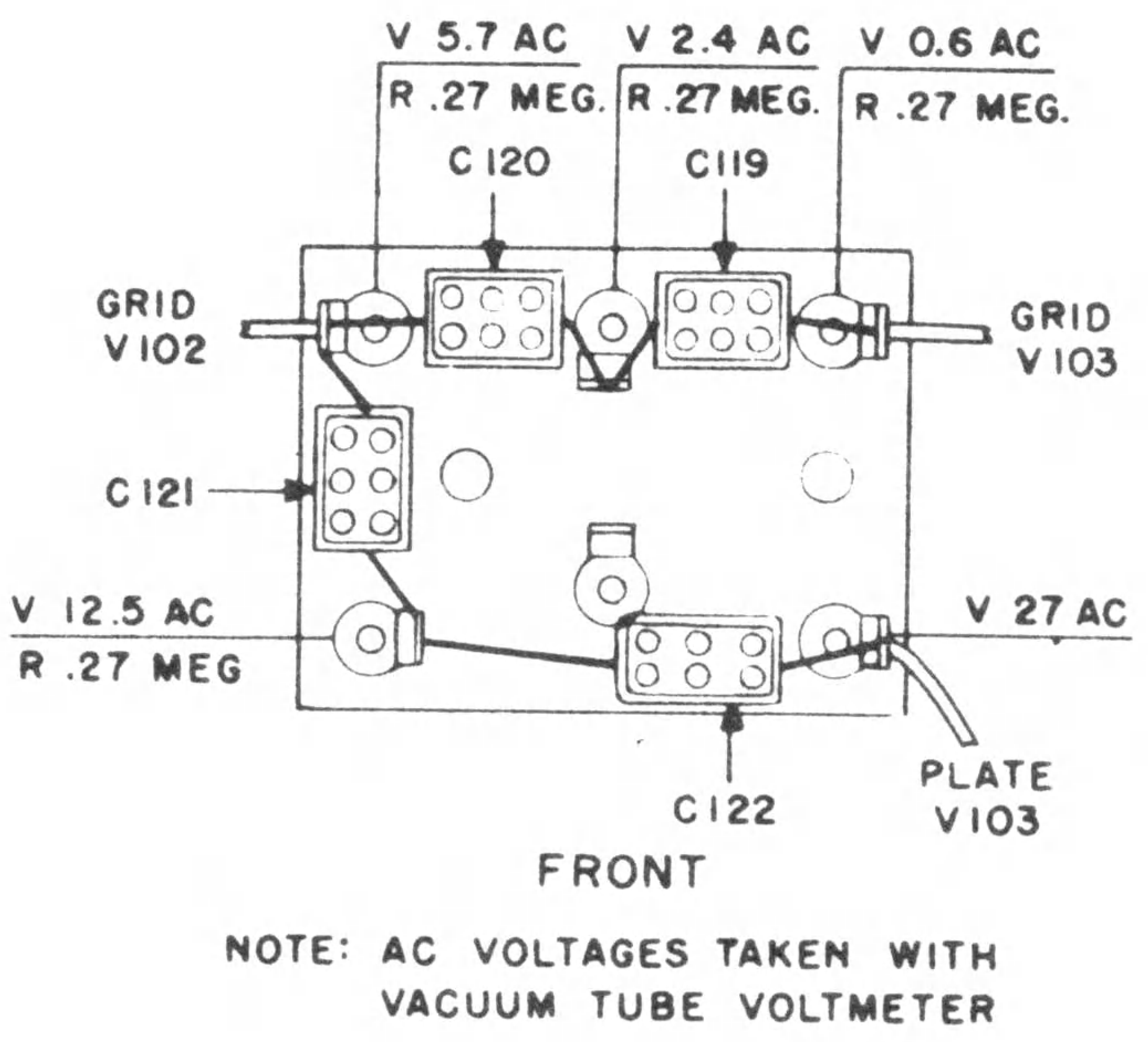


Figure 5-4. Capacitor-Resistor Assembly, E106.

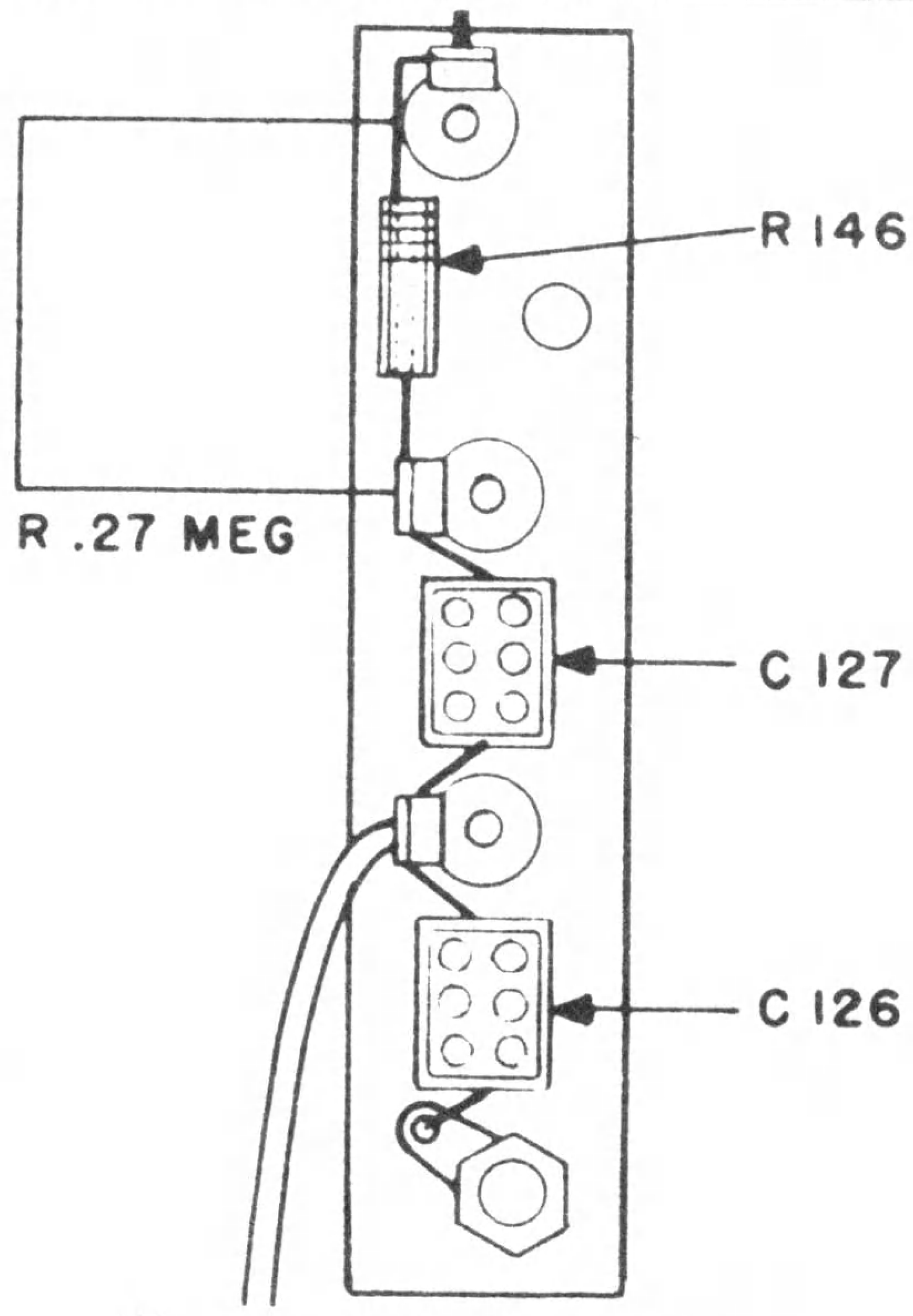


Figure 5-6. Capacitor-Resistor Assembly, E108.

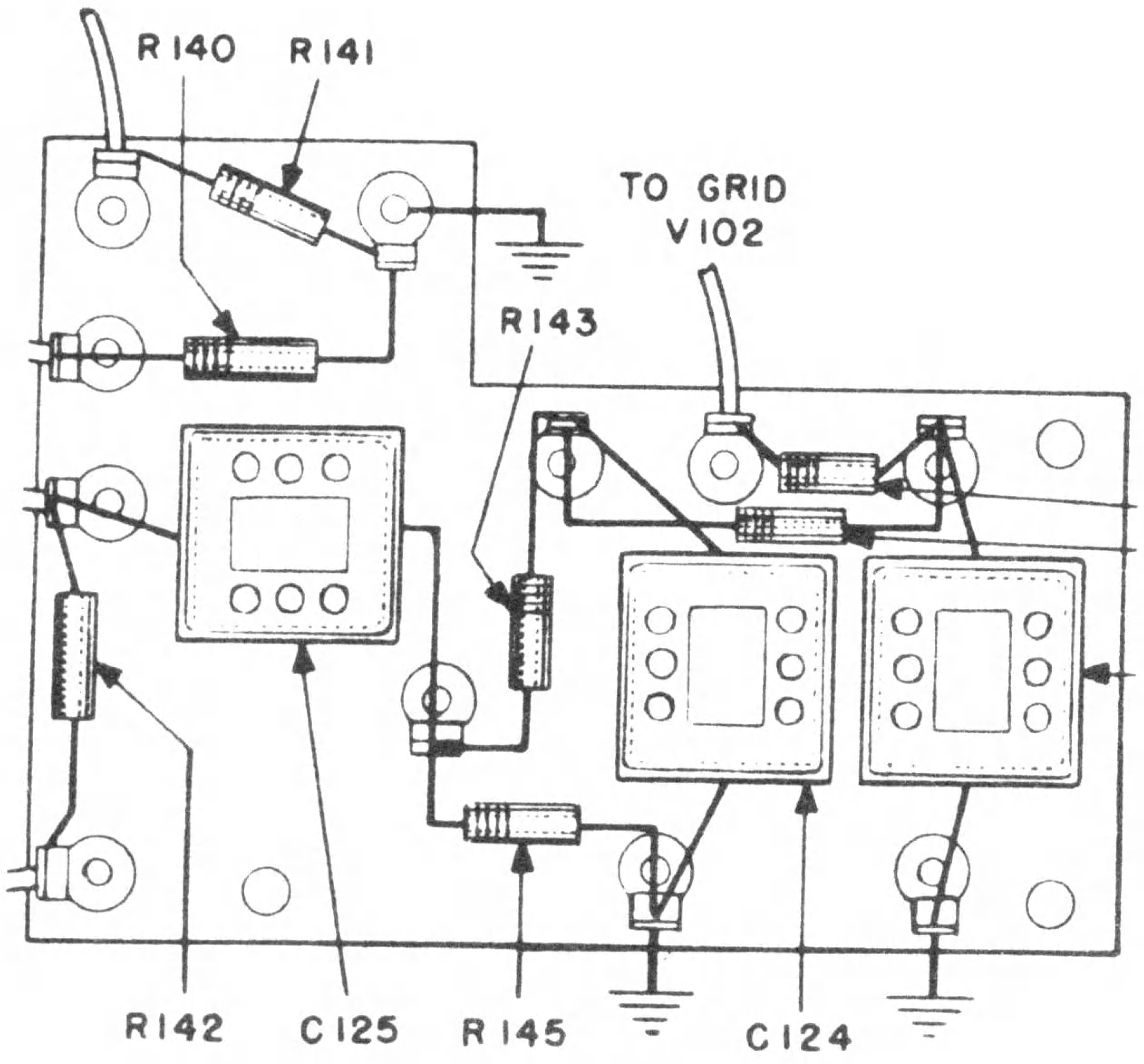


Figure 5-5. Capacitor-Resistor Assembly, E107.

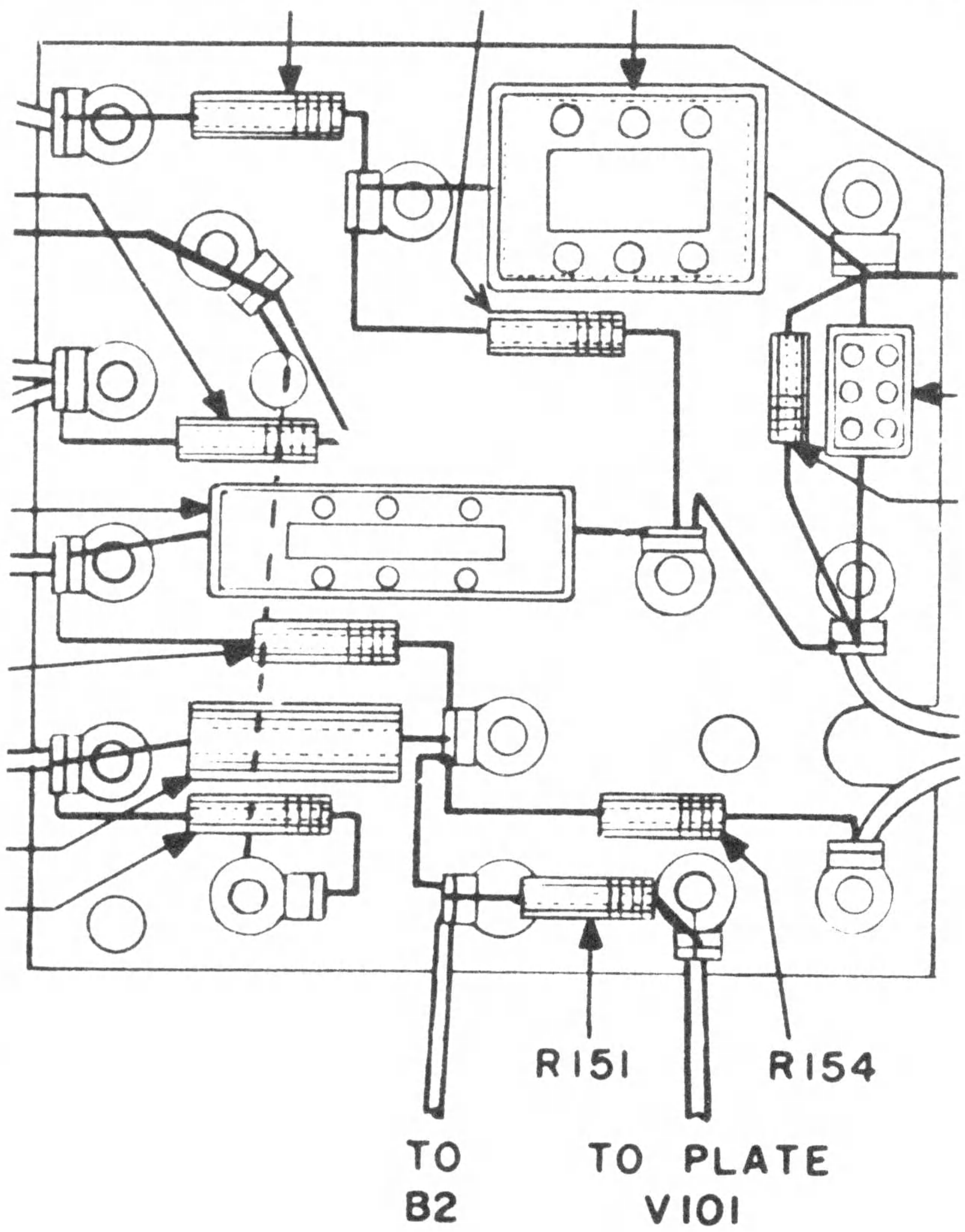


Figure 5-7. Capacitor-Resistor Assembly, E109.

6. TROUBLE SHOOTING CHART.
(See Table 5-3)

Commonly encountered trouble symptoms, probable location of faults and procedures for locating defective components are contained in Table 5-3 to be used in conjunction with Table 5-2. Refer to the callouts in the various photographs and line illustrations for the location of components. Table 5-4 lists the appearances of the callouts and will aid in doing this.

7. REPLACEMENT OF ELECTRON TUBES.

Any electron tube in the ZM-11/U may be replaced without recalibration of the instrument except for the operational calibrations described in Section 4. Figures 5-2 and 5-3 show the locations of the electron tubes as seen from the bottom of the chassis while Figure 5-11 shows the locations from the top of the chassis.

To replace V101 (see Figure 5-11) release the clamp around the base and insert a thin tool, if necessary, between the tube base and socket to pry the tube upward until the pins are released. The tube may then be passed upward through the viewing bezel. Insert a new tube in the reverse way.

Tubes V102, V103 and V105 (see Figure 5-9) are enclosed by shields. There is sufficient overhead clearance to pass these shields upward free of the tube. Press the shield and turn it slightly to release the bayonet lock on it. It will then spring upward and can be passed over the tube and off, after which the tube may be removed.

Tube V108 (see Figure 5-6) is readily removable after removal of the clamp securing it. Pinch the back lip of the clamp toward the post to release it.

Access to tubes V106, V107 and V104 is had after removal of

TABLE 5-3. TROUBLE SHOOTING CHART.

SYMPTOMS CONTROL SETTINGS Section 4. Par. ( )	PROBABLE LOCATION OF FAULT	PROCEDURE CORRECTIONS
1. No INDICATOR pattern but pilot lights with line POWER "ON".	High voltage power supply	Make socket v. analysis V108. If a-c OK but cathode low, replace V108 or look for short in B_1 or B_2 leads.
	Indicator tube or circuit.	Make socket v. and r. analysis of V101 and/or replace V101.
2. Binding post pilot does not light on C. CHG. (6d)	High voltage power supply.	See (1) above.
	Pilot light circuit	Check R154 and continuity from I101 through S105E to chassis.
3. VOLTAGE CONTROL erratic. (2a, 6d, 7a)	Resistor R105	Worn or damaged? Replace.
4. Can't get 500 v. output with load. (6d) (Table 5-1, 4)	Weak r-f power unit	Make socket v. analysis of V107. If OK replace V107. Do same V106. If not OK make socket r. analysis V107 and V106. Inspect contacts S104B. Test T103 for open or high resistance.
	Voltmeter off calibration	Check M101, R115, R120. See Par. 8k.
5. Milliammeter reads off tolerance. (6d). Table 5-1, 5.	Meter, shunts or switch S103	See Sec. 5, Par. 81. Check and recalibrate.

6. INS. RES. test won't calibrate. (7a).	Meter calibration	See (4) above.
	R-F power supply	See (4) above.
If meter reads 500 and can't adjust.	Indicator circuit	Make socket v. analysis of V101, especially cathode and R104. If OK replace V101. Check 3 v. drop across R120 when panel meter reads 500 v.
7. CAPACITOR QUALITY TEST won't calibrate. (2a)	Electron voltmeter circuit	Make socket v. analysis of V104. If no plate voltage, check contacts of S105C, S104A,-R101 and R109. If voltage OK replace V104.
8. CAP. QUAL. OPEN test (2a) Meter drops with open test clips.	P101, J101, Z101	Test for shorts to ground.
Meter doesn't drop to 300 with shorted test clips.	P101, J101	Test for open or bad contact. Also contacts S104A-f. Output winding T104 open?
	Weak r-f oscillator	Make socket v. analysis of V107. If OK replace V107 unless performance on C. CGH was OK. Check all resistances, T104.
9. CAP. QUAL. SHORT. (2b). Meter drops with open test clips.	Cable P101	Test for open. Also contacting of P101 in J101.
Meter doesn't drop to 250 v. with open test clips.	P101 and J101 Low amplifier-oscillator output	Check for shorts. Check secondary voltage T102-10 v. a-c. If OK, trace it through switches and thence to end of P101. If low, see (9).

TABLE 5-3. TROUBLE SHOOTING CHART. (CONT.)

SYMPTOMS CONTROL SETTINGS Section 4. Par. ( )	PROBABLE LOCATION OF FAULT	PROCEDURE CORRECTIONS
10. Broad balance or no balance. All bridge functions.	Oscillator-amplifier	If T102 output is weak, inspect insulated joint in T102 mount. Par. 9i. Make socket v. analysis of V103. If OK replace V103. Same for V102. If still weak analyze E106, Fig. 5-4.
	Amplifier-indicator	If T102 output OK, analyze socket v. of V105 and V101. Analyze elements of E109, Fig. 5-7.
11. Innaccuracies. All bridge functions and ranges.	MULTIPLY BY dial	Check for loose or forced pointer on R157. Damaged R157 or R156. Replace and/or recalibrate R157 per Par. 8c.
12. Innaccuracies. Certain functions and/or ranges.		Investigate and chart the difficulties until the specific element can be isolated by reference to Table 5-2.

TABLE 5-4. SYMBOL NUMBERS — REFERENCES AND CALLOUTS.

Symbol Desig.	Detail Schematic	Pictorial Callout	Symbol Desig.	Detail Schematic	Pictorial Callout
C101	2-6,2-11, 2-13	5-8,5-11	E102	2-3,2-4 2-11,2-14	5-2,5-9
C102	2-6,2-11	5-10	E103	2-6	5-2,5-9
C103	2-2	5-11	E104	2-4,2-6 2-11	5-2,5-9
C104	2-14	5-8,5-11	E105		5-2,5-9
C105	2-12		E106		5-2,5-4
C106	2-7		E107	2-2	5-2,5-5
C107	2-7		E108		5-6,5-9 5-10
C108	2-7,2-12		E109	2-3	5-2,5-7
C109	2-12,2-13	5-2	E110		5-8
C110	2-12,2-13	5-11	E113		5-9
C111	2-3	5-11	E114		5-9
C112		5-8,5-11	E115		5-9
C113		5-8,5-11	E116		5-9
C114	2-7,2-12 2-13	5-9,5-11	E120		5-9,5-10
C115	2-12	5-10	E124		5-8
C116		5-11	E125		5-9
C117	2-14	5-12	E126		5-9
C118	2-14	5-9,5-12	E128		5-9
C119	2-2	5-4	E130		5-9
C120	2-2	5-4	F101		5-10
C121	2-2	5-4	F102		5-10
C122	2-2	5-4	F103		5-2
C123	2-2	5-5	H102		5-8
C124	2-2	5-5	H103		5-8
C125	2-2	5-5	H108		5-10
C126	2-3	5-6	H109		5-10
C127	2-3	5-6	H110		5-10
C128	2-3	5-7	H113		5-8
C129	2-3	5-7	H117		5-8
C130	2-3	5-7	I101		5-10
E101	2-14	5-2,5-9			

TABLE 5-4. SYMBOL NUMBERS — REFERENCES AND CALLOUTS. (CONT.)

Symbol Desig.	Detail Schematic	Pictorial Callout	Symbol Desig	Detail Schematic	Pictorial Callout
I102		5-10	R118	2-14	5-12
J101	2-12,2-13	5-10	R119	2-14	5-12
M101	2-12,2-13 2-14	5-10	R120	2-14	5-10
			R121	2-7	
N101		5-8	R122	2-12	
N102		5-8	R123	2-7,2-12	5-12
N103		5-8	R124	2-12,2-13	5-11
O102		5-9	R125		5-2
O105		5-9	R126	2-7,2-12, 2-13	5-2
O109		5-9	R127		5-10
O110		5-2	R128	2-14	5-12
P101	2-12,2-13	4-1	R129	2-14	5-12
R101	2-12	5-12	R130	2-14	5-12
R102	2-6,2-11	5-10	R131	2-14	5-12
R103	2-11	5-10	R132	2-14	5-12
R104	2-14	5-10	R133	2-14	5-12
R105	2-7,2-12, 2-13	5-10	R134	2-4,2-6, 2-11	
R106	2-6	5-12	R135	2-2	5-4
R107	2-4,2-6, 2-11	5-12	R136	2-2	5-4
R108	2-4,2-6, 2-11	5-12	R137	2-2	5-4
			R138	2-2	5-4
R109	2-12	5-12	R139	2-2	5-5
R110	2-4,2-6, 2-11	5-12	R140	2-2	5-5
			R141	2-2	5-5
R111	2-4	5-10,5-12	R142	2-2	5-5
R112	2-4	5-12	R143	2-2	5-5
R113		5-10	R144	2-2	5-5
R114		5-10	R145	2-2	5-5
R115	2-14	5-10	R146	2-3	5-6
R116	2-6	5-12	R147	2-3	5-7
R117	2-6	5-12	R148	2-3	

TABLE 5-4. SYMBOL NUMBERS — REFERENCES AND CALLOUTS. (CONT.)

Symbol Desig.	Detail Schematic	Pictorial Callout	Symbol Desig.	Detail Schematic	Pictorial Callout
R149	2-3	5-7	T104	2-12	5-11
R150	2-3	5-7	TB105		5-2
R151	2-3,2-14	5-7	V101	2-3,2-14	5-11
R152	2-3	5-7	V102	2-2	5-11
R153	2-3	5-7	V103	2-2	5-11
R154		5-7	V104	2-12,2-13	5-11
R155	2-3	5-7	V105	2-3	5-11
R156	2-4,2-6,2-11	5-10	V106	2-7	5-11
			V107	2-7,2-12	5-11
R157	2-4,2-6,2-11	5-10	V108		5-11
			W101		4-1
R158		5-7	W102		4-1
S101		5-10,5-12	W103		4-1,5-8
S102	2-3,2-4,2-6,2-11	5-10	XV101		5-2
			XV102		5-2
S103		5-10	XV103		5-2
S104	2-7,2-12,2-13	5-2,5-12	XV104		5-2
			XV105		5-2
S105	2-3,2-11,2-12,2-14	5-2,5-9,5-10,5-12	XV106		5-2
			XV107		5-2
T101		5-11	XV108		5-2
T102	2-2,2-13	5-11	Z101	2-12	5-11
T103	2-7	5-11	Others	5-14	

For symbol numbers not mentioned in this table see Figure 5-14 (tip-in at the end of this section and Section 6.

---

the end shield covering them (see Figure 5-8). Remove the two screws under the handle marked "A". Loosen the six screws marked B; these will pass through the slots as the shield is slid out. The shield may be started by a tool inserted through a slot at the lower edge. These three tubes are secured by post-type clamps like the one securing V108.

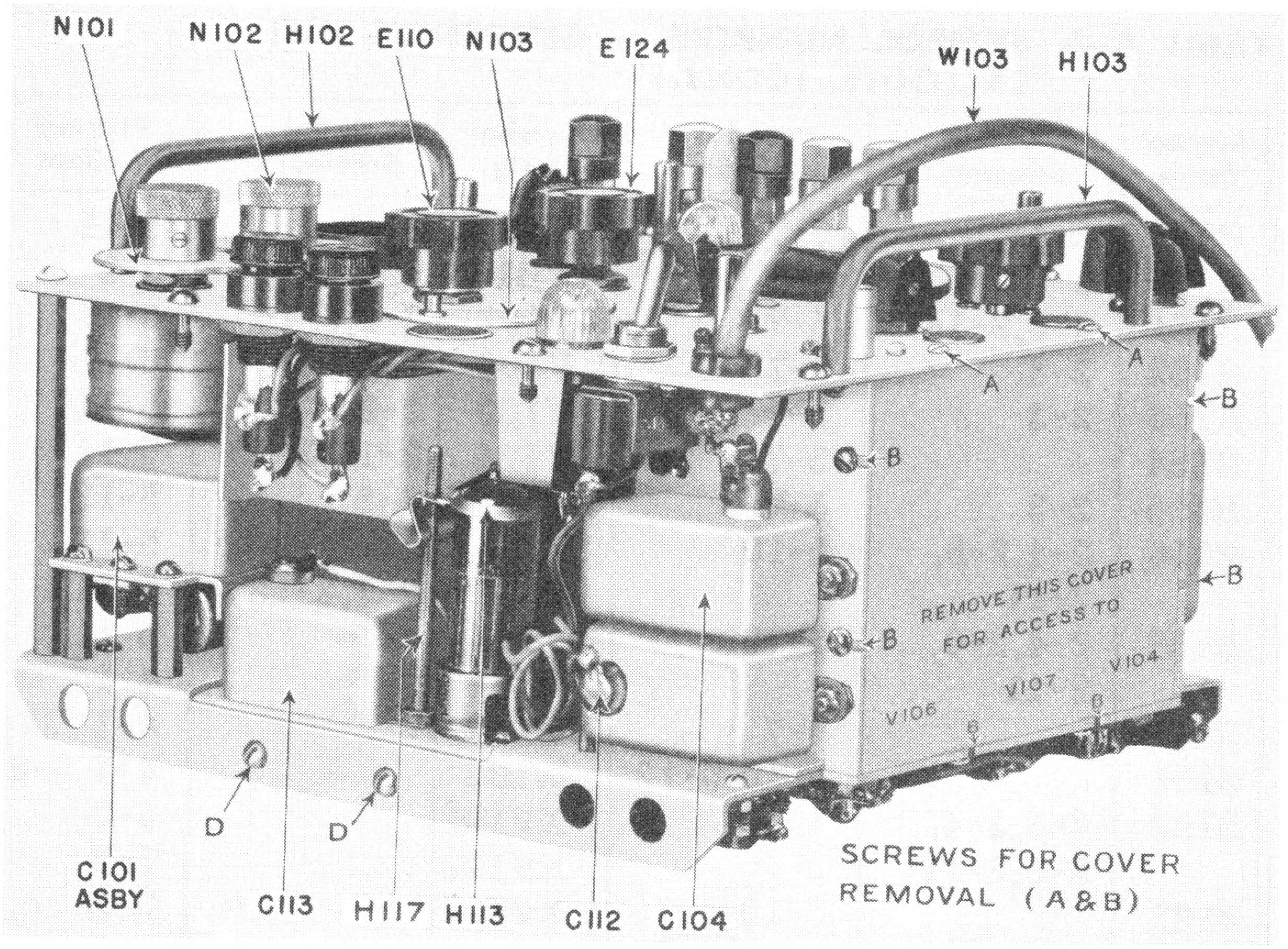


Figure 5-8. Bridge ZM-11/U, Front Side.

8. CALIBRATION.

a. GENERAL - Bridge ZM-11/U was calibrated when manufactured. In general, replacement of any of the components shown in Table 5-5 will require recalibration of part or all of the functions in order to assure the original accuracy of the instrument. Table 5-5 shows the minimum required recalibration work by reference to the paragraph in which the recalibration procedure is described. Other parts may be replaced without effect on the calibration provided care is used not to disturb the parts enumerated in Table 5-5 or the connections thereto.

NOTE

The calibration procedures assume a normal room temperature of 22 degrees Centigrade throughout.

TABLE 5-5. REPLACEMENT OF PARTS REQUIRING RECALIBRATION

FUNCTION	SYMBOL OF PART	RECAL. PAR.
"A" RATIO ARM	R156, R157, or E110	8c (8e)
"B" RATIO ARM	R106, R107, R108, E112, or R110	8d (8e)
RESISTANCE STANDARDS	R111 or R112	8f
CAPACITANCE STANDARDS	C101 or C102 (T102)	8g(8j)
COMPENSATION (Low C)	R116 or R117	8g
D CONTROL	R102 or N101	8h
Q CONTROL	R158, R159, R160 or N102	8i
D-C VOLTMETER	M101, R115, or R120	8k
D-C MILLIAMMETER	M101, R113, or R114	8l
INSULATION TEST	R120, R128, R129, R130, R131 R132, or R133	8m

b. EQUIPMENT REQUIRED - The following equipment is needed for complete calibration of the ZM-11/U Bridge:-

(1) Resistance bridge, wide range d-c type, accuracy 0.15 percent such as Resistance Bridge ZM-4/U Series or equivalent.

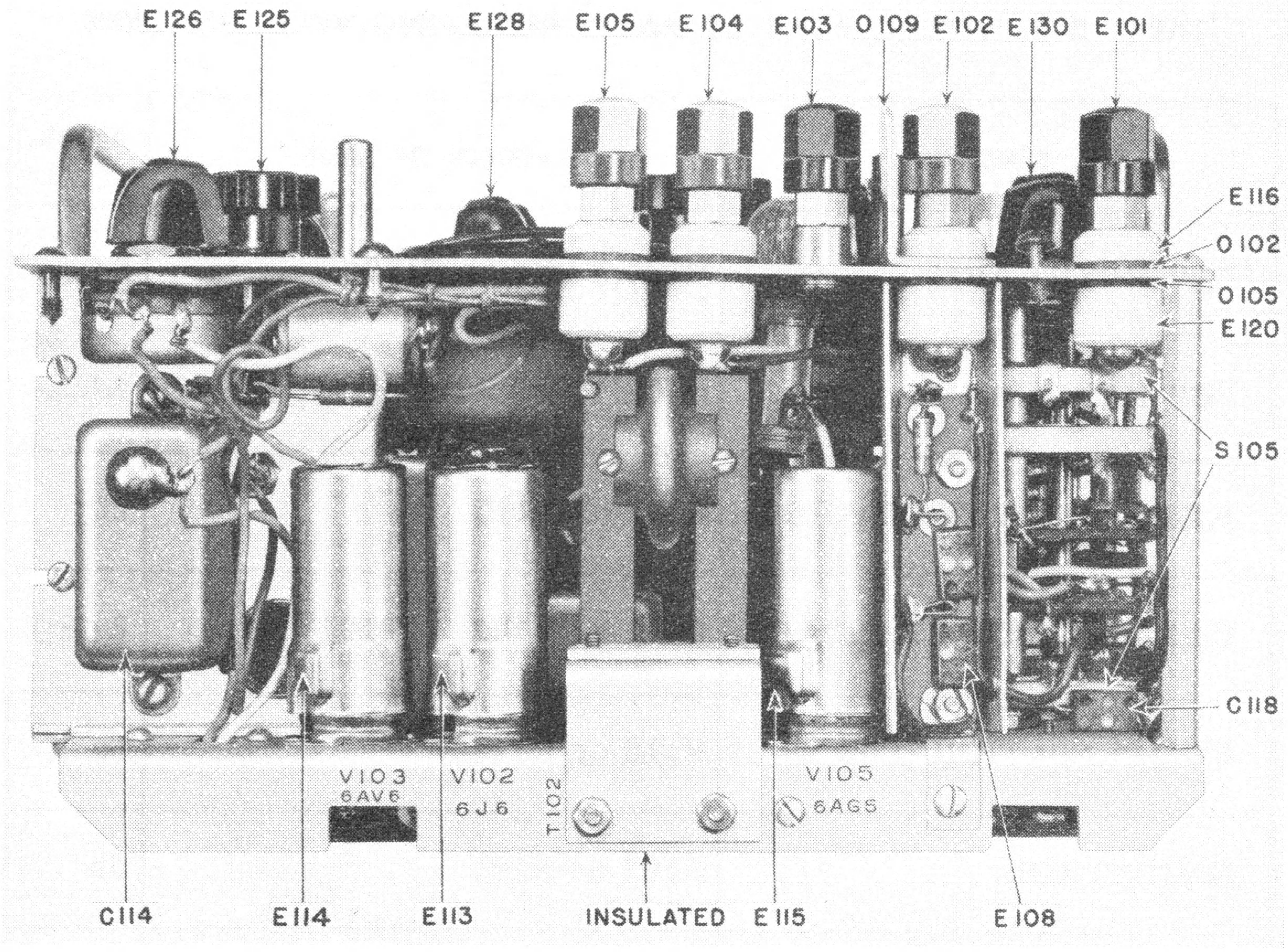


Figure 5-9. Bridge, ZM-11/U, Back Side.

(2) Two four-dial decade resistance boxes, 11,110 ohms per box, accuracy 0.1 percent at 1000 cycles. In lieu of these, stable non-inductive resistors freshly calibrated on the precision d-c bridge (1) may be used.

(3) Standard capacitances of 10 uuf, 100 uuf, 1000 uuf, 0.01 uf and 1.0 uf; accuracy 1 uuf or 0.25 percent, whichever is greater. The number of values shown is minimum for complete calibration of the capacitance ranges. The two smaller values should be physically arranged so that they may be plugged into the C posts of the ZM-11/U Bridge with a minimum of connecting lead error. If a decade or otherwise subdivided unit of large capacitance is available, it will be useful for checking the upper ranges of capacitance.

(4) Standard inductors as available. Inductance and dissipation or storage factor at 1000 cycles should be known; 0.25 percent for inductance and 5 percent for the factor.

(5) A d-c voltmeter - to 500 or 600 volts, accuracy 0.25 percent, such as standard Navy Stock Number G-17-V-960 or equivalent. An adjustable d-c power supply will also be required to deflect the standard meter over its entire range.

(6) A standard millivoltmeter such as standard Navy Stock Number SNSN G-17-M-2625, 0 to 15 and 0 to 150 millivolts, accuracy 0.25 percent, or equivalent. This should be provided with standard precision shunting resistors for forming milliammeter ranges consistent with those of the ZM-11/U Bridge.

c. CALIBRATION OF THE "A" RATIO ARM. (R156, R157) - Disconnect one end of the secondary of transformer T102 to prevent its appearing in shunt to the ratio arms. Turn the FUNCTION SWITCH to N_1/N_2. Connect the precision d-c bridge to binding posts E103 and E104 where it will now measure R157 and R156 in series. Now set the d-c bridge to measure 1000 ohms and turn the shaft of R157 until balance is had. At this rotation of R157, the pointer must read exactly 1.0. If it does not, the pointer set screws should be released and the pointer turned until this is true. Other points of the dial should be checked for the tolerances shown in Table 5-6.

TABLE-5-6. TOLERANCES FOR MULTIPLY BY DIAL.

Mult. By Dial	RESISTANCE — OHMS	
	Low	High
1.0	1000	1000
4.0	3910	4090
7.0	6880	7120
10.0	9850	10150

If the arm is outside the tolerances shown, the potentiometer R157 is worn out or damaged beyond use and should be replaced in accordance with Paragraph 9m. After calibration or replacement, the connection to the secondary of T102 should be resoldered.

d. CALIBRATION OF THE "B" ARM - Disconnect one end of the secondary of transformer T102 to prevent its appearance in shunt to the ratio arms. Connect the precision d-c bridge to binding posts E103 and E105. Turn the FUNCTION switch to N_1/N_2. Table 5-2 shows which of the "B" arm resistors is in service at each setting of the RANGE switch. Measure each value. It should be within 1/2 percent of the value stated in the parts list. If any value is found out of tolerance, the unit should be replaced. When all five values of the "B" arm measure correctly in the eight positions of the RANGE switch, the secondary of T102 should be reconnected.

e. CHECKING THE BASIC RATIOS - TURN RATIO. - The basic ratios of the Bridge Type ZM-11/U may be checked, together with the performance of the 1000 cycle oscillator-amplifier and amplifier - indicator by turning the FUNCTION switch to N_1/N_2 and connecting standard resistors to the corresponding N_1 and N_2 posts. These standard resistors are most conveniently settings of two decade resistance boxes but may also be a pair of ordinary radio type resistors carefully measured on the precision d-c bridge and their ratio calculated, just prior to use. Such a pair will be required for each ratio to be tested. The basic ratio of the ZM-11/U with the MULTIPLY BY dial at 10.0 is shown in parenthesis in Table 5-2 under the "B" arm resistor symbol for each position of the RANGE switch. Other settings than 10.0 may be employed, the ratio being proportionate to the dial setting.

If this ratio test is carefully carried out for all ranges, the results should be found to be within the tolerance indicated for Turn Ratio in Table 4-3. If not, then probably some faulty element has been overlooked in the tests of Paragraphs 8c or 8d and that work should be repeated. When the stated accuracies have been confirmed, the accuracy of the ratio arms has been confirmed for all bridge functions. Additionally, the basic accuracy of the Turn Ratio test is assured because there is no consideration of coupling to be considered as would be the case with actual transformer samples.

f. CHECKING THE RESISTANCE STANDARDS - The standard resistors R111 and R112 may be checked independent of the ratio arms by connecting the precision d-c bridge to binding posts E102 and E105 and turning the FUNCTION switch to R. The standard in service is shown in Table 5-2 for various settings of the RANGE switch. The standards should measure within 0.5 percent of nominal value.

Confirming data on the resistance ranges may be had by energizing the ZM-11/U Bridge and measuring a decade resistance box at various settings or various resistor units previously measured on the precision d-c bridge.

g. CHECKING THE CAPACITANCE RANGES. - Examination of Table 5-2 shows that, if the basic ratios of the bridge are correct as tested in Paragraph 8e, the accuracy of the capacitance measurments depends on the accuracy of the capacitance standards C101 and C102, except for the first two ranges where the values of the compensating resistors R116 and R117 also enter.

To check the accuracy of the standard C101 and, thereby the probable accuracy of the upper four capaçitance ranges, repeat the ratio test of Paragraph 8e for the number 5 position of the RANGE switch and, with externally connected standard resistors having a ratio of exactly 1.00, balance the bridge and record the exact reading of the MULTIPLY BY dial. This may not be exactly 10.0 but some value such as 9.95 or 10.03. Now, turn the FUNCTION switch to C and connect the 1.0 uf external standard to the C posts and balance it on the ZM-11/U bridge as an unknown. The exact balance point on the MULTIPLY BY dial should be the same as previously noted in the ratio test or to as much as 1/2 percent higher, corresponding to the permissible tolerance in C101. If this is not the case, then probably the standard capacitor C101 is out of tolerance (+ 0.0, -1/2 percent). Confirm this, if possible by direct measurement on a precision capacitance bridge before discarding C101.

If larger external standard capacitors are available, the upper ranges of the ZM-11/U may be checked against these; otherwise they will have to be taken for granted premised on the ratio tests and the test on internal standard C101.

The smaller internal standard C102 is never replaced for any but the grossest defects inasmuch as it is adjustable within the ZM-11/U Bridge. To find out if such adjustment is necessary, make the ratio test of Paragraph 8e with the RANGE switch in the number 4 position and with externally connected resistors having a ratio of exactly 10.00. Balance the bridge and record the exact required setting of the MULTIPLY BY dial. Turn the FUNCTION switch to C and connect the external 0.01 uf standard capacitor to the C posts. Balance the ZM-11/U Bridge for C in the usual manner. The required balance point on the MULTIPLY BY dial should be exactly the same as was required and noted in the ratio test. If it is not, insert a long insulated screw driver into the bridge from the front, alongside the fuses, to engage the slot in capacitor C102B (see Figure 5-10) and adjust as necessary to obtain exactly the same balance point obtained in the ratio test. The smaller of the internal standards has now been adjusted for the third and fourth capacitance ranges, but the compensation for binding post and stray capacitances remains to be checked in the first and second ranges.

Turn the RANGE to 100 mmf and balance the 100 uuf and 1000 uuf external standards successively on this range. Record the reading of the MULTIPLY BY dial for each. If there is any discrepancy in common to the two readings, a correction in the compensating resistor R117 is indicated. For example, assume the 100 uuf standard balanced at 1.1 (110 mmf) and the 1000 uuf standard at 10.13 (1013 mmf). The common discrepancy is 10 mmf and the MULTIPLY BY dial has a variational rate of 10 ohms per mmf in this range, hence the indication is to increase R117 by 100 ohms over its existing value.

In the same way, the first range is tested for compensation by balancing the 10 uuf and 100 uuf external standards on the 10 mmf setting of the RANGE switch. The common discrepancy is again noted while the compensating resistor R116 for this range is altered at the rate of 100 ohms per uuf of common discrepancy.

h. CHECKING THE DISSIPATION CONTROL - This is actually a dual control, R102A and R102B. The terminals of the control are conveniently accessible under the lower left-hand corner of the panel and they are best checked with the d-c precision bridge. Table 5-7 shows tolerances for various settings of the "D" dial.

i. CHECKING THE "Q" CONTROL - This is also a dual control, R158A and R158B. The resistance elements of the control are swamped by resistors R159 and R160 respectively. At low

TABLE 5-7. D DIAL—RESISTANCE TOLERANCES.

D DIAL	R102A—FRONT Low (Ohms)	R102A—FRONT High (Ohms)	R102A—BACK Low (Ohms)	R102A—BACK High (Ohms)
0	0	320	0	3.2
.02	2540	3820	25.4	38.2
.04	5410	7310	54.1	73.1
.06	8280	10820	82.8	108.2

settings of the Q dial, the swamps have little affect on the calibration. At higher settings the swamps affect the calibration materially. These calibrations are also readily checked by connecting the d-c precision resistance bridge directly to the terminals of the unit in question. The FUNCTION switch should be in the CAP. QUAL. position to eliminate extraneous resistance elements from the determination. Resistance for the "Q" controls are shown in Table 5-8.

If the Q dial has been removed from R158 or the control has been replaced, turn the shaft of R158 counter-clockwise to the stop. Place the Q dial squarely, as it appears in Figure 4-1 and secure the dial set screws. Turn the dial to read exactly 15, with the precision d-c bridge, select the swamps R159 and R160 until the effective resistance values Q = 15, Table 5-8 are secured. For the other Q dial settings of Table 5-8, measure the

TABLE 5-8. Q DIAL—CALIBRATION DATA.

Actual Q	Resistance R158A—Front Ohms	Q Dial	Resistance R158B—Rear Ohms	Q Dial
.5	79,500	____	79.5	____
1	159,000	____	159	____
2	318,000	____	318	____
3	477,000	____	477	____
5	795,000	____	795	____
10	1,590,000	____	1,590	____
15	2,385,000	15	2,385	15
20	3,180,000	____	3,180	____

terminal resistances and record them. This is the data for a new correction curve in the lid of the ZM-11/U.

j. CALIBRATION OF THE INDUCTANCE RANGES - The basic design and construction of the ZM-11/U Bridge is such that, if the basic ratios check according to Paragraph 8e and the capacitance ranges check in accordance with Paragraph 8g, it is a valid assumption that the inductance ranges are correct, assuming that good clean balances can be obtained throughout the "L" ranges.

If suitable inductance standards are at hand, ranges corresponding to their values may be cross-checked, however, by connecting such standards as unknowns and balancing them on the ZM-11/U Bridge. In order to obtain a check, it is particularly important that the inductance standards used shall have been certified at 1000 cycles and that, if they contain iron cores, they shall have been certified at values of voltage across terminals comparable to those impressed by the ZM-11/U Bridge.

k. CALIBRATING THE VOLTMETER - Make certain that the line cord of the ZM-11/U is not in the power socket and turn the FUNCTION SWITCH to C CHG. Connect the positive terminal of the precision voltmeter and its connected power supply to binding post E102, second from the left, and the negative terminal to E103, third from the left. The precision voltmeter should now be set to various cardinal values throughout the range 0 to 500 volts and the corresponding readings of the ZM-11/U meter recorded. Such readings should be true to within one percent plus 10 volts. Failure to meet these tolerances probably indicates improper value of the multiplier resistance R115, a shorted or open sub-multiplier R120 or incorrect current sensitivity in the meter M101, which should be proportional to 1.0 milliampere full scale and ± 0.02 MA at any scale division.

l. CALIBRATING THE MILLIAMMETER - Insert a 10,000 ohm variable resistance in series with the standard milliammeter (or millivoltmeter arranged as a milliammeter) and connect the combination to the C posts, observing the polarity marking. Turn the FUNCTION switch to C. CHG; the OSCILLATOR switch to D.C. VOLTS; and the RANGE switch to 100 MF. With various settings of the VOLTAGE CONTROL, adjust the external series resistance to the desired panel meter current and compare with the reading of the external standard. Tolerances are stated in Table 4-3.

Failure to meet tolerance in the 1 MA range will be accounted for by the basic current sensitivity of meter M101, stated in Paragraph 8k. Discrepancies in the basic meter current will also be evident in the 5 MA and 25 MA ranges in addition to discrepancies in the respective current shunts R113 and R114. The stated values of these shunts is premised on a meter drop of 100 millivolts ± 2-1/2 percent at 22 degrees C.

m. CALIBRATING THE INSULATION RESISTANCE TEST - The panel voltmeter calibration, Paragraph 8k, is part of the Insulation Test calibration.

With the precision d-c bridge, measure the resistance from the grid (pin 3) of V101 to CHASSIS with the FUNCTION switch in the 10000M position and again with the FUNCTION switch in the 5000M position. These values should be 60 megohms and 30 megohms, respectively, ± 5 percent. If the precision bridge lacks range or sensitivity to measure these values the individual resistors R128, R129, R130, R131, R132, and R133 may be measured and summed. Now, measure the value of the drop resistor R120. This is nominally 3000 ohms but some selection may be necessary to make it high or low by the same percentage that the previously measured 60 megohm value was high or low.

Accurate and stable standards of resistance of the order measured by the Insulation Test are unusual and assuming that the operations above are properly carried out and that the Insulation Test circuits are functionally correct as indicated by (5) of Table 5-1, the calibration of the Test will be assumed to be correct.

9. REMOVAL AND REPLACEMENT OF PARTS.

a. CAPACITOR ASSEMBLY, C101 - This unit, see Figures 5-8 and 5-11, consists of one major capacitor of 1.0 uf, or slightly less, swamp-adjusted by none to three smaller capacitors and all mounted on a metal mounting plate. Because of the close tolerance maintained in its construction it is replaceable only as a unit. The whole plate should be removed when replacement is contemplated.

b. CAPACITOR-RESISTOR ASSEMBLY, E106 - This is called out in Figure 5-2 and detailed in Figure 5-4. To remove it:-

Remove three connecting leads.

Remove two hex nuts.

This terminal board is preferable replaced as a unit. In an emergency, individual parts may be replaced always within the tolerances stated in the Parts List. The frequency of the oscillator-amplifier must then be checked to 1000 cycles ±5 percent. If the frequency falls outside this, individual selection of components will have to be made to correct the frequency. Increasing the size of elements deceases the frequency and vice-versa. In checking the frequency, the input of the calibrating oscilloscope should be connected to either plate of V102 (pin 1 or 2) and chassis. In this way the input impedance of the oscilloscope cannot alter the frequency.

c. CAPACITOR-RESISTOR ASSEMBLY, E107. - This appears at the upper center of the chassis, Figure 5-2 and again in detail in Figure 5-5. To remove it:-

Remove five connecting wires.

Remove four hex nuts.

It is preferably replaced as a unit, although in an emergency minor replacements of a single element may be made. Major replacement will require that a check be made of the phase of the grid voltages on amplifier V102. These must be substantially 180 degrees out of phase and equal in amplitude to secure true push-pull operation of the amplifier. This can be checked with Oscilloscope OS-8/U or equivalent. Connect the vertical input across the cathode resistor R140 of the amplifier V102. Key the linear sweep externally to the output of amplifier V102.

When the ideal push-pull condition has been brought about the vertical deflection will be either zero or show a small symmetrical trace of harmonic frequency, that is, the 1000 cycle fundamental will cancel out in the cathode lead.

d. CAPACITOR-RESISTOR ASSEMBLY, E108. - This unit, shown in detail in Figure 5-6, mounts in a shielding channel beneath the binding post E102, Figure 5-9. Do not remove the shield channel or the bracket but simply:-

Remove the two connecting leads.

Remove the two hex nuts. (bearing on E108)

The bakelite panel will now come out. It is preferably replaced as a whole although individual elements may be replaced. If each element is within specified tolerance satisfactory operation will be had without special test.

e. CAPACITOR-RESISTOR ASSEMBLY, E109. - This appears at the upper right of the chassis in Figure 5-2. A detail is shown in Figure 5-7. To remove it:

Remove eight connecting leads.

Remove four hex nuts.

This panel is preferably replaced as a unit due to the close and interdependent tolerances involved. If replacement of individual parts is necessary, test the remaining values to make certain they are within specified tolerance. Connect the vertical side of the oscilloscope to the grid (pin 1) of V105 and the horizontal to the plate (pin 2) of V101. Measure some capacitor on the ZM-11/U in the usual manner and then unbalance until the indicator pattern shows about 1/16 inch fringe on each side. Adjust the oscilloscope gains until a square phase pattern is formed. If the indicated phase exceeds 15 degrees, suitable selection of either or both C129 and C130 should be made to correct it.

f. BINDING POSTS - At the upper right hand of Figure 5-9, a group of four call-outs brings to particular attention the insulated parts employed for mounting the binding post E101. In addition to the mating ceramic parts E116 and E120, two bakelite washers O102 and O105 are employed on either side of the panel. These provide for expansion and contraction of the metal parts and should never be omitted in mounting binding posts E101, E102, E104 or E105.

g. IMPEDANCE UNIT, Z101. - To remove this unit:-

Remove the tube access shield, Figure 5-8.

Remove two connections.

Remove one hex nut, securing Z101. (Figure 5-11)

The unit may now be removed from the shield partition. It is always replaced as a unit.

h. POWER TRANSFORMER, T101. - Referance to Figures 5-2 and 5-8 shows that the transformer T101, tube and socket V106 and capacitor C113 are mounted on a plate which secures to the chassis from the underside. To remove this plate:-

Remove the two round-head screws through the flange of the chassis and plate, "D" in Figures 5-2 and 5-8.

From the underside of the chassis, remove the seven round-head screws around the edge of the transformer plate. These engage permanently staked T-nuts.

Remove all leads from transformer T101 and release the two cable slamps. The cable can now be pushed aside.

The whole plate with enumerated components may now be removed from the underside of the chassis. The transformer is secured to the plate by four nuts engaging its threaded studs. The mounting of the other parts is apparent from inspection of the unit.

i. REMOVAL OF TRANSFORMER, T102 - To do this:-

Remove two secondary leads from upper end, adjacent to binding posts. (See Figure 5-9)

Remove three primary leads from lower end, under chassis. (See Figure 5-2)

Remove terminal board R107 (See Paragraph 9c).

Remove two screws, thereby exposed, holding the rear end of the transformer bracket.

Remove the two nuts and screws securing the front of the transformer bracket to the flange of the chassis, Note position of and save the insulating strip between bracket and chassis and the two extruded bakelite washers between chassis flange and nuts.

The transformer T102 can now be tilted forward and out of the assembly. It is ordinarily replaced as a unit. The primary tuning capacitor may be replaced provided facilities are at hand to permit selection of proper capacitance to tune the primary to resonance at 1000 cycles.

In reassembling, pay particular attention to insulation of the joint between the end of the transformer bracket and the chassis. If this bracket shorts to the shield it acts as a low resistance short-circuited turn on the transformer and low 1000 cycle output will result. There is no other test method for this joint, hence the closest visual inspection is necessary.

j. RF TRANSFORMER, T103. - To remove this unit:-

Remove the tube access shield, Figure 5-8. This will expose the parts shown in the lower portion of Figure 5-11, except that the panel will still be in place.

Remove V106 together with its clamp and clamp-post, the latter secured by one nut under the chassis.

Remove E101, as instructed in Paragraph 9g.

Remove four connections from T103, under chassis.

Remove two hex nuts from T103 under chassis.

The transformer may now be snaked out. It may be replaced as a unit or the nut on top of the shield may be removed, then the shield. The latter may be locked by the fungus-proof lacquer employed; turn the shield with respect to the base to break the seal if necessary. With the shield removed coil L101, tuning capacitor C132, grid capacitor C133 and grid-lead R161 will be in view. These may be replaced individually with units of tolerance as specified in the Parts List.

k. RF TRANSFORMER, T104. - To remove this unit:-

Remove the tube-access shield, Figure 5-8.

Remove V104, together with its clamp and clamp-post, the latter secured by one nut under chassis.

Remove the knob from OSCILLATOR ADJUST. This will expose two screws on the panel side which should be removed, releasing capacitor C115.

Disconnect the ground lug from C115 and lay the capacitor to one side.

Remove four connections from T104, underside of chassis.

Remove two hex nuts from T104, underside of chassis.

The transformer may now be snaked out. It may be replaced as a unit or the shield may be removed by taking off one hex nut above it. Removal of the shield exposes the coil L102, tuning capacitor C134, bypass C135, grid-blocker C136 and isolation resistor R162. These may be individually replaced as desired from parts in accordance with the parts list.

l. CHASSIS REMOVAL - UNSANDWICHING - Review of Paragraphs 9a through 9k, above, indicates that many of the major parts of the Bridge ZM-11/U have been made accessible without separating the panel assembly from the chassis assembly as has been done in the companion views, Figures 5-10 and 5-11. Careful study of other situations should be made before attempting this unsandwiching operation for, as will be seen from study of the unwiring schedule below, many disconnects are required before the units can be separated as has been done in the illustration.

For simple checking and minor repairs a complete separation is unnecessary; with this in mind considerable slack has been left in those leads where it is electrically permissible. Such leads are marked with an asterisk (*) in the schedule.

Disconnect Schedule.

Left hand side of ZM-11/U

Black lead at R102A
Red lead at R102B
Gray lead at contact 9, S102C.
Yellow lead at contact 10, S102C.
Green lead at contact 5, S105D.
Gray lead at contact 7, S105A.
Blue lead at contact 8, S105C.
Yellow lead at contact 9, S105C.

Binding post side of ZM-11/U. (See Figure 5-9)

Bare wire at E104.
Bare wire at E105.
Green lead at C126 on E108.
* White lead at R105.
* Red lead at C106.
* Orange lead at C114.

Right hand side of ZM-11/U

Blue lead at C115.
Brown lead at J101.

Fuse-post side of ZM-11/U. (See Figure 5-8)

* Brown lead at C104.
* Gray lead at S101.
* Gray lead at XI102.

Underside of Chassis. (See Figure 5-2)

Green lead at R153 on E109.
Red lead at R154 on E109.
Orange lead at solder lug adjacent to T102.

To complete the unsandwiching:-

Remove the tube access shield, Figure 5-8.

Remove the knob from the OSCILLATOR switch.

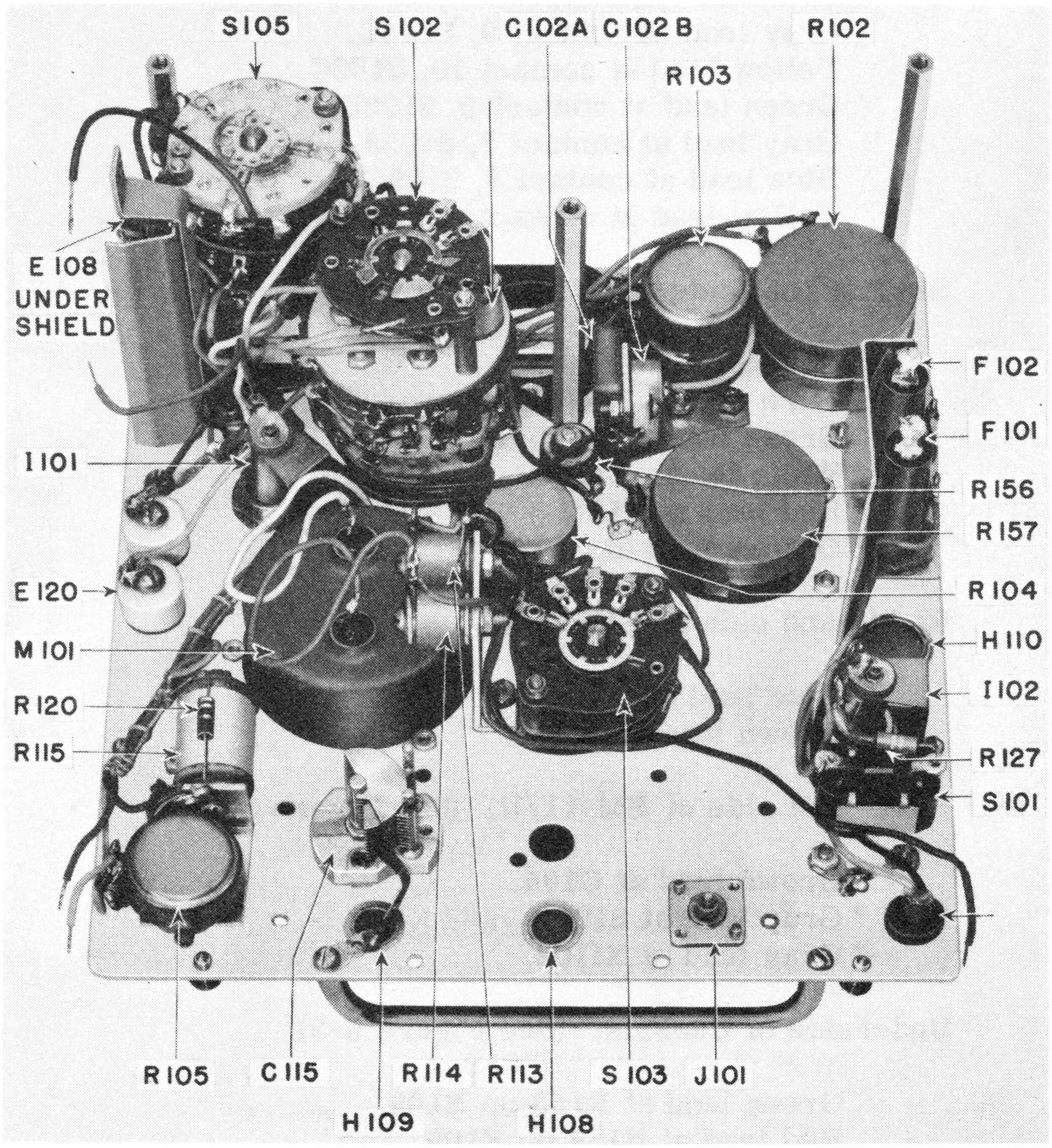


Figure 5-10. Bridge, ZM-11/U, Panel Assembly, Unsandwiched.

Remove the 3/8 inch nut and lockwasher securing switch S104 to the panel.

Remove six bright nickel hex-head screws from the panel. Two are just under the QUALITY TEST

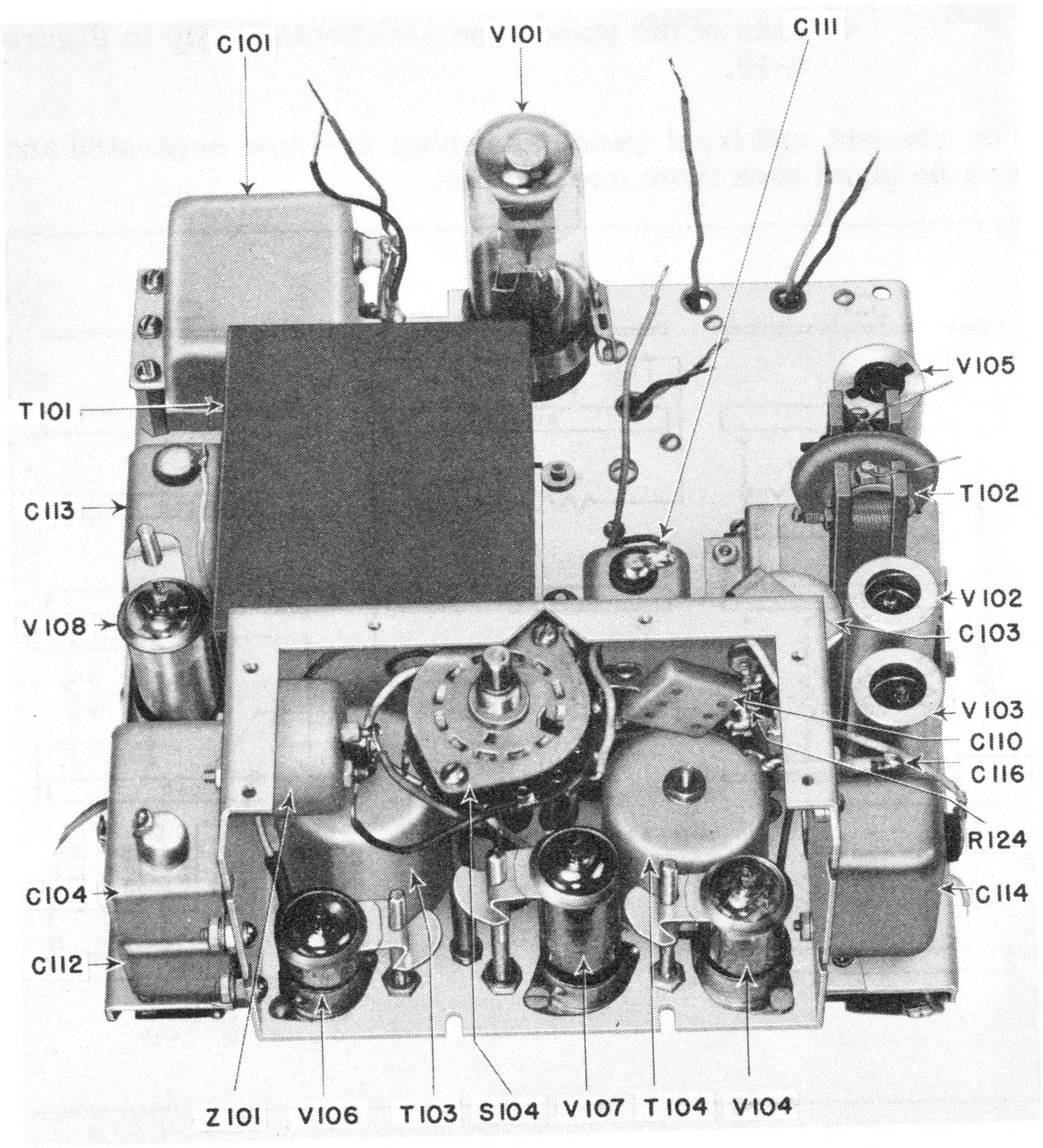


Figure 5-11. Bridge, ZM-11/U, Chassis Assembly, Unsandwiched.

jack; two to the left of the OSCILLATOR switch; and two just above the OSCILLATOR adjust knob. (See Figure 4-1)

Remove three round-head screws from the under side of the chassis, corresponding to the lower ends of the stanchions seen prominently in Figure 5-10.

The chassis and front panel assembly are now separated and may be layed back from one another.

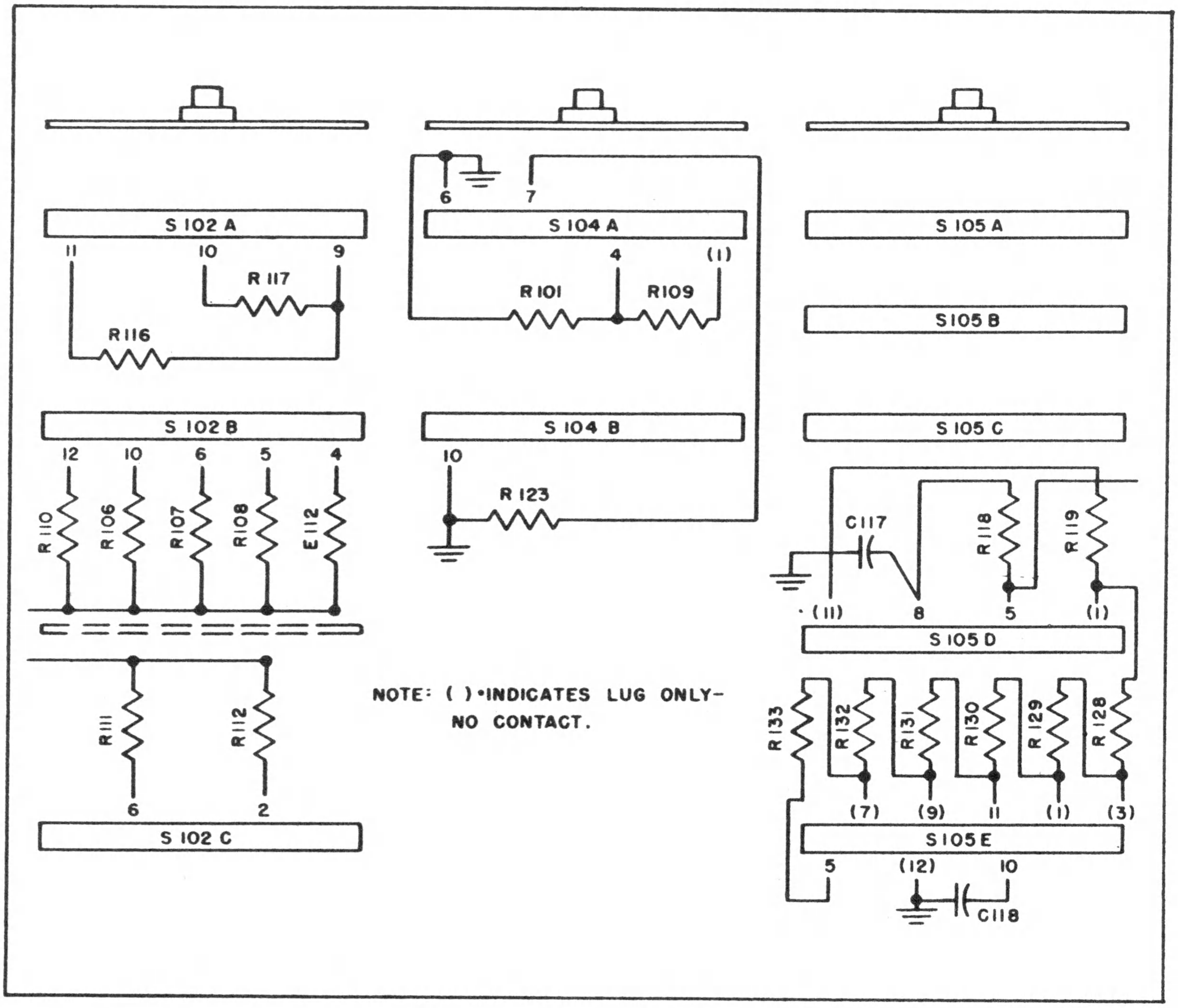


Figure 5-12. Components Mounted Between Switch Decks.

m. REPLACEMENT OF THE "A" RATIO ARM, R156, R157. - Replacement of either of these units is always done as a combination, the variable resistor R157, the end-limiting resistor R156 and the panel dial plate. To do this:-

Loosen two set screws in the MULTIPLY BY dial pointer and remove the pointer.

Unsandwich the chassis and front panel in accordance with Paragraph 91.

Remove the 3/8 inch hex nut and lockwasher securing R157.

Remove the two panel stop-pins which also secure the dial.

Remove the end resistor R156.

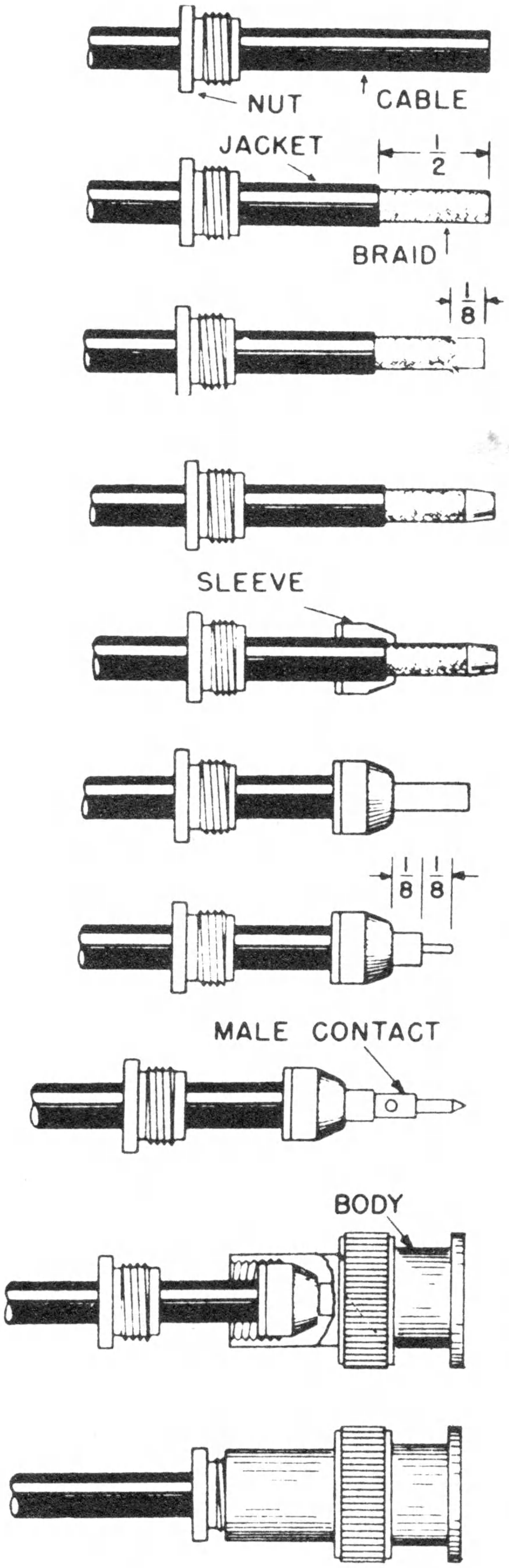
When R157, R156 and the dial plate are replaced it is well to make the necessary calibration of them in accordance with Paragraph 8c, before reassembling the front panel to the chassis. If, then, for any reason the new unit is not in tolerance much labor will have been avoided.

10. CABLE ASSEMBLY AND TEST LEADS.

a. CABLE ASSEMBLY, P101. - Because the electrical performance of this unit is related to its mechanical length it is important that no repair or replacement of it be made with due regard for this fact. The correct original length of the cable is 48 inches measured from the end of the clip on the center conductor to the extreme end of the connector. For repair, either end may be cut down by as much as one inch - no more. If the cable becomes damaged or worn to an extent requiring a greater cut, if should be replaced entirely.

Figure 5-13 shows the correct procedure for replacing the connector on the cable.

b. TEST LEADS - The length of these leads has no electrical importance and they may be cut and repaired until they become too short to be practical for use. If intermittant opens appear, the wires should be replaced entirely.



Cut end of cable even.

Remove vinyl jacket ½" *don't nick braid.*

Push braid back, and remove 1/8" of insulation and conductor.

Taper braid.

Slide sleeve over tapered braid. Fit inner shoulder of sleeve squarely against end of jacket.

With sleeve in place, comb out braid, fold back smooth as shown, and trim 3/32".

Bare center conductor 1/8" *don't nick conductor.*

Tin center conductor of cable. Slip male contact in place and solder. Remove excess solder. *Be sure cable dielectric is not heated excessively and swollen so as to prevent dielectric entering body.*

Push into body as far as it will go. Slide nut into body and screw into place, with wrench, until moderately tight. Hold cable and shell rigidly and rotate nut.

FINAL ASSEMBLY

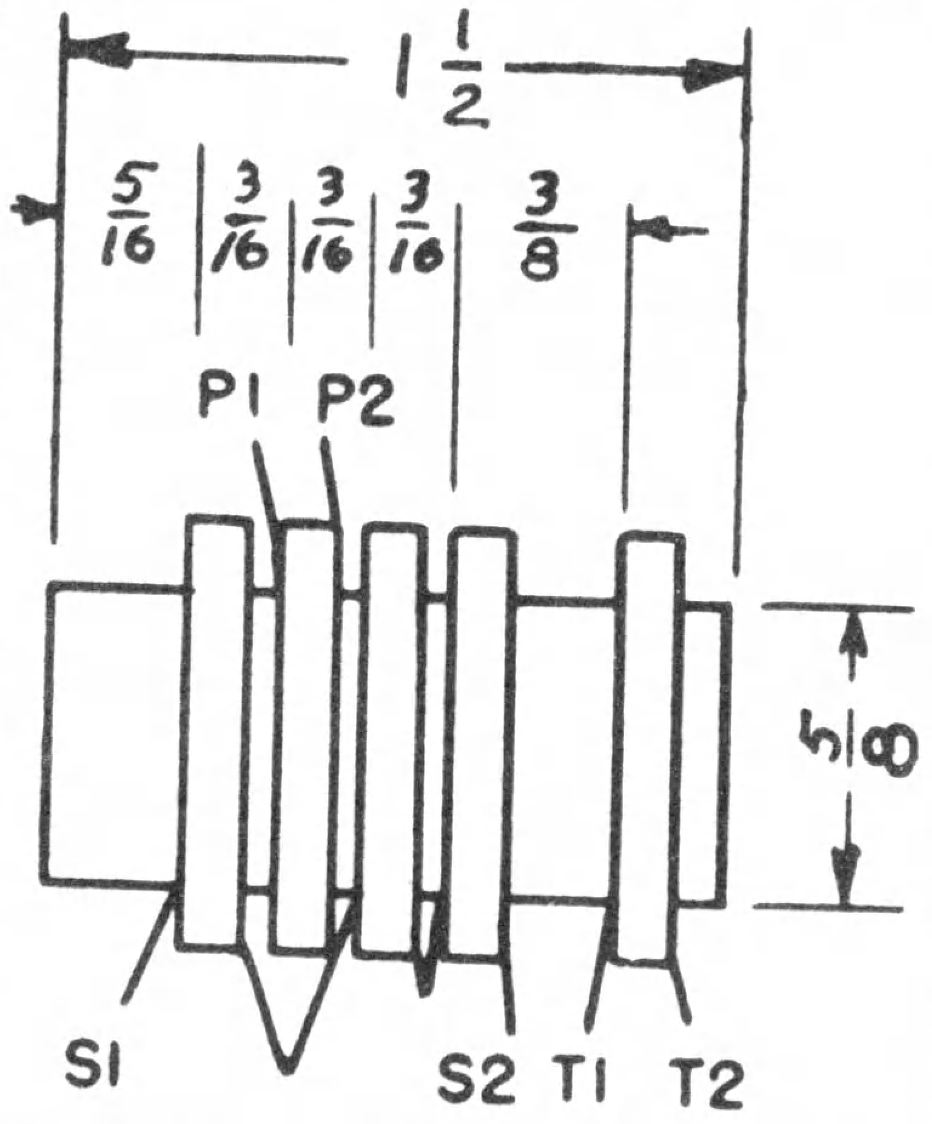
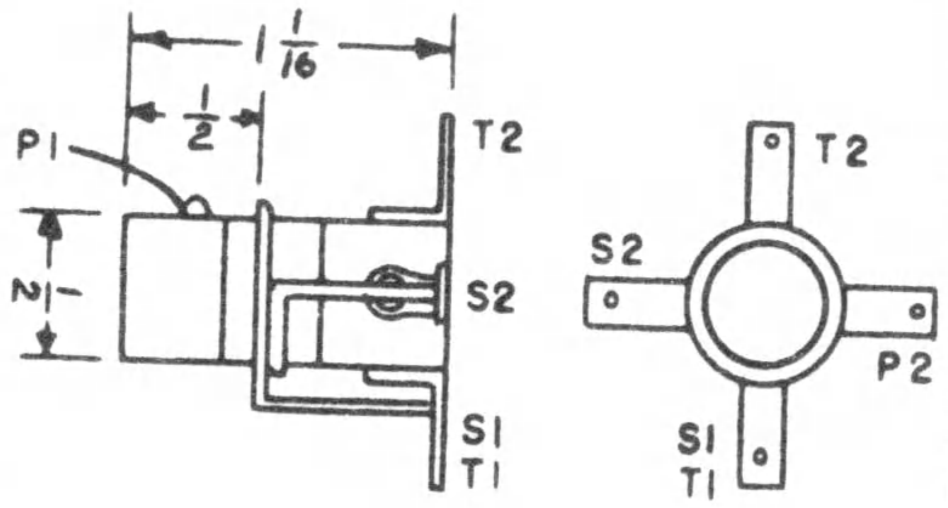
Figure 5-13. Cable P101, Assembly Instructions for Connecting UG-88/U to RG-58/U.

TABLE 5-9. TUBE OPERATING VOLTAGES AND CURRENTS.

TUBE TYPE	FUNCTION	PLATE (E)	PLATE (MA)	SCREEN (E)	SCREEN (MA)	CATHODE (E)	GRID (E)	HEATER (E)	TARGET (E)
6AG5	Amplifier	(1) 80	(1) .28	(1) 30	(1) .15	(1) 0.2	(1) -0.1	6.3	
6AL5W	Rectifier	(2)	(2)			(3) 0-500		6.3	
6AQ5	RF Oscillator	(4)	(4)	(4)	(4)	0	(4)	6.3	
6AV6	Oscillator, 1 kc	120	0.7			0.6	(3)	6.3	
6AV6	Electronic voltmeter	(4)	1.0			0		6.3	
6E5	Indicator	(1) 30	(1) 0.2			(5) 0	(1) 0.1	6.3	230
6J6	Amplifier, 1 kc	300 300	7.3 7.3			12	(2)	6.3	
6X4W	Rectifier	240 AC 240 AC				300		6.3	

Notes: (1) With R, N_2 binding posts shorted to chassis.
(2) Not measured.
(3) Depends on setting of VOLTAGE CONTROL.
(4) Depends on switch and control settings-See Fig. 5-3.
(5) Except for INS. RES. - See Fig. 5-3.
(6) Measurements are made with a 20,000 ohms per volt meter for dc and a VTVM for ac.

TABLE 5-10. WINDING DATA.

Symbol	CLB Part No.	DIAGRAM	Winding	Wire Size	Turns	D.C. Resistance Ohms	Inductance	REMARKS
L101			Primary Sect. 2	#38 SSE	325	44	@1 KC 5.6 MH	Universal wound on E-910-29 powdered iron core served .005" Cel. Ac. tape. Coil dryed 4 hours 250 deg. F and two thin coats Amphenol #912, air dryed. Test wnd to wnd and wnd to core 1000 v a-c.
			Second. Sect. 1, 3, 4	#38 SSE	975	133	30 MH	
			Tickler Sect. 5	#38 SSE	425	60	7.9 MH	
L102	L-910-5		Primary	#23 PE	11-3/4	.044	@10.75 MC 1.2 UH	Coat with Amphenol #912. Air dryed. Dip in Zophar Mills #1563 wax.
			Second. (Over Prim)	#20 Dble Cel.	1-1/4	.004	.15 UH	
			Tickler	#28 SSE	2-1/2	.03	.20	

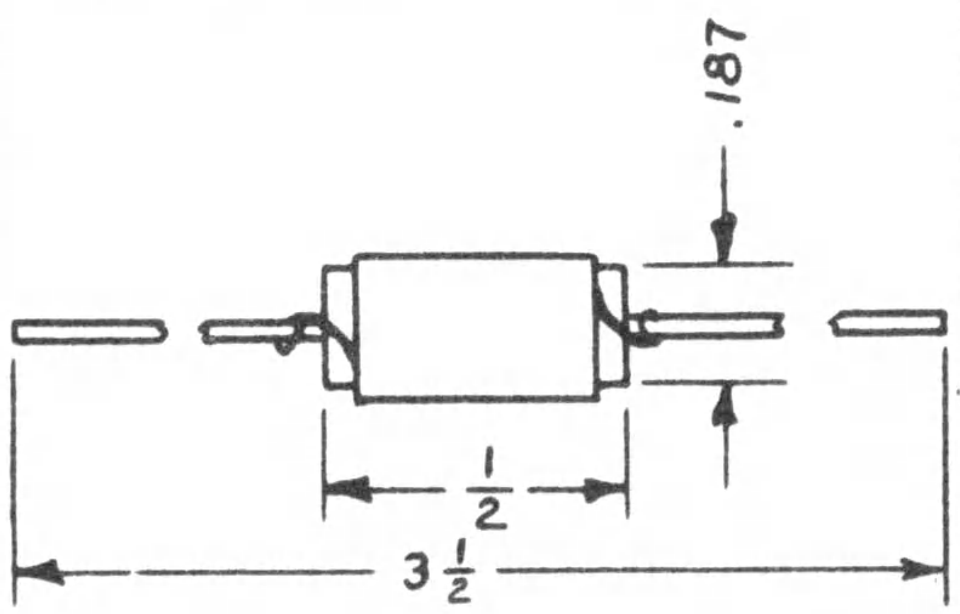
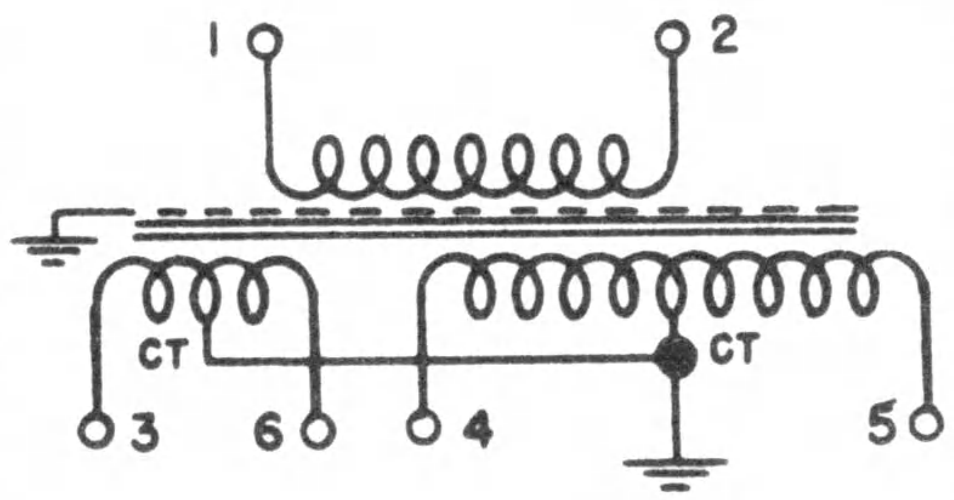
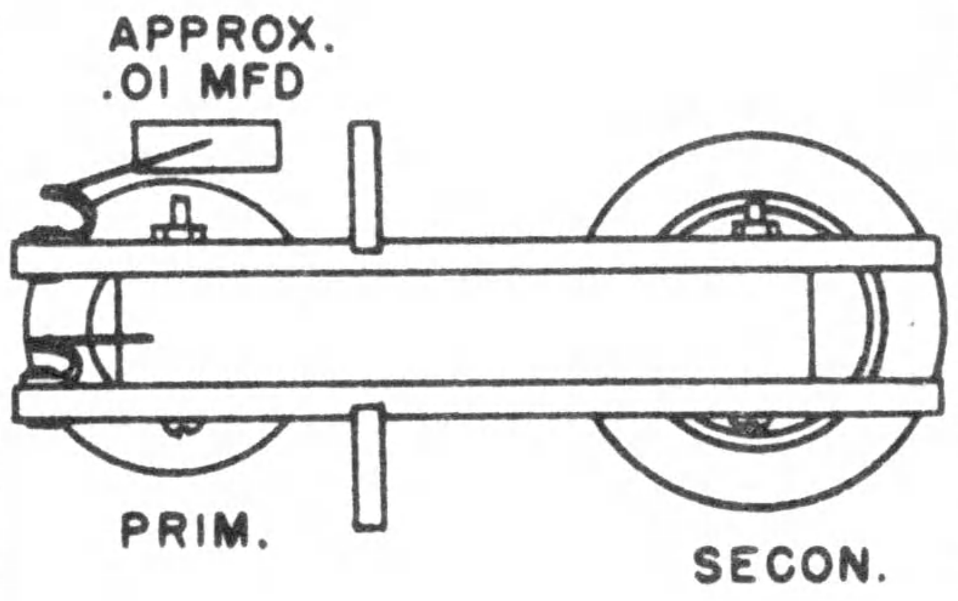
L103	L-910-3		Single Layer	#30 PE	15	.08	@ 1 KC .7 UH	Coat with Amphenol #912. Air dry.
T101	T-910-1		Primary Second. Filam.	#28 PE #37 #18	593 2882 CT 36 CT	15. 690. .14	Open cct v 115 Applied 279 279 7.0	1500 v insulation. Potted and hermetic sealed. Navy Spec. 16T30, Grade 1, Class A.
T102	T-910-2		Primary Layer wnd. Second. Univer-sal wnd.	#40 PE #23 SSE	2600 CT 292	600 14		Primary, paper section. Second wnd on bakelite tube 7/8"OD x 1/16 wall. 72 laminations Allegheny L-12, #26 gu Audio Trans A. Primary end dipped Zophar Mills #1563 wax. Capacity selected for 1 KC primary resonance.

TABLE 5-11. RATED TUBE CHARACTERISTICS.

Tube Type	Filament Voltage (V)	Filament Current (A)	Plate Voltage (V)	Grid Bias (V)	Screen Voltage (V)	Plate Current (MA)	Screen Current (MA)	A-C Plate Resistance (Ohms)	Voltage Amplification Factor (MU)	TRANSCONDUCTANCE (MICROMHOS) Normal	TRANSCONDUCTANCE (MICROMHOS) Minimum	EMISSION ISS (MA)	EMISSION Test Volt
6AG5	6.3	.30	250	(4) 200	150	7.0	2.0			5000	4000	25	10
6AL5W	6.3	.30	(1) 150			(2) 9.0		(2) 60				40	10
6AQ5	6.3	.45	250	12.5	250	45.	4.5	52,000		4100		100	10
6AV6	6.3	.30											
Triode			100	1.0		0.8		54,000	70	1300		25	30
Diodes	Not	used											
6E5	6.3	.30	250	0	(3) 250	0.2	(3) 2.0	1,000,000				15	30
6J6	6.3	.45	250	(4) 500		(2) 9.0			38	(2) 5650	(2) 4000	40	10
6X4W	6.3	.60	(1) 325			(2) 70		(2) 150				140	50

Notes: (1) A-C applied
(2) Each unit
(3) Target
(4) R_k in ohms

S105 "FUNCTION"	
POSITION	READS
1	CAP. QUAL.
2	R
3	N_I/N_2
4	L (D)
5	L (Q)
6	C
7	C_{CHG}
8	5000M
9	10,000M
10	CAL.

S102 "RANGE"				
POS	R	L	C	N_I/N_2
1	1 Ω	100 UH	10 UUF	.01
2	10 Ω	10 UH	100 UUF	.1
3	100 Ω	1 UH	1000 UUF	1
4	1K Ω	.1 UH	.01 UF	10
5	10K Ω	10H	.1 UF	
6	.1M Ω	1H	1 UF	
7	1M Ω		10 UF	
8			100 UF	

S104 OSCILLATOR	
POSITION	READS
1	DC VOLTS
2	OFF
3	OPEN
4	SET METER
5	SHORT

S103 "METER"	
POS	READS
1	DC VOLTS
2	25 MA
3	5 MA
4	1 MA

NOTES:

1. ALL VALUES EXPRESSED IN MICRO-MICROFARADS, MICROHENRIES, AND OHMS UNLESS OTHERWISE INDICATED.

2. ROTARY SWITCHES ARE VIEWED FROM KNOB END AND IN POSITION 1 (EXTREME COUNTER-CLOCKWISE POSITION). SECTIONS DESIGNATED A ARE NEAREST THE KNOB END. THE FRONT SIDE OF THE SECTION IS DESIGNATED BY F AND THE REAR SIDE BY R.

3. UNDERLINED VALUES ARE D.C. RESISTANCE IN OHMS OF WINDINGS.

Figure 5-14. Bridge, ZM-11/U, Schematic Diagram

SECTION 6
PARTS LIST

TABLE 6-1. TABLE OF REPLACEABLE PARTS

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
C101	N16-C-66201-1275	CAPACITOR ASSEMBLY: matched capacitors; 1 MF total capacity; +0 -.5% total tolerance; 600v DC total working voltage; parallel connection between capacitors; size 2-1/2" lg x 2" wide x 1-7/8" high; Clough-Brengle Co. Pt/dwg #C-910-1	Capacity Standard
C102	N16-C-66261-3501	CAPACITOR ASSEMBLY: two capacitors; parallel connection between capacitors; size 1-1/2" lg x 1" wide x 7/8" high; consists of C102A and C102B; Clough-Brengle Co. Pt/dwg #C-910-2	Capacity Standard
C102A	N16-C-20921-8819	CAPACITOR, fixed, mica, dielectric JAN-CM30E911G Spec JAN-C-5; Part of C102	Part of Capacity Standard
C102B	N16-C-64139-1181	CAPACITOR, variable, ceramic dielectric JAN-CV11D450 Spec JAN-C-81; Part of C102	Part of Capacity Standard
C103	N16-C-47335-5866	CAPACITOR, fixed paper dielectric JAN-CP25A3EC504X Spec JAN-C-25	V103 Cathode By-pass
C104	N16-C-47335-7305	CAPACITOR, fixed paper dielectric JAN-CP53B2EF504X Spec JAN-C-25	RF Filter
C105	N16-C-45814-9321	CAPACITOR, fixed paper dielectric JAN-CP29A3EF104X Spec JAN-C-25	RF Filter
C106	N16-C-18786-1771	CAPACITOR, fixed ceramic dielectric; case style No. 4 MBCA Ref Dwng Group 1; 1500 MMF capacity 20% tolerance; 500v DC working; variable temp coefficient; 5/8" lg x 7/32" diameter; Centralab No. DA 717-044	RF Filter

C107		Same as C106	RF Filter
C108		Same as C106	V107 Screen By-pass
C109	N16-C-30188-3670	CAPACITOR, fixed mica dielectric; 510 MMF±5% 300v DCW; temp coefficient letter C; 1/2" lg x 9/32" wide x 11/64" thk; moulded low loss bakelite case; 2 axial wire leads; Electro Motive Mfg. Co. #CM15C511J	V104 Plate By-pass
C110	N16-C-33627-7705	CAPACITOR, fixed mica dielectric JAN-CM35B103M Spec JAN-C-5	Coupling to V104 Grid
C111	N16-C-19542-3151	CAPACITOR, fixed electrolytic JAN-CE62C080P Spec JAN-C-62	V105 Cathode By-pass
C112		Same as C111	Power Filtering
C113		Same as C111	Power Filtering
C114	N16-C-19639-7713	CAPACITOR, fixed electrolytic JAN-CE62C150K Spec JAN-C-62	Power Filtering
C115	N16-C-60282-1536	CAPACITOR, variable, air dielectric; plate meshing type 75 MMF max; 6 MMF min; 1-3/8" lg x 15/16" wide x 1-1/4" high; Hammarlund Mfg. Co. Part #APC-75-B	Oscillator Tuning
C116		Same as C106	RF Filter

TABLE 6-1. TABLE OF REPLACEABLE PARTS—(Continued)

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
C117	N16-C-29665-9256	CAPACITOR, fixed, mica dielectric; 300 MMF ±10% 500v DCW; temp coefficient letter C; 1/2" lg x 9/32" wide x 11/64" thk; moulded low loss bakelite case; 2 axial wire leads; Electro Motive Mfg. Co. Part #CM15C301K	RF Filter
C118		Same as C117	RF Filter
C119	N16-C-29819-2202	CAPACITOR, fixed mica dielectric; 360 MMF ±5% 500v DCW; temp coefficient letter C; 1/2" lg x 9/32" wide x 11/64" thk; moulded low loss bakelite case; 2 axial wire leads; Part of E106 Electro Motive Mfg. Co. Part #CM15C361J	Phase Shifting
C120		Same as C119; Part of E106	Phase Shifting
C121		Same as C109; Part of E106	Phase Shifting
C122		Same as C109; Part of E106	Phase Shifting
C123	N16-C-31349-1684	CAPACITOR, fixed mica dielectric JAN-CM30B132J Spec JAN-C-5; Part of E107	Phase Shifting
C124	N16-C-31903-1084	CAPACITOR, fixed mica dielectric JAN-CM30B222J Spec JAN-C-5; Part of E107	
C125		Same as C110; Part of E107	V103 Output Coupling

C126	N16-C-28558-1533	CAPACITOR, fixed mica dielectric; 100 MMF±10% 500v DCW; temp coefficient letter C; 1/2" lg x 9/32" wide x 11/64" thk; moulded low loss bakelite case; 2 axial wire leads; Part of E108; Electro Motive Mfg. Co. Part #CM15C101K	V105 Input Tuning
C127	N16-C-30003-7116	CAPACITOR, fixed mica dielectric; 430 MMF±5% 300v DCW; temp coefficient letter C; 1/2" lg x 9/32" wide x 11/64" thk; moulded low loss bakelite case; 2 axial wire leads; part of E108; Electro Motive Mfg, Co. Part #CM15C431J	V105 Input Tuning
C128		Same as C110; Part of E109	AF Filter
C129	N-16-C-30742-4792	CAPACITOR, fixed mica dielectric, JAN-CM25B821J Spec JAN-C-5; Part of E109	V105 Output Coupling
C130		Same as C126; Part of E109	Phase Shifting
C131	N16-C-27466-3828	CAPACITOR, fixed mica dielectric; 43 MMF±2% 500v DCW; temp coefficient letter C; 1/2" lg x 9/32" wide x 11/64" thk; moulded low loss bakelite case; 2 axial wire leads; Part of E112; Electro Motive Mfg. Co. Part #CM15C430G	Phase Shifting
C132	N16-C-26121-2190	CAPACITOR, fixed mica dielectric; 110 MMF±2% 500v DCW; temp coefficient letter C; 1/2" lg x 9/32" wide x 11/64" thk; moulded low loss bakelite case; 2 axial wire leads; Part of T103; Electro Motive Mfg. Co. Part #CM15C110G	Oscillator Tuning
C133		Same as C117; Part of T103	Oscillator Grid Capacitor
C134		CAPACITOR, fixed mica dielectric; 180 MMF±2% 500v DCW; temp coefficient letter C; 1/2" lg x 9/32" wide x 11/64" thk; moulded low loss bakelite case; 2 axial wire leads; Part of T104; Electro Motive Mfg. Co. Part #CM15C181G	Oscillator Tuning

TABLE 6-1. TABLE OF REPLACEABLE PARTS—(Continued)

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
C135		Same as C109; Part of T104	RF By-pass
C136		Same as C117; Part of T104	Oscillator Grid Capacitor
C137		Same as C134; Part of Z101	Capacitive Element of Artificial Line
C138		CAPACITOR, fixed mica dielectric; 160 MMF; ±2% 500v DCW; temp coefficient letter C; 1/2" lg x 9/32" wide x 11/64" thk; moulded low loss bakelite case; 2 axial wire leads; Part of Z101; Electro Motive Mfg. Co. Part #CM15C161G	Capacitive Element of Artificial Line
		Miscellaneous Electrical Parts	
E101		POST, Binding; black bakelite cap; nickel plated brass base; no mounting stud; .164" diameter tapped hole; .0935 max dia of wire hole; Clough-Brengle Co. pt/dwg E-910-1	Bridge Terminal
E102		POST, Binding; red bakelite cap; nickel plated brass base; no mounting stud; .164" dia. tapped hole; .0935 max dia. of wire hole; Clough-Brengle Co. pt/dwg E-910-2	Bridge Terminal
E103		Same as E101	Bridge Terminal

E104		Same as E102	Bridge Terminal
E105		Same As E102	Bridge Terminal
E106	N16-T-10551-1045	CAPACITOR-RESISTOR ASSEMBLY; used in 1000 cycle oscillator circuit; consists of TB101, C119, C120, C121, C122, R135, R136, R137, and R138; 1-5/8" lg x 1-1/8" wd x 7/16" high; Clough-Brengle Co. pt/dwg #E-910-6	Oscillator Network
E107	N16-T-20551-1044	CAPACITOR-RESISTOR ASSEMBLY; used in 1000 cycle oscillator circuit; consists of TB102, C123, C124, C125, R139, R140, R141, R142, R143, R144, and R145; 2-7/8" lg x 2-1/16" wd x 3/8" high; Clough-Brengle Co. pt/dwg #E-910-7	Oscillator Output Circuit
E108	N16-T-20551-1043	CAPACITOR-RESISTOR ASSEMBLY; used in amplifier input circuit; consists of TB103, C126, C127 and R146; 2-3/8" lg x 1/2" wide x 5/16" high; Clough-Brengle Co. pt/dwg #E910-8	Amplifier Input Circuit
E109	N16-T-20551-1042	CAPACITOR-RESISTOR ASSEMBLY; used in amplifier output circuit; consists of TB104, C128, C129, C130, R147, R148, R149, R150, R151, R152, R153, R154 and R155; 2-1/4" lg x 1-1/8" wd x 3/8" high; Clough-Brengle Co. pt/dwg #E-910-9	Amplifier Output Circuit
E110		KNOB, rd with pointer; plastic with brass pointer; black; designed to accommodate shaft; brass insert; w/o marking; 1-11/16" lg x 1-1/8" dia. x 11/16" high; Kurz-Kasch, Inc. Part #S-308-64-40277-BB	Multiplier Knob
E111	N16-R-93273-2670	RESISTOR-ASSEMBLY; consists of R156 and R157 connected in series; Clough-Brengle Co. pt/dwg E910-11	"Multiply By" Control

TABLE 6-1. TABLE OF REPLACEABLE PARTS—(Continued)

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
E112		CAPACITOR-RESISTOR ASSEMBLY; consists of C131 and R134; Clough-Brengle Co. pt/dwg #E-910-12	Ratio Arm
E113	N16-S-34557-8351	Shield, Electron tube, TS102U02, Per JAN-S-28A	Shield For V102
E114		Same as E113	Shield For V103
E115		Same as E113	Shield For V105
E116		INSULATOR BUSHING; white L-5 ceramic, glazed finish; rd shank shape; MBCA Dwg Group 9, item code No. 76 MBCA Ref Dwg Group 9, D 5/8", E 1/4", G.406" H .175". L 15/32", R 1/16"; mounts in 13/32" hole; Centralab Part #X375W	Insulates Bridge Terminal
E117		Same as E116	Insulates Bridge Terminal
E118		Same as E116	Insulates Bridge Terminal
E119		Same as E116	Insulates Bridge Terminal

E120		INSULATOR BOWL; white L-5 ceramic; glazed finish, rd counterbore shape; MBCA Ref Dwg Group 9; item code No. 123 MBCA Ref Dwg Group 9; D 5/8", E 1/4", F .437", H .175", K 5/32", L 13/32"; one .175" mtg hole in center; Centralab Part #X376W	Insulates Bridge Terminal
E121		Same as E120	Insulates Bridge Terminal
E122		Same as E120	Insulates Bridge Terminal
E123		Same as E120	Insulates Bridge Terminal
E124	N16-K-700314-523	KNOB: rd; plastic; black; designed to accommodate shaft; brass insert; w/o marking; 1-1/8" dia. 5/8" high; Kurz-Kasch, Inc. Part #S-308-64-B-BB	Knob for R104
E125		Same as E124	Knob for C115
E126	N16-K-700065-545	KNOB: bar; plastic; black; designed to accommodate shaft; brass insert; w/o marking; 1-1/4" lg x 3/4" wide x 5/8" high; Kurz-Kasch, Inc. Part #S292-3L	Knob for R105
E127		Same as E126	Knob for S104
E128		Same as E126	Knob for S103

TABLE 6-1. TABLE OF REPLACEABLE PARTS—(Continued)

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
E129		Same as E126	Knob for S102
E130		Same as E126	Knob for S105
F101	N17-F-16302-70	Fuse, cartridge; 3/4 ampere 250v; instantaneous; ferrule type terminal; enclosed glass body; 1-1/4" lg 1/4" dia over-all dim; one time; non-indicating; Little Fuse, Inc. Part #3AG 3/4 amp	Line Power Protection
F102		Same as F101	Line Power Protection
F103		Same as F101	Spare Fuse
H101		HANDLE; case handle; bakelite and brass; U shape; rd; screw-on installation; 5-3/8" lg x 5/8" wide x 2-17/32" high; Clough-Brengle Co. pt/dwg H-910-1	Carrying Handle
H102		HANDLE; panel handle; brass; round; screw-on installation; 4-3/4" lg x 1/4" wide x 1-7/32" high" Clough-Brengle Co. pt/dwg H-910-2	Panel Guard
H103		Same as H102	Panel Guard

H104		FASTENER, latch;cabinet; steel 2-7/16" lg x 1-1/8" wide x 1/2" Corbin Cabinet Lock Co. Part #15794-B	Case Latch
H105		Same as H-104	Case Latch
H106		Same as H104	Case Latch
H107		Same as H104	Case Latch
H108		VENT, air; brass; nickel finish; round; mounts in 13/32" hole; Edw. B. Stimpson Co. Part #D53	Ventilation
H109		Same as H108	Ventilation
H110		VENT, air; brass; nickel finish; round; mounts in 5/8" hole; Edw. B. Stimpson Co. Part #D54	Ventilation
H111		Same as H110	Ventilation
H112		Same as H110	Ventilation
H113		CLAMP, electrical; stainless steel; slot type; mounts on 8-32 threaded rod; designed to hold miniature tube; 1-7/16" lg x 27/32" in dia; 9/16" high; Times Facsimile Corp. Part #1T	V108 Retainer
H114		Same as H113	V104 Retainer
H115		Same as H113	V106 Retainer
H116		Same as H113	V107 Retainer

TABLE 6-1. TABLE OF REPLACEABLE PARTS—(Continued)

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
H117		BOLT, machine; stainless steel; finished; no head; 1/2" min. lgth at one end, 1" min. lgth at other end; Times Facsimile Corp. Part #25 POST	V108 Retainer
H118		Same as H117	V107 Retainer
H119		BOLT, machine; stainless steel; finished; no head; 1/2" min. lgth at one end; 1" min. lgth at other end; Times Facsimile Corp. Part #23 POST	V104 Retainer
H120		BOLT, machine; stainless steel; finished; no head; 1/2" min. lgth at one end; 1" min. lgth at other end; Times Facsimile Corp. Part #17 POST	V106 Retainer
H121	N16-C-300798-452	CLAMP, electrical; stainless steel; latch type; 1-5/32" dia x 3/4" high; mounted by mounting hole 3/16" dia in base of clamp; Birtcher Corporation Part #926A	V101 Retainer
I101		LAMP, glow; 105-125v; 1/25 watt; .00035 amp; miniature bayonet base; size T-3-1/4; clear finish; emits red light 65v AC striking voltage; 90v DC striking voltage; 2 electrodes; General Electric Co. Part #NE-51	Warning Indicator
I102		Same as I101	Power Indicator
J101	N17-C-73108-1267	Connector, receptacle; UG290/U; Spec Mil-C-3608	Receptacle For W103

L101		COIL: RF Part of T103 primary 5.6 MH at 1000 cycles; Secondary 30 MH at 1000 cycles; Tickler 7.9 MH at 1000 cycles; Primary 325 turns; secondary 975 turns; tickler 425 turns; copper; enamel and single silk covered; pie universal winding; 6 terminations; wire lead type; located at windings; Clough-Brengle Co. Part #L-910-4	Oscillator Coil R-F Power Supply
L102		COIL: RF Part of T104; Primary 1.2 UH at 10.75 MC; Secondary .15 UH at 10.75 MC; Tickler .03 ohms DC resistance; 4 terminals; 1 termination; solder lug type; wire lead type; located at ends; Clough-Brengle Co. Part #L-910-5	Oscillator Coil Cap. Qual. Test
L103		COIL: radio frequency; 15 turns; #30AWG copper; enamel covered wire; single layer winding; unshielded; phenolic form; 2 terminations; wire lead type; terminal mounted; 1/2" lg 3/16" dia; part of Z101; Clough-Brengle Co. Part #L-910-3	Inductive Element of Artificial Line
M101	N17-M-29374-1203	METER: arbitrary scale; panel mounted; DC round; phenolic case: style No. 15 MBCA Ref Dwg Group 27; flange size 3-11/16" dia x 3/16" thick; 2-5/32" body dia; 1-11/32" body depth from mtg surface, excluding terminals; Sun Electric Corp. Part #M-910-1	Indicator
N101	N16-D-46338-3690	DIAL: Control; knob type; "D", 0 to 06 cw; direct drive; 1/4" dia shaft; 11/16" high x 1-1/2" dia; set screw mounted; dial not illuminated; Clough-Brengle Co. pt/dwg #N-910-1	"D" Dial
N102	N16-D-46338-3655	DIAL: Control; knob type; "Q" .5 to 20 cw; graduated in increments of .5 to 5; and in increments of 1 thereafter; direct drive; 1/4" shaft; 11/16" high x 1-1/2" dia; set screw mounted; dial not illuminated; Clough-Brengle pt/dwg #N-910-2	"Q" Dial

TABLE 6-1. TABLE OF REPLACEABLE PARTS—(Continued)

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
N103		DIAL, scale; "multiply range setting by"; 1 to 11 left to right; graduated in 100 scale, divisions; approximately 274° arc; round; 3" dia 3/8" dia center hole; 3/8" mounting hole; aluminum "an-odized; acquered; part of E111; Clough-Brengle Co. pt/dwg "N-910-6	Multiplier Dial
O101		BRACKET, capacitor mounting; "L" shape; anodized aluminum; 5/16" lg x 7/8" high; mts by two .144" holes; Clough-Brengle Co. pt/dwg A-910-17	C102 Mounting
O102		WASHER, flat; round; bakelite; JAN-P-13" dim; center hole 7/16" dia; outside 5/8" dia; 1/16" nominal material thickness; Clough-Brengle Co. pt/dwg E-910-24	Insulator Buffer
O103		Same as O102	Insulator Buffer
O104		Same as O102	Insulator Buffer
O105		Same as O102	Insulator Buffer
O106		Same as O102	Insulator Buffer
O107		Same as O102	Insulator Buffer

O108		Same as O102	Insulator Buffer
O109		BRACKET, shielding for binding post; "L" shape; aluminum; 13/16" lg x 11/16" wide x 1-1/8" high; mts by one 13/32" hole; Clough-Brengle Co. pt/dwg A-910-15	Shielding
O110		SHIELDS, light; brass; black enamel finish; 1-1/4" inside dia; cylindrical; 2" dia. 7/16" high; three mtg holes .144" dia. on 7/8" radius spaced 120 deg apart; Clough-Brengle Co. pt/dwg A-910-24	Light Shield
O111		GASKET; cover seal; neoprene; no holes; rectangular, 8-3/4" lg x 8-1/4" wide x 1/4" thick over-all; Clough-Brengle Co. pt/dwg H-910-16	Water Seal
P101	N17-L-63389-1285 *	CABLE ASSEMBLY; RF; AN type RG-58/U 4 Ft. lg overall;45" lg excluding terminations; Type UG-88/U plug at one end; Type 60S clip and type 60HS clip at other end; Consists of P101A, P101B, P101C, P101D and P101E; Clough-Brengle Co. pt/dwg P-910-1	Capacitor Quality Test Cable
P101A	N15-C-12201-5Ø	CABLE, RF type RG58/U per JAN-C-17A; Part of P-101	Part of P101
P101B	N17-©-71408-5333	CONNECTOR, plug; Type UG-88/U per MIL-C-3608; Part of P101	Part of P101
P101C		CLIP, electrical; alligator style 1 MBCA ref dwg group 37; steel; cadmium plated finish: 2" lg x 7/16" wide x 5/16" high; 1 terminal; screw type; 3/8" jaw opening when fully spread; Part of P101 Mueller Electric Co. Part #60S	Part of P101

*Not furnished as a maintenance part. If failure occurs do not request replacement unless the item cannot be repaired or fabricated.

TABLE 6-1. TABLE OF REPLACEABLE PARTS—(Continued)

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
P101D		CLIP, electrical; alligator style 1 MBCA Dwg Group 37; steel; cadmium plated finish; 2-1/4" lg x 7/16" wide x 5/16" high; plastic insulation; 1 terminal; screw type; 3/8" jaw opening when fully spread; Part of P101; Mueller Electric Co. Part #60HS	Part of P101
P101E		SPRING, helical extension type; cord holder; .032" dia brass spring wire; 1"; 19/64" dia; approximately 31 turns; Part of P101; Clough-Brengle Co. Pt/dwg E-910-23.	Part of P101
R101	N16-R-50740-431	RESISTOR, fixed comp. RC20BF274J per JAN-R-11	Voltage Divider
R102	N16-R-92679-1810	RESISTOR, variable; 2 sections: 1-5/8" dia; 1-1/4" deep; 1/4" dia rd metal shaft: 3/4" lg from mtg surface; normal torque; insulated; no off position; consists of R102A and R102B; P.R. Mallory Co. Part "SPO-74655	"D" Control
R102A		RESISTOR, variable; wire wound element; 1 section; 9950 ohms; ±10%; 4 watts nominal power rating; 2 terminals; solder lug type; metal case; 1-5/8" dia x 5/8" deep; insulated; no off position; Part of R102 For reference only.	Part of "D" Control
R102B		RESISTOR, variable; wire wound element; 1 section; 95.5 ohms; ±10%; 4 watts nominal power rating; 2 terminals; solder lug type; 1/4" dia. 3/4" lg from mtg. surface; normal torque; insulated; no off position; Part of R102 For reference only.	Part of "D" Control

R103	N16-R-93349-8345	RESISTOR ASSEMBLY; two matched pairs parallel connected; consists of R158, R158A, R158B, R159 and R160; one section; 3.18 megohms 5%; one section 3180 ohms ±5%; Clough-Brengle Co. Pt/dwg R-910-3	"Q" Control
R104	N16-R-78700-6959	RESISTOR, variable composition JAN-RV2AUFD253B Spec JAN-R-94	Ins. Res. Calibration
R105		RESISTOR, variable, composition element, 1 section; 100,000 ohms, ±10%, 2W nominal power rating; Std F taper, MBCA Ref Dwg Group 3; 3 terminals; metal case; 1-3/32" diam x 19/32" deep; 1/4" rnd metal shaft; 3/4" lg from mounting surface; normal torque; insulated; no "off" position; non turn device located on 17/32" radius at 9 o'clock; Allen-Bradley Co. Part #29831	Voltage Divider
R106		RESISTOR, fixed WW; body style No. 7; non-inductive winding; 10 ohms total resistance; ±.5% tolerance; 1/3W power rating; 85° C max continuous operating temp 5/8" lg; 17/32" OD; wax coated; resistant to humidity; 2 terminals; lug type; 3/16" wd. 1/4" lg; screw std; req. .144" dia mtg hole; Shallcross Mfg. Co. Part #BX-183	Ratio Arm
R107	N16R-78908-6279	RESISTOR, fixed WW; body style No. 7; non-ductive winding; 100 ohms total resistance; ±5% tolerance; 1/3W power rating; 85° OD; wax coated; resistant to humidity; 2 terminals; lug type; 3/16" wide; 1/4" lg; screw mtd; req. .144" dia mtg hole; Clough-Brengle Pt.dwg R-910-7	Ratio Arm
R108	N16-R-79098-4551	RESISTOR, fixed WW; body style No. 7; non-inductive winding; 1000 ohms total resistance; ±.5% tolerance; 1/3W power dis; 85° C max continuous operating temp; 9/16" lg, 9/16" OD body dim; wax coated; resistant to humidity; 2 terminals; lug type; dim 3/16" wide 1/4" lg; screw mtd; .144" dia mtg hole; Clough-Brengle Co. Pt/dwg R-910-8	Ratio Arm

TABLE 6-1. TABLE OF REPLACEABLE PARTS—(Continued)

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
R109	N16-R-50929-431	RESISTOR, fixed Composition, JAN-RF2OBF824J Spec JAN-R-11	Voltage Divider
R110		RESISTOR, fixed, wire wound; body style No. 7; non-inductive winding; 100,000 ohms total resistance; ±.5% tolerance; 1/3W power dis; 85° C continuous operating temp; 5/8" lg x 17/32" OD; wax coated; resistant to humidity; 2 terminals; lug type; dim 3/16" wide x 1/4" lg; screw mtd; .144" dia mtg hole; Shallcross Mfg. Co. Part #BX183	Ratio Arm
R111		Same as R110	Resistance Standard
R112		Same as R107	Resistance Standard
R113	N16-R-78771-3419	RESISTOR, fixed WW; body style No. 7; inductive winding; 20 ohms total resistance; ±1% tolerance; 1/3W power dis; 85° C max continuous operating temp; body dim 9/16" OD; wax coated; resistant to humidity; 2 terminals; lug type; dim 3/16" wide 1/4" lg; screw mtd; req. .144" dia mtg hole; Clough-Brengle Co. pt/dwg R-910-13	Meter Shunt
R114	N16-R-78643-8819	RESISTOR, fixed WW; body style No. 7; inductive winding; 5 ohms resistance; ±1% tolerance; 1/3W power dial 85° C max continuous operating temp; body dim 9/16" lg, 9/16" OD; wax coated; resistant to humidity; 2 terminals; lug type; dim 3/16" wide 1/4" lg; screw mtd; req. .144 in dia. Mtg hole; Clough-Brengle pt/dwg R-910-10	Meter Shunt

R115		RESISTOR, fixed, wire wound RB13B49702F per JAN-R-93	Meter Multiplier
R116	N16-R-49985-811	RESISTOR, fixed, Comp; RC20BF182K per JAN-R-11	Capacity Compensator
R117	N16-R-49643-811	RESISTOR, fixed; Comp; RC20BF181K per JAN-R-11	Capacity Compensator
R118	N16-R-50632-432	RESISTOR, fixed; Comp; RC20BF104J per JAN-R-11	RF Filter
R119	N16-R-50975-811	RESISTOR, fixed composition; RC20BF105K per JAN-R-11	Isolates R120
R120	N16-R-50047-436	RESISTOR, fixed comp; body style No. 14; 3000 ohms; 5%; 1/2 watt; F characteristic; .375" lg .140 dia. insulated; resistant to humidity and salt water immersion; 2 terminals; wire lead type; Allen-Bradley Co. Part #EB3025	Voltage Divider
R121		Same as R120	RF Filter
R122		RESISTOR, fixed comp; body style No. 14; 6800 ohms; 5%; 1 watt; .562" lg .225 dia; F characteristic; insulated; resistant to humidity and salt water immersion; 2 terminals; wire lead type; Allen Bradley Co. Part #GB6825	RF Filter
R123		RESISTOR, fixed comp; body style No. 14; 51,000 ohms; 5%; 1/2 watt; F characteristic; .375" lg .140" dia; insulated; resistant to humidity and salt water immersion; 2 terminals; wire lead type; Allen Bradley Co. Part #EB5135	V107 Grid Resistor
R124	N16-R-50822-811	RESISTOR: fixed comp; RC20BF474K per JAN-R-11	V104 Grid Resistor

R134	N16-R-79257-1101	RESISTOR, fixed; WW; body style No. 7; non-inductive winding; 10,000 ohms; ±.5%; 1/3 watt power dis; 85° C max continuous operating temp; 5/8" lg x 17/32" OD; wax coated; resistant to humidity; 2 terminals; lug type; 3/16" wide x 1/4" lg; screw mtd; req. .144" dia mtg hole; part of E112; Shallcross Mfg. Co. Part #BX183	Ratio Arm
R135		Same as R101; part of E106	Phase Shifter
R136		Same as R101; part of E106	Phase Shifter
R137		Same as R101; part of E106	Phase Shifter
R138		Same as R101; part of E106	Phase Shifter
R139	N16-R-49463-811	RESISTOR, fixed; composition RC20BF560K per JAN-R-11; part of E107	Parasitic Suppressor
R140	N16-R-49876-390	RESISTOR, fixed; composition; body style no. 14; 820 ohms; 5%; 1/2 watt; F characteristic; .375" lg, .140" dia; insulated; resistant to humidity and salt water immersion; 2 terminals; wire lead type; Part of E107; Allen-Bradley Co. Part #EB8215	V102 Cathode Resistor
R141		Same as R140; Part of E107	V103 Cathode Resistor
R142	N16-R-50677-431	RESISTOR, fixed; composition RC20BF154J per JAN-R-11; Part of E107	V103 Plate Resistor

TABLE 6-1. TABLE OF REPLACEABLE PARTS—(Continued)

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
R143		Same as R118; Part of E107	Phase Shifter
R144		Same as R127; Part of E107	Phase Shifter
R145		Same as R119; Part of E107	Phase Shifter
R146		Same as R101; Part of E108	V105 Input Tuning
R147	N16-R-49768-431	RESISTOR, fixed; composition RC20BF471J per JAN-R-11; Part of E109	V105 Cathode Resistor
R148	N16-R-50335-431	RESISTOR, fixed; composition; RC20BF153J per JAN-R-11; Part of E109	Voltage Divider
R149	N16-R-50857-431	RESISTOR, fixed; composition; RC20BF564J per JAN-R-11; Part of E109	V105 Plate Resistor
R150		Same as R119; Part of E109	Feed-back Coupling
R151		Same as R119; Part of E109	V101 Plate Resistor
R152	N16-R-51091-431	RESISTOR, fixed; composition; RC20BF275J per JAN-R-11; Part of E109	V105 Grid Resistor

R153		Same as R128; Part of E109	V101 Grid Resistor
R154		Same as R124; Part of E109	Voltage Dropping
R155	N16-R-50632-756	RESISTOR, fixed; composition; body style no. 14; 100,000 ohms; 5%; 1 watt; F characteristic; .562" lg .225" dia; insulated; res to humidity and salt water immersion; 2 terminals; wire lead type; Part of E109; Allen-Bradley Co. Part #GB1045	Voltage Divider
R156	N16-R-66000-3861	RESISTOR, fixed WW; body style No. 7; non-inductive winding; 900 ohms total res; ±2% tolerance; 1/3 watt; 85° C max continuous operating temp; 9/16" lg; 9/16" OD; wax coated; resistant to humidity; 2 terminals; lug type; 3/16" wide; 1/4" lg; screw mtd; req. .144" dia mtg hole; Part of E111; Clough-Brengle Co. Pt/dwg R-910-6	Make-up For R157
R157	N16-R-91288-3310	RESISTOR, variable; wire wd; element; 1 section 10,000 ohms ±2%; 3 watts nominal power rating; std A taper MBCA ref dwg group 3; 3 terminals; solder lug type; phenolic body; metal; rd; 1/4" dia; insulated; no "off" position; mtd by bushing; Part of E111; Clarostat Mfg. Co. Part #R-910-1	Multiplier
R158	N16-R-89290-2013	RESISTOR, variable; composition element; 2 sections; lst section 5 megohms; second section 5000 ohms; ±20% first section; ±10% second section; 2 watts nominal power rating each section; std F taper MBCA ref dwg group 3 both sections; 3 terminals each section; solder lug type; metal case; phenolic body; metal; round; 1/4" dia; insulated; no "off" position; mtd by bushing; Part of R103; Allen-Bradley Co. Part #32380	Variable Part of R103

TABLE 6-1. TABLE OF REPLACEABLE PARTS—(Continued)

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
R158A	N16-R-93791-1020	RESISTOR, variable: composition element; 1 section; 5 megohms; ±20%; 2 watts nominal power rating; std F taper MBCA ref dwg group 3; 3 terminals; solder lug type; metal case; phenolic body; enclosed; metal round; 1/4" dia; insulated; no "off" position; Mtd by bushing; Part of R158; Allen-Bradley Co. Part #32380-First Section For Reference only.	Part of R158
R158B	N16-R-93791-1019	RESISTOR, variable; composition element; 1 section; 5000 ohms; ±10%; 2 watts nominal power rating; std F taper, MBCA ref dwg group 3; 3 terminals; solder lug type; metal case; phenolic body; enclosed; 1-3/32" dia; 9/16" deep; metal; round; 1/4" dia; insulated; no "off" position; mtd by bushing; Part of R158; Allen-Bradley Co. Part #32380-Second Section For Reference only.	Part of R158
R159	N16-R-51307-431	RESISTOR, fixed; composition RC20BF915J per JAN-R-11; Part of R103	Swamp for R158A
R160	N16-R-50263-431	RESISTOR, fixed; composition; RC20BF912J per JAN-R-11; Part of R103	Swamp for R158B
R161	N16-R-50443-321	RESISTOR, fixed; composition; body style No. 14; 39,000 ohms; 5%; 1/2 watt; F characteristic; .375" lg . 140" dia; insulated; resistant to humidity and salt water immersion; 2 terminals; wire lead type; Part of T103; Allen-Bradley Co. Part #EB3935	V107 Grid Resistor
R162		Same as R120; Part of T104	RF Filter
S101	N17-S-70412-4406	SWITCH, toggle; SPST; JAN-#ST42A; Spec JAN-S-23	Power Switch

S102	N17-S-65457-9440	SWITCH, rotary; 3 sections; 8 positions; non "pile-up" type; 8 contacts section A; 6 contacts section B; 5 contacts section C; brass contacts; silver-plated contact finish; sections A and B ceramic; section C phenolic; 3-13/16" lg x 1-5/8" wide x 1-7/8" high; mtd by 1/4" lg; 3/8" -32 thread bushing; rd type; 5/8" lg; 1/4" dia; solder lug type terminals; Includes S102A, S102B, and S102C; Oak Mfg. Co. Part #47341-H3C; Clough-Brengle Co. pt/dwg S-910-6	Range Switch
S102A	N17-S-91641-1012	SWITCH SECTION, rotary; consists of 1 wafer; 1 rotor; 8 contacts; 1-7/8" lg x 1-5/8" wide x 9/16" high; mounts in two 1/8" holes; 1-9/16" c to c; Part of S102; Clough-Brengle Co. pt/dwg S-910-6A	Part ot S102
S102B	N17-S-91649-1021	SWITCH SECTION, rotary; consists of 1 wafer; 1 rotor; 6 contacts; 1-7/8" lg x 1-5/8" wide x 3/8" high; mounts in two 1/8" holes; 1-9/16" c to c; Part of S102; Clough-Brengle Co. pt/dwg S-910-6B	Part of S102
S102C	N17-S-91641-1011	SWITCH SECTION, rotary; consists of 1 wafer; 1 rotor; 5 contacts; 1-7/8" lg x 1-5/8" wide x 5/16" high; mounts in two 1/8" holes; 1-9/16" c to c; Part of S102; Clough-Brengle Co. pt/dwg S-910-6C	Part of S102
S103	N17-S-59272-7194	SWITCH, rotary; 1 section; 4 positions; non "pile-Up" type; 6 brass contacts; silver-plated contact finish; phenolic section; 1-1/2" lg x 1-5/8" wide x 1-7/8" high; mtd by 1/4" lg 3/8" -32 thread bushing; rd type; 5/8" lg, 1/4" dia; solder lug type; terminals; Oak Mfg. Co. Part #47343-QH; Clough-Brengle Co. pt/dwg S-910-3	Meter Range Switch

TABLE 6-1. TABLE OF REPLACEABLE PARTS—(Continued)

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
S104	N17-S-63687-7954	SWITCH, rotary; 2 sections; 5 positions; non "pile-up" type; 11 contacts on section A; 8 contacts on section B; brass contacts; silver-plated contact finish; phenolic sections; 4-3/8" lg x 1-5/8" high; mtd by 1/4" lg 3/8" -32 thread bushing; rd type; 5/8" lg; 1/4" dia; solder lug type terminals; includes S104A and S104B; Oak Mfg. Co. Part #47340-H2; Clough-Brengle Co. pt/dwg S-910-4	Oscillator Switch
S104A	N17-S-91681-1017	SWITCH SECTION, rotary; consists of 1 wafer; 1 rotor; 11 contacts; 7/8" lg x 5/8" wide x 1/2" high; mounts in two 1/8" holes; 1-9/16" c to c; Part of S104; Clough-Brengle Co. pt/dwg S-910-4A	Part of S104
S104B	N17-S-91649-1004	SWITCH SECTION, rotary; consists of 1 wafer; 1 rotor; 8 contacts; 1-7/8" lg x 1-5/8" wide x 5/16" high; mounts in two 1/8" holes; 1-9/16" c to c; Part of S104; Clough-Brengle Co. pt/dwg S-910-4B	Part of S104
S105	N17-S-66623-5062	SWITCH, rotary; 5 sections; 10 positions; non "pile-up" type; 9 contacts section A; 4 contacts Section B; 11 contacts section C; 8 contacts section D; 10 contacts section E; brass contacts; silver-plated contact finish; sections A, B and E ceramic; sections C and D phenolic; 3-13/16" lg x 1-5/8" wide x 1-7/8" high; mtd by 1/4" lg 3/8" -32 thread bushing; rd type; 5/8" lg; 1/4" dia; solder lug type terminals; includes S105A, S105B, S105C, S105D and S105E; Oak Mfg. Co. Part #47342-H5C; Clough-Brengle Co. pt/dwg S-910-5	Function Switch
S105A		SWITCH SECTION, rotary; consists of 1 wafer; 1 rotor; 9 contacts; 1-7/8" lg x 1-5/8" wide x 9/16" high; mounts in two 1/8" holes; 1-9/16" c to c; Part of S105; Clough-Brengle Co. pt/dwg S-910-5A	Part of S105

S105B	N-17-S-91633-1013	SWITCH SECTION, rotary; consists of 1 wafer; 1 rotor; 4 contacts; 1-7/8" lg x 1-5/8" wide x 3/8" high; mounts in two 1/8" holes; 1-9/16" c to c; Part of S105; Clough-Brengle Co. pt/dwg S-910-5B	Part of S105
S105C	N17-S-91689-1006	SWITCH SECTION, rotary; consists of 1 wafer; 1 rotor; 11 contacts; 1-7/8" lg x 1-5/8" wide x 1/2" high; mounts in two 1/8" holes; 1-9/16" c to c; Part of S105; Clough-Brengle Co. pt/dwg S-910-5C	Part of S105
S105D		SWITCH SECTION, rotary; consists of 1 wafer; 1 rotor; 8 contacts; 1-7/8" lg x 1-5/8" wide x 1/2" high; mounts in two 1/8" holes; 1-9/16" c to c; Part of S105; Clough-Brengle Co. pt/dwg S-910-5D	Part of S105
S105E	N17-S-91649-1022	SWITCH SECTION, rotary; consists of 1 wafer; 1 rotor; 11 contacts; 1-7/8" lg x 1-5/8" wide x 3/8" high; mounts in two 1/8" holes; 1-9/16" c to c; Part of S106; Clough-Brengle Co. pt/dwg S-910-5E	Part of S105
T101	N17-T-74163-9934	TRANSFORMER, power; step-down and step-up; hermetically sealed; metal; 115v AC; 50-1000 cycles; single phase; 2 output windings; no. 1 secondary 528v; no. 2 secondary 6.3v; no. 1 secondary .02 amp; no. 2 secondary 3 amp; no. 1 secondary center tapped; 1500v insulation; varnish impregnated; potted; 3-3/8" lg x 2-3/4" wide x 2-3/8" high; 6 terminals; solder lug type; located on bottom; four 8/32"by 3/8"; mtg studs on 2-1/2" x 2" mounting centers; MBCA ref dwg group 12; Chicago Transformer Div. Part #16596; Clough-Brengle Co. pt/dwg T-910-1	Power and Heater Supply

TABLE 6-1. TABLE OF REPLACEABLE PARTS—(Continued)

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
T102	N17-T-65696-5409	TRANSFORMER, audio frequency; plate coupling type; 14,000 ohms primary; 177 ohms secondary; primary center tapped; primary rated 10 MA; 700v test voltage; silicon steel core; 3-1/4" lg x 1-3/8" wide x 1-7/16" deep; 8.9 to 1 ratio of turns, primary to secondary; frequency 1000 cycles; tuned; .01 mf capacitance; 6 terminals; solder lug type; located on top and bottom, 4 mtg holes; tapped; 4-40 on 1" x 1-1/8" mtg centers; wax impregnated; not shielded; Clough-Brengle Co. pt/dwg T-910-2	Bridge Transformer
T103	N17-T-81238-9251	TRANSFORMER, radio frequency; 3 windings; universal winding; primary; 5.6 millihenries at 1000 cycles per sec; tickler 7.9 millihenries at 1000 cycles per sec; secondary, 30 millihenries at 1000 cycles per sec; primary, 325 turns, #38 SSE wire; tickler, 425 turns, #38 SSE wire; secondary, 975 turns, #38 SSE wire; DC res; primary, 44.3 ohms; tickler, 60.4 ohms; secondary 133.4 ohms; 300 kilocycles peak frequency; untapped; rd shield can; aluminum; anodized; wd on powd. iron core; 1-1/2" lg x 5/8" dia.; no adjustable tuning; 5 terminals; stud type; located on bottom; Shield marked T-910-3 includes C132, C133, L101, and R161; Clough-Brengle Co. pt/dwg T-910-3	Oscillator Coil

T104		TRANSFORMER, radio frequency; 3 windings; layer wound; primary, 1.2 microhenries at 10.75 MC; tickler, .2 microhenries at 10.75 MC; secondary .15 microhenries at 10.75 MC; Turns and wire size; primary 11-3/4 turns #23 PE wire; tickler 2-1/2 turns #28 SSE wire, secondary 1-1/3 turns #20 double celanese covered wire; DC resistance primary .004 ohms; tickler .03 ohms, secondary .004 ohms; 10.75 megacycles peak frequency; untapped; rd anodized aluminum shield can; wd on phenolic coil form; air core; no adjustable tuning; 1-1/2" lg x 5/8" dia; mts into two .144 in dia holes, 1/2 in c to c; five terminals, stud type; located on bottom; shield marked T-910-4; includes C134, C135, C136, L102, R162; Clough-Brengle Co. pt/dwg T-910-4	Oscillator Coil
		Electron Tubes	
V101	N16-T-56255	TUBE, electron; JAN-6E5; tuning indicator	Balance Indicator
V102	N16-T-56360	TUBE, electron; JAN-6J6; twin triode	Amplifier
V103	N16-T-56203-60	TUBE, electron; JAN-6AV6; diode-triode	Oscillator
V104		Same as V103	VTVM
V105	N16-T-56175	TUBE, electron; JAN-6AG5; pentode	Amplifier
V106	N16-T-56195-50	TUBE, electron; JAN-6AL5W; diode	Rectifier
V107	N16-T-56198	TUBE, electron; JAN-6AQ5; pentode	Oscillator
V108	N16-T-56840-50	TUBE, electron; JAN-6X4W; rectifier	Rectifier

TABLE 6-1. TABLE OF REPLACEABLE PARTS—(Continued)

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
W101	N17-L-63362-6616 *	LEAD SET, test; JAN type No. WS-17/U; #18 AWG stranded copper cord; 65 #36 AWG strands; Buna S, red; 1000v RMS max; 33" lg excluding termination; Mueller #85 clip and red #87 insulator on one end, American Radio Hdwe Co. #16 phone tip on other end; includes W101A, W101B, W101C and W101D; Clough-Brengle Co. pt/dwg W-910-1	Test lead
W101-A	N15-W-2195-5200	WIRE, electrical; stranded conductor; insulated; rd conductor; No. 18 AWG; 65 strands; No. 36 AWG strands; copper; soft; tinned finish on conductor; Buna S insulated; 1000v RMS AC max rated working voltage; colored red; U. S. Army specification 71-3310; WS-17/U; Part of W101	Part of W101
W101B	N17-C-803186-101	CLIP, electrical; crocodile style No. 1; MBCA ref dwg group 37; steel; cadmium plated finish; 2-3/16" lg x 1/2" wide x 11/32" high; 1 terminal; screw type; 7/16" jaw opening when fully spread; part of W101; Mueller Electric Co. Part #85	Part of W101
W101C	N17-T-47049-7465	TIP, phone; rd point end type; brass; nickel plated finish; No. 18 AWG wire accommodated; 15/16" lg x 5/32" dia; soldered wire connection; Part of W101; American Radio Hdwe Co. Part #16	Part of W101
W101D	N17-C-945001-519	INSULATION, sleeving; electrical; flexible sleeving; polyvinyl acetate; 1/2" ID; 1/16" wall thickness; supplied in fabricated lengths; 1-3/4" lg over-all; not rated for di-electric strength; red colored; part of W101; Mueller Electric Co. Part #87	Part of W101

*Not furnished as a maintenance part. If failure occurs do not request replacement unless the item cannot be repaired or fabricated.

W102	N17-L-63362-6601 *	LEAD SET, test; JAN type no. WS-16/U; #18 AWG stranded copper cord; 65 #36 AWG strands; Buna S; black; 1000v RMS max; 33" lg excluding termination; Mueller #85 clip and black #87 insulator on one end; American Radio Hdwe Co. #16 phone tip on other end; includes W102A, W102B, W102C and W102D; Clough-Brengle Co. pt/dwg W-910-2	Test lead
W102A		WIRE, electrical; stranded conductor; insulated; rd conductor; No. 18 AWG; 65 strands; No. 36 AWG strands; copper; soft; tinned finish on cond; Buna S ins; 1000v RMS max rated work voltage; colored black; U.S. Army Specification 71-3310 WS-16/U; Part of W102	Part of W102
W102B		Same as W101B; Part of W102	Part of W102
W102C		Same as W101C; Part of W102	Part of W102
W102D	N17-C-945001-299	INSULATION, sleeving electrical; flexible sleeving; poly-vinyl acetate; 1/2" ID; 1/16" wall thickness; supplied in fabricated lengths; 1-3/4" lg over-all; not rated for dielectric strength; black colored; Part of W102; Mueller Electric Co. Part #87	Part of W102
W103	N17-C-48590-6626	CABLE ASSEMBLY, power, electrical; 2 conductors stranded; No. 22 AWG; polyethylene insulation; rayon braid; tinned copper braid shield; chrome vinyl plastic jacket; 7 ft. -7-1/2" lg over-all; 1 terminal fitting; Harvey-Hubbell, Inc. 2 pole male plug; Type 1372; Conductors stripped and tinned 1/2" on one end; jacket and shield stripped 7" on same end; includes W103A and W103B; Clough-Brengle Co. pt/dwg P-910-2	Line cord

*Not furnished as a maintenance part. If failure occurs do not request replacement unless the item cannot be repaired or fabricated.

TABLE 6-1. TABLE OF REPLACEABLE PARTS—(Continued)

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
W103A	N15-C-32550	CABLE, special purpose, electrical; 2 conductors; tinned copper; No. 22 AWG; stranded; 16 strands; colorless; rayon braid; tinned copper braid shield; chrome vinyl plastic jacket; rd cross section; .235 in. dia over-all; copper shield around 2 No. 22 AWG conductors; Part of W103; Belden Mfg. Co. Part #8422	Part of W103
W103B	N17-C-71435-8532	CONNECTOR, plug; 2; male; flat; straight type; 1-1/2" lg x 7/8" wide x 1-3/8" high; 15 amp; 125v rectangular shape; rubber; 5/16" dia max cable opening; Part of W103; Harvey Hubbel Co. Part #1372	Part of W103
XF101	N17-F-74266-9246	FUSE HOLDER; extractor post type; 250v, 15 amp; 1 fuse; cartridge type; 1-1/4" lg 1/4" dia; phenolic body; brass contacts; 2-1/4" lg 11/16" dia; 2 terminals; solder lug type; mts in 1/2" dia hole; hole in cap for insertion of test prod. Bussman Mfg. Co. Part #HKP-HQRJ	Fuse Holder
XF102		Same as XF101	Fuse Holder
XI-101	N17-L-76743-3978 *	LIGHT, indicator; supplied w/lens; 5/8" dia; clear; smooth; accommodates T-3-1/4 lamp; miniature bayonet base; brass shell; nickel plated; enclosed; 2-3/32" lg x 3/4" dia; 11/16" dia mtg hole is required; accommodates up to 3/8" thick panel; vertically mtd; lamp replaceable from front of panel; 2 terminals; solder lug type; located on bottom of lamp-holder; both insulated from frame; includes XI-101A and XI-101B; Drake Mfg. Co. Part #101	Socket for I-101

*Not furnished as a maintenance part. If failure occurs do not request replacement unless the item cannot be repaired or fabricated.

XI-101A	N17-L-76656-2458	LIGHT, indicator; accommodates lens 5/8" dia; screw mtd lens-holder; accommodates T-3-1/4 lamp; miniature bayonet base; brass shell; nickel plated; enclose; over-all dim. 1-19/32" lg x 3/4" dia; 11/16" dia. mtg hole is required; accommodates up to 3/8" thick panel; 2 terminals; solder lug type; located on bottom of lamp-holder; both insulated from frame; Part of XI-101	Socket for I-101
XI-101B	N17-L-250181-510	LENS; 5/8" dia. 1/2" lg; non-focusing; clear; plastic; screw-in mount; 23/32" lg 5/8" dia; Part of XI-101	Lens for I-101
XI-102		Same as XI-101; Includes XI-102A and XI-102B	Socket for I-102
		Same as XI-101A; Part of XI-102	Socket for I-102
XI-102A		Same as XI-101B; Part of XI-102	Lens for I-102
XI-102B		SOCKET, electron tube; 6 contacts; beryllium; silver plated; 6 prong; oval; 2-1/4" lg x 1-11/16" wide x 1/4" high; ceramic body; two hole mtg; mtg. dim 1-1/4" dia; chassis hole req. 2 mtg. holes; .170" x 17/64" slot; spaced 1-3/4" c to c; treated with Dow Corning #200; E. F. Johnson Co. Part #122-226-6	Socket for V101
XV-101			
XV-102	N16-S-62603-6702	SOCKET, electron tube; JAN-TS102 P01Spec JAN S-28A	Socket for V102
XV-103		Same as XV-102	Socket for V103
XV-104		Same as XV102	Socket for V104

TABLE 6-1. TABLE OF REPLACEABLE PARTS—(Continued)

REFERENCE SYMBOL	STANDARD NAVY STOCK NUMBER	NAME AND DESCRIPTION	LOCATING FUNCTION
XV-105		Same as XV102	Socket for V105
XV-106		Same as XV-102	Socket for V106
XV-107		Same as XV-102	Socket for V107
XV-108		Same as XV-102	Socket for V108
Z-101	*	FILTER; R.F. operates as 10.75 megacycle quarter wave line when connected to 4 feet; RG-58/U cable; 50 ohms output; 50 ohms input; 1-1/8" dia. 1-1/8" high; cased; cylindrical; aluminum; one 6-32X1/4" lg mounting stud; 2 terminals; post type; includes C137; C138, L103; Clough-Brengle Co. Part/dwg T-905-5	Part of Quarter Wave Line Section
TB-101	N17-B-77734-8364	TERMINAL BOARD; molded phenolic board; 6 terminals; solder lug type; w/o barriers; overall dim; 1-5/8" lg x 1-1/8" wide x 11/32" high; two .144" dia mtg holes spaced 7/8" c to c; Part of E106; Clough-Brengle Co. Pt/dwg E-910-6A	E106 Board
TB-102	N17-B-77958-6345	TERMINAL BOARD; molded phenolic board; 11 terminals; solder lug type; w/o barriers; over-all dim; 2-7/8" lg x 2-1/16" wide x 11/32" high; mts on four 4-40 screws; part of E107; Clough-Brengle Co. Pt/dwg E-910-7A	E107 Board

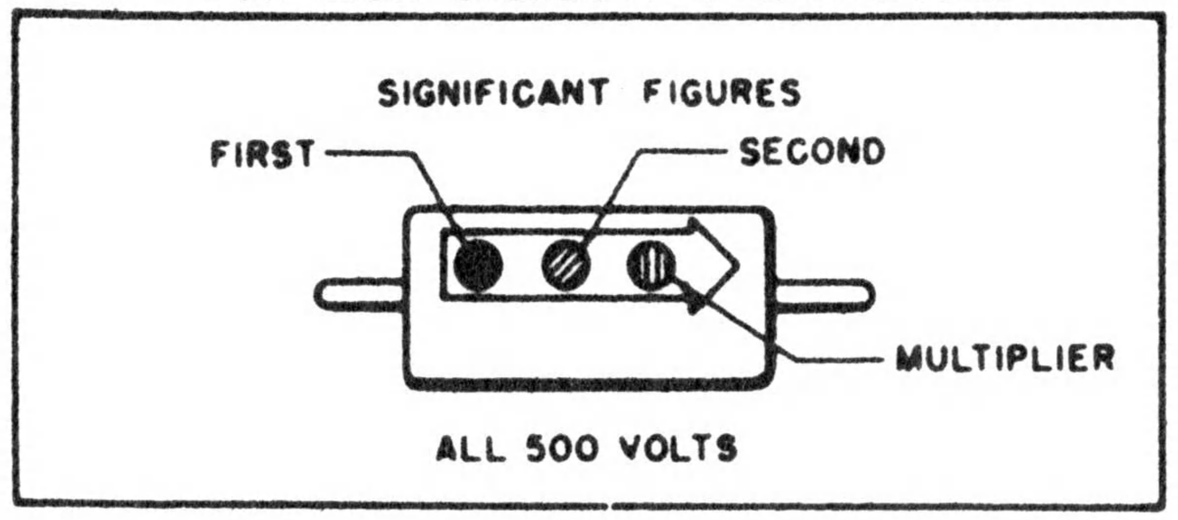
*Not furnished as a maintenance part. If failure occurs do not request replacement unless the item cannot be repaired or fabricated.

TB103	N17-B-77586-9439	TERMINAL BOARD; molded phenolic board; 3 terminals; solder lug type; w/o barriers; over-all dim; 2-3/8" lg x 1/2" wide x 11/32" high; two .144" dia mtg holes spaced 1-21/32" c to c; Part of E108; Clough-Brengle Co. pt/dwg E-910-8A	E108 Board
TB104	N17-B-78033-8314	TERMINAL BOARD; molded phenolic board; 14 terminals; solder lug type; w/o barriers; over-all dim; 2-1/4" lg x 2-1/8" wide x 11/32" high; mts on four 4-40 screws; Part of E109; Clough-Brengle Co. pt/dwg E-910-9A	E109 Board
TB105	N17-B-77635-1699	TERMINAL BOARD; molded phenolic board; 4 terminals; solder lug type; w/o barriers; over-all dim; 1-5/8" lg x 11/16" wide x 11/32" high; two .144" dia mtg holes; Clough-Brengle Co. pt/dwg E-910-15	Resistor Mounting Board
TB106	N17-B-77685-4726	TERMINAL BOARD; molded phenolic board; 5 terminals; solder lug type; w/o barriers; over-all dim; 1-3/4" lg x 1-1/8" wide x 11/32" high; Clough-Brengle Co. pt/dwg E-910-16	Capacitor Resistor Mounting

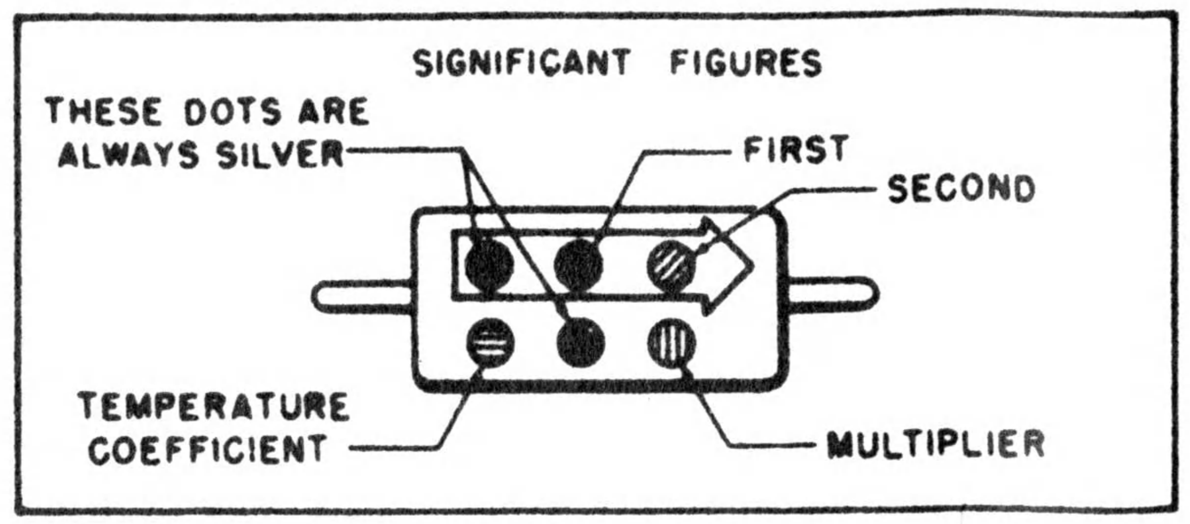
TABLE 6-3. APPLICABLE COLOR CODES

CAPACITOR COLOR CODES

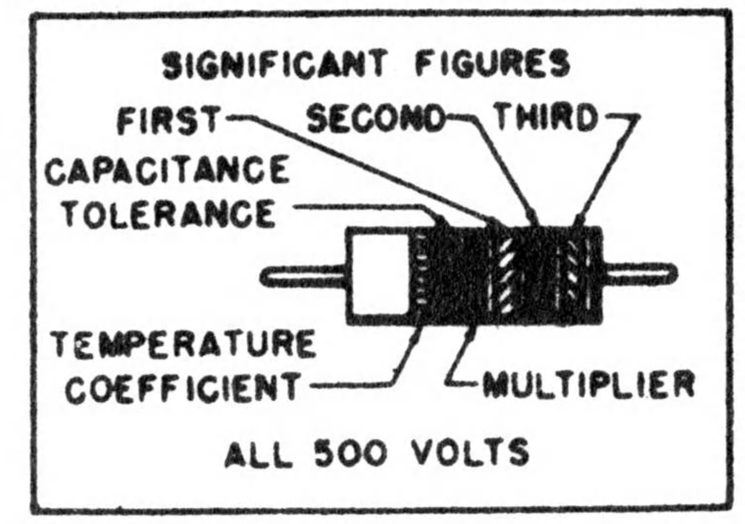
RMA 3-DOT COLOR CODE
FOR MICA-DIELECTRIC CAPACITORS



JAN 6-DOT COLOR CODE
FOR PAPER-DIELECTRIC CAPACITORS

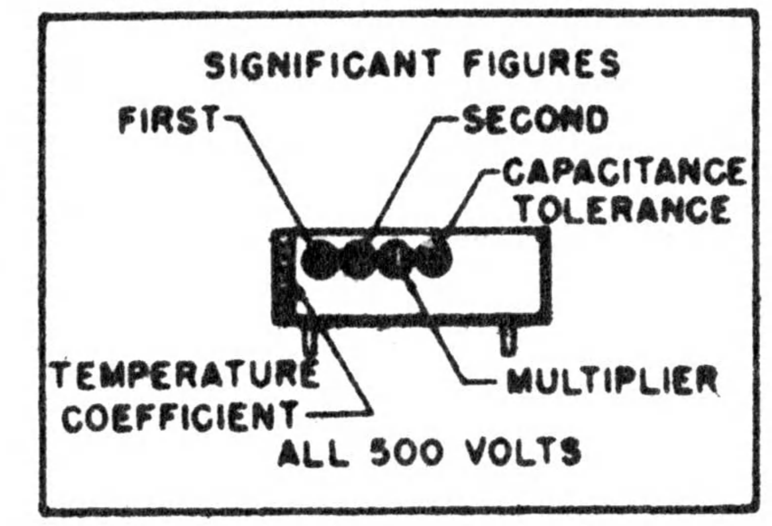


RMA COLOR CODE FOR TUBULAR
CERAMIC-DIELECTRIC CAPACITORS

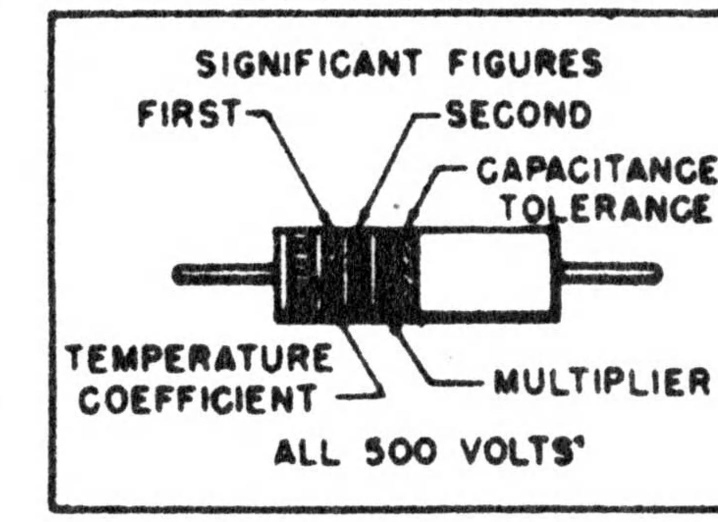


JAN COLOR CODE FOR FIXED CERAMIC-DIELECTRIC CAPACITORS

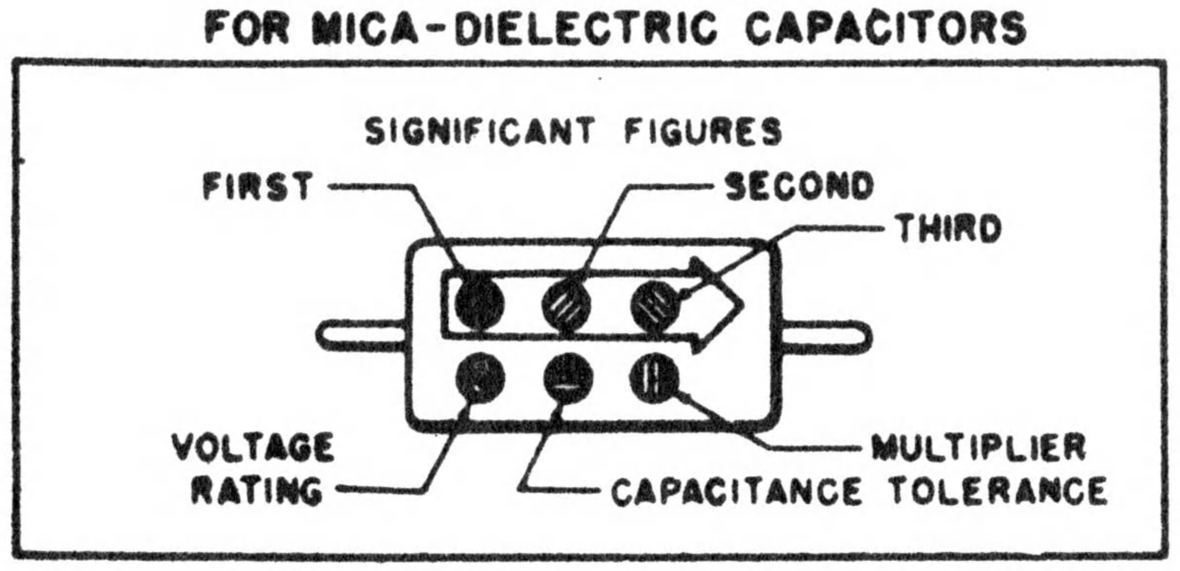
RADIAL TYPE NON-INSULATED



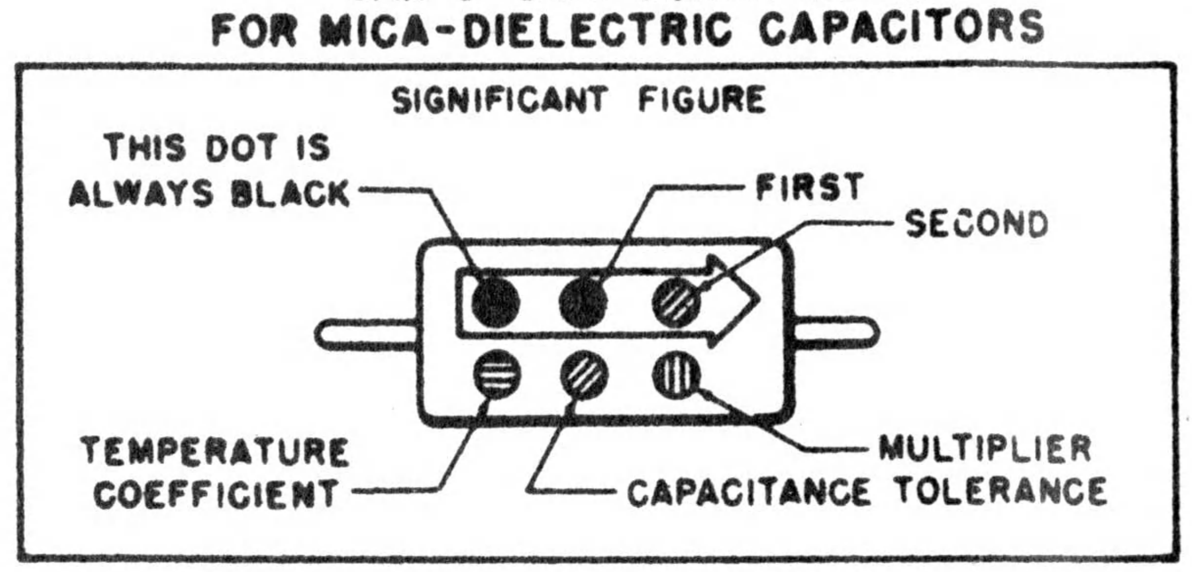
AXIAL TYPE INSULATED



RMA 6-DOT COLOR CODE
FOR MICA-DIELECTRIC CAPACITORS



JAN 6-DOT COLOR CODE
FOR MICA-DIELECTRIC CAPACITORS



RMA: RADIO MANUFACTURERS ASSOCIATION
JAN: JOINT ARMY-NAVY

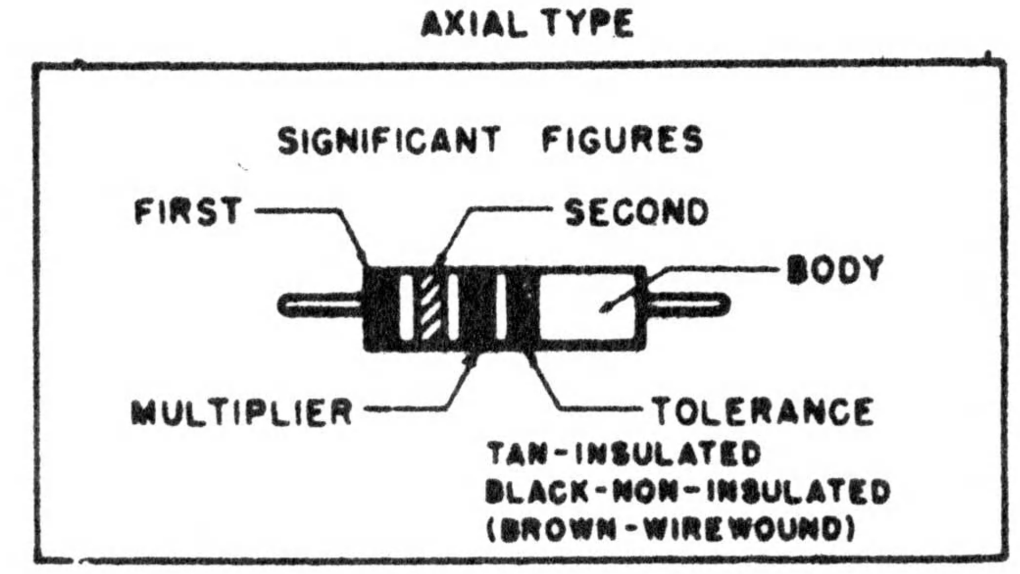
VALUE IN MICROMICROFARADS — VALUE IN OHMS

CAPACITORS							RESISTORS	
		MULTIPLIER						
VOLTAGE RATING	TEMPERATURE COEFFICIENT	RMA MICA AND CERAMIC-DIELECTRIC	JAN MICA AND PAPER-DIELECTRIC	JAN CERAMIC DIELECTRIC	SIGNIFICANT FIGURE	COLOR	TOLERANCE	MULTIPLIER
	A	1	1	1	0	BLACK		1
100	B	10	10	10	1	BROWN		10
200	C	100	100	100	2	RED		100
300	D	1,000	1,000	1,000	3	ORANGE		1,000
400	E	10,000			4	YELLOW		10,000
500	F	100,000			5	GREEN		100,000
600	G	1,000,000			6	BLUE		1,000,000
700		10,000,000			7	VIOLET		10,000,000
800		100,000,000		0.01	8	GRAY		100,000,000
900		1,000,000,000		0.1	9	WHITE		1,000,000,000
1,000		0.1	0.1			GOLD	5	0.1
2,000		0.01	0.01			SILVER	10	0.01
500						NO COLOR	20	

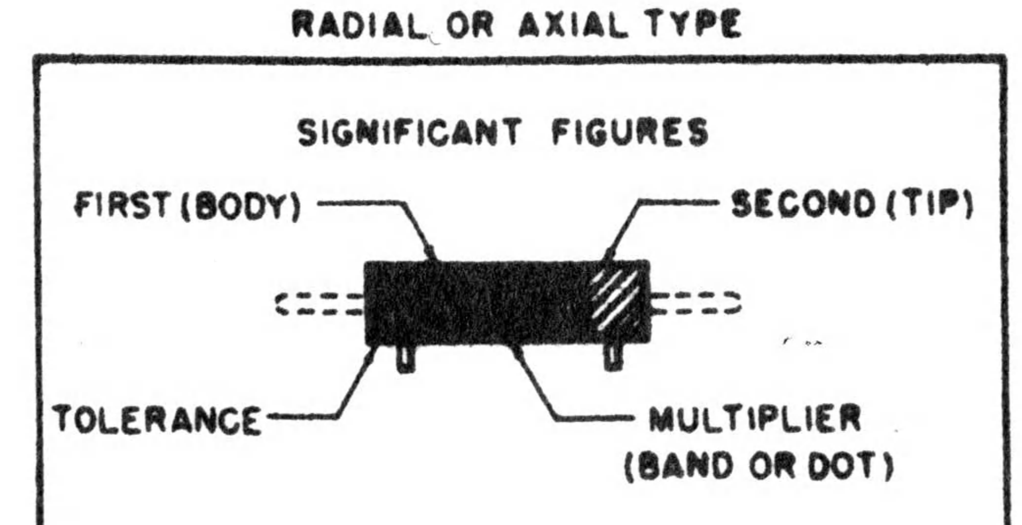
RESISTOR COLOR CODES

RMA COLOR CODE
FOR FIXED
COMPOSITION RESISTORS

AXIAL TYPE

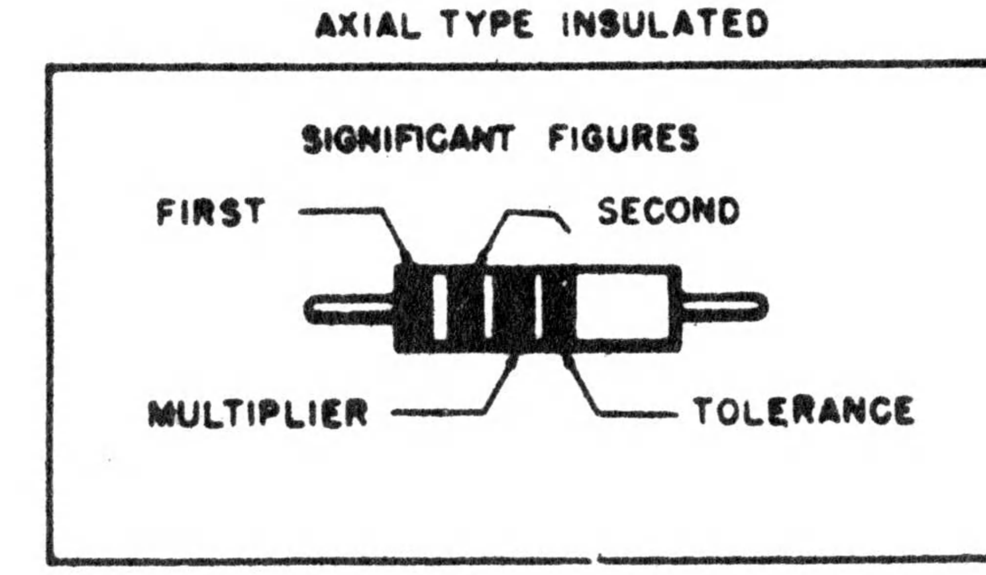


RADIAL OR AXIAL TYPE

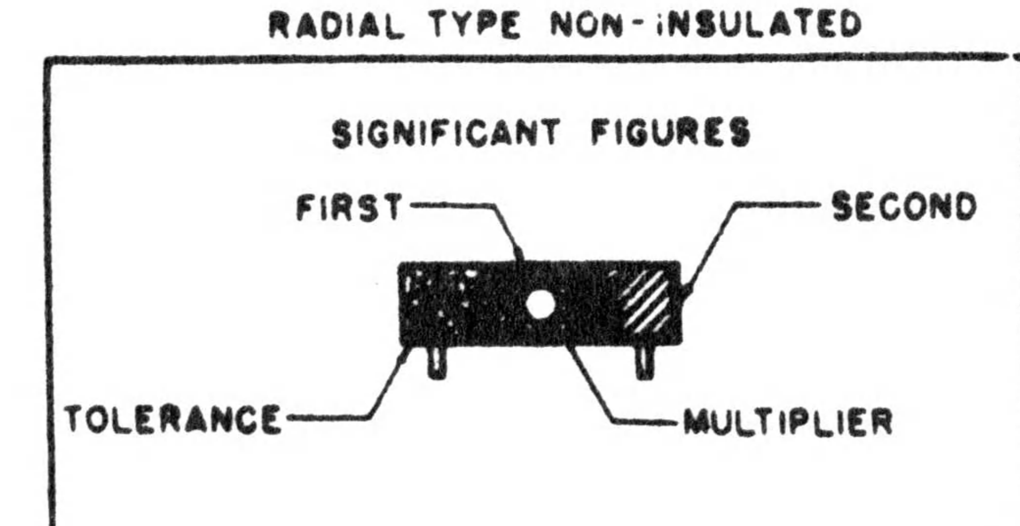


JAN COLOR CODE
FOR FIXED
COMPOSITION RESISTORS

AXIAL TYPE INSULATED



RADIAL TYPE NON-INSULATED



INDEX

INDEX (CONT.)

INDEX (CONT.)

D

INDEX (Cont.)

INDEX (Cont.)

INDEX (Cont.)

INDEX (Cont.)

INDEX (Cont.)

INDEX (Cont.)