OPERATING AND SERVICE MANUAL

(-hp- Part No. 03555-90001)

MODEL 3555A

TELEPHONE TEST METER

Serials Prefixed: 722-

Copyright Hewlett-Packard Company 1967
P. O. Box 301, Loveland, Colorado, 80537 U. S. A.

COPYRIGHT AND DISCLAIMER NOTICE

Copyright – Agilent Technologies, Inc. Reproduced with the permission of Agilent Technologies Inc. Agilent Technologies, Inc. makes no warranty of any kind with regard to this material including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. Agilent Technologies, Inc. is not liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material or data.

MANUAL CHANGES

MODEL 3555A

TELEPHONE TEST METER

Serials Prefixed: 722
-hp- Part No. 03555-90001

New or revised item

Instrument Serial Number	Make Manual Changes
ALL	ERRATA
ALL	CHANGE #1
722-00118 and above	CHANGE #2
722-00101 thru -105, -107, -109, -110, -111	CHANGE #3
-115, -118, -119, -120 -121, -122-124	CHANGE #3
722-00126 and above	CHANGE #3
ALL	CHANGE #4

ERRATA:

Page 1-2, Specifications:
Change "90V rms 20 Hz ringing voltage and ± 130V carrier" to read "90V rms 20 Hz ringing voltage or ± 130 V carrier".

Page 5-2, Table 5-1:
Change the 1 dB/step attenuator to 355C.

Page 5-12, Paragraph 5-13b:
Change FUNCTION setting from FLAT to 600.

Paragraph 5-13a:
Change to read. . . "Connect the 3555A and the 652A Test Oscillator as shown in Figure 5-2 and connect the 741B to the AC MON terminals".

Table 6-1:
Change A1R8 from: 0684-2231, 10K
to: 0683-3035, 30K.
Change A2C26 from: 1.4 to 9.2 pF
to: 1.2 to 3.5 pF.
Change A2R33 from: 0684-1011, 100 ohms
to: 0684-1001, 10 ohms
Change A2R76 from: 0684-2211, 220 ohms
to: 0684-5611, 560 ohms
Change A4C1 from: 0160-0127, 1 μF.
to: 0150-0084, 0.1 μF.
Change A4R17 from 3116 ohms to 3160 ohms.
Change A5 Assembly from: 03555-61903, Switch Assembly: weighting
to: 03555-61901, Switch Assembly: Range
Change J1 part number from 1251-1009 to 1251-0148.
Add J15, Jack: telephone Part No. 1251-0071.
Change R13 from Part No. 0684-1231 to 0683-1235.
Change Part No. 1251-1035 to 1251-0135.

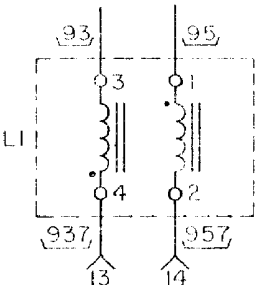
Page 7-11, Figure 7-5:
Add pin numbers to the board connector near A2R18.

ERRATA (Cont'd)

Page 7-11, Figure 7-5 (Cont'd):
The pin with 91 wire connected to it is pin 9.
The remaining pin number is 10 with 917 wire connected to it.

Page 7-13/7-14, Figure 7-7:
Change value of A2C26 from: 1.4 - 9.2 pF.
to: 1.2 to 3.5 pF.

Page 7-9:
Change pin numbers of L1 to:



CHANGE #1

Page 6-2 and Page 7-7/7-8, Figure 7-2:
Change A1R1 from: 147 kΩ, Part No. 0698-3452
to: 130 kΩ, Part No. 0757-0468.

Page 6-5 and Page 7-9, Figure 7-3:
Change A3R22 from: 37.4Ω, Part No. 0698-4377
to: 38.3Ω, Part No. 0698-3435.

Page 6-3, Page 7-5/7-6, Figure 7-1, and Page 7-13/7-14, Figure 7-7:
Change A2C25 from: 22 μF, Part No. 0180-0228
to: 10 μF, Part No. 0180-0374.

Page 6-7:
Change C6 from: 22 μF, Part No. 0180-0228
to: 39 μF, Part No. 0180-0393.

Page 7-5/7-6 and Page 7-13/7-14:
Change C6 from: 100 μF to 39 μF

Page 6-8 and Page 7-5/7-6, Figure 7-1 and Page 7-13/7-14, Figure 7-7:
Change R9 from: 2320Ω, Part No. 0698-4434
to: 2000Ω, Part No. 0757-0283.

Page 6-8:
Add R14, 10 kΩ, Part No. 0757-0442, 1% met flm

Page 7-5/7-6 and Page 7-13/7-14:
Connect a 10 kΩ resistor across M1 terminals and label R14.

Page 6-4, Page 7-5/7-6 and Page 7-13/7-14:
Change A2R55 from: 3160Ω, Part No. 0757-0279
to: 3830Ω, Part No. 0698-3153.

Page 6-5:
Change A2R84 from: Part No. 0698-6679
to: Part No. 0698-3450

CHANGE #1 (Cont'd)

Page 1-1, Level Accuracy:

Between 0°F and +32°F, the following specification applies the 600 and 900 function on all ranges:

FREQUENCY	TOLERANCE
30 Hz to 100 Hz	0 to -1 dB
1 MHz to 2 MHz	0 to -1 dB
2 MHz to 3 MHz	0 to -2 dB

CHANGE #2

Page 6-6:

Change A4Q3, A4Q6, A4Q9 and A4Q12
from: 2N4122, Part No. 1853-0069
to: 2N3906, Part No. 1853-0036.

CHANGE #3

Page 7-11, Figure 7-5 and Pages 6-2 and 6-4:

Change A2R31 from: 365Ω, Part No. 0757-0412
to: 1 kΩ, Part No. 0757-0280.
Change A2C19 from: 39 pF, Part No. 0140-0190
to: 5 pF, Part No. 0160-0763.
Change A2C21 from: 150 pF, Part No. 0140-0196
to: 39 pF, Part No. 0140-0190.
Change A2R47 from: 365Ω, Part No. 0757-0412
to: 1kΩ, Part No. 0757-0280.

Page 7-11, Figure 7-5 and Page 6-7:

Change A5R8 from: 357Ω, Part No. 0698-3432
to: 365Ω, Part No. 0757-0412.
Add a 33kΩ resistor in parallel with A5R8, Part No. 0684-3
Label this resistor A5R20. Add this resistor to Table 6-1.
Place an asterisk (factory selected value) by this resistor.

Page 7-13/7-14, Figure 7-7, and Page 6-5 and Page 6-6:

Change A4C5 from: 0.033 μF, Part No. 0160-0163
to: 0.039 μF, Part No. 0160-0164.
Change A4R37 and A4R38 from: 46.4K, Part No. 0698-316
to: 45.3K, Part No. 0698-449
Change A4C19 from: 0.033, Part No. 0160-0163
to: 0.015, Part No. 0160-0194.

Page 7-9, Figure 7-3:

Add a 12 pF capacitor between the unused terminal of S3 an ground. This is a factory selected value. Designate this capacitor C9.

Page 6-7, Table 6-1:

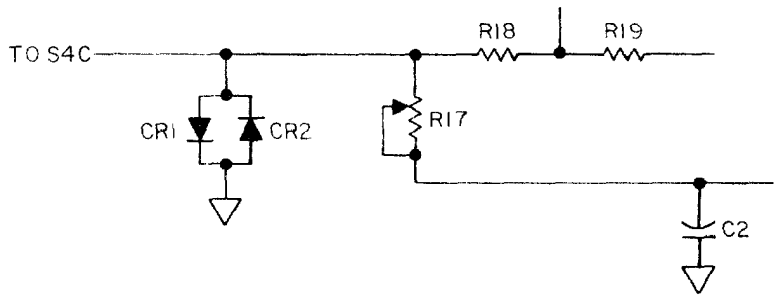
Add: C9, 0160-0987, 12 pF fxd mica.

CHANGE #4 Page 7-9, Figure 7-3:

Connect a neon lamp in parallel with each winding of L1 and designate these lamps DS-1 and DS-2.

Add these lamps (Part No. 2140-0298) to Table 6-1.

Connect two diodes from the junction of R17-R18 to ground as shown below:



Add these diodes (Part No. 1901-0026) to Table 6-1.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF ILLUSTRATIONS

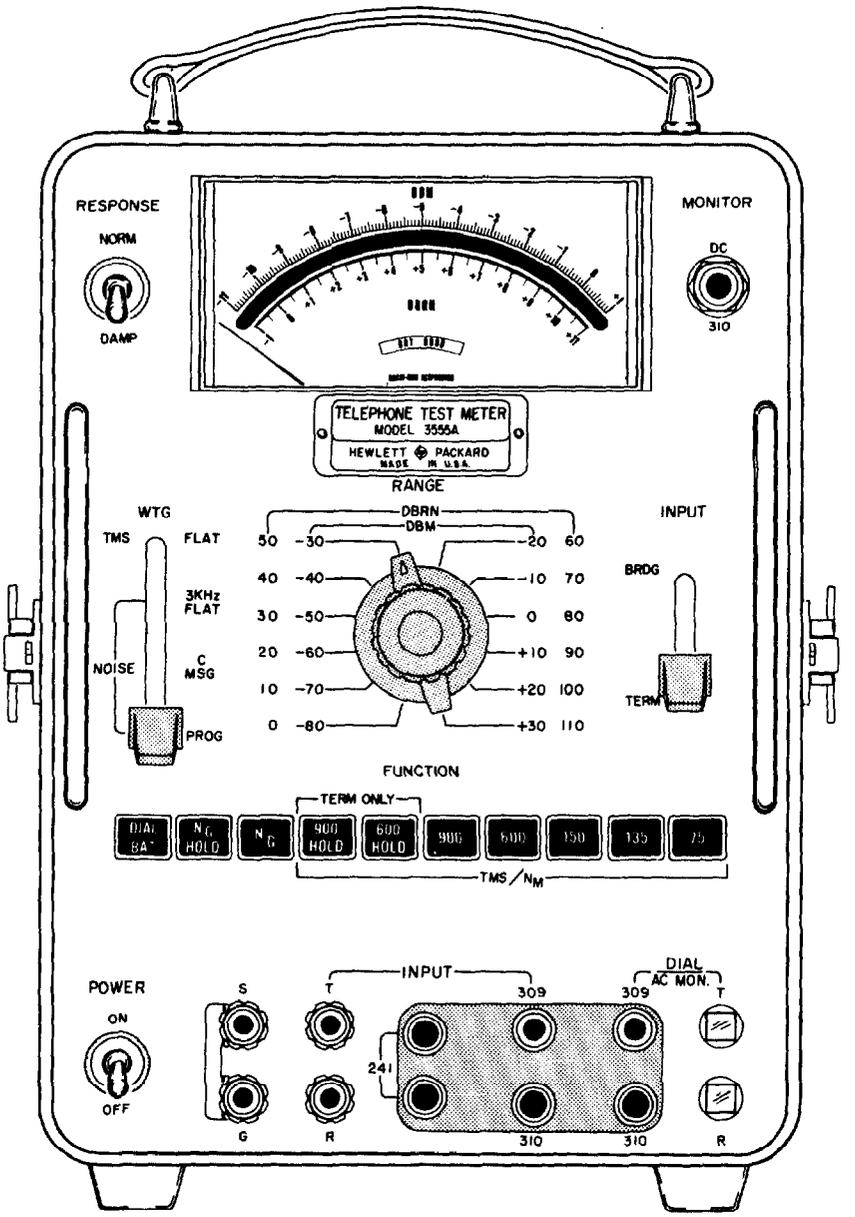


Figure 1-1. Model 3555A Telephone Test Meter

Table 1-1. Specifications

LEVEL MEASUREMENTS

Range: -80 DBM to +30 DBM full scale in 12 ranges.

Frequency Range: 30 Hz to 3 MHz

Level Accuracy:

RANGE	FREQUENCY									
	30 Hz	100 Hz	200 Hz	20 kHz	50 kHz	100 kHz	300 kHz	1 MHz	2 MHz	3 MHz
+30 DBM	±.5dB	±.5dB	±.1dB	±.2dB						
+20 DBM	±.5dB	±.5dB	±.1dB	±.2dB	±.5dB					
+10 DBM	±.5dB	±.5dB	±.1dB	±.2dB	±.5dB					
0 to -40 DBM	±.5dB	±.5dB	±.1dB	±.2dB	±.5dB			±.5dB		±1dB
-50 to -80 DBM	±.5dB	±.5dB	±.2dB	±.5dB						

600Ω and 900Ω Functions only -80 DBM through +30 DBM

600Ω and 900Ω Functions only

Input Impedance: Terminated, 75, 135, 150, 600, 900Ω ±2%, balanced.

Bridging: -80 to -20 DBM: 100 kΩ, balanced
-10 to +30 DBM: 200 kΩ, balanced
(Meter automatically indicates in DBM for the impedance selected. 0 DBM = 1 mW dissipated into the impedance).

NOISE MEASUREMENTS

Range: +10 dBRN to +120 dBRN full scale in 12 ranges.

Accuracy: ± 1 dB

Weighting Networks: 3 kHz Flat, C-Message, and Program, selectable with front panel switch. (CCITT and other networks available on special order). Filter characteristics comply with the joint standards of Bell System and Edison Electric Institute.

Table 1-1. Specifications (Cont'd)

Input Impedance:

Noise Metallic:
Terminated: 75, 135, 150, 600, 900 ±2%, balanced
Bridging: -80 to -20 DBM: 100 kΩ, balanced
-10 to +30 DBM: 200 kΩ, balanced
Noise to Ground: 80 kΩ across line; 100 kΩ to ground

GENERAL

Meter Indication: reads rms value of input signal.

Meter Dynamic Response: 200 msec ±50 msec to 0 DBM. Approximates VU characteristics.

Input Balance: > 70 dB, 30 Hz to 30 kHz
> 60 dB, 30 kHz to 100 kHz
> 40 dB, 100 kHz to 600 kHz

Input Isolation: ± 200 V dc between input and case ground. Input circuit will withstand 48 V dc CO battery with superimposed 90 V rms 20 Hz ringing voltage and ± 130V carrier supply.

Maximum Longitudinal Noise: -80 to -20 DBM ranges, 5V rms
-10 to +30 DBM ranges, 150V rms

DC Holding Coil: 700Ω ±10% dc resistance; 60 mA max. loop current at 100 Hz.

AC Monitor: 1.4 V rms with 10 kΩ output impedance (output available at DIAL/AC MONITOR jacks).

DC Monitor: -1 V with 2 kΩ output impedance. Jack accepts 310 plug.

Temperature Range: 0°F to 120°F.

Input Jacks: Accepts Western Electric 241, 309 and 310 plugs. Binding posts accept banana plugs, spade lugs, phone tips or bare wires. Removable shorting bar between sleeve and ground binding posts.

Dial Jacks: Accepts standard 309 and 310 plugs. Clip posts accept Western Electric 1011B lineman's handset clips.

Power Requirements:
Line: 115V/230V ±10% ac, 50 to 1000 Hz, < 1 W.
Internal Battery: single NEDA 202 45 V "B" battery (included).
48 V CO Battery: 310 jack (tip negative).
Battery Life: 150 hrs. on a 3 hr./day duty cycle at 77°F.

SECTION I

GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The Hewlett-Packard Model 3555A Telephone Test Meter is a versatile se designed for uses in testing telecommunications equipment. The extreme sensitivity of this set, linked with its wide and flat frequency response make it suitable for noise and level measurements on voice, program and carrier frequencies from 30 Hz to 3 MHz. Levels from -80 dBm to +30 dBm (+10 dBRN to +120 dBRN) full scale can be measured and are displayed on a taut band meter ca ibrated to read both in dBm for level measurements and in dBRN for noise measu ments.

1-3. Input impedances of 75, 135, 150, 600 or 900 ohms, bridging or terminated can be easily selected by means of pushbutton switches. Bridging impedance is over 100 kilohms allowing measurements with a bridging loss of less than 0.05 dl The meter reads directly in dBm for any selected input impedance.

1-4. Included in the 3555A is a 3 kHz flat, C-Message and Program Weighting filter conforming to the standards set up by the Bell System and Edison Electric Institute. These filters are selectable by a front panel switch and use active com ponents to permit very precise waveshaping.

1-5. A noise-to-ground (N_G) and a noise-to-ground hold (N_G HOLD) function is i cluded in the 3555A which permits the measurement of longitudinal noise. When noise-to-ground measurements are being made, the impedance between INPUT terminals is greater than 80 kilohms and 100 kilohms between each INPUT terminal and ground. The input circuit provides 40 dB longitudinal noise attenuation while noise-to-ground measurements are being made.

1-6. The Model 3555A can be operated from either the internal 45 V dry cell battery, an external 48 V CO battery or from 115/230 Vac, 50 to 1000 Hz. A jac is provided for operation from the -48 V office battery A special device is incl ed in the cover to automatically turn the set off when the cover is replaced.

1-7. A DIAL/BAT function permits connecting a lineman's handset to the line f the purpose of dialing and at the same time connects the front panel meter to th power supply so that the battery voltage or unregulated power supply voltage can monitored.

1-8. Jacks accepting Western Electric 241, 309 and 310 plugs are provided for INPUT connections to the 3555A. Dual binding posts accept banana plugs, wires, lugs or phone tips and a pair of special connectors permit the attachment clip leads from a lineman's handset.

1-9. ACCESSORY EQUIPMENT SUPPLIED.

1-10. The accessory equipment supplied with the Model 3555A is listed in Table 1-1.

Table 1-2. Accessory Equipment Supplied

-hp- Part No.	Description	Quantity
8120-0078	Power Cord	1
1420-0026	Battery, 45V dry cell	1

1-11. INSTRUMENT IDENTIFICATION.

1-12. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on your set do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your set and the Model 3555A described in this manual. If the serial number is preceded by a letter, the set was manufactured outside the United States.

SECTION II

INSTALLATION

2-1. INSPECTION.

2-2. The set was carefully inspected both mechanically and electrically before shipment. It should be physically free of mars or scratches and in perfect electrical condition on receipt. To confirm this, the set should be inspected for physical damage in transit, for supplied accessories and for electrical performance. Paragraph 5-6 outlines the electrical performance checks using test equipment listed in Table 5-1. If there is damage or deficiency, see the warranty on the inside rear cover of this manual.

2-3. POWER REQUIREMENTS.

2-4. This set is designed to operate from a 45-volt internal battery, an external 48 V CO battery, or an ac power source (115 Vac or 230 Vac, 50 to 1000 Hz). The power source is selected by a slide switch on the side of the case. Normally, the power transformer will be connected for 115 Vac unless otherwise specified. If a change to 230 Vac power supply voltage is desired, the dual primary of the power transformer is changed from a parallel configuration to a series configuration. These connections are shown in the schematic diagram Figure 7-2. A 0.15 A slow-blow fuse is used to protect the set.

2-5. THREE-CONDUCTOR POWER CABLE.

2-6. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the panel and cabinet be grounded. This set is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the set. The offset pin on the power cable three-prong connector is the ground wire. This power cable is detachable from the set and is stored inside the front cover.

2-7. BATTERY.

2-8. This set is operated from a single NEDA 202 45 V dry cell internal battery or an external 48 V CO battery when the power selection switch, on the side of the case, is in the BAT position. Inserting a Western Electric 310 plug into the battery jack disconnects the internal battery. (See Table 2-1 for batteries suitable for use in this instrument.

Table 2-1. Suitable Batteries Meeting NEDA 202 Specifications

Manufacturer	Mfr. Part No.
Hewlett-Packard	1420-0026
Western Electric	KS-14370
Military	BA-59
Eveready	482
Burgess	M-30
RCA	VS103
Bright Star	3033-158, 30-33
Mallory	M-202
Ray-O-Vac	202, P7830
Sears	6461
Wards	42
Wizard	3B6241
Zenith	2783
General	W30B
Marathon	4202
National Carbon	482

2-9. INSTALLATION AND REMOVAL OF BATTERY.

2-10. To install or replace a battery, turn the four 1/4 turn fasteners on the battery cover on the rear of the case counterclockwise to remove the cover. Lift off the cover, lift the battery out of its recess and unplug the three-prong connector.

2-11. Reverse the above procedure when installing a new battery.

2-12. COVER REMOVAL.

2-13. To remove the cover from the instrument, release the two spring latches on either side of the instrument, then lift cover. When replacing the cover, first check the latches for released position; then place cover in position for latching. The power cord is stored inside the cover by wrapping it around the retainer fastened inside the cover.

CAUTION

DO NOT FORCE COVER INTO PLACE! THERE IS A PROJECTION ON THE COVER WHICH TURNS THE POWER SWITCH TO THE OFF POSITION TO PRESERVE BATTERY LIFE. IF THIS IS NOT BINDING, THE COVER FITS EASILY INTO PLACE. THE COVER MAY BE INSTALLED IN EITHER POSITION.

2-14. REPACKAGING FOR SHIPMENT.

2-15. The following is a general guide for repackaging an instrument for shipment. If you have any questions, contact your local Sales and Service Office. (See Appendix B for locations.)

a. Place instrument in original container if available. If not available, one can be purchased from your nearest -hp- Sales and Service Office.

b. Wrap instrument in heavy paper or plastic before placing in inner container.

c. Use plenty of packing material around all sides of instrument.

d. Use a heavy carton or wooden box to house the instrument and inner container and use strong tape or metal bands to seal the shipping container.

e. Mark shipping container with "Delicate Instrument" or "Fragile".

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. The Model 3555A Telephone Test Meter is an extremely versatile transmission and noise measuring set which satisfies many of the demands that must be met in testing telecommunications equipment. The 3555A features choices of 75, 135, 150, 600 and 900 ohm bridging or terminated inputs for noise and level measurement. A noise-to-ground (N_G) function is included to permit measurement of longitudinal noise. The choice of a 3 kHz Flat Weighting filter, a C message weighting filter or a Program weighting filter aids in determining and measuring noise sources. A 600 HOLD, 900 HOLD and a N_G HOLD function simulates an off-hook condition while measurements are being made. A DIAL/BAT function is provided to permit connecting a lineman's handset to the line for the purpose of dialing and talking.

3-3. This section of the manual contains the information necessary in the operation of the 3555A along with a description of all controls, connectors and indicators.

3-4. CONTROLS, INDICATORS AND CONNECTORS.

3-5. Figure 3-1, 3-2 and Table 3-1 illustrate and describe the function of all front and side panel controls, connectors and indicators.

3-6. OPERATION.

3-7. To operate the Model 3555A, refer to Figure 3-1 and proceed as follows:

a. Before connecting the 3555A to an ac power source, insure that the power transformer jumper wires (Refer to Figure 7-2) are connected for the line voltage to be used. If the set is to be operated from 230 Vac, the jumper wires connected between board terminals 2 and 4 and between terminal 1 and 3 should be removed and a jumper wire connected between board terminals 2 and 3 as shown in Figure 7-2. The set is normally shipped from the factory wired for 115V operation unless otherwise specified.

b. If the set is to be operated from the internal battery or from an external office battery, place the AC/BAT switch (located on the side of the instrument) to the BAT position using a small pointed tool; if the set is to be operated from the ac line, place the AC/BAT switch to the AC position. For operation from a 48V office battery, connect a patch cord with a Western Electric 310 plug to the battery jack on the side of the case and then connect the cord to the office battery jack on the test board or bay. Inserting the plug disconnects the internal battery. The office battery jack is arranged for -48 ±4V operation with the negative terminal of the battery connected to the tip and the ground terminal connected to the sleeves. Current consumption by the 3555A is approximately 15 mA.

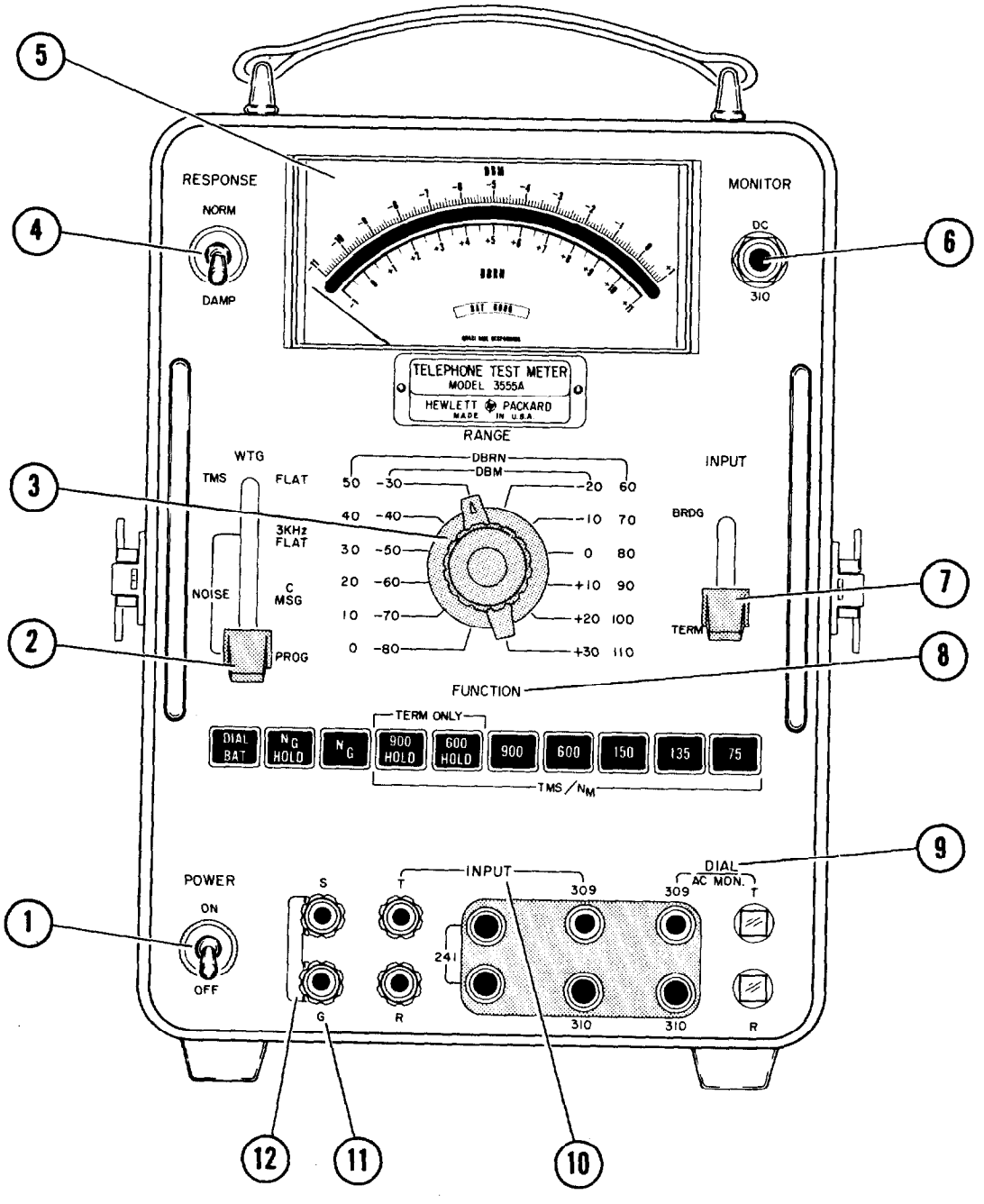


Figure 3-1. Front Panel Controls, Indicators and Connectors

Table 3-1. Front, Side and Rear Panel Controls, Indicators and Connectors

(1) POWER ON/OFF Switch: Turns on all instrument power. Operates on AC, external office battery or internal battery supply.

(2) WTG Switch: Selects weighting filter for noise measurements. FLAT-TMS weighting bypasses the filters and allows the full frequency range of the set to be used in general purpose transmission and level measurements. 3 KHz FLAT, C-MESSAGE and PROGRAM are noise weighting filters standardized by the Bell System and Edison Electric Institute for measurement of message circuit noise.

(3) RANGE Switch: Selects dBm or dBRN ranges of input sensitivity. The RANGE switch markings correspond to the O markings on the meter scale, (5) . The black markings are dBm for transmission measurements and the blue markings are dBRN for noise measurements.

(4) RESPONSE Switch: Selects NORM meter response for transmission measurements or DAMP for noise measurements where the noise is impulsive in nature.

(5) Meter: A taut-band individually calibrated meter with shaped pole pieces to provide a linear dBm indication with equal accuracy and resolution over the entire scale. The dBm scale is marked in black and has 0.1 dBm resolution for transmission measurements. The O marking at the right end of the scale corresponds to the black RANGE switch setting. The dBRN scale is marked in blue for noise measurements. The O marking at the left hand end of the scale corresponds to the blue RANGE switch setting. The green arc marked BAT GOOD corresponds to the green DIAL/BAT pushbutton for checking the battery condition. The left edge of the arc corresponds to the battery cut-off voltage of 30 volts and the right edge represents 45 volts.

(6) MONITOR Jack: Accepts a Western Electric 310 or 347 plug for tip negative and sleeve connection to an external DC recorder. Output voltage is proportional to the input voltage on any one setting of the RANGE switch.

(7) INPUT Switch: Selects BRDG or TERM input conditions for the impedance selected on the FUNCTION pushbuttons. The 600 HOLD and 900 HOLD FUNCTION pushbuttons bypass this switch and are always terminating.

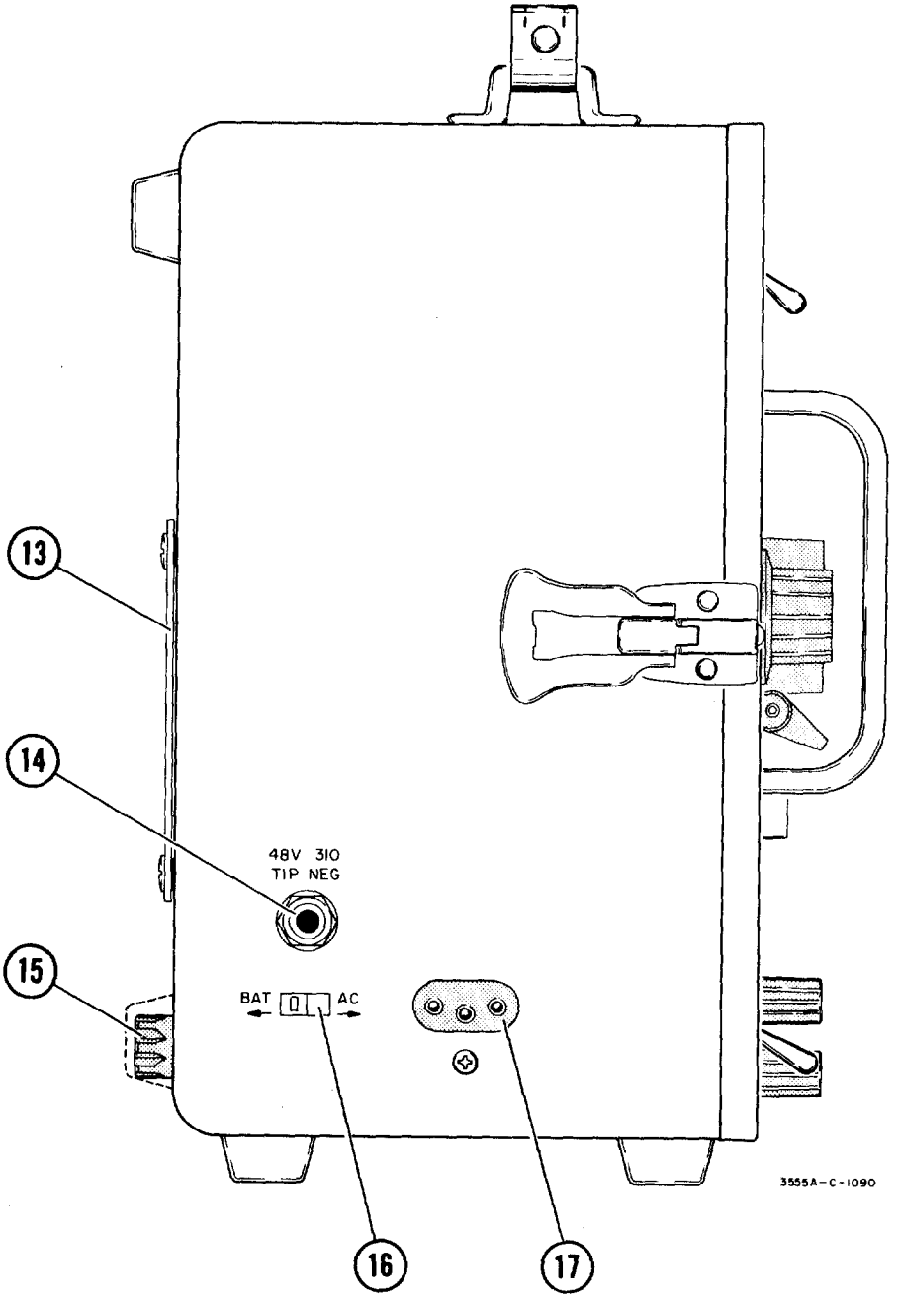


Figure 3-2. Rear and Side Panel Controls, Indicators and Connectors

Table 3-1. Front, Side and Rear Panel Controls, Indicators and Connectors (Cont'd)

(8) FUNCTION Switch: A series of interlocking pushbuttons with the following functions:

a) DIAL-BAT: Connects the multiple INPUT jacks in parallel with the DIAL/AC MON jacks for the dial and talk operation. The circuit is arranged for loop dialing and the line under test must supply talk battery. Connects the meter circuit and a load to the internal power supplies to check the condition of the battery, ac power or external office battery as read on the green meter scale. POWER, (1) , must be ON for the battery test.

b) N_G HOLD: Selects the noise-to-ground input circuit and applies a dc holding bridge across the metallic line. Earth ground should be connected to the black G binding post, (11) .

c) N_G: Same as N_G HOLD except the holding bridge is not used. Attenuation of 40 dB is inserted in both N_G functions.

d) 900 HOLD: Selects the input circuit for balanced 900 ohm circuits and applies a DC holding bridge across the metallic circuit. The meter will read in dBm for any of the impedances selected.

e) 600 HOLD: Selects the input circuit for balanced 600 ohm circuits and applies a dc holding bridge across the metallic circuit.

f) 900, 600, 150, 135, 75: Selects input circuitry for these balanced circuits. DC blocking is present on all these buttons.

(9) DIAL/AC MON: A set of multiple jacks accepting Western Electric 309 or 310 plugs and a pair of special clip posts marked T and R which accept a Western Electric 1011B lineman's handset for the dial and talk operation when the FUNCTION pushbutton marked DIAL/BAT is depressed. Loop dialing is used and the circuit must supply talk battery. When any other FUNCTION pushbutton, (8) , is depressed, the tip and ring of the jacks are connected to the AC monitor output of the internal amplifiers for monitoring purposes. The jack marked 310 will also accept a 347 plug.

(10) INPUT: A set of multiple jacks accepting Western Electric 241 (or 289), 309 and 310 plugs and a pair of binding posts marked T and R for banana plugs, spade lugs, phone tips or bare wires providing connection to the input circuitry of the measuring set. When the DIAL/BAT pushbutton, (8a) , is depressed, the INPUT jacks are connected in parallel with the DIAL/AC MON jacks, (9) .

Table 3-1. Front, Side and Rear Panel Controls, Indicators and Connectors (Cont'd)

(11) S and G Jacks: Binding posts accepting banana plugs, spade lugs, phonetips or bare wires for connection to case ground (G) and the sleeves (S) of all INPUT jacks (10) and DIAL/AC MON jacks (9).

(12) Shorting Strap: A swing-away shorting strap connecting the S and G terminals (11) together which may be used to isolate the jack sleeves from case ground. Not for use with type 347 plugs.

(13) Battery Cover: Removeable by four 1/4 turn screw fasteners to expose the internal battery for replacement.

(14) 48V - 310: A jack accepting a Western Electric 310 plug with tip negative and sleeve ground to supply external office battery power to the set. Insertion of a 310 plug into this jack disconnects the internal battery. The BAT-AC switch (16) must be set to BAT for office battery operation.

CAUTION

INSERT PATCH CORD PLUG INTO THIS JACK FIRST, THEN CONNECT TO BAY MOUNTED -48V SUPPLY JACK TO AVOID SHORTING -48V SUPPLY.

(15) 0.15A-SPARE Fuse: A 0.15A slo-blo fuse and a spare for measuring set protection when operating from AC power. Fuses are not used when the set is battery powered.

(16) BAT-AC Switch: A slide switch for selecting the ac power source or the internal battery and office battery jack, (14), power source. The switch may be operated by a small screwdriver or pointed tool inserted into the slot in the switch.

(17) AC Power Receptacle: A 3 prong power receptacle for the special power cord stored inside the front cover. The BAT-AC switch (16), must be positioned to AC for this power source.

CAUTION

THE CORD MUST BE CONNECTED TO THE MEASURING SET BATTERY JACK FIRST AND THEN PLUGGED INTO THE BATTERY SUPPLY TO AVOID SHORTING THE OFFICE BATTERY TO GROUND.

c. Turn the POWER switch to ON and depress the DIAL/BAT pushbutton on the FUNCTION switch. The meter pointer should indicate in the green BAT GOOD area indicating that the battery condition is good if the set is being operated from the internal battery. The meter will also monitor the ac supply voltage or the external office battery voltage providing an indication of low voltage should it exist. The voltage should cause meter deflection above the lower end of the green BAT GOOD area for proper set operation.

3-8. BATTERY.

3-9. The internal dry cell battery has a voltage range between 45 volts when new to 30 volts at cut-off which is the end of useful life. These voltages are the two ends of the green BAT GOOD area on the meter. The condition of the battery and the approximate time to cut-off can be estimated by observing the position of the meter pointer in the BAT GOOD area.

3-10. The internal battery is of the carbon-zinc type with its attendant limitations due to temperature. The service obtained from carbon-zinc batteries depends on factors such as current drain, discharge temperature, discharge time and storage prior to use. The battery supplied with the 3555A should provide in excess of 150 hours of operation based on a 3 hours/day duty cycle at 77°F (25°C). At other temperatures this time will change. At temperatures above 131°F (55°C) the batteries may fail suddenly while at temperatures below -40°F (-20°C), the service life will be short.

3-11. High storage temperature is damaging to dry cells and tends to reduce shelf life. Low storage temperature is beneficial to battery life although the battery should be warmed to room temperature prior to use. Turning off the set when not in use and consideration of the above factors will maximize battery life. The instant turn characteristics of this set with no warm-up time required allows turning off between measurements.

3-12. LEVEL MEASUREMENTS.

3-13. The 3555A can be used as a wide level range and wide frequency range Transmission Measuring Set (TMS) for voice, program and carrier multiplex measurements. The set will operate over a wide range of environmental conditions and maintain a high degree of accuracy.

3-14. In general, transmission or level measurements are made by connecting the circuit under test to the INPUT jacks with a suitable patch cord, selecting the proper bridging or terminate condition and impedance and then operating the RANGE switch to provide an on-scale meter indication. FLAT WTG is usually used in transmission measurements and the set has its maximum frequency range in this position.

3-15. The multiple INPUT jacks and binding posts accept the Western Electric 309 and 310 single plugs and the 241 or 289 twin plug. The two red binding posts marked T (tip) and R (ring) will accept banana plugs, spade lugs, phone tips or bare wires. These jacks and binding posts are all connected in parallel and only one should be used at a time. A patching cord such as the Western Electric 3P12H, consisting of a cord with a 310 plug on one end and a 309 plug on the other end, should be kept with the instrument as a universal patch cord.

3-16. The sleeves of all the INPUT and DIAL jacks are connected together and to the black binding post marked S. This binding post is in turn, connected through a swing-away shorting strap to a second black binding post marked G. This binding post is the measuring set case ground. Where it is necessary to establish a battery or ground condition on the sleeve for PBX testing purposes, this shorting strap may be disconnected by loosening the black binding posts and swinging the strap away. A lead is then connected to the S terminal and may be connected to battery or ground for the test. Type 347 plugs must not be used when the shorting strap is removed.

3-17. The multiple jacks marked DIAL/AC MON are connected in parallel and accept a 309 or 310 plug. A dial with the impulse springs connected to the tip and ring of a 309 or 310 plug may be used or a lineman's handset (also referred to as a butt-in) such as the Western Electric 1011B may be connected to the two square clip posts for the dialing and talk operation. When the FUNCTION pushbutton marked DIAL/BAT is depressed, the DIAL jacks are connected to the INPUT jacks and a number may be dialed on the line connected to the INPUT jacks. The circuit is arranged for loop dial operation and the circuit under test must supply talk battery.

3-18. Once the switching equipment has been seized by the dialing operation, the connection can be held by depressing one of the pushbuttons marked HOLD. This places a DC bridge, consisting of a high inductance retardation coil, across the INPUT terminals. This coil has negligible effect on measurements of voice frequencies. Once any button other than the DIAL/BAT pushbutton is depressed, the AC output of the internal amplifier circuit is returned to the DIAL/AC MON jacks for an external headphone which can be used to monitor the noise or tones being measured. The lineman's handset which was used for the dialing operation can be used for monitoring by leaving it connected to the clip posts. The jacks marked 310 will

accept a headphone or recorder connected to the tip and ring of a 310 or tip and sleeve of 347 plug. The performance of the set is not affected by this output and any impedance headphone may be used.

3-19. The DIAL/BAT function, also checks the power source used. The green arc on the meter marked BAT GOOD, corresponding to the green BAT marking on the pushbutton, indicates the range of voltages for proper operation. The right end of the arc corresponds to a battery voltage of 45 volts and the left end of the arc corresponds to the battery cut-off voltage of 30 volts. Thus the remaining battery life can be estimated by noting the position of the pointer in the green arc. Since the set POWER must be turned ON to perform this check, the battery is properly loaded to give a true indication of its condition. When operating from the external office battery or AC power, the meter monitors this voltage to indicate if it is the correct level to properly power the set. The POWER switch turns OFF and ON all power to the set.

3-20. The remaining FUNCTIONS are used to set up the input conditions. The two NG FUNCTIONS will be discussed in Paragraphs 3-36 and 3-37. The input impedance of the set is selected by the pushbuttons marked 900, 600, 150, 135 and 75. The 900 and 600 ohm impedances are normally used for loop plant testing while 600, 150, 135 and 75 ohms are usually reserved for carrier system measurements. Because of this, the 150, 135 and 75 ohm impedances are not recommended at frequencies below 100 Hz. The maximum high frequency range occurs in the 600 position as indicated on the accuracy charts appearing in the specifications, Table 1-1. To utilize this high frequency range on other impedances, select 600Ω bridging input and use an external terminating resistor of the proper value. The meter will indicate dBm for 600Ω circuits and a correction factor must be added to obtain a dBm indication for the actual circuit impedance. For 75Ω add 9 dBm, for 135Ω add 6.5 dBm and for 150Ω add 6 dBm to the meter indication. Observe the sign of the meter indication and RANGE switch setting to obtain the proper level. The pushbutton marked with the impedance corresponding to that of the circuit under test should always be depressed. A bridged or terminated condition is determined by the position of the INPUT switch. Using this method will cause the meter to read in dBm for the impedance selected, bridging or terminated. The terminations, when used, are provided with a dc blocking capacitor. Accidental application of carrier or telegraph battery, office battery or ringing voltage will not damage the set. The two pushbuttons marked 900 HOLD and 600 HOLD bypass the INPUT switch and terminate the circuit in addition to placing the holding bridge across the line that is connected to the INPUT.

3-21. The switch marked WTG selects the internal weighting filters for noise and level measurements. The position marked FLAT-TMS allows the full frequency range of the set to be utilized and is generally used for transmission measurements. The remaining positions are used in noise measurements as discussed in Paragraph 3-27.

3-22. The RANGE switch selects the dBm range of the meter. To avoid overloading the set, turn the RANGE switch to +30 dBm when connecting a circuit for measurement. Once the circuit is connected, turn the RANGE switch counterclockwise until an on-scale meter indication is present. The black DBM marking on the

RANGE switch identifies the input level required to deflect the meter to the 0 mark on the black scale. This meter uses shaped pole pieces to present linear dB markings on the scale with marks at 0.1 dB increments. The accuracy and resolution of this type of meter is the same at any point on the scale and it is not necessary to keep the pointer in the upper portion of the scale for maximum accuracy. The accuracy of the meter is not affected by the position of the set. This type of meter will have the pointer off-scale to the left when no input signal is applied and a mechanical zero adjust screw is not required. The actual input level to the set is the algebraic sum of the black RANGE switch setting plus the indication on the black dBm meter scale. For example, RANGE is set at -40DBM and the meter indicates -6.3DBM. The input level is then (-40) + (-6.3) = -46.3DBM. If the RANGE is at +20DBM and the meter indication is -4.7DBM, the level is (+20) + (-4.7) = +15.3 DBM.

3-23. All panel markings corresponding to the proper settings for transmission measurements are in black. The DBM markings on the RANGE switch and meter face are in black, as is the FLAT-TMS position of the WTG switch. The blue markings correspond to the settings for noise measurements as discussed in Paragraph 3-27. The response of the meter rectifier circuit is RMS which allows the set to measure the true power of any arbitrary input waveform provided the crest factor does not exceed 4:1. Crest factor is defined as the ratio of the peak value of a waveform to the rms value of that waveform. In most telephonic measurements, consideration of this crest factor is not necessary.

3-24. The balanced input to the set is achieved by the use of a transistorized differential amplifier instead of a repeat coil. This allows better balance, wider frequency range and better accuracy but cannot handle the same level of longitudinal voltages as a transformer can. This applies to the level and noise-metallic measurements. On the -20 dBm range and below, the maximum longitudinal voltage must be limited to 5 volts. (+16 dBm on 600 ohm circuits). The -10 dBm range and above is limited to 150 V. (+46 dBm on 600 ohm circuits). To check for this limitation, make a noise-to-ground measurement as described in Paragraph 3-36. For the -20 dB range and below the noise-to-ground level should not exceed +66 dBRN. The -10 dBm range and above can have noise-to-ground levels as high as +96 dBRN. If the level is too high, a repeat coil such as the Western Electric 120 series should be used at the INPUT to the set to isolate the longitudinal voltage.

3-25. The switch marked RESPONSE determines the speed of the meter response and is usually left in the NORM position for transmission measurements.

3-26. The jack marked DC MON accepts a Western Electric 310 or 347 plug with connections to the tip and sleeve. The dc voltage supplied by this jack can be used to operate a dc potentiometric recorder requiring 1 V or a dc galvonometric recorder requiring 500 μA This dc output is proportional to the input level on any one range and not meter deflection since the meter is logarithmically scaled. Knowing the current required to drive the recorder full scale and the input impedance of the recorder, enter these numbers into the recorder compatibility chart Figure 3-4 to determine if the recorder is suitable for use with this set. If these numbers do not fall within the compatibility area, refer to Paragraph 3-40. Connect an input voltage to the set and adjust the RANGE switch until a near full-scale indication is observed on the meter. Connect the recorder plug with the tip negative to the DC MON jack and adjust the input level until the meter indicates at 0DBM. Mark

this point, which should be near full scale, on the recorder paper. Decrease the input level until the meter reads -1. Mark this point on the recorder paper. Continue until the recorder has been calibrated for each of the major dB divisions on the meter. The actual input level to the set as indicated on the recorder, will be the algebraic sum of the RANGE switch setting and the dB indication on the recorder.

3-27. NOISE MEASUREMENT.

3-28. One of the primary functions of this set is to measure message circuit noise both metallic and noise-to-ground. The weighting filters built into this set are switch selected and their characteristics conform to the standards set up by the Bell System and Edison Electric Institute.

3-29. In general, noise-metallic measurements are made by connecting the circuit under test to the INPUT jacks with a suitable patch cord, selecting the proper bridging or terminate condition and impedance, selecting the proper weighting filter and operating the RANGE switch to provide an on-scale meter indication. Noise measurements involve many of the same operations as the level measurements discussed in Paragraph 3-12 and only the differences will be discussed.

3-30. Three filters are supplied for noise measurements; C-MESSAGE and 3 kHz Flat for message circuit noise measurement and PROG for broadcast studio-transmitter links and telephone company program circuits. These filters are necessary to allow the measuring set to approximate the response of the human ear and give an indication representative of a person's subjectiveness to noise. The frequency response of these filters is shown in Figure 4-3.

3-31. Once a circuit has been connected, the RANGE switch is adjusted until the noise fluctuations appear on-scale on the meter and a two to three minute observation of the pointer fluctuations is made to establish the point at which the pointer appears most of the time, disregarding the occasional high peaks. For rapidly fluctuating noise such as atmospheric static or switching noise, operate the RESPONSE switch to DAMP. In this position of the switch, the level of the most frequently occurring peaks should be read. Noise is specified in dBRN (decibels above Reference Noise) and the type of filter used is noted, for example, dBRNC meaning C-message weighting is used.

3-32. The noise-metallic level is the algebraic sum of the indication on the blue DBRN meter scale and the blue DBRN RANGE switch setting. For example, RANGE is set to 40 DBRN and the meter indicates +7 DBRN. The noise-metallic level is (40) + (+7) = +47 DBRN. The RANGE switch marking indicates the level at the 0 DBRN mark on the left end of the meter scale.

3-33. Occasionally other message circuit weightings such as the older Bell System F1A weighting or the International Telecommunication Union's CCITT or psophmetric weighting may be required. To convert from C-message to F1A, subtract 6 dBRN from the C-message indication. The units for F1A weighting are dBa, meaning decibels adjusted. To convert from C-message to CCITT or psophmetric weighting, subtract 1 dBm from the C-message level as read on the black dBm meter scale and RANGE switch setting. This will give the noise level in dBm which is acceptable for psophmetric measurements.

3-34. As an aid in identifying the source of noise, the DIAL/AC MON jacks can be used with a monitoring receiver to listen to the noise which will have approximately the same quality as that heard by a subscriber. Particular types of noise like power line induction, switching noise, atmospheric static, crosstalk or random noise may be identified by this listening test. To aid in bringing up the level of the lower frequency power line noise, the 3 kHz flat weighting is used. A substantial increase in meter indication with the 3 kHz flat weighting indicates the presence of low frequency noise and it will also sound louder in the monitoring headphone.

3-35. In some cases recording of the noise during a busy period is necessary. The recorder connections and operation is discussed in Paragraph 3-26. The calibration should be done using the dBRN scale rather than the dBm scale and it should be noted that the RESPONSE switch also damps the recorder.

3-36. Noise-to-ground measurements are made by a special input circuit arrangement which is used when either the N_G or N_G HOLD pushbutton is depressed. Dial and talk may be accomplished on the metallic circuit and the metallic connection held by using the N_G HOLD pushbutton. It is necessary to establish a good earth or system ground and connect it to the black binding post marked G. The noise-to-ground measurement is 40 dB less sensitive than the noise metallic measurement because of the voltage divider in the input circuit. This requires adding 40 dB to the meter indication to arrive at the correct noise-to-ground level. The level is the algebraic sum of the blue RANGE switch setting and the blue meter scale indication plus 40 dB. For example, RANGE is set to 20 dBRN and the meter indicates +3 dBRN. The noise-to-ground level is 20 + (+3) + 40 = 63 dBRN. Some telephone company operating procedures disregard the 40 dB correction factor in which case the noise-to-ground level would be 20 + 3 = 23 dBRN.

3-37. The N_M and N_G indications can be used to compute the balance of a facility since balance is defined as the degree of rejection of longitudinal signals. The degree of balance in dB where the major part of noise-metallic is due to noise-to-ground, is given by the equation, Balance in dB = $N_M - N_G$. For example, if the noise-metallic level of a circuit is +26 dBRN and the noise-to-ground of the same circuit is +90 dBRNC, the balance in dB is (+26) - (+90) = -64 dB. In the case mentioned above where the 40 dB correction factor is neglected, the balance in dB = $(N_M) - (N_G + 40)$.

3-38. Other general purpose uses of the 3555A are volume and crosstalk measurements. The ballistic characteristics of the set make it approximately correct for VU measurements. The RANGE switch should be adjusted until the meter pointer fluctuations are on-scale and should be observed for the maximum of the frequently occurring peaks, disregarding the occasional high peaks. The meter indication in dBm is equal to VU (volume units.)

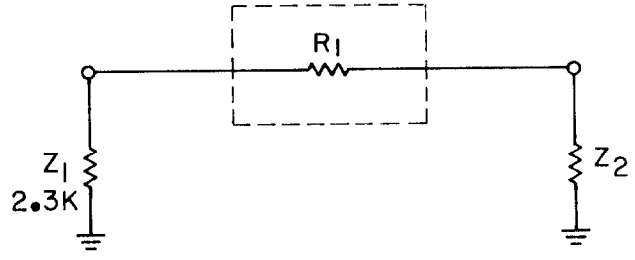
3-39. Crosstalk measurements involve low level measurements and part of the meter indication may be caused by noise in addition to crosstalk. The general technique is to measure with crosstalk and noise present and then measure noise alone. A correction factor must then be applied and can be found in Table 3-2.

3-40. RECORDER COMPATIBILITY.

3-41. If an external recorder is to be used to monitor the dc output of the 3555A, the Recorder Compatibility graph, Figure 3-4 should be consulted to determine if your particular recorder can be used. Recorders with input characteristics that fall below the compatibility area can be used provided a suitable resistor is used between the 3555A dc output and the recorder input.

3-42. To choose the value of this resistance, simply follow the line designating the full scale current of your recorder, horizontally until it intersects the top line in the Recorder Compatibility graph. From this intersection follow the vertical line to find the total impedance R_T required for full scale deflection. (See Figure 3-3). The input impedance of the recorder should be subtracted from this value R_T to determine the value of R1. For example, assume that your particular recorder has an input impedance of 2000 ohms with a full scale sensitivity of 20 μA. Follow the 20 μA line to the right until it intersects the top line at 48 kΩ. The value of R1 will then be 48 kΩ -2 kΩ input impedance = 46 kΩ.

3-43. Recorders with input characteristics that fall above the compatibility area in Figure 3-4 cannot be used to monitor the 3555A dc output since full scale deflection of the recorder cannot be accomplished by the 3555A.



Z_1 = 3555A DC MON OUTPUT IMPEDANCE

Z2 = RECORDER INPUT IMPEDANCE

R1 = R_T (from figure 3-4) MINUS Z_2

Figure 3-3. Impedance Matching 3555A to Recorder

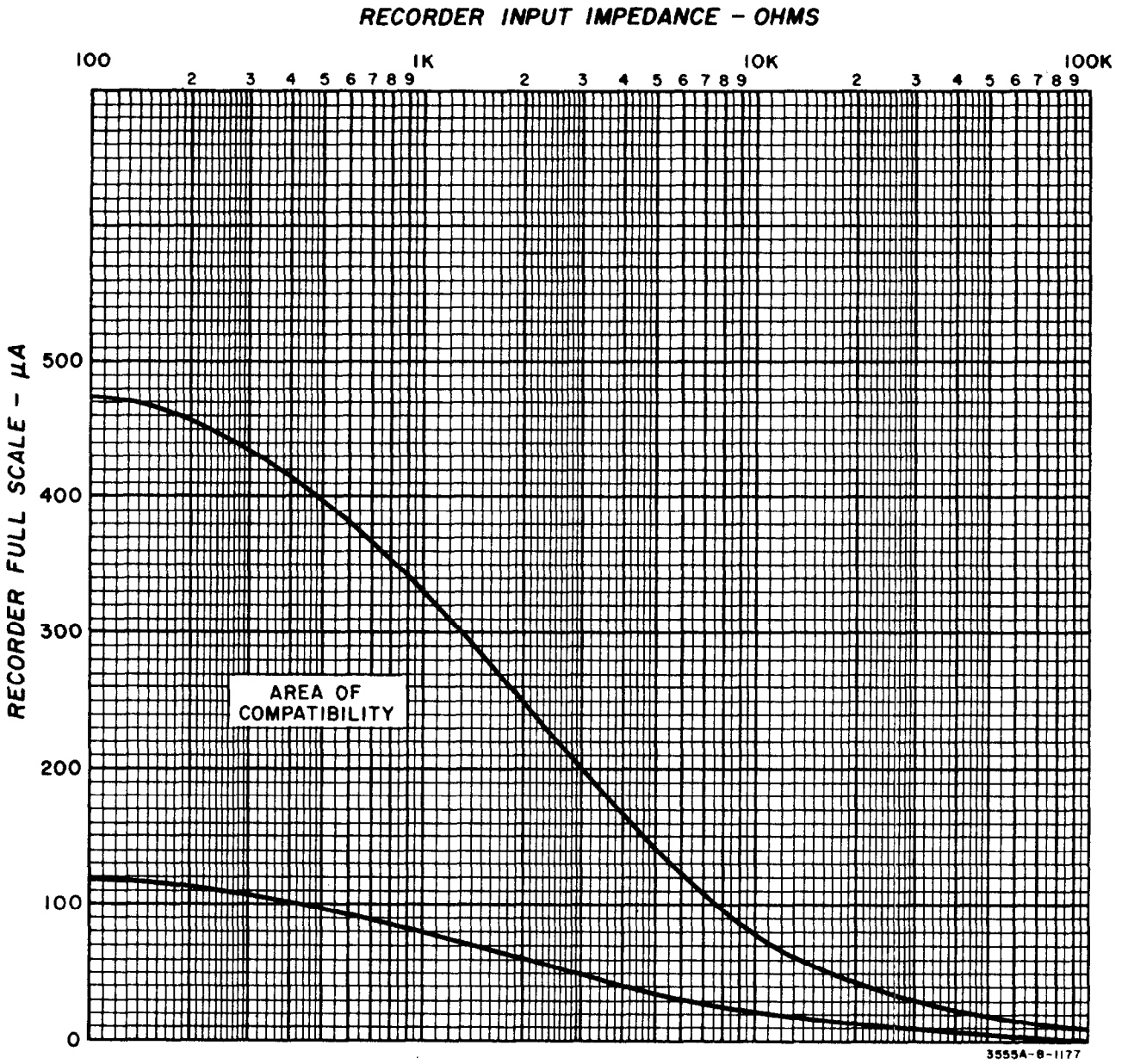


Figure 3-4. Recorder Compatibility Chart

Table 3-2. Crosstalk Correction Factor

(Crosstalk + Noise) in dB Minus Noise Alone in dB	dB Correction Factor Crosstalk in dB = (Crosstalk + Noise) Minus Correction Factor
1	7
2	4
3	3
4 to 5	2
6 to 8	1
9 and above	0

3-44. APPLICATIONS.

3-45. Sometimes it is necessary to transmit or send a tone on a line and then measure the received signal coming back on the same line. Rather than change connections back and forth between the 3555A and 236A when changing from SEND to RECEIVE and thus take a chance on dropping the line, it is much more convenient to make one set of connections and then select SEND or RECEIVE by means of a switch. Refer to Figure 3-5.

3-46. By utilizing the test set-up shown in Figure 3-5, send and receive can be accomplished with a minimum number of operations. To dial, set both function switches to DIAL and dial the desired line on the butt-in. To send, change the 236A FUNCTION switch to 600 HOLD or 900 HOLD, depending on the impedance required. To receive a tone, set the 3555A FUNCTION switch to either 600 HOLD or 900 HOLD (whichever is appropriate) and change the 236A FUNCTION switch to DIAL. To send again, simply change the 236A to 600 HOLD or 900 HOLD. If holding is not required or dialing is not required, simply select the impedance and switch back and forth on the 236A FUNCTION switch.

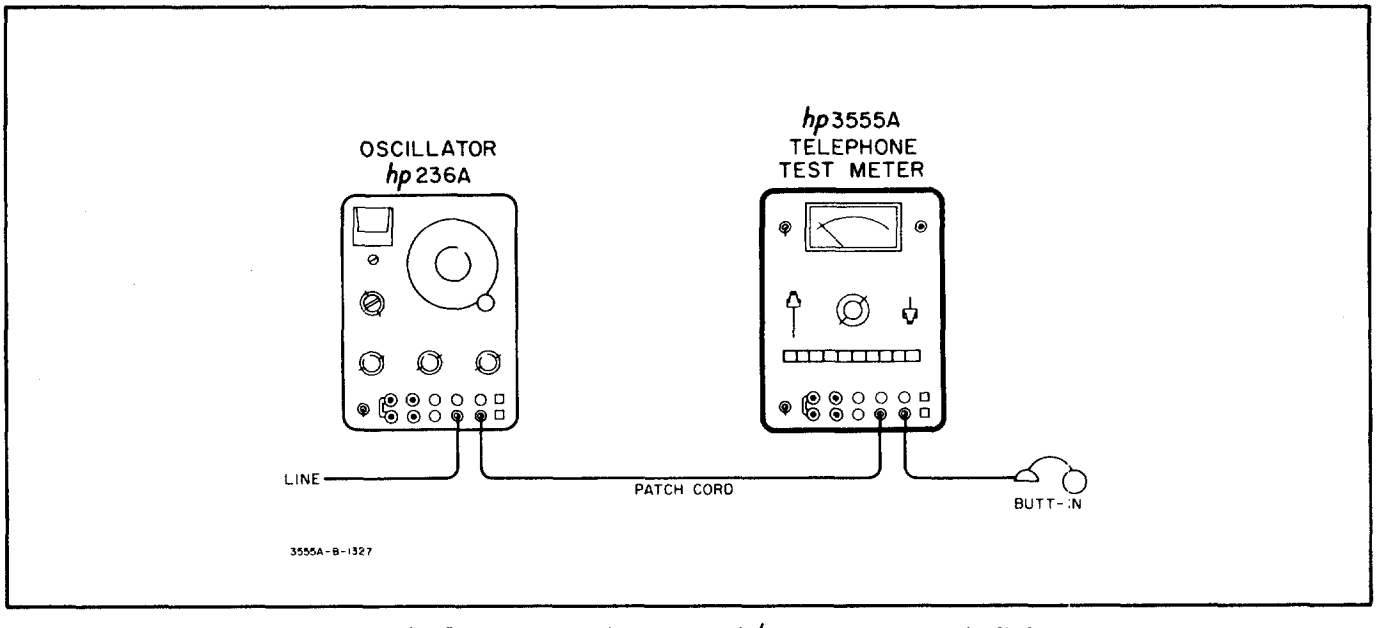


Figure 3-5. Simplified Send/Receive Test Set-up

3-47. TRANSMISSION LOSS MEASUREMENTS.

3-48. Transmission loss is defined as the ratio of power from a transmission line by a receiving terminal to the power available from the sending equipment and is dependent on three factors; power dissipated by the dc resistance of the line, power losses because of impedance mismatch, power transferred to other circuits by inductive or capacitive coupling. (See Figure 3-6).

3-49. These factors are difficult to measure separately. Their sum, however, is relatively easy to measure with the -hp- 236A/3555A combination.

3-50. Figure 3-6 shows a typical transmission loss measurement setup. The oscillator is adjusted for a reference level and the signal is measured at the other end of the line with a level meter. Loss measurements are usually made at various frequencies to determine the response of the line.

3-51. Ideally the man at each end of the line will have both an oscillator and a Transmission Measuring Set (TMS) so that the loss can be measured in both directions. If the line that is being tested passes through central office switching equipment, the oscillator or TMS at the remote end is placed in the DIAL mode and the lineman's handset connected to the DIAL posts, permitting the repairman to bypass the instrument circuitry and dial his test board at the central office. Tests are then made in the 600 or 900 ohm HOLD positions, which provide a dc path to hold the switching relays.

3-52. CROSSTALK MEASUREMENTS.

3-53. Crosstalk is interference on a transmission line caused by inductive and capacitive coupling between pairs of transmission lines in close proximity. Crosstalk can be classified as near-end and far-end. Far-end crosstalk is interference at the end of the transmission line opposite the signal source while near-end crosstalk is interference detected at the same end of the line as the signal source.

3-54. Since different frequency bands are used for each direction of transmission on two wire carrier systems, near-end crosstalk cannot be detected. The situation is quite different, however, for far-end crosstalk since it is in the same frequency band as the desired signal and can be detected.

3-55. Referring to Figure 3-7, one pair of lines is designated A-B and the other pair designated C-D with A and C representing the near-end of the one of the pairs, and band D representing the far-end of the other pair. First measure the transmission loss between A and B. Then measure the transmission loss from A to D. The crosstalk coupling loss in dB is the difference in the reading from A to B and the reading from A to D.

3-56. IDENTIFYING NOISE CHARACTERISTICS.

3-57. Normally, a frequency selective voltmeter is used to identify the characteristics of transmission line interference in order to trace it down to its origin and apply the appropriate corrective action. As an expedient for troubleshooting, there are several subjective measurements that the 236A/3555A can make to help identify the interference characteristics.

3-58. Since power line noise is the most common nuisance, a quick check with the 3555A should be made first. By noting the difference in noise readings between the 3 kHz FLAT and C-message weighted modes, an indication of line frequency disturbance can be ascertained if the 3 kHz flat mode shows a substantially higher reading.

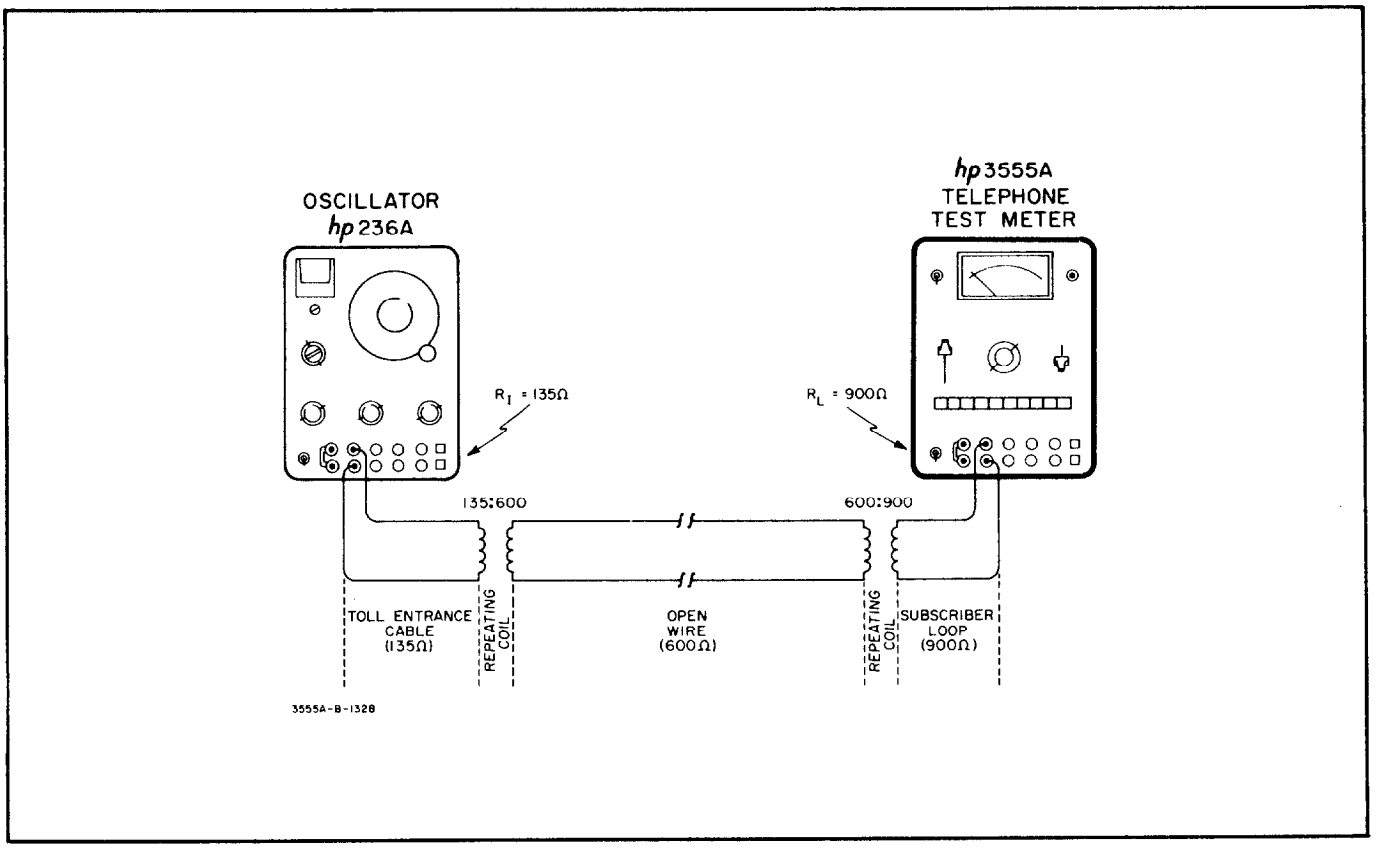


Figure 3-6. Typical Test Setup for Measuring Transmission Loss

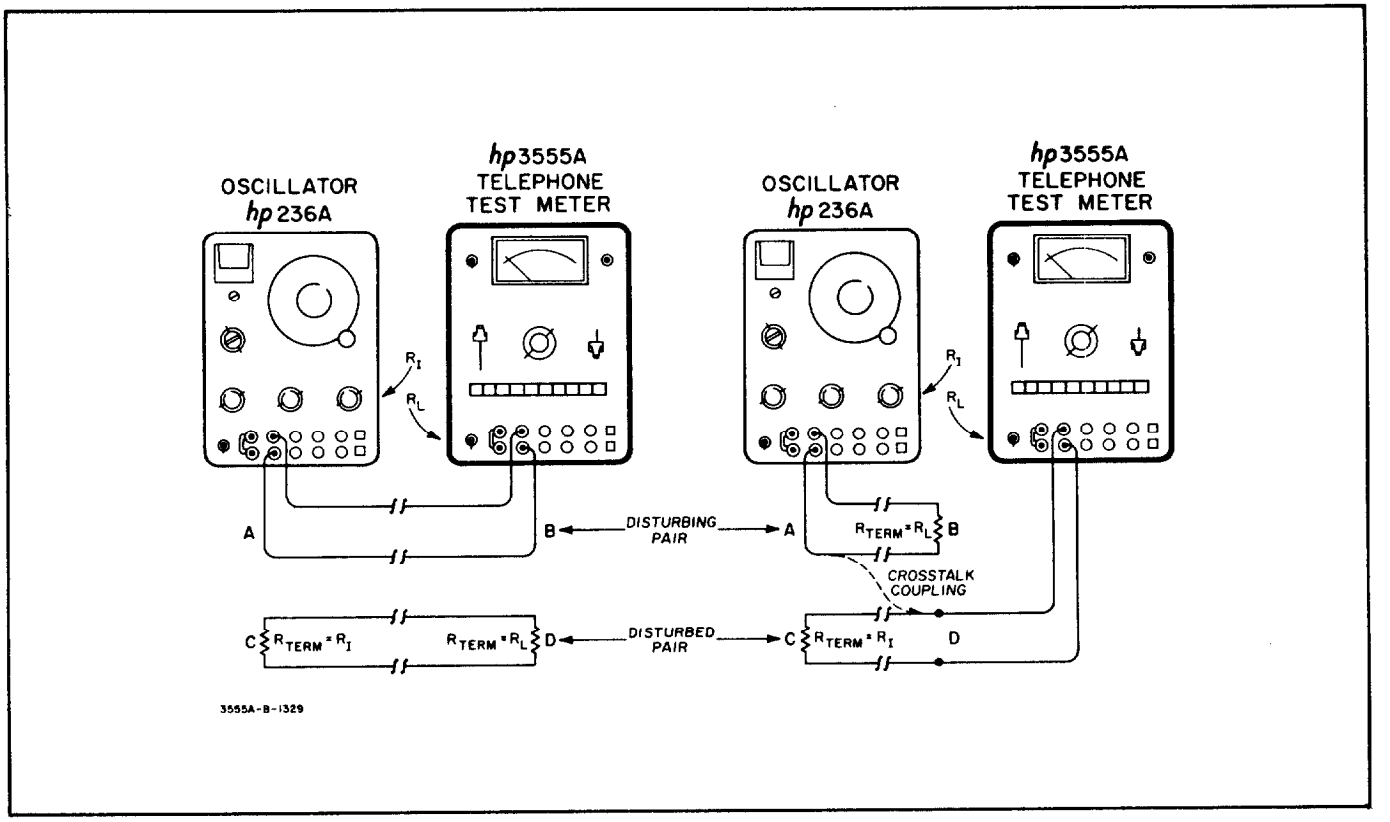


Figure 3-7. Test Setup for Measuring Crosstalk Coupling Loss

3-59. As a further aid in identifying noise, the lineman's handset can be connected to the AC MONITOR terminals and an aural analysis made. Although the handset will not respond to 60 Hz, line interference is usually very rich in odd harmonics and 180 Hz can easily be identified. This test also helps to identify "babble" and other audio frequency interference.

3-60. Vagrant noise, such as atmospheric noise, can be analyzed by connecting a strip chart recorder to the DC MONITOR terminals. Long-term seasonal and temperature effects can also be measured very conveniently with a recorder.

3-61. Frequency of strong interfering periodic signals, such as radio transmitters, can be roughly determined with the 236A and 3555A. The 236A is connected to one end of the line and the 3555A to the remote end, as with transmission loss measurements. The oscillator output is increased until the test meter barely indicates a signal above the noise. The oscillator frequency is then changed very slowly while the repairman observes the 3555A for a beat. By tuning for a beat, the frequency of the interfering signal can be read directly off the oscillator frequency dial to an accuracy of approximately ±3%. In practice, this measurement would probably be made using a "loop around" technique. The oscillator would be connected to a quiet line at the remote location and this line would be tied to the noisy line back at the central office. This permits one man to operate both the oscillator and the test meter.

3-62. When a current flows through a conductor, it sets up two distinct fields around the conductor -- the electrostatic (capacitive) field and the magnetic (inductive) field. Both are capable of inducing longitudinal voltages in adjacent conductors, and both increase in proportion to the power and frequency of the current from which they result. They differ greatly, however, in how they affect nearby circuits. The voltage resulting from magnetic induction varies inversely with the impedance of the line. That is, the higher the line impedance, the less voltage that can be induced by a magnetic field. Capacitively coupled voltage, on the other hand, increases in direct proportion to line impedance -- the higher the impedance, the greater the capacitive coupling. By means of a simple test, it is possible to identify the coupling between two lines, as shown in Figure 3-8. Since induced voltages are inversely proportional to line impedance, the voltage coupled from pair A into pair B (Figure 3-8a) will increase as the impedance is lowered (i.e., shorted). Conversely, since capacitively coupled voltages are directly proportional to impedance, the coupled voltage in Figure 3-8b would increase as the impedance is increased (i.e., open circuited). Both tests in Figure 3-8 should be performed to correlate the result.

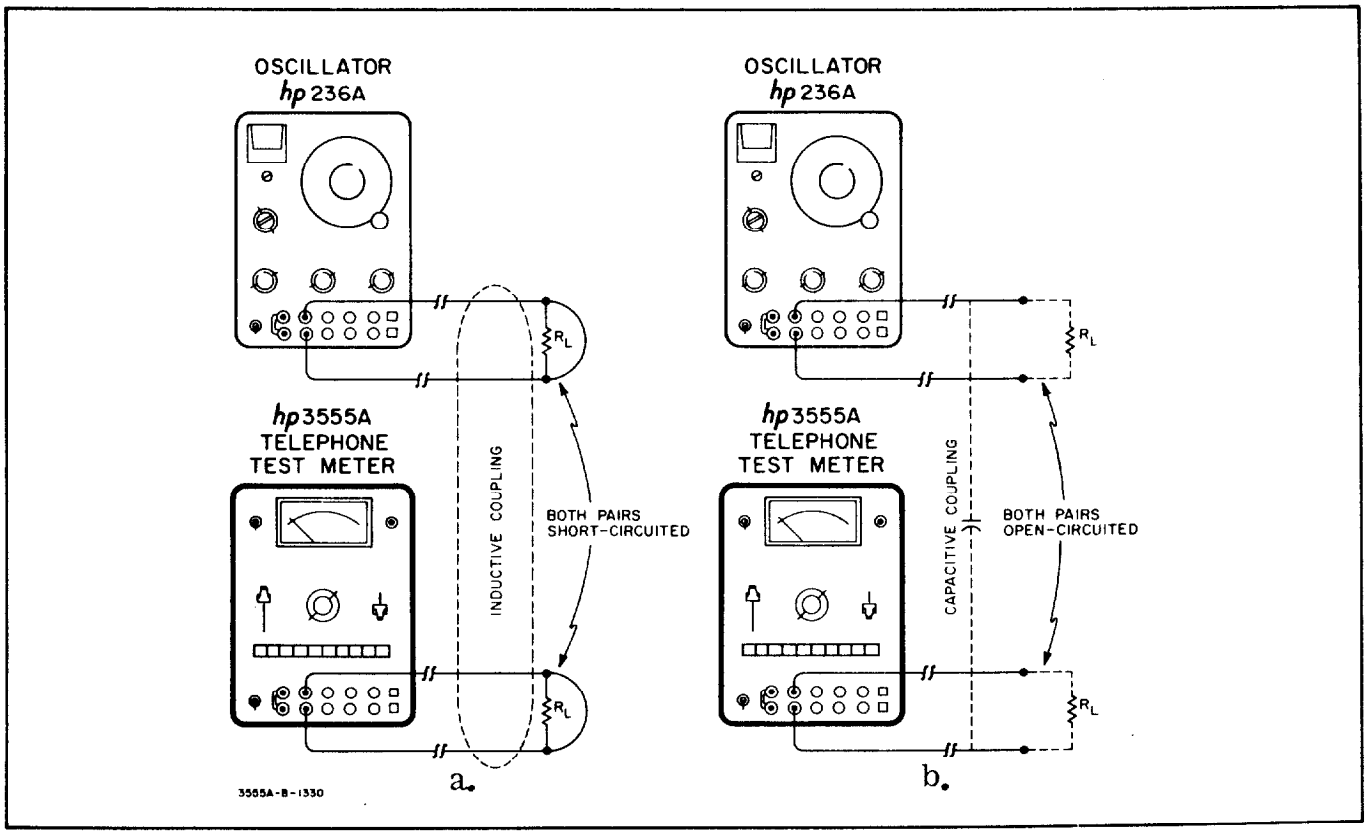


Figure 3-8. Simple Test For Inductive and Capacitive Coupling

3-63. MEASUREMENTS IN DBC.

3-64. The term dBC means dB Collins and is defined as 0 dBC = 0.775V across any impedance as read on an -hp- Model 400D AC Vacuum Tube Voltmeter. Thus, the dBC is strictly a relative term.

3-65. Measurements can easily be made in dBC by utilizing the Model 3555A Telephone Test Meter. To make these measurements, set FUNCTION to 600 and the INPUT switch to BRDG. Any termination required other than 600 ohms must be provided externally and connected across the two binding posts T and R. Termination can also be made using a patch cord and any one of the other INPUT jacks since all INPUT jacks are connected in parallel. If a 600 ohm termination is to be used, the internal termination can be utilized by placing the INPUT switch to the TERM position. Note that this does not work in either of the hold positions since they are terminate only.

SECTION IV

THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. The Model 3555A Telephone Test Meter is a special level and noise measuring set designed for uses in testing telecommunications equipment. Inputs between -80 dBm and +30 dBm full scale can be selected for level measurements in twelve ranges and corresponds to the black markings on the meter face and RANGE switch. Noise measurements between +10 dBRN and +120 dBRN full scale can also be measured, selectable in twelve ranges and corresponding to the blue markings on the meter face and RANGE switch. When measuring rapidly fluctuating noises, a damping circuit can be inserted by the RESPONSE switch.

4-3. Impedances of 75, 135, 150, 600 and 900 ohms, terminated or bridging, can be selected by the pushbutton FUNCTION switch. When a bridging input is selected by the INPUT switch, the input impedance is greater than 100 kΩ, causing less than 0.05 dB bridging loss. A 900 HOLD and 600 HOLD function is included to simulate an off-hook condition and is terminated regardless of the position of the INPUT switch.

4-4. The 3555A features a DIAL/BAT function which permits connecting a lineman's handset to the line for the purpose of dialing and talking. When the DIAL/BAT pushbutton is depressed, the front panel meter is connected to the power supply so that the internal battery voltage, office battery voltage or ac supply voltage can be monitored. (Refer to Paragraph 3-19 for a more detailed description.)

4-5. A Noise-to-ground (N_G) function is included so that longitudinal noise (common-mode) measurements can be made. When the N_G pushbutton is depressed, 40 dB of attenuation is placed across the INPUT terminals and the input to the differential amplifier is then referenced to ground. The N_G HOLD function is identical to the N_G function except that a high inductance holding coil is connected across the INPUT terminals.

4-6. A variety of INPUT and DIAL jacks are available which accept Western Electric type 241 double plugs, 309 and 310 single plugs, dual banana plugs, clip leads and bare wires.

4-7. CIRCUIT DESCRIPTION.

4-8. Refer to Figures 7-2 through 7-7 for the following discussions.

4-9. POWER SUPPLY (A1).

4-10. The Model 3555A Telephone Test Meter can be operated from either the internal 45 V dry cell battery, an external 48 V office battery or from 115/230 Vac. A jack is provided on the side of the measuring set which accepts a Western Electric

type 310 plug for operation from an external 48 V office battery (tip negative). The set is initially shipped from the factory wired for 115 Vac operation. However, if 230 Vac operation is desired, jumper wires must be changed on the Power Supply A1 board (see Figure 7-2).

4-11. When the 3555A is operated from an ac source, power transformer A1T1 supplies power through the AC BAT switch to the diode rectifier A1CR1. The rectified voltage from A1CR1 is filtered by A1C1 before being applied to a series regulator circuit. When operated from the internal battery or external office battery, the dc input voltage is applied through the AC BAT switch and A1CR1 to the input of the series regulator. Inserting a 310 plug into the 48 V 310 TIP NEG jack disconnects the internal battery.

4-12. OPERATION.

4-13. If a change in the -26 V supply should occur, the base of A1Q5 will sense this change. After being amplified by A1Q5 and A1Q4, this change is applied to the base of A1Q2 which controls the base current of series regulator A1Q1 and thus its conduction level. The change in conduction of A1Q1 restores the output to -26 volts. The emitter of A1Q5 is held at -13 volts by reference diode A1CR6 so that only changes in the -26 volt output will determine changes in conduction level. Transistors A1Q6 and A1Q7 provide a current source for the -13 volt supply with A1CR7 acting as the reference.

4-14. Nominal current consumption by the 3555A is 15 mA. However, in case of an accidental short circuit within the set, the maximum current that can be drawn from the power supply is limited to approximately 50 mA. Diodes A1CR4 and A1CR5, in conjunction with A1R4 and A1Q2, act as a current limiter. When the current through A1R4 reaches 50 mA, diodes A1CR4 and A1CR5 become forward biased and the current through A1Q2 can no longer increase. Therefore, the maximum current that can be drawn by the set is limited in order to protect the power supply.

4-15. The battery supplied with the 3555A should provide in excess of 150 hours of operation based on a 3 hour/day duty cycle at 77°F (25°C). However, this time will vary depending upon the time and temperature at which the set is operated. (Refer to Paragraph 3-8 for more detailed information.)

4-16. FUNCTION SWITCH ASSEMBLY.

4-17. DIAL/BAT.

4-18. The DIAL/BAT pushbutton when depressed, serves the dual function of permitting connecting the lineman's handset to the line and at the same time connects the front panel meter to the power supply so that the power source can be monitored.

4-19. In the depressed position of the DIAL/BAT switch, jacks accepting Western Electric type 309 and 310 plugs and a special pair of DIAL posts are connected to the INPUT jacks. The tips of the DIAL jacks are connected to the tips of the INPUT

jacks through A3 pin 20, A3S1A, A3S2A, A3S3A and A3 pin 22. The DIAL jack rings are connected to the INPUT jack rings through A3 pin 19, A3S1B, A3S2B, A3S3B and A3 pin 10. The DIAL tips and rings are also connected to the INPUT attenuator through pins A3 pin 16 and A3 pin 15 respectively. Refer to Figure 4-1.

4-20. Power Supply A1 is connected to the front panel meter through A3S1C when the DIAL/BAT pushbutton is depressed. When the 3555A is operated from the internal battery or an external office battery and the DIAL/BAT button is depressed, the front panel meter monitors the battery voltage. When the 3555A is operated from an ac source and the DIAL/BAT button is depressed, the front panel meter gives a relative indication of the ac line voltage.

4-21. N_G, N_G HOLD.

4-22. An N_G (noise-to-ground) and N_G HOLD function is included in the 3555A to permit measurement of longitudinal noise (common mode). When either the N_G or N_G HOLD pushbutton is depressed, the INPUT jacks are bridged by a 40 dB attenuator consisting of A3R15, A3R16, A3R2, A3C1 and A3R1. Therefore, 40 dB must be added to the reading obtained in order to get a true indication of noise-to-ground. The meter amplifier is normalized at 600 ohms so that the meter will indicate directly in dBRN. Refer to Figure 4-2 for simplified diagram.

4-23. The tip INPUT is connected to Input Attenuator through A3 pin 22, A3S4A through A3S10A and to the 40 dB attenuator consisting of A3R15, A3R2, A3C1 and A3R1. The signal from A3R1 then passes through either S2A (N_G HOLD) or S3A (N_G) to A3 pin 16 and to the INPUT attenuator. The ring INPUT signal follows a similar path through A3 pin 10, A3S4B through A3S10B and to the 40 dB attenuator.

4-24. When either of the N_G pushbuttons is depressed, the impedance between INPUT terminals is 80 kΩ with 100 kΩ between each INPUT terminal and ground. The N_G HOLD function places a high inductance holding coil across the INPUT terminals to simulate an off-hook condition.

4-25. 900 HOLD.

4-26. When the 900 HOLD pushbutton is depressed, the INPUT terminals are terminated in 900 ohms, a holding coil is placed across the INPUT terminals and gain switching is performed in the Meter Amplifier.

4-27. The 900 ohm terminating resistors A3R3 and A3R6 are connected in series across the INPUT terminals (tip) through A3 pin 22, A3S4A, the INPUT switch S3, C1, A3S4B and A3 pin 10 (ring). Holding coil L1 is connected between the INPUT terminals and consists of two separate windings that are connected in series by A3S4C when the 900 HOLD button is depressed. Contacts of switch A3S4C remove the short from A3R18, thus placing it in the Meter Amplifier gain control circuit. The 900 HOLD function is terminated regardless of the position of the INPUT switch.

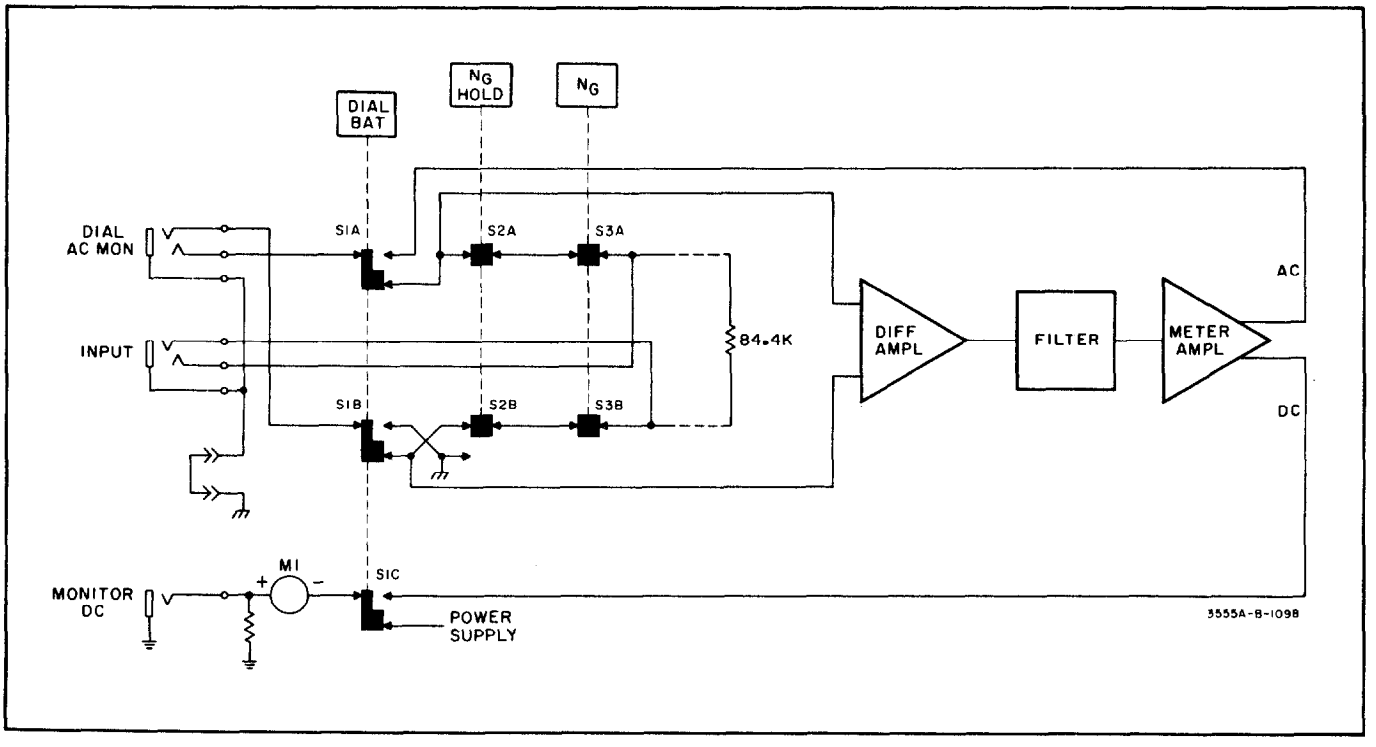


Figure 4-1. Simplified DIAL/BAT Function

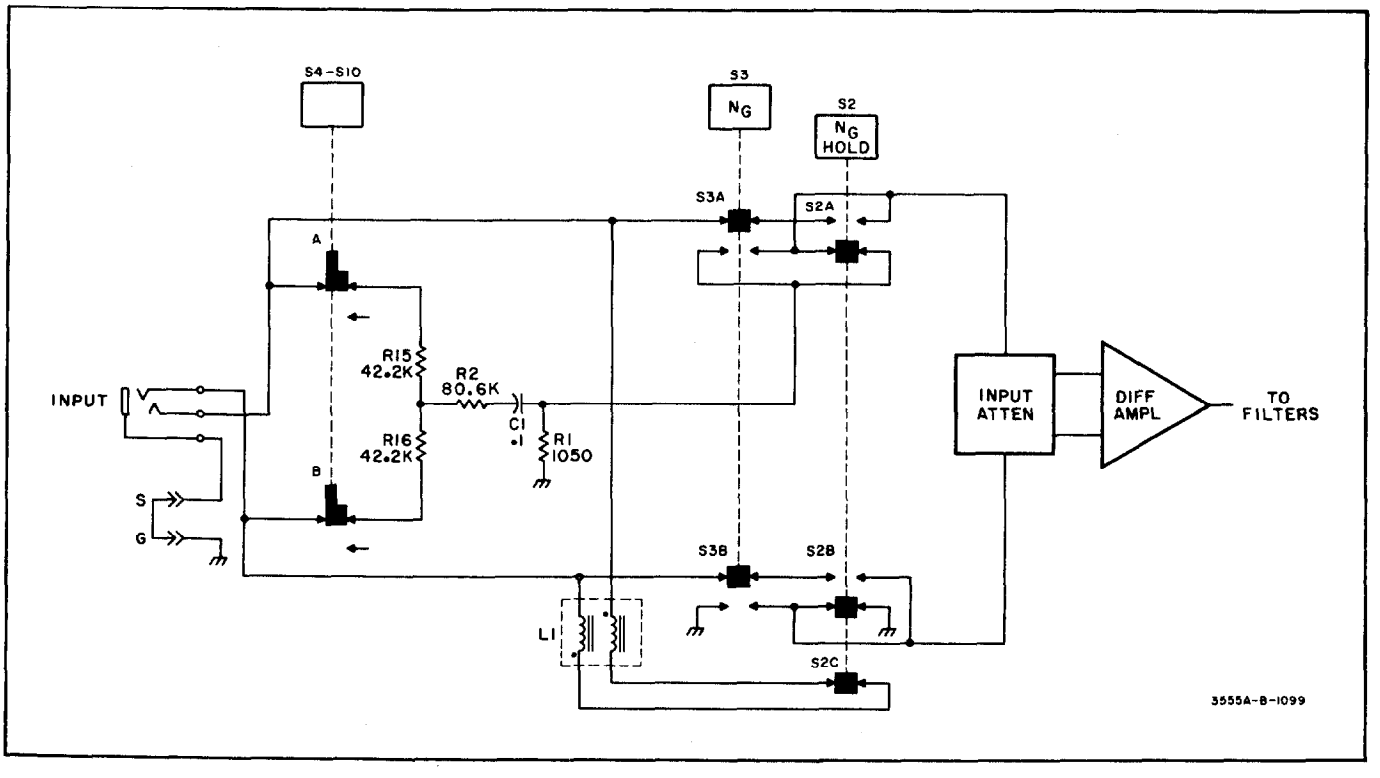


Figure 4-2. Simplified Noise-to-Ground Function

4-28. 600 HOLD.

4-29. The 600 HOLD function is similar to the 900 HOLD function except for the value of terminating resistors selected and the switch contacts involved in switching. Terminating resistors A3R4 and A3R8 are placed across the INPUT terminals by A3S5A and A3S5B. The holding coil L1 is placed across the INPUT terminals by A3S5C. There is no gain switching in the Meter Amplifier when the 600 HOLD pushbutton is depressed since the Meter Amplifier is normalized at 600 ohms.

4-30. 900.

4-31. When the 900 pushbutton is depressed, 900Ω terminating resistors A3R5 and A3R6 are selected by A3S6A and A3S6B. These terminating resistors are connected across the INPUT terminals when the INPUT switch is in the TERM position or can be removed from the INPUT circuit for a bridging input. When the INPUT switch is in the BRDG position the balanced input impedance is 100 kΩ. Gain switching is performed in the Meter Amplifier so that the meter will always read in dBm regardless of the impedance level selected. When the 900 button is depressed, the short is removed from A3R18, thus changing the gain of the Meter Amplifier.

4-32. 600.

4-33. The 600 pushbutton switch, when depressed, performs essentially the same function as the 900 pushbutton switch except for the value of the terminating resistors selected. Resistors A3R7 and A3R8 provide a 600Ω termination when the 600 pushbutton is depressed and the INPUT switch is in the TERM position and are selected by A3S7A and A3S7B. There is no gain switching in the Meter Amplifier in the 600 position of the function switch since the amplifier is normalized at 600Ω. (See Figure 4-4 for simplified gain switching circuit.)

4-34. The 150, 135 and 75 positions of the function switch are identical to the 900 position except for the termination resistors, gain switching resistors, and the switching contacts involved.

4-35. The 150 ohm terminating resistors A3R9 and A3R10 are selected by A3S8A and A3S8B respectively. Gain switching for the Meter Amplifier is performed by A3S8C.

4-36. The 135 ohm termination resistors A3R11 and A3R12 are selected by A3S9A and A3S9B respectively. Gain switching is performed by A3S9C.

4-37. The 75 ohm termination resistors A3R13 and A3R14 are selected by A3S10A and A3S10B respectively. Gain switching is performed by A3S10C.

4-38. RANGE SWITCHING.

4-39. Range switching in the 3555A can be performed in twelve 10 dBm steps from -80 dBm to +30 dBm full scale for level measurements and from +10 dBRN to +120 dBRN full scale for noise measurements. These twelve ranges are selected by the

Input Attenuator, by gain switching in the Differential Amplifier (p/o A2) and by the Post Attenuator. (Refer to Table 4-1 and Figure 7-5 for this discussion)

4-40. The input signal is first applied through the FUNCTION switch to the Input Attenuator (p/o A5). In positions 1 through 7, (-80 dBm through -20 dBm) the signal passes unattenuated to the input of the balanced Differential Amplifier (p/o A2). The input impedance of the set is 100K bridging. In positions 8 through 12 (-10 dBm through +30 dBm) the Input Attenuator provides a constant 30 dB of attenuation and the input impedance is 200 kΩ.

4-41. Additional range switching is accomplished by changing the gain of the input Differential Amplifier. In positions 1 through 4 (-80 dBm through -50 dBm) the Differential Amplifier provides gains of 40, 30, 20 and 10 dB respectively. In positions 5 through 12 (-40 dBm through +30 dBm) the Differential Amplifier provides a constant 0 dB gain. (Refer to Paragraph 4-44 for further discussion of gain switching in the Differential Amplifier.)

4-42. The third range switching circuit is the Post Attenuator. In positions 1 through 5 and 8, the Post Attenuator provides no attenuation. In positions 6 and 7, this attenuator provides 10 dB and 20 dB of attenuation respectively. In positions 9 through 12, 10 dB, 20 dB, 30 dB and 40 dB of attenuation respectively is provided by the Post Attenuator.

Table 4-1. Table of Attenuation and Differential Amplifier Gain

RANGE (DBM)	INPUT ATTEN. (dB)	DIFF. AMPL. GAIN (dB)	POST ATTEN. (dB)
-80	0	40	0
-70	0	30	0
-60	0	20	0
-50	0	10	0
-40	0	0	0
-30	0	0	10
-20	0	0	20
-10	30	0	0
0	30	0	10
+10	30	0	20
+20	30	0	30
+30	30	0	40

4-43. DIFFERENTIAL AMPLIFIER (P/O A2).

4-44. The Differential Amplifier consists of transistors A2Q1 through A2Q and receives its input from the Input Attenuator. Since amplifier A2Q1A through A2Q3 and amplifier A2Q1B, A2Q5 and A2Q6 are symmetrical, only the first will be discussed.

4-45. The input to the Differential Amplifier is coupled to the base of A2Q1A by A2C1. The input is protected from extraneous voltages by A2CR1, A2CR2 and A2CR3. If the input voltage should go in a positive direction more than -8 volts, diodes A2CR1 and A2CR7 will conduct. If the input goes more negative than -18 volts diode A2CR2 will conduct and the input will be conducted through A2CR8 to the -26 volt supply, which is protected. Diode A2CR3 is used to protect A2Q1A in the event a high amplitude voltage, (90 V, 20 Hz ringing voltage, etc) should appear while a measurement is being made. During the negative half cycle of this extraneous voltage, A2Q1A would become reverse biased and probably be damaged except for the inclusion of A2CR3. Instead, A2CR3 conducts on the negative half cycle, thus protecting A2Q1A. The protection afforded by A2CR1, A2CR2 and A2CR3 is particularly essential on ranges 1 through 7 (-80 dBm through -20 dBm) since the Input Attenuator provides no attenuation of the input signal.

4-46. Amplifier A2Q1A has in its emitter circuit, a series of gain switching resistors which control the negative ac feedback from A2Q3 emitter to A2Q1A. These resistors are selectable by the RANGE switch in positions 1 through 4. In positions 1, 2, 3 and 4 the Differential Amplifier has gains of 40, 30, 20 and 10 dB respectively. The gain of A2Q1A is controlled by the ratio of the value of A2R7 to one-half the value of the range switching resistor and is expressed by the equation:

$$\text{GAIN} = \frac{\frac{\text{A5R5}}{2} + \text{A2R7}}{\frac{\text{A5R5}}{2}} = 40 \text{ dB}$$

In each successive position of the RANGE switch, the added resistance of A5R6, A5R7 and A5R8 must be added to the value of A5R5 in the equation.

4-47. The signal is amplified by A2Q1A and applied to the base of common emitter A2Q2. Resistor A2R5 and capacitor A2C3 is included in the base circuit of A2Q2 for frequency stabilization. The signal is amplified by A2Q2 and A2Q3 and coupled through A2R28 to the base of A2Q13.

4-48. A special feature of this amplifier is its common mode rejection capability. Connected between the bases of A2Q1A and A2Q1B, are two resistances of equal value (A2R2 and A2R10). Therefore, any common mode voltage appearing at the junction of these resistors will be amplified by A2Q7 through A2Q12. Since transistors A2Q7 through A2Q12 control the supply voltages for transistors A2Q1 through A2Q6, this supply voltage is modulated by the common mode voltage and drives both halves of the Differential Amplifier in the same direction by the same amount. Thus, the common mode voltage appears at the output (emitters of A2Q3 and A3Q6) with unity gain.

4-49. The manner in which the common mode voltage modulates the supply voltage for the input amplifiers can best be explained in the following manner. A voltage divider consisting of A2R24, A2R22, and A2R20 is connected between -26 volts and ground. The voltage appearing at the base of A2Q11 is approximately -18 volts.

Therefore, the emitter of A2Q11 and the supply voltage for the input amplifier must be 0.6 V less negative than -18 volts or -17.4 volts. Transistor A2Q12 acts as a current source in this circuit. The common mode voltage from A2Q7 and A2Q8 is coupled by A2C10 to the base of A2Q11 to modulate the supply voltage to the input amplifier. Transistors A2Q9 and A2Q10 are identical to A2Q11 and A2Q12 except for the level at which they operate. The output of A2Q10 is approximately -7.4 volts.

4-50. The signal from A2Q3 is amplified by a complementary symmetry amplifier consisting of A2Q13 through A2Q15 where it is referenced to ground before being applied to the Post Attenuator. Transistors A2Q16 and A2Q17 are symmetrical to A2Q13 and A2Q14 respectively in this amplifier.

4-51. FILTERS.

4-52. The 3555A contains a C-message weighting filter, a 3 kHz Flat weighting filter and a Program weighting filter. The A4 Filter Assembly consists of four amplifiers which are used in combinations along with associated feedback elements, to form each of the three filters. Since the four amplifiers are identical in operation except for gain and feedback elements, only the first one will be discussed in detail. Curves for each of the filters are shown in Figure 4-3.

4-53. The first amplifier consists of A4Q1 through A4Q3 along with associated circuitry. Transistors A4Q1 and A4Q2 form a differential amplifier with A4Q3 providing positive ac feedback through A4R6 and A4C4 to the base of A2Q1, and negative feedback to base of A2Q2. This positive feedback, along with A4R6-A4C3 and A4R10-A4C4 is used for frequency response. Since the gain of this amplifier stage without feedback is very high, the overall gain with feedback is controlled by the amount of negative feedback to the base of A4Q2. Thus, the gain can be calculated by the equation,

$$\text{Gain} = 1 + \frac{\text{A4R13}}{\text{A4R12}}.$$

4-54. The second amplifier consists of A4Q4 through A4Q6 and is identical in operation to the first except for the feedback elements involved and the amplifier gain. The gain of this amplifier is fixed by A4R25 in all WTG switch S4 positions except 3 kHz FLAT. In this position, A4R24 is connected in parallel with A4R25 to increase the amplifier gain.

4-55. The third amplifier consists of A4Q7 through A4Q9 with the value of A4R32 chosen to control the gain of this amplifier stage.

4-56. The fourth amplifier consists of A4Q10 through A4Q12 with one additional amplifier, A4Q13 included for additional shaping of the C-message curve. The gain of this stage is fixed by A4R41.

4-57. FLAT.

4-58. In the FLAT position of the WTG switch S4, the output of the Post Attenuator is coupled through the switch contacts directly to the input of the Meter Amplifier. Therefore the entire passband of the 3555A is utilized.

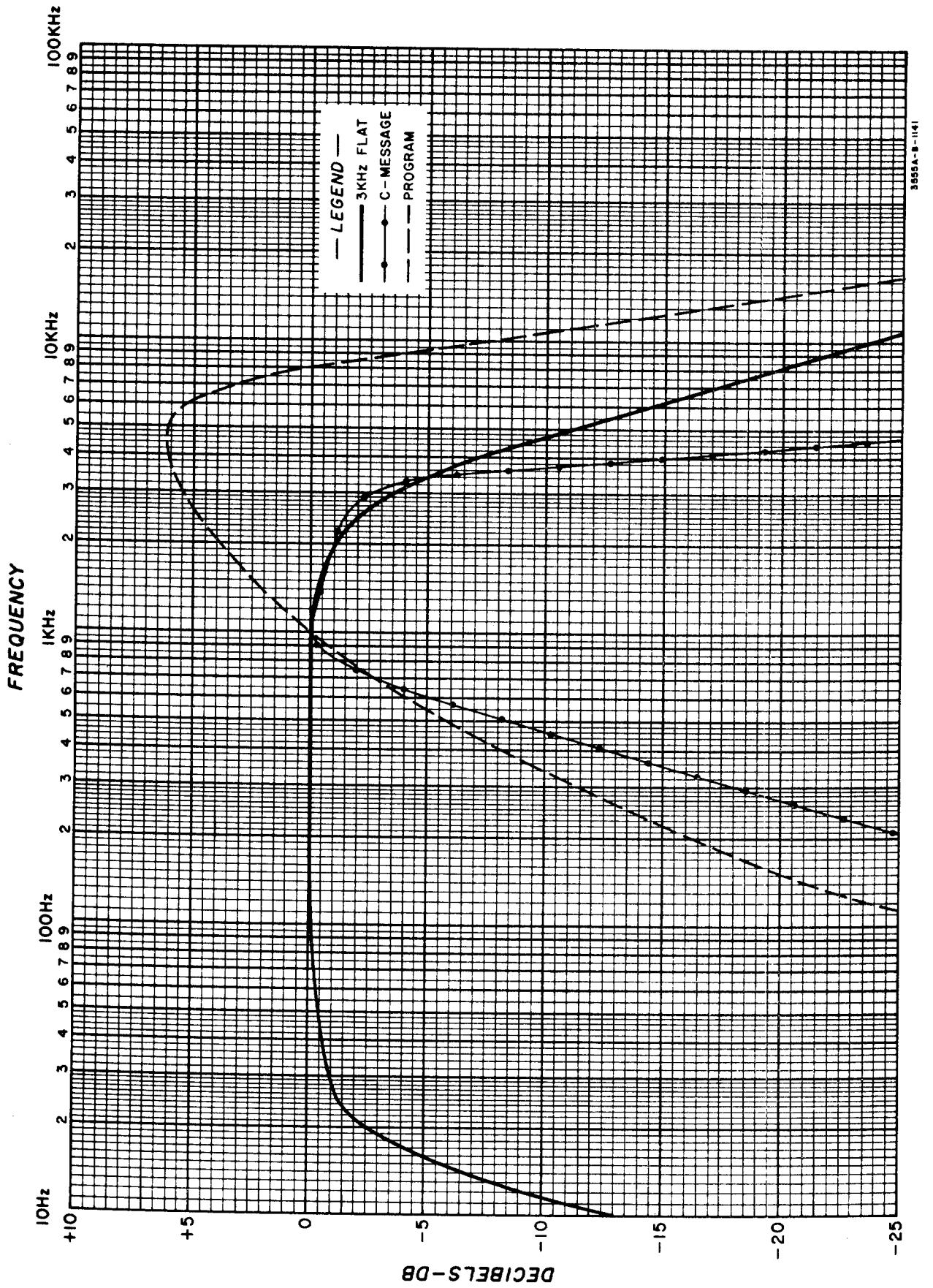


Figure 4-3. Weighting Filter Curves

4-59. 3 KHZ FLAT.

4-60. The 3 kHz Flat weighting filter is included in the 3555A for noise measurements that require additional low frequency response. This filter utilizes only the second amplifier discussed in Paragraph 4-51 through 4-54.

4-61. When the WTG switch is in the 3 kHz FLAT position, the output of the Post Attenuator is coupled through A4C1, A4R2 and R1 to the base of A4Q4. The shaping circuit at the input of this amplifier utilizes A4R2, A4R3, A4R4 and C2 in forming one frequency pole with R1-A4C8 forming the other pole. Resistors A4R4, A4R3 and A4R2 form a series-parallel circuit that provides 60.4 kilohms for use in one of these circuits. Resistor A4R24 is connected in parallel with A4R25 to change the stage gain when this amplifier is used in the 3 kHz FLAT position.

4-62. C MSG.

4-63. The C-message filter in the 3555A utilizes all four of the amplifiers discussed in Paragraphs 4-51 through 4-56 and is included for measuring noise on message circuits.

4-64. When the WTG switch is in the C-MSG position, the output of the Post Attenuator is coupled through A4R7, A4C3 and A4C4 to the base of A4Q1. The waveshaping circuit at the input of this amplifier consists of A4C3-A4R6 and A4C4-A4R10.

4-65. The output of A4Q3 is coupled through A4R15 and R2 to the base of A4Q4. The waveshaping circuit at the input of the second amplifier consists of A4R15-C2 and R2-A4C8. The frequency poles of the third amplifier are determined by R5-C4 and R6-A4C11 while the poles in the fourth amplifier are determined by A4R37-A4C14 and A4R38-A4C15. The output of A4Q12 is further amplified by A4Q13 where additional waveshaping is performed by A4R44 and A4C18.

4-66. PROG.

4-67. The Program weighting filter in the 3555A is included to permit noise measurements on program circuits such as studio-to-transmitter lines. Since program circuits must handle higher frequencies than message circuits, the program filter must be capable of passing these higher frequencies in order to measure the noise present on these circuits.

4-68. The Program filter utilizes the second and third amplifiers discussed in Paragraphs 4-54 and 4-55. The waveshaping circuits in the second amplifier consist of A4R17 through A4R20 connected in a parallel-series configuration which is used in conjunction with C2 and R3-A4C8. The frequency poles in the third amplifier are determined by R7-C4 and R8-A4C11. The output of A4Q9 is coupled by C5 to the input of the Meter Amplifier, p/o A2.

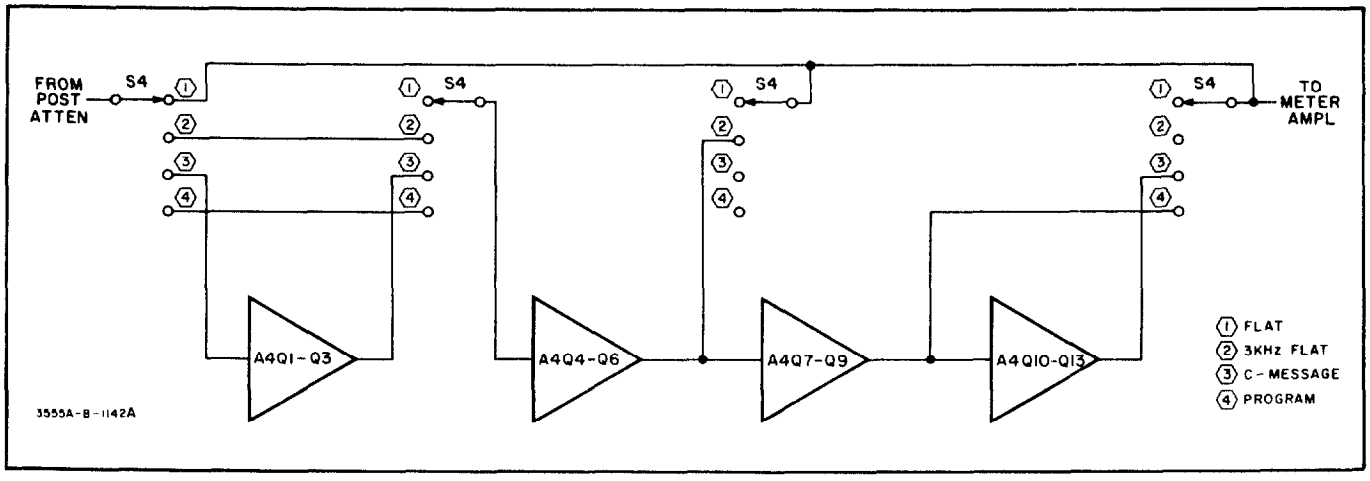


Figure 4-3. Simplified Filter Switching

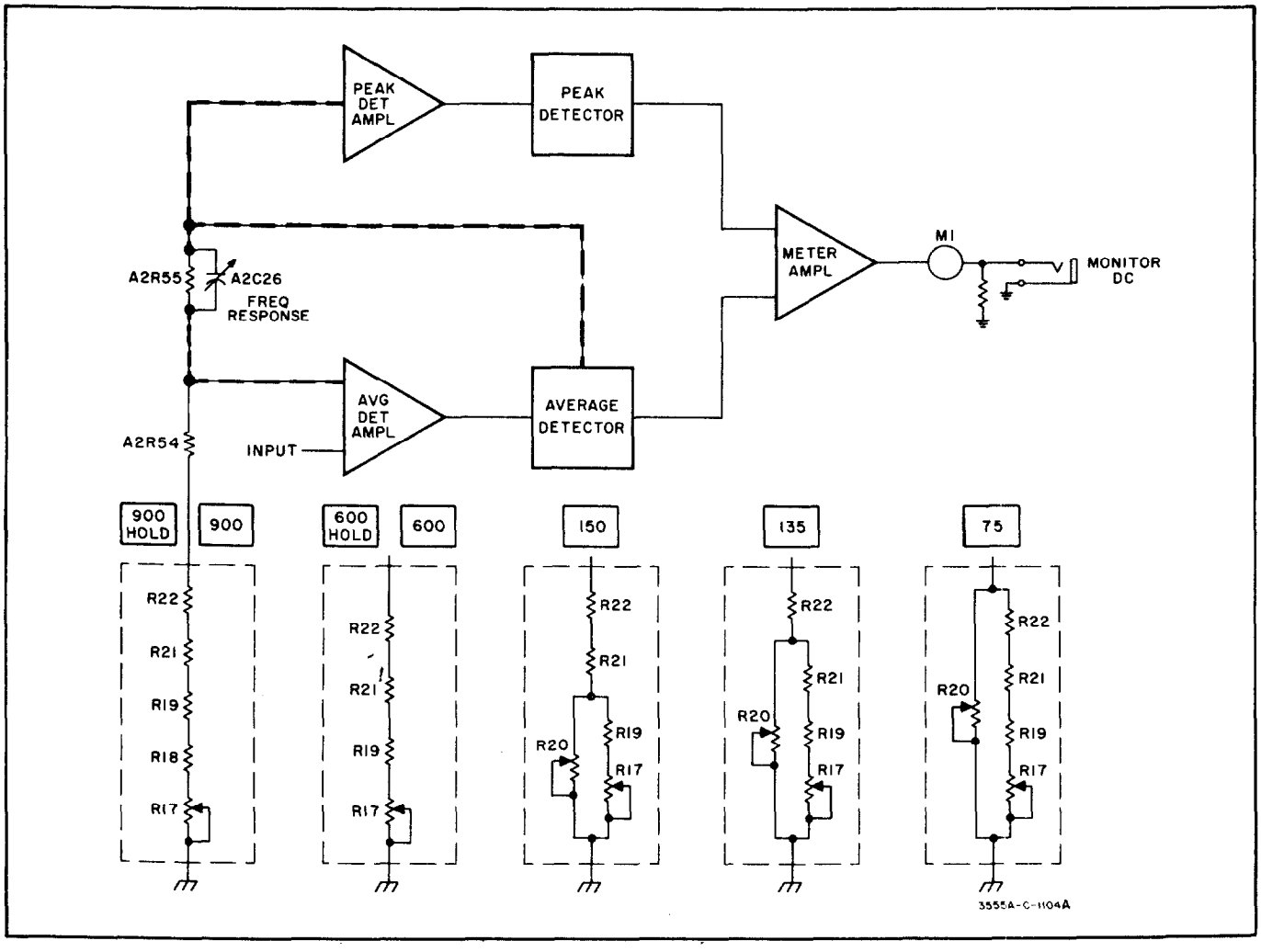


Figure 4-4. Simplified Meter Amplifier Gain Switching

4-69. METER AMPLIFIER.

4-70. The Meter Amplifier consists of an average detector amplifier, an average detector, a peak detector amplifier, a peak detector and a meter driver. The average detector amplifier consists of transistors A2Q18 through A2Q23 and associated circuit components. The input to A2Q18 comes from the weighting filter switch S4. The signal is amplified by A2Q18 and coupled to the base of A2Q20. The base circuit of A2Q20 contains a high frequency shaping circuit consisting of A2C27 and A2R56. Transistors A2Q19, acting as a load for A2Q20, couples the signal to the base of emitter follower A2Q21. The emitter of A2Q21 supplies a dc feedback through A2R60 and A2R52 to the emitter of A2Q18. The ac signal is bypassed by A2C28. The signal is taken from the collector of A2Q22 and coupled to the average detector.

4-71. The signal from A2Q22 is detected by A2CR9 and A2CR10 to charge capacitors A2C41, A2C42, A2C43 and A2C44. As the signal amplitude increases, capacitors A2C43 and A2C44 take on more charge in order to supply the meter driver transistors A2Q29 and A2Q30 with more current. The increase in conduction of A2Q30 causes greater deflection of meter M1. The ac signal at the junction of A2C41 and A2C42 is coupled by A2R55, A2C26 and A2C25 to the emitter of A2Q18 as negative feedback. This ac feedback signal is controlled by the function switch to provide different amplifier gains to match the particular terminating impedance being used. (See Figure 4-4). The ac feedback signal is also used to drive the peak detector amplifier.

4-72. The peak detector amplifier consists of differential amplifier A2Q24, A2Q25 and common emitter A2Q26. The signal from the collector of A2Q26 is used to drive push-pull amplifier A2Q27 and A2Q28. Transistor A2Q27 increases in conduction on the positive half cycle while A2Q28 increases in conduction on the negative half cycle thus forming a push-pull output to drive the peak detector and provide an ac monitor output. Negative feedback is coupled by A2R74 from the emitter of A2Q27 to the base of A2Q25.

4-73. The peak detector is a peak to peak low output impedance voltage doubler consisting of A2C35, A2R76, A2CR11, A2CR12 and A2C36. This peak detected signal is coupled through a high impedance current source, A2Q31 before being applied to the meter M1 where it is summed in the proper proportion with the average detected signal from A2Q30 to produce an rms response.

$$I_{RMS} = I_{AVG} + K\,(I_{PEAK})$$

The signal at the emitters of A2Q27 and A2Q28 is coupled through an RC filter and the FUNCTION switch to the DIAL jacks where it can be used as an ac monitor signal.

4-74. METER M1.

4-75. The meter uses shaped pole pieces to provide a linear scale, which is calibrated to read in both dBm for level measurements and in dBRN for noise measurements. A damping circuit has been included (C6) to minimize meter variations when measuring rapidly fluctuating noise. The damping circuit is controlled by the

RESPONSE switch S5. Diode A2CR13 is included for meter protection when the DIAL/BAT pushbutton is released.

4-76. A MONITOR DC output is available from a front panel jack and is provided so that an external dc recorder can be used to monitor the measured signal. (Refer to Paragraph 3-26 for more detailed discussion).

4-77. When the DIAL BAT pushbutton is depressed the meter is connected to the Power Supply A1 so that the internal battery voltage, office battery voltage, or external ac voltage can be monitored, depending upon the power source being used. (See Figure 4-1).

SECTION V

MAINTENANCE

5-1. INTRODUCTION.

5-2. This section of the manual contains information necessary in the maintenance of the -hp- Model 3555A Telephone Test Meter. Included are performance checks, adjustments and calibration procedures and troubleshooting procedures.

5-3. The test equipment needed to properly maintain and service the Model 3555A is listed in Table 5-1. Included in Table 5-1 is the equipment to be used, required specifications and recommended model. If the recommended model is not available, other equipments can be substituted provided they meet the required specifications.

5-4. FACTORY SELECTED VALUES.

5-5. Factory selected values are denoted on the schematic diagrams by an asterisk. Reference is also made to the paragraph number in the manual where the method of selection can be found.

5-6. PERFORMANCE CHECKS.

5-7. The performance checks presented in this section are in-cabinet checks designed to compare the Model 3555A with its published specifications. These checks can be used for incoming inspection, periodic maintenance checks and to verify performance after adjustment or repair. A performance check test card appears at the end of this section which can be used to record the performance specifications of your instrument.

5-8. INPUT IMPEDANCE CHECK.

a. BRDG IMPEDANCE CHECK.

(1) Connect the 3555A and the 652A Test Oscillator as shown in Figure 5-1 and set the 3555A controls as follows:

FUNCTION	600
INPUT	BRDG
RANGE	0 DBM
WTG	FLAT

Table 5-1. Required Test Equipment

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	RECOMMENDED MODEL
Oscilloscope	Passband: dc to 3 MHz Sensitivity: 50 mV/cm Input Impedance: 1 Megohm	-hp- Model 175A with 1752B and 1780A plug-ins.
Oscillator	Frequency Range: 30 Hz to 3 MHz Output Impedance: 50 and 600 ohms Output Levels: 0.001 volts to 3 volts Monitor: Metering circuit with expand function	-hp- Model 652A
AC/DC Differential Voltmeter	Accuracy: 0.05% Resolution: 0.005% Frequency Range: 30 Hz to 100kHz	-hp- Model 741B
Feedthru Termination	Impedance: 50 ohms Accuracy: 0.25%	-hp- Model 11048B
Attenuator	Range: 100 dB, 10 dB/step Accuracy: ± 0.05 dB	355D with known error
Attenuator	Range: 10 dB, 1 dB/step Accuracy: ± 0.05 dB	355D with known error
Voltmeter	Function: ac, dc, ohms Range (ac): 3 V Range (dc): 100 V Range (ohms): RX10, RX100, RX1K, RX100K, RX1M, RX10M	-hp- Model 427A
Resistors	300 ohms ± 0.1% 100 kilohms ± 1% 66.5 kilohms ± 1% 49.9 ohms ± 1% 110 ohms ± 1% 124 ohms ± 1% 576 ohms ± 1% 875 ohms ± 1% 825 ohms ± 1%	-hp- Part No. 0811-0029 -hp- Part No. 0757-0342 -hp- Part No. 0698-4749 -hp- Part No. 0698-4110 -hp- Part No. 0757-0713 -hp- Part No. 0698-4562 -hp- Part No. 0698-4598 Use 825 ohms in series with 49.9 ohms -hp- Part No. 0757-0731

(2) Adjust the output of the 652A until the 3555A meter indicates exactly 0 DBM with the 652A frequency set to 1 kHz and switch S1 in position 2.

(3) Change switch S1 to position 1. The 3555A meter should indicate -6 DBM ± 0.15 DBM.

(4) Change the value of R1 to 66.5 kilohms ± 1% and the 3555A RANGE switch to -20 DBM. Change S1 to position 2 and adjust the output of the 652A for 0 DBM indication on the 3555A meter.

(5) Change S1 to position 1. The 3555A meter should indicate -6 DBM ± 0.15 DBM.

b. TERM IMPEDANCE CHECK.

(1) Connect the equipment as shown in Figure 5-1. Change R1 to 49.9Ω ±1%, set S1 to position 1, and set the 3555A controls as follows:

FUNCTION	75
INPUT	BRDG
RANGE	0 DBM
WTG	FLAT

(2) Adjust the output of the 652A for 0 DBM indication on the 3555A meter at a frequency of 1 kHz.

(3) Change the 3555A INPUT switch to TERM. The 3555A meter should indicate -6 dBM ± 0.15 DBM.

(4) Return the INPUT switch to BRDG and change R1 to a 110Ω ±1% resistor.

(5) Depress the 135 pushbutton and adjust the output of the 652A for 0 DBM indication on the 3555A meter with S1 in position 1.

(6) Change the INPUT switch to TERM. The 3555A meter should indicate -6 DBM ± 0.15 DBM.

(7) Using the above described procedure, check the 150, 600 and 900 positions of the FUNCTION switch using values of 124, 576 and 875 ohms ± 1% respectively for R1. In each check, the 3555A meter should indicate -6 DBM ± 0.15 DBM.

c. N_G IMPEDANCE CHECK.

(1) Connect an ohmmeter between the tip (T) and ring (R) inputs of the 3555A and depress the N_G pushbutton. The ohmmeter should indicate 80 kilohms ± 4 kilohms.

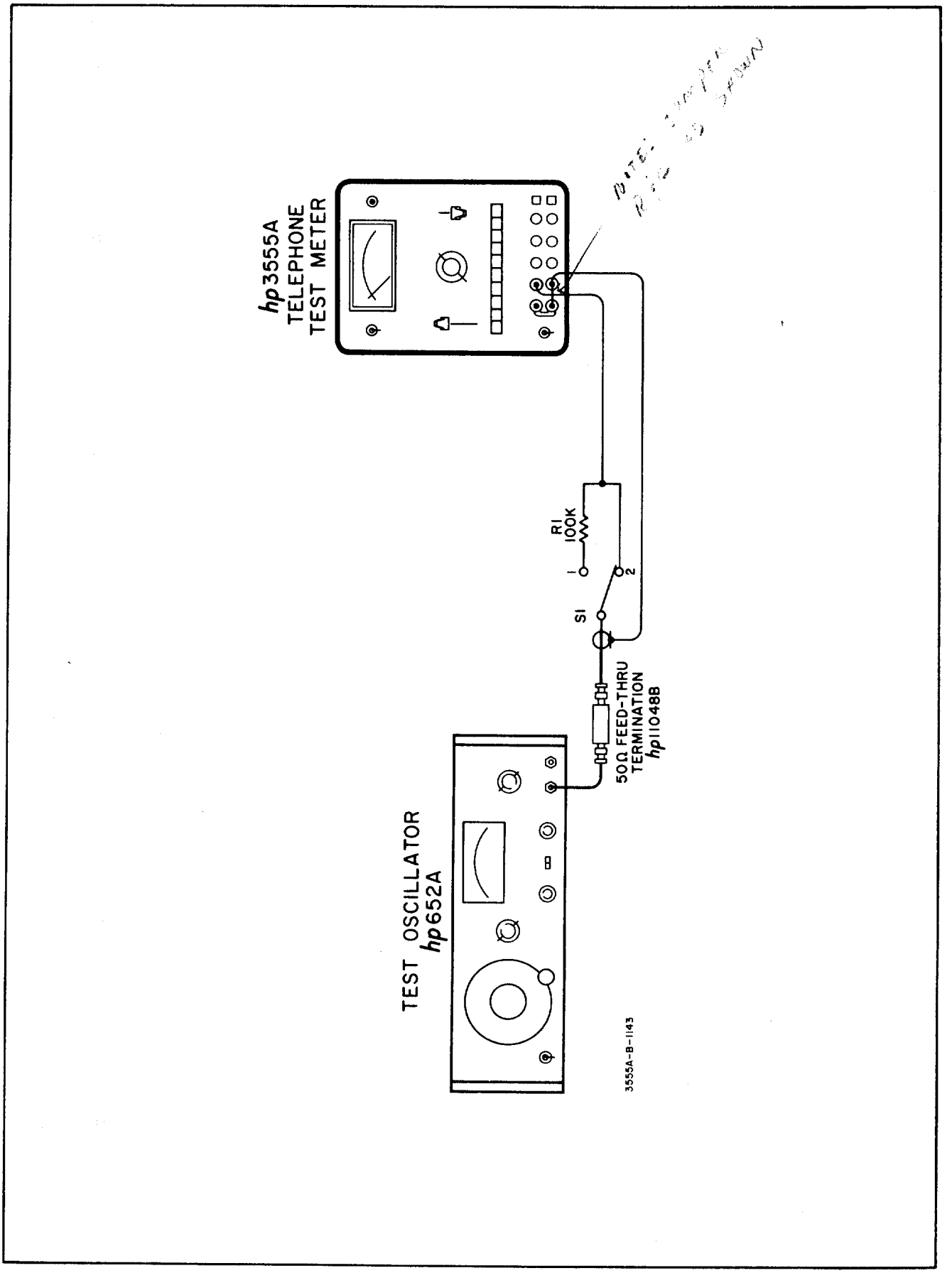


Figure 5-1. Input Impedance Test Setup

(2) With the equipment connected as shown in Figure 5-1, remove the short between ring and ground (G). Change R1 to 100 kΩ ±1% and set the 3555A controls as follows:

FUNCTION	N_G
RANGE	-40 DBM
INPUT	BRDG
WTG	FLAT

(3) With the tip and ring shorted together and S1 in position 2, connect the 652A between the (T) and (R) junction and (G). Adjust the output of the 652A for 0 DBM indication on the 3555A meter.

(4) Change S1 to position 1. The 3555A meter should indicate -6 DBM ± 0.5 DBM.

5-9. RANGE ACCURACY AND TRACKING CHECK.

NOTE

Any inaccuracy in the substitution attenuator must be considered in the following check.

a. Connect the equipment as shown in Figure 5-2 and connect the ring (R) terminal to ground. Set the 3555A controls as follows:

FUNCTION	900
INPUT	BRDG
WTG	FLAT
RANGE	+10 DBM

b. Set the substitution attenuators to 0 and adjust the output of the 652A for 3 volts at 1 kHz as indicated on the 741B Differential Voltmeter.

c. Disconnect the 741B and insert 10 dB of attenuation in the 10 dB/step substitution attenuator.

d. Change the RANGE switch on the 3555A to 0 DBM. The 3555A meter should indicate 0 DBM ± 0.1 DBM.

e. Insert another 10 dB in the substitution attenuator and change the 3555A RANGE switch to -10 DBM. The 3555A meter should indicate 0 DBM ±0.1 DBM.

f. Continue the above procedure, checking each range on the 3555A down to -80 DBM.

g. Return the 3555A RANGE switch to +10 DBM and the substitution attenuators to 0.

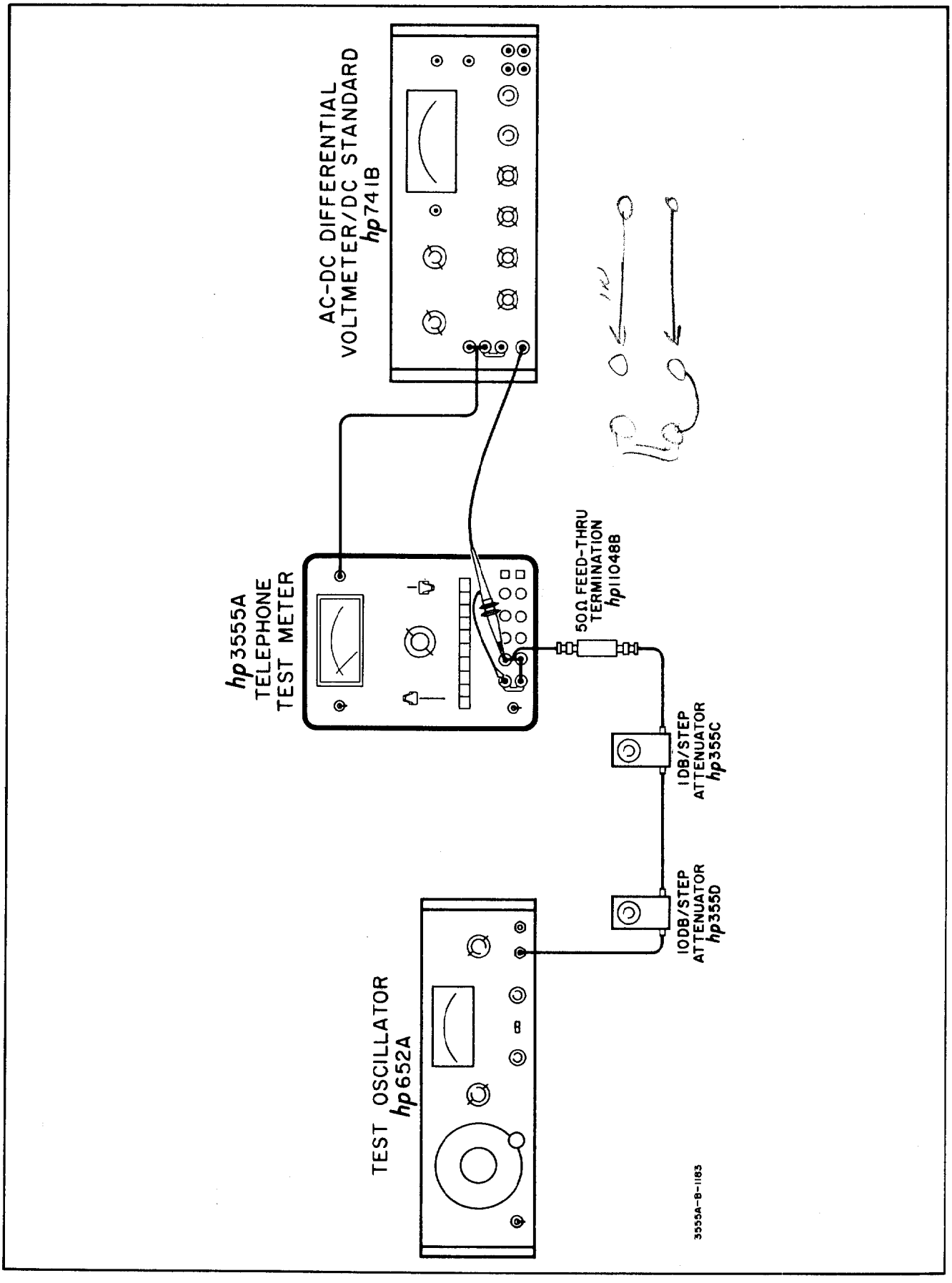


Figure 5-2. Range Accuracy and Tracking Test Setup

h. Insert 10 dB of attenuation into the 1 dB step attenuator in 1 dB steps, noting the indication on the 3555A meter in each step. The 3555A meter pointer should fall exactly over a major DBM division ±0.1 DBM.

i. Return the 1 dB step attenuator to 0.

j. Change the 3555A RANGE switch to +20 DBM. The 3555A meter should indicate -10 DBM ± 0.1 DBM.

k. Insert 10 dB of attenuation into the substitution attenuator. Set the 3555A RANGE switch to +10 DBM and depress the 75 FUNCTION pushbutton.

l. Adjust the output of the 652A for exactly 0 DBM indication on the 3555A meter.

m. Change the 3555A RANGE switch to +20 DBM. The 3555A meter should indicate -10 DBM ±0.1 DBM.

n. Remove 10 dB of attenuation from the substitution attenuator and change the 3555A RANGE switch to +30 DBM. The 3555A meter should return to -10 DBM ±0.1 DBM.

5-10. FREQUENCY RESPONSE CHECK.

a. With the equipment connected as shown in Figure 5-2, set the substitution attenuators to zero and set the 3555A controls as follows:

FUNCTION	900
INPUT	BRDG
WTG	FLAT
RANGE	+10 DBM

b. Set the 652A output frequency to 1 kHz and adjust the amplitude control for any convenient up-scale indication on the 3555A meter.

c. Set the 652A for an expanded reading and set a reference level on the 652A meter.

d. Check the frequencies listed in Table 5-2 for the tolerances indicated. Be sure to maintain the reference level set up on the 652A.

e. Insert 30 dB of attenuation in the substitution attenuator and change the 3555A RANGE switch to -20 DBM. Check the frequencies listed in Table 5-2 for the tolerances indicated. Maintain reference level set up on the 652A.

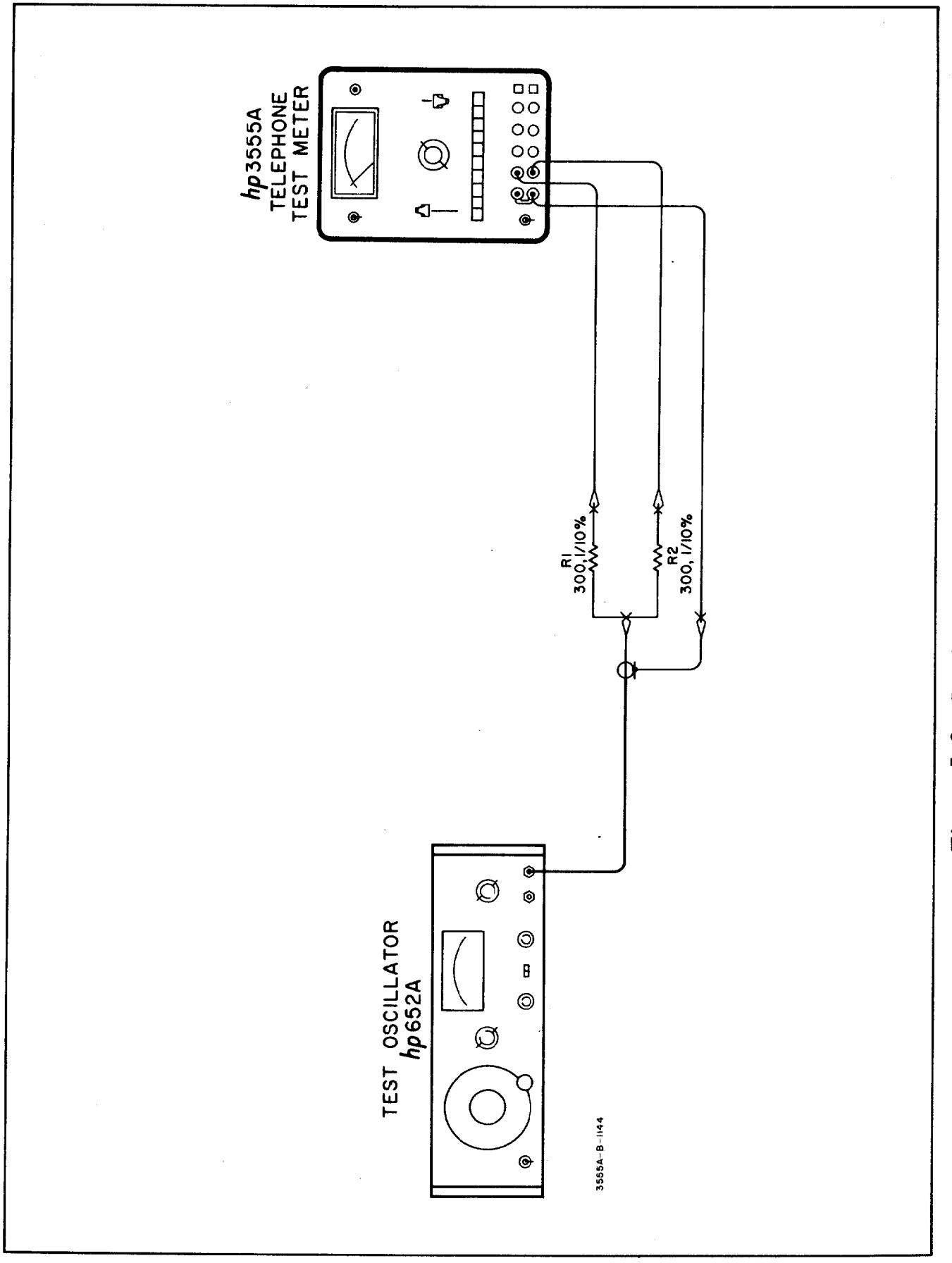


Figure 5-3. Input Balance Test Setup

f. Insert 40 dB more of attenuation (70 dB total) and change the 3555A RANGE switch to -60 DBM. Check the frequencies listed in Table 5-2 for the tolerances indicated, maintaining the reference level set up on the 652A.

Table 5-2. Frequency Response Check

Frequency	+10 DBM Range	-20 DBM Range	-60 DBM Range
	Tolerance in DBM	Tolerance in DBM	Tolerance in DBM
30 Hz		±0.5	±0.5
100 Hz	±0.5	±0.5	
200 Hz	±0.5	±0.5	±0.5
20 kHz	±0.1	±0.1	±0.2
100 kHz	±0.2	±0.2	±0.5
600 kHz	±0.5	±0.5	
2 MHz		±0.5	
3 MHz		±1	

5-11. FILTER RESPONSE CHECK.

a. C MSG FILTER RESPONSE CHECK.

(1) Connect the equipment as shown in Figure 5-2. Set the substitution attenuators to 0 and set the 3555A controls as follows:

FUNCTION	600
RANGE	0 DBM
INPUT	BRDG
WTG	C MSG

(2) Adjust the output of the 652A for 0 DBM indication on the 3555A meter at 1 kHz and check the frequencies and tolerances listed in Table 5-3 for the C MSG filter.

b. 3 kHz FLAT FILTER RESPONSE CHECK.

(1) Change the 3555A WTG switch to 3 KHZ FLAT. Recheck and if necessary, set the 0 DBM reference on the 3555A meter at 1 kHz. Check the frequencies and tolerances listed in Table 5-3 for the 3 KHZ FLAT filter.

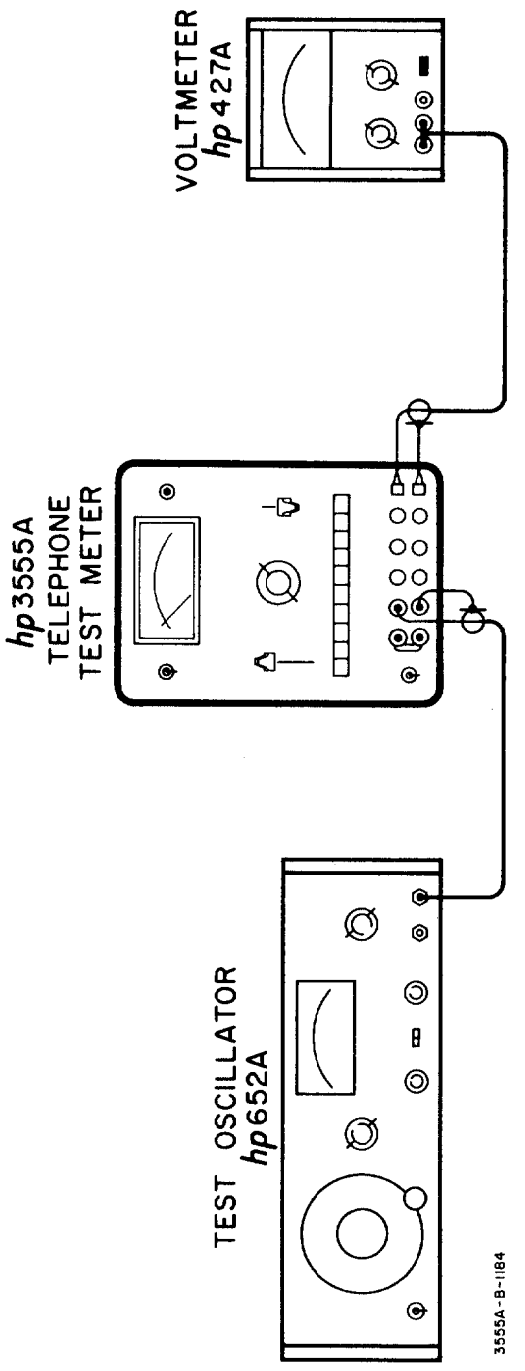


Figure 5-4. AC Monitor Test Setup

c. PROG FILTER RESPONSE CHECK.

(1) Change the 3555A WTG switch to PROG, recheck for the 0 DBM reference at 1 kHz and check the frequencies in Table 5-3 for the indicated tolerances.

Table 5-3. Filter Response

FREQUENCY	INPUT LEVEL (DBM)	3555A INDICATION (DBM)		
		C MSG	3 KHZ FLAT	PROG
200 Hz	0	-25 $^{+1.2}_{-1}$	0 $^{+0.1}_{-0.3}$	-16.3 $^{+1.1}_{-0.8}$
500 Hz	0	-7.6 $^{+0.9}_{-0.7}$		- 6.2 ±0.5
1 kHz	0	0	0	0
2 kHz	0	-1.5 $^{+0.3}_{-0.5}$		
4 kHz	0	-14.6 $^{+1.4}_{-1.6}$	-7.5 $^{+2}_{-1.5}$	
10 kHz	0		-23.5 $^{+2}_{-1.5}$	- 8 $^{+2}_{-3}$

5-12. INPUT BALANCE CHECK.

a. Set the 3555A controls as follows:

FUNCTION	600
INPUT	BRDG
RANGE	0 DBM
WTG	FLAT

b. Connect the 652A 600 ohm output to the tip and ring input of the 3555A. Set the 652A output frequency to 1 kHz and adjust the amplitude control for 0 DBM indication on the 3555A meter.

c. Change the 3555A input connection to that shown in Figure 5-3.

d. Change the 3555A RANGE switch to -70 DBM and tune the 652A between 30 Hz and 30 kHz. The 3555A meter indication must be down at least 70 DBM through this frequency range.

e. Change the 3555A RANGE switch to -60 DBM and tune the 652A from 30 kHz to 100 kHz. The 3555A meter indication must be down at least 60 DBM through this frequency range.

f. Change the 3555A RANGE switch to -40 DBM and tune the 652A between 100 kHz and 600 kHz. The 3555A meter indication must be down at least 40 dB through this frequency range.

5-13. AC MONITOR CHECK.

a. Connect the 3555A, 741B Voltmeter and 652A Test Oscillator as shown in Figure 5-2.

b. Set the 741B to measure ac and set the 3555A controls as follows:

FUNCTION	FLAT
RANGE	0 DBM
INPUT	BRDG
WTG	FLAT

c. Set the 652A frequency to 1 kHz and adjust the amplitude control for full scale (0 DBM) deflection on the 3555A meter. The 741B should indicate 1.4 V ± 0.15 V.

5-14. DC MONITOR CHECK.

a. Using the same setup as in Paragraph 5-13, change the 741B to measure dc and connect to the DC MON output. The 741B should indicate -1 V ± .01 V.

5-15. HOLDING COIL RESISTANCE CHECK.

a. Disconnect the 652A and 741B, and connect the 427A (Ohms Function) across the tip and ring of the INPUT.

b. Depress the 600 HOLD pushbutton. The 427A should indicate 700 ohms ± 70Ω.

5-16. ADJUSTMENT AND CALIBRATION PROCEDURES.

5-17. POWER SUPPLY CHECK.

a. Set up the Model 741B for dc voltmeter measurements with the RANGE switch set to 100, and connect the INPUT terminals to A2 pin 7 of the 3555A.

b. Turn ON the 3555A and note the indication on the 741B. The indication should be -26 volts ± 1 volt.

c. Change the 741B INPUT leads to A2 pin 9. The 741B should indicate -13 ± 1 volt.

d. If the power supply voltages do not meet the specified limits, depress the DIAL/BAT pushbutton and check the condition of the battery. If the 3555A meter does not indicate in the BAT GOOD area, replace the battery and again perform steps a through c. If the battery checks good, check A1CR6 to see that it is regulating at -13 volts ± 1 volt. If A1CR6 is not regulating within this limit, it should be changed.

5-18. COMMON MODE REJECTION ADJUSTMENT.

a. Connect the equipment as shown in Figure 5-5. Set the 3555A controls as follows:

FUNCTION	600
INPUT	BRDG
WTG	FLAT
RANGE	-30 DBM

b. Adjust the output of the 652A for 1 kHz at approximately 3 volts on the 652A meter.

c. Set the oscilloscope controls for a suitable presentation and adjust A2R44 for minimum deflection on the oscilloscope.

d. Change the 652A frequency to 10 kHz and adjust A2C17 for minimum deflection on the oscilloscope.

e. Repeat steps c through d once to minimize interaction of the adjustments.

5-19. REFERENCE CALIBRATION.

a. Connect the equipment as shown in Figure 5-2 and set the substitution attenuators to 0. Set the 3555A controls as follows:

FUNCTION	900
INPUT	BRDG
WTG	FLAT
RANGE	-20 DBM

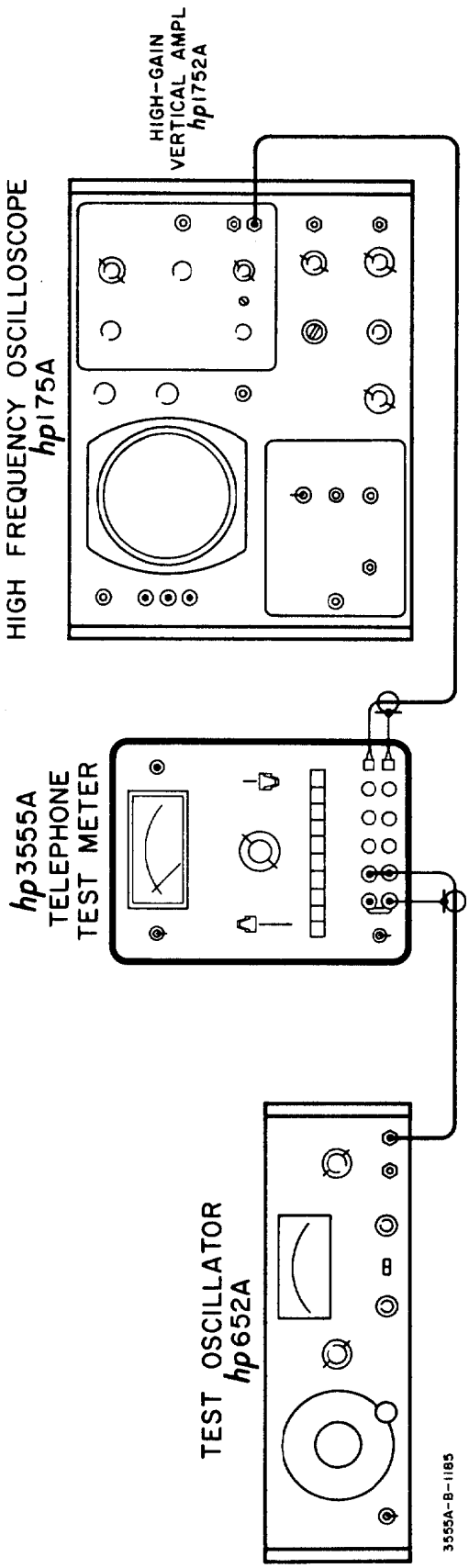


Figure 5-5. Common Mode Adjust Test Setup

b. Set the 741 to the 1 V RANGE with the FUNCTION switch to AC.

c. Adjust the output of the 652A at 1 kHz for 0.09 volt indication on the 741B. Using the 741B VOLTAGE SET controls, set in exactly 0.09487 and change the 741B FUNCTION switch to Δ VM. Adjust the 652A for a maximum null (zero indication) on the 741B meter.

d. Adjust A3R17 until the 3555A meter indicates exactly 0 DBM.

e. Adjust the output of the 652A for exactly 0.03674 volts using the procedure described in steps b and c.

f. Change the 3555A FUNCTION switch to 135 and adjust A3R20 until the 3555A meter indicates exactly 0 DBM.

g. Using the above described procedure, check the 600 function using 0.07746 V as an input, the 150 function using 0.03873 V as an input and the 75 function using 0.02793 V as an input. In each case, the 3555A meter should indicate 0 DBM ± 0.1 DBM.

5-20. INPUT ATTENUATOR ADJUSTMENT.

a. With the equipment connected as shown in Figure 5-2 and the substitution attenuators set to 30, set the 3555A controls as follows:

FUNCTION	600
INPUT	BRDG
WTG	FLAT
RANGE	-20 DBM

NOTE

Since it is necessary to hinge open the A2 board in making the following adjustments, indications will change when the board is closed. Therefore, after adjustments are made, the board should be closed when making readings.

b. Set the 652A for a 1 kHz output frequency and adjust the amplitude control for exactly 0 DBM indication on the 3555A meter.

c. Using the 741B Δ VM function, measure the MONITOR DC output of the 3555A to the nearest 3 decimal places.

d. Change the 3555A RANGE switch to 0 DBM and change the substitution attenuator to -10 dB.

e. Adjust R10 (chassis mounted near the RANGE switch, right side) for the same reading obtained in step c.

f. Reverse the tip (T) and ring (R) connections to the 3555A INPUT and adjust R11 for the same indication obtained in step c and e.

g. Change the 652A output frequency to 1 MHz and repeat the above procedure, using A5C1 to adjust the tip signal and A5C4 to adjust the ring signal.

5-21. NOISE-TO-GROUND CHECK.

a. With the equipment connected as shown in Figure 5-4, disconnect the 427A, and set the 3555A controls as follows:

FUNCTION	600
INPUT	BRDG
WTG	FLAT
RANGE	+10 DBM

b. Set the 652A for an output frequency of 1 kHz and adjust the amplitude control for 0 DBM indication on the 3555A meter.

c. Change the INPUT to the 3555A so that the output is applied to both the tip (T) and ring (R) and the ground terminal of 652A connected to the terminal marked G. Be sure that the shorting bar is connected between the G terminal and the S terminal.

d. Push the N_G pushbutton and change the 3555A RANGE switch to 50 DBRN. The 3555A meter should indicate 0 DBM ± 0.2 DBM.

5-22. RANGE ACCURACY AND METER TRACKING.

NOTE

Any inaccuracy in the substitution attenuator must be considered in the following check.

a. Connect the equipment as shown in Figure 5-2 for a tip driven signal and connect the ring (R) terminal to ground. Set the 3555A controls as follows:

FUNCTION	900
INPUT	BRDG
WTG	FLAT
RANGE	+10 DBM

b. Set the substitution attenuators to 0 and adjust the output of the 652A for 1 kHz at 3 volts as indicated on the 741B Differential Voltmeter.

c. Disconnect the 741B and insert 10 dB of attenuation in the 10 dB/step substitution attenuator.

d. Change the RANGE switch on the 3555A to -10 DBM. The 3555A meter should indicate 0DBM, ± 0.1 DBM.

e. Insert another 10 dB in the substitution attenuator and change the 3555A RANGE switch to -20 DBM. The 3555A meter should indicate 0DBM ± 0.1 DBM.

f. Continue the above procedure, checking each range on the 3555A down to -80 DBM.

g. If the range tracking on the bottom four ranges is not within specifications, the value of A5R19 may be changed. If the 3555A meter reads too high, decrease the value of A5R19. If the meter indicates too low, increase the value of A5R19.

h. Return the 3555A RANGE switch to +10 DBM and the substitution attenuators to 0.

i. If necessary, adjust the 652A amplitude control for exactly 0DBM indication on the 3555A meter.

j. Insert 10 dB of attenuation into the 1 dB step attenuator in 1 dB steps, noting the indication on the 3555A meter in each step. The 3555A meter pointer should fall exactly over a major DBM division ± 0.1 DBM.

k. If the meter indicates too high at the low end of the scale, increase the value of A2R82 approximately 200 kilohms/0.1 dB of change required. If the meter indicates too low, lower the value of A2R82.

l. Return the 1 dB step attenuator to 0 and again adjust the output of the 652A for exactly 0DBM indication on the 3555A meter.

m. Change the 3555A RANGE switch to +20 DBM. The 3555A meter should indicate -10 DBM ± 0.1 DBM.

n. Set the 3555A RANGE switch to +10 DBM and depress the 75 FUNCTION pushbutton. Insert 10 dB of attenuation into the substitution attenuator.

o. Adjust the output of the 652A for exactly 0DBM indication on the 3555A meter.

p. Change the 3555A RANGE switch to +20 DBM. The 3555A meter should indicate -10 DBM ± 0.1.

q. Remove 10 dB of attenuation from the substitution attenuator and change the 3555A RANGE switch to +30 DBM. The 3555A meter should return to -10 DBM ± 0.1.

5-23. FREQUENCY RESPONSE ADJUSTMENT.

a. With the equipment connected as shown in Figure 5-2, set the substitution attenuators to 0 and set the 3555A controls as follows:

FUNCTION	900
INPUT	BRDG
WTG	FLAT
RANGE	+10 DBM

b. Set the 652A output frequency to 1 kHz and adjust the amplitude control for 0 DBM indication on the 3555A meter.

c. Set the 652A for an expanded reading and set a reference level on the 652A meter. Change the 652A output to 30 Hz, maintaining the reference level set up on the 652A expand scale for the remainder of the response checks.

d. Adjust A2R62 until the 3555A meter indicates 0 DBM.

e. If A2R62 has insufficient range for this adjustment, A2C24 may be changed. To select A2C24, set A2R62 to midrange and change A2C24 approximately 2 μF/0.1 dB change required. Increase A2C24 to lower the low frequency response. Decrease A2C24 to increase low frequency response.

f. Tune the 652A to 1 MHz, maintaining set reference and adjust A2C26 for 0 DBM on the 3555A meter.

g. Check the frequencies listed in Table 5-2 for the tolerances indicated for the +10 DBM range.

h. Change the 3555A RANGE switch to -20 DBM, set up the 652A output reference at 1 kHz and check the frequencies listed in Table 5-2 for the tolerances indicated for the -20 DBM range.

i. Repeat the above procedure with the 3555A RANGE switch set to -60 DBM and check the frequencies listed in Table 5-4 for the tolerances indicated for the -60 DBM range.

5-24. WEIGHTING FILTER ADJUSTMENT AND CHECKS.

a. With the equipment connected as shown in Figure 5-2, set the 3555A controls as follows:

FUNCTION	600
INPUT	BRDG
RANGE	0 DBM
WTG	FLAT

b. Adjust the output of the 652A for 0 DBM indication on the 3555A meter at a frequency of 1 kHz. Set the 652A for EXPAND and set up a reference on the 652A meter. Maintain this reference throughout the remainder of the filter checks.

c. Change the WTG switch to 3 kHz FLAT and adjust A4R4 (middle pot on the filter board) for exactly 0 DBM indication on the 3555A meter.

d. Change the WTG switch to C MSG and adjust A4R9 (left pot as viewed from the component side of the board) for 0 DBM indication on the 3555A meter.

e. Change the WTG switch to PROG and adjust A4R19 (pot on right side) for 0 DBM indication on the 3555A meter.

f. Now that the reference has been set for all three filters, check the frequencies listed in Table 5-3 for the tolerances indicated. If any check fails refer to the troubleshooting procedure, Paragraph 5-35.

5-25. TROUBLESHOOTING.

5-26. The following troubleshooting procedures are designed to aid in locating malfunctions in the 3555A in a minimum of time. In addition to logical troubleshooting procedures, certain troubleshooting tips have been included to further aid in locating faulty components which might not otherwise be theoretically obvious.

5-27. In order to effectively troubleshoot the 3555A, certain conditions must first be established. Figure 5-4 shows the test setup to be used with the 3555A controls set as follows unless otherwise specified in the procedure.

FUNCTION	600
RANGE	0 DBM
INPUT	BRDG
WTG	FLAT

5-28. The 652A Test Oscillator should be set to a frequency of 1 kHz and the output amplitude control adjusted for 0 DBM using the tip (T) and ring (R) inputs with the ring grounded.

5-29. With the conditions described in Paragraph 5-27 and 5-28 set up, use the simplified Troubleshooting Tree, Figure 5-6 in conjunction with Figure 7-1 to isolate the malfunction to a block. Once the malfunction has been isolated to a block, refer to the troubleshooting procedures in Paragraphs 5-30 through 5-37 for the particular block where the malfunction is located.

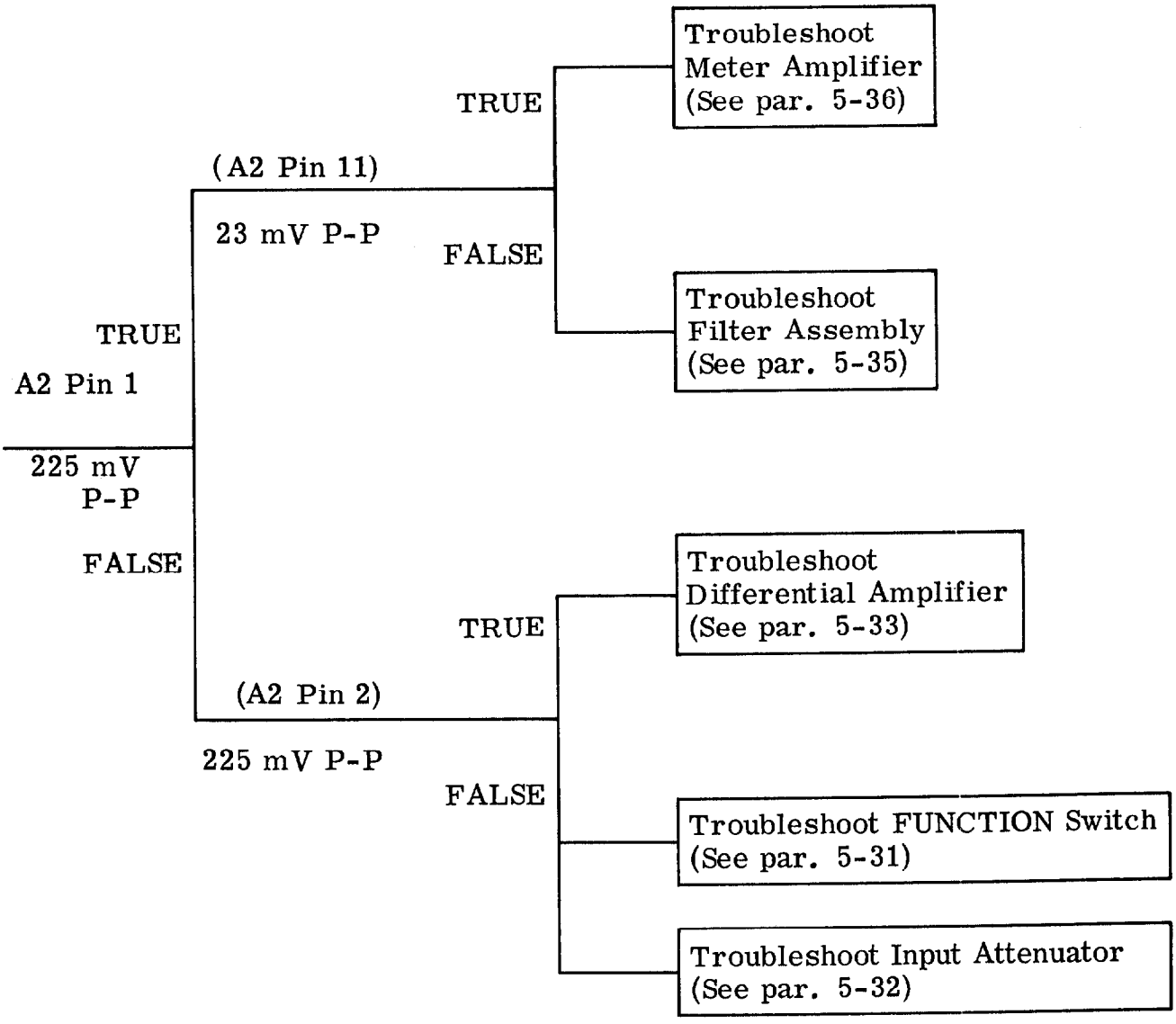


Figure 5-6. Simplified Troubleshooting Tree

5-30. POWER SUPPLY TROUBLESHOOTING.

a. Since the power supply A1 operates from either ac or battery, it should first be determined if the set will operate from either source.

b. Connect a dc voltmeter between the -26 volts (A2 Pin 7) and ground. Depress the DIAL/BAT pushbutton and turn the POWER switch to ON. Refer to Table 5-4 for assistance in troubleshooting the Power Supply.

Table 5-4. Power Supply Troubleshooting

SYMPTOM	CHECK
1. Operates on AC but not on BAT	BT1, S2, S1 J2
2. Operates on BAT but not on AC	F1, T1, S1, S2 A1CR1 and power cord.
3. No meter indication on DIAL/BAT check, AC or BAT operation	A1R1, S1, S2
4. DIAL/BAT check good, -26 V indicates high or low	A1CR6
5. DIAL/BAT good, -26 V supply near -14 volts	A1R7
6. DIAL/BAT good, -26 V supply near -40 volts	A1R6 A1Q1 - A1Q5

5-31. FUNCTION SWITCH TROUBLESHOOTING.

a. The best procedure to use in troubleshooting the FUNCTION switch is to first determine which function is not performing properly, depress that particular pushbutton and perform the resistance checks listed in Table 5-5. Turn the POWER switch to OFF and place a short across C1 for the resistance checks. Shorting strap should be connected between S and G terminals. Don't forget to remove the short from C1 after completion.

Table 5-5. Function Switch Resistance Checks

	INPUT JACKS						DIAL JACKS		
	Tip To Ring		Tip To Gnd		Ring To Gnd		Tip To Ring	Ring To Gnd	Tip To Gnd
	TERM	BRDG	BRDG	TERM	BRDG	TERM			
DIAL/BAT	200kΩ	200kΩ	100kΩ	100kΩ	100kΩ	100kΩ	200kΩ	100kΩ	100kΩ
N_G HOLD	700Ω	700Ω	∞	∞	∞	∞	∞	0	∞
N_G	84.4kΩ	84.4kΩ	∞	∞	∞	∞	∞	0	∞
900 HOLD	390Ω	390Ω	50 kΩ	50 kΩ	50 kΩ	50 kΩ	∞	0	∞
600 HOLD	320Ω	320Ω	50 kΩ	50 kΩ	50 kΩ	50 kΩ	∞	0	∞
900	900Ω	200kΩ	100kΩ	50 kΩ	100kΩ	50 kΩ	∞	0	∞
600	600Ω	200kΩ	100kΩ	50 kΩ	100kΩ	50 kΩ	∞	0	∞
150	150Ω	200kΩ	100kΩ	50 kΩ	100kΩ	50 kΩ	∞	0	∞
135	135Ω	200kΩ	100kΩ	50 kΩ	100kΩ	50 kΩ	∞	0	∞
75	75Ω	200kΩ	100kΩ	50 kΩ	100kΩ	50 kΩ	∞	0	∞

5-32. INPUT ATTENUATOR TROUBLESHOOTING.

a. To troubleshoot the Input Attenuator, connect the 427A (Ohms function) between the tip (T) input terminal and A2 Pin 2.

b. In -80 DBM through -20 DBM, the 427A should indicate zero resistance. In -10 DBM through +30 DBM, the 427A should indicate 97.6 kilohms.

c. Repeat step b with the 427A connected between the ring (R) input terminal and A2 Pin 4. Resistance measurements should be the same as in step b.

d. If the above resistances check o.k., check A5C1 through A5C4, A5R1 through A5R4 and chassis mounted R10 and R11.

5-33. DIFFERENTIAL AMPLIFIER TROUBLESHOOTING.

5-34. With the set turned ON and the controls set as described in Paragraphs 5-27 and 5-28, proceed with the following checks:

a. Measure the ac signal at the following points with the input connected to the tip and ring with the ring grounded.

(1)	Base of A2Q1A	225 mV P-P
(2)	Emitter of A2Q3	225 mV P-P
(3)	Collector of A2Q13	225 mV P-P
(4)	Emitter of A2Q15	225 mV P-P

b. Reverse the input connections to the 3555A and ground the tip. Make the following measurements:

(1)	Base of A2Q1B	225 mV P-P
(2)	Emitter of A2Q6	225 mV P-P
(3)	Collector A2Q16	225 mV P-P
(4)	Emitter A2Q15	225 mV P-P

c. In positions 1 through 4 of the RANGE switch, the ac voltage at A2 Pin 1 will appear with gains of 40, 30, 20 and 10 dB respectively with respect to the ac voltage at A2 Pin 2.

d. Check the dc voltages as indicated on the schematic diagram Figure 7-5.

e. Refer to Paragraph 5-37, Troubleshooting Tips for further assistance in troubleshooting the Differential Amplifier.

5-35. FILTER TROUBLESHOOTING.

a. The A4 Filter Assembly has four amplifiers which are used in combinations to form each of the three filters. The amplifiers are designed to have unity gain. Therefore, when a 1 kHz signal (reference frequency) is being used,

the signal at the output (A2 Pin 11) should be identical to the input to the filter assembly (see Figure 7-1).

b. It should first be determined by checking each filter position which one is defective. Utilizing Figure 7-1, the malfunction can easily be isolated to a particular amplifier. The 3 kHz FLAT filter utilizes only the second amplifier while the C MSG filter utilizes all four of the amplifiers. The PROG filter utilizes the second and third amplifier.

c. Check the dc voltages on schematic diagram, Figure 7-7.

5-36. METER AMPLIFIER TROUBLESHOOTING.

a. Check the input to the Meter Amplifier at A2 Pin 11. With the input conditions described in Paragraph 5-27 and 5-28, the voltage at this point should be 23 mV P-P.

b. Check the ac voltage at the junction of A2R55 and A2C32. This voltage should be 240 mV P-P. If not, troubleshoot the Average Detector Amplifier (A2Q18 through A2Q23) and the Average Detector (See Figure 7-7). If this voltage is normal, go to the next step.

c. Check the ac signal at A2 Pin 13. This signal should be 4 V P-P. If not, troubleshoot the Peak Detector Amplifier. If this voltage is normal, check the Peak Detector.

d. Refer to Paragraph 5-37, Troubleshooting Tips for further aids in troubleshooting the Meter Amplifier.

5-37. TROUBLESHOOTING TIPS.

a. Power Supply.

(1) If the -26 V supply is out of tolerance (-26 V ± 1) change A1CR6.

(2) If the -26 V supply is near -14 V, check A1R7.

(3) If the -26 V supply is near -40 V, check A1R6.

(4) If the -26 V supply is good, but the -13 V supply is not, (A2, pin 9) check A1CR7, A1R8, A1Q6 and A1Q7.

b. Differential Amplifier.

(1) If the collector voltage of A2Q3 or A2Q6 is zero, check A2CR7.

(2) If the collector voltage of A2Q2 or A2Q5 is at -26 volts, check A2CR8.

(3) If A2Q1A or B is found to be bad, diodes A1CR1 through A1CR6 should be checked.

(4) If the set cannot be calibrated on the lower ranges, change A2Q1.

C. Meter Amplifier.

(1) If the set appears to be insensitive (indicates about 18 to 20 DBM low) and the meter oscillates, check the amplifier gain switching on all impedances (A2 Pin 14 to ground). The gain switching resistors and CAL pots are located on the FUNCTION switch assembly.

(2) If the meter indicates low (about 30%), check the Peak Detector.

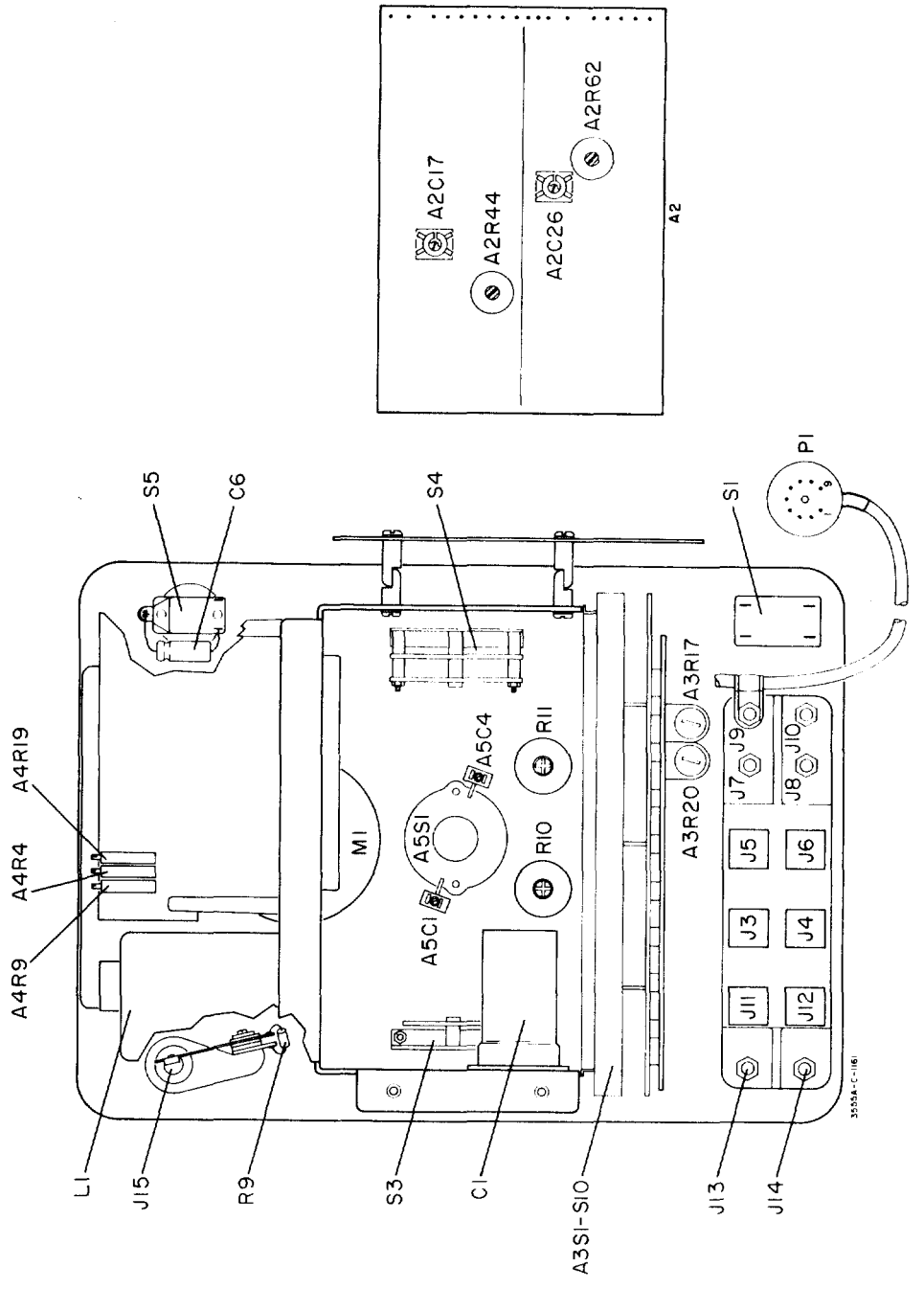


Figure 5-7. Adjustment and Component Location

PERFORMANCE CHECK TEST CARD

Hewlett-Packard Model 3555A
Telephone Test Meter
Serial No. _____

Tests performed by _____
Date _____

Description	Par.	Check	
1. INPUT IMPEDANCE CHECK	5-8		
a. BRDG IMPEDANCE CHECK			
(1) Ranges 1-7 -80 DBM thru +20 DB		_____	100 kΩ (-6 DBM ± 0.15)
(2) Ranges 8-12 -10 DBM thru +30 DB		_____	200 kΩ (-6 DBM ± 0.15)
b. TERM IMPEDANCE CHECK			
(1) 75 ohm		_____	75Ω ± 1% (-6 DBM ± 0.15)
(2) 135 ohm		_____	135Ω ± 1% (-6 DBM ± 0.15)
(3) 150 ohm		_____	150Ω ± 1% (-6 DBM ± 0.15)
(4) 600 ohm		_____	600Ω ± 1% (-6 DBM ± 0.15)
(5) 900 ohm		_____	900Ω ± 1% (-6 DBM ± 0.15)
c. N_G IMPEDANCE CHECK			
(1) Tip to ring		_____	80kΩ ± 4kΩ
(2) Tip and ring to ground		_____	100kΩ ± 1% (-6DBM ± 0.15)
2. RANGE ACCURACY AND TRACKING	5-9		
-10 DBM		_____	± 0.1 DBM
-20 DBM		_____	± 0.1 DBM
-30 DBM		_____	± 0.1 DBM
-40 DBM		_____	± 0.1 DBM
-50 DBM		_____	± 0.1 DBM
-60 DBM		_____	± 0.1 DBM
-70 DBM		_____	± 0.1 DBM
-80 DBM		_____	± 0.1 DBM
+20 DBM		_____	± 0.1 DBM
+30 DBM		_____	± 0.1 DBM
3. FREQUENCY RESPONSE	5-10		
a. +10 DBM RANGE			
100 Hz		_____	± 0.5 DBM Variation
200 Hz		_____	± 0.5 DBM Variation
20 kHz		_____	± 0.1 DBM Variation
100 kHz		_____	± 0.2 DBM Variation
600 kHz		_____	± 0.5 DBM Variation
b. -20 DBM RANGE			
30 Hz		_____	± 0.5 DBM Variation
100 Hz		_____	± 0.5 DBM Variation
200 Hz		_____	± 0.5 DBM Variation
20 kHz		_____	± 0.1 DBM Variation
100 kHz		_____	± 0.2 DBM Variation
600 kHz		_____	± 0.5 DBM Variation
2 MHz		_____	± 0.5 DBM Variation
3 MHz		_____	± 1 DBM Variation

PERFORMANCE CHECK TEST CARD (Cont'd)

c. -60 DBM RANGE		
30 Hz	_____	± 0.5 DBM Variation
200 Hz	_____	± 0.5 DBM Variation
20 kHz	_____	± 0.2 DBM Variation
100 kHz	_____	± 0.5 DBM Variation
4. FILTER RESPONSE 5-11		
a. C MSG		
(1) 200 Hz	_____	-25 +1.2/-1 DBM
(2) 500 Hz	_____	-7.6 +0.9/-0.7 DBM
(3) 1 kHz	_____	0 DBM (Reference)
(4) 2 kHz	_____	-1.5 +0.3/-0.5 DBM
(5) 4 kHz	_____	-14.6 +1.4/-1.6 DBM
b. 3 kHz FLAT		
(1) 200 Hz	_____	0 +0.1/-0.3 DBM
(2) 1 kHz	_____	0 DBM (Reference)
(3) 4 kHz	_____	-7.5 +2/-1.5 DBM
(4) 10 kHz	_____	-23.5 +2/-1.5 DBM
c. PROG		
(1) 200 Hz	_____	-16.3 +1.1/-0.8 DBM
(2) 500 Hz	_____	-6.2 ± 0.5 DBM
(3) 1 kHz	_____	0 DBM (Reference)
(4) 10 kHz	_____	-8 +2/-3 DBM
5. INPUT BALANCE 5-12		
a. 30 Hz to 30 kHz	_____	> 70 DBM
b. 30 kHz to 100 kHz	_____	> 60 DBM
c. 100 kHz to 600 kHz	_____	> 40 DBM
6. AC MONITOR 5-13	_____	1.4 V rms ± 0.15
7. DC MONITOR 5-14	_____	1 volt ± 0.01
8. HOLDING COIL RESISTANCE 5-15	_____	700 ± 70 ohms

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alphameric order of their reference designators and indicates the description, -hp- part number of each part, together with any applicable notes, and provides the following:

a. Total quantity used in the instrument (TQ column). The total quantity of a part is given the first time the part number appears.

b. Description of the part. (See list of abbreviations below.)

c. Typical manufacturer of the part in a five-digit code. (See Appendix A for list of manufacturers.)

d. Manufacturer's part number.

6-3. Miscellaneous parts are listed at the end of Table 6-1.

6-4. ORDERING INFORMATION.

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office. (See Appendix B for list of office locations.) Identify parts by their Hewlett-Packard part numbers. Include instrument model and serial numbers.

6-6. NON-LISTED PARTS.

6-7. To obtain a part that is not listed, include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

DESIGNATORS

A	= assembly	F	= fuse	MP	= mechanical part	TC	= thermocouple
B	= motor	FL	= filter	P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
BT	= battery	HR	= heater	Q	= transistor		
C	= capacitor	IC	= integrated circuit	QCR	= transistor-diode	W	= cable
CR	= diode	J	= jack	R	= resistor	X	= socket
DL	= delay line	K	= relay	RT	= thermistor	XDS	= lampholder
DS	= lamp	L	= inductor	S	= switch	XF	= fuseholder
E	= misc electronic part	M	= meter	T	= transformer	Z	= network

ABBREVIATIONS

Ag	= silver	ID	= inside diameter	ns	= nanosecond (s) = 10^{-9} seconds	sl	= slide
Al	= aluminum	impg	= impregnated	nsr	= not separately replaceable	SPDT	= single-pole double-throw
A	= ampere (s)	incd	= incandescent			SPST	= single-pole single-throw
Au	= gold	ins	= insulation (ed)	Ω	= ohm (s)		
C	= capacitor	kΩ	= kilohm (s) = 10^{+3} ohms	obd	= order by description	Ta	= tantalum
cer	= ceramic	kHz	= kilohertz = 10^{+3} hertz	OD	= outside diameter	TC	= temperature coefficient
coef	= coefficient	L	= inductor	p	= peak	TiO_2	= titanium dioxide
com	= common	lin	= linear taper	pc	= printed circuit	tog	= toggle
comp	= composition	log	= logarithmic taper	pF	= picofarad (s) = 10^{-12} farads	tol	= tolerance
conn	= connection	m	= milli = 10^{-3}	piv	= peak inverse voltage	trim	= trimmer
dep	= deposited	mA	= milliampere (s) = 10^{-3} amperes	p/o	= part of	TSTR	= transistor
DPDT	= double-pole double-throw	MHz	= megahertz = 10^{+6} hertz	pos	= position (s)	V	= volt (s)
DPST	= double-pole single-throw	MΩ	= megohm (s) = 10^{+6} ohms	poly	= polystyrene	vacw	= alternating current working voltage
elect	= electrolytic	met flm	= metal film	pot	= potentiometer	var	= variable
encap	= encapsulated	mfr	= manufacturer	p-p	= peak-to-peak	vdcw	= direct current working voltage
F	= farad (s)	mtg	= mounting	ppm	= parts per million	W	= watt (s)
FET	= field effect transistor	mV	= millivolt (s) = 10^{-3} volts	prec	= precision (temperature coefficient, long term stability, and/or tolerance)	w/	= with
fxd	= fixed	μ	= micro = 10^{-6}			wiv	= working inverse voltage
GaAs	= gallium arsenide	μV	= microvolt (s) = 10^{-6} volts			w/o	= without
GHz	= gigahertz = 10^{+9} hertz	my	= Mylar Ⓡ			ww	= wirewound
gd	= guard (ed)	nA	= nanoampere (s) = 10^{-9} amperes	R	= resistor	*	= optimum value selected at factory, average value shown (part may be omitted)
Ge	= germanium	NC	= normally closed	Rh	= rhodium		
grd	= ground (ed)	Ne	= neon	rms	= root-mean-square		
H	= henry (ies)	NO	= normally open	rot	= rotary	**	= no standard type number assigned (selected or special type)
Hg	= mercury	NPO	= negative positive zero (zero temperature coefficient)	Se	= selenium		
Hz	= hertz (cycle (s) per second)			sect	= section (s)		
				Si	= silicon		

REV 6

Ⓡ Dupont de Nemours

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1	03555-66501		1	Board: Etched Ckt Assy Power Supply	-hp-	
A1C1	0180-1819		1	C: fxd Al elect 100 μF +75% -10% 50 vdcw	56289	30D107G050DH2-DSM
A1C2	0180-0061		1	C: fxd Al elect 100 μF +75% -10% 15 vdcw	56289	30D107G015DC2-DSM
A1C3	0180-0049		1	C: fxd Al elect 20 μF +75% -10% 50 vdcw	56289	30D206G050CC2-DSM
A1C4	0180-1942		1	C: fxd Al elect 150 μF +75% -10% 15 vdcw	56289	30D157G015DD2-DSM
A1CR1 thru A1CR5	1901-0025		6	Diode: Si 100 wiv 12 pF 100 mA	24446	SS410
A1CR6, A1CR7	1902-3190		2	Diode: breakdown zener 13 V ±5% 400 mW	04713	SZ 10939-215
A1CR8	1901-0025			Diode: Si 100 wiv 12 pF 100 mA	03877	SG-817
A1J1	1200-0062		1	Socket: tube	000LB	121-51-11-060
A1Q1	1854-0090		1	TSTR: Si NPN 2N3053	04713	SM8158
A1Q2	1853-0036		18	TSTR: Si PNP 2N3906	07263	obd
A1Q3, A1Q4	1854-0215		26	TSTR: Si NPN 2N3904	01295	SK 1124
A1Q5	1853-0036			TSTR: Si PNP 2N3906	07263	obd
A1Q6	1854-0215			TSTR: Si PNP 2N3904	01295	SK 1124
A1Q7	1853-0036			TSTR: Si PNP 2N3906	07263	obd
A1R1	0698-3452		1	R: fxd prec met flm 147K ±1% 1/8 W	75042	CEA T-O obd
A1R2	0684-4711		1	R: fxd comp 470Ω ±10% 1/4 W	01121	EB 4711
A1R3	0684-4741		1	R: fxd comp 470K ±10% 1/2 W	01121	EB 4741
A1R4	0684-1001		1	R: fxd comp 10Ω ±10% 1/4 W	01121	EB 1801
A1R5	0684-5621		1	R: fxd comp 5600Ω ±10% 1/4 W	01121	EB 5621
A1R6	0757-0467		1	R: fxd prec met flm 121K ±1% 1/8 W	75042	CEA T-O obd
A1R7	0698-3451		2	R: fxd prec met flm 133K ±1% 1/8 W	75042	CEA T-O obd
A1R8	0684-2231		1	R: fxd comp 22K ±10% 1/4 W	01121	EB 2231
A1R9	0684-5621			R: fxd comp 5600Ω ±10% 1/4 W	01121	EB 5621
A1R10	0684-1231		1	R: fxd comp 12K ±10% 1/4 W	01121	EB 1231
A1R11	0684-1021		1	R: fxd comp 1000Ω ±10% 1/4 W	01121	CB 1021
A1T1	9100-0172		1	Transformer: power	-hp-	
A2	03555-66502		1	P.C. Assembly Amplifier Board	-hp-	
A2C1	0170-0038		2	C: fxd my 0.22 μF ±10% 200 vdcw	56289	Type 148P #118P22492
A2C2	0160-0127		5	C: fxd cer 1.0 μF ±20% 25 vdcw	56289	5C13C
A2C3	0160-2009		2	C: fxd mica 820 pF ±5%	04062	RDM15F821J3C
A2C4	0170-0038			C: fxd my 0.22 μF ±10% 200 vdcw	56289	Type 148P #118P22492
A2C5	0160-0127			C: fxd cer 1.0 μF ±20% 25 vdcw	56289	5C13C
A2C6	0160-2009			C: fxd mica 820 pF ±5%	04062	RDM15F821J3C
A2C7	0160-0127			C: fxd cer 1.0 μF ±20% 25 vdcw	56289	5C13C
A2C8				Not assigned		
A2C9, A2C10	0180-0374		5	C: fxd Ta elect 10 μF ±10% 20 vdcw	56289	150D106X9020B2-DYS
A2C11	0150-0093		1	C: fxd cer 0.01 μF +80% -20% 100 vdcw	91418	TA obd
A2C12 thru A2C14				Not assigned		
A2C15	0180-0228		5	C: fxd Ta elect 22 μF ±10% 15 vdcw	56289	150D226X9015B2-DYS
A2C16				Not assigned		
A2C17	0121-0196		1	C: var air 1.3-5.4 pF	74970	189-352-5
A2C18, A2C19	0140-0190		2	C: fxd mica 39 pF ±5%	04062	RDM15E90J3C
A2C20				Not assigned		
A2C21	0140-0196		2	C: fxd mica 150 pF ±5% 300 vdcw	04062	DM15F151J 300 V
A2C22				Not assigned		

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2C23	0160-0127			C: fxd cer 1.0 μF ±20% 25 vdcw	56289	5C13C
*A2C24	0180-0116		1	C: fxd Ta elect 6.8 μF ±10% 35 vdcw	56289	150D685X9035B2-DYS
A2C25	0180-0228			C: fxd Ta elect 22 μF ±10% 15 vdcw	56289	150D226X9015B2-DYS
A2C26	0121-0128		1	C: var air trim 1.4 pF to 9.2 pF	74970	189-503-5
A2C27	0140-0196			C: fxd mica 150 pF ±5% 300 vdcw	04062	DM15F151J300 V
A2C28	0180-0100		1	C: fxd Ta elect 4.7 μF ±10% 35 vdcw	56289	150D475X9035B2-DYS
A2C29	0180-0197		1	C: fxd Ta elect 2.2 μF ±10% 20 vdcw	56289	150D225X9020A2-DYS
A2C30	0180-0228			C: fxd Ta elect 22 μF ±10% 15 vdcw	56289	150D226X9015B2-DYS
A2C31				Not assigned		
A2C32	0160-0127			C: fxd cer 1.0 μF ±20% 25 vdcw	56289	5C13C
A2C33	0180-0374			C: fxd Ta elect 10 μF ±10% 20 vdcw	56289	150D106X9020B2-DYS
A2C34	0150-0012			C: fxd cer .01 μF ±20% 100 vdcw	56289	29C214A3
A2C35, A2C36	0160-0127			C: fxd Ta elect 1.0 μF ±20% 25 vdcw	56289	5C13C
A2C37, A2C38	0150-0014		2	C: fxd cer 0.005 μF 500 vdcw	04222	D1-4 obd
A2C39	0150-0084		2	C: fxd cer 0.1 μF +80% -20% 50 vdcw	56289	33C41 obd
A2C40	0180-0393		1	C: fxd Ta elect 39 μF ±10% 10 vdcw	56289	150D396X9010B2-DYS
A2C41, A2C42	0180-0228			C: fxd Ta elect 22 μF ±10% 15 vdcw	56289	150D226X9015B2-DYS
A2C43, A2C44	0180-1702		2	C: fxd Ta elect 180 μF ±20% 6 vdcw	56289	150D606X0006B2-DYS
A2CR1 thru A2CR8	1901-0040		8	Diode: Si 30 wiv 30 mA 2 pF 2 ns	07263	FDG 1088
A2CR9, A2CR10	1901-0027		2	Diode: Si 1N4392 1 pF 10 wiv 0.5 ns	73293	obd
A2CR11, A2CR12	1910-0022		2	Diode: Ge** 5 wiv 3.5 ns	000LE	G401 obd
A2CR13	1902-0761		1	Diode: breakdown 1N821 5.9 to 6.5V	04713	obd
A2Q1A, A2Q1B	1854-0221		1	TSTR: Si NPN Dual	000LP	BD-1148
A2Q2	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906-5
A2Q3	1854-0215			TSTR: Si NPN 2N3904	04713	2N3904-5
A2Q4				Not assigned		
A2Q5	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906-5
A2Q6	1854-0215			TSTR: Si NPN 2N3904	04713	2N3904-5
A2Q7	1855-0057		1	TSTR: field effect	04713	MPF-105-5
A2Q8	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906-5
A2Q9	1854-0215			TSTR: Si NPN 2N3904	04713	2N3904-5
A2Q10, A2Q11	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906-5
A2Q12, A2Q13	1854-0215			TSTR: Si NPN 2N3904	04713	2N3904-5
A2Q14	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906-5
A2Q15, A2Q16	1854-0215			TSTR: Si NPN 2N3904	04713	2N3904-5
A2Q17, A2Q18	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906-5
A2Q19, A2Q20	1854-0215			TSTR: Si NPN 2N3904	04713	2N3904-5
A2Q21	1854-0215			TSTR: Si NPN 2N3904	04713	2N3904-5
A2Q22	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906-5
A2Q23 thru A2Q25	1854-0215			TSTR: Si NPN 2N3904	04713	2N3904-5
A2Q26	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906-5
A2Q27	1854-0215			TSTR: Si NPN 2N3904	04713	2N3904-5
A2Q28, A2Q29	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906-5
A2Q30, A2Q31	1854-0071			TSTR: Si NPN 300 mW 150 MHz	01295	SK 1124

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A2R1 thru A2R3	0757-0472		6	R: fxd prec met flm 200K ±1% 1/8 W	75042	CEA T-O	obd
A2R4	0757-0290		2	R: fxd prec met flm 6190Ω ±1% 1/8 W	75042	CEA T-O	obd
A2R5	0684-5601		2	R: fxd comp 56Ω ±10% 1/4 W	01121	CB 5601	
A2R6	0757-0446		3	R: fxd prec met flm 15K ±1% 1/8 W	19701	MF5C T-O	obd
A2R7	0757-0416		2	R: fxd prec met flm 511Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R8	0757-0436		3	R: fxd prec met flm 4320Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R9 thru A2R11	0757-0472			R: fxd prec met flm 200K ±1% 1/8 W	75042	CEA T-O	obd
A2R12	0757-0290			R: fxd prec met flm 6190Ω ±1% 1/8 W	75042	CEA T-O	obd
A2R13	0684-5601			R: fxd comp 56Ω ±10% 1/4 W	01121	CB 5601	
A2R14	0757-0446			R: fxd prec met flm 15K ±1% 1/8 W	19701	MF5C T-O	obd
A2R15	0757-0416			R: fxd prec met flm 511Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R16	0757-0436			R: fxd prec met flm 4320Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R17	0757-0334			R: fxd prec met flm 301Ω ±1% 1/4 W	19701	MF5C T-O	obd
A2R18	0684-2211			R: fxd comp 220Ω ±10% 1/4 W	01121	CB 2211	
A2R19	0684-2221		3	R: fxd comp 2200Ω ±10% 1/4 W	01121	CB 2221	
A2R20	0757-0462		2	R: fxd prec met flm 75K ±1% 1/8 W	19701	MF5C T-O	obd
A2R21	0684-2221			R: fxd comp 2200Ω ±10% 1/4 W	01121	CB 2221	
A2R22	0698-3451			R: fxd prec met flm 133K ±1% 1/8 W	75042	CEA T-O	obd
A2R23	0684-2231		2	R: fxd comp 22K ±10% 1/4 W	01121	CB 2231	
A2R24	0757-0464		1	R: fxd prec met flm 90.9K ±1% 1/8 W	19701	MF5C T-O	obd
A2R25	0684-2221			R: fxd comp 2200Ω ±10% 1/4 W	01121	CB 2221	
A2R26	0684-1011		1	R: fxd comp 100Ω ±10% 1/4 W	01121	CB 1011	
A2R27	0757-0334			R: fxd prec met flm 301Ω ±1% 1/4 W	19701	MF6C T-O	obd
A2R28	0757-0442		11	R: fxd prec met flm 10K ±1% 1/8 W	75042	CEA T-O	obd
A2R29	0698-4488		6	R: fxd prec met flm 26.7K ±1% 1/8 W	75042	CEA T-O	obd
A2R30, A2R31	0757-0412		4	R: fxd prec met flm 365Ω ±1% 1/8 W	75042	CEA T-O	obd
A2R32	0698-4488			R: fxd prec met flm 26.7K ±1% 1/8 W	75042	CEA T-O	obd
A2R33	0684-1011		2	R: fxd comp 100Ω ±10% 1/4 W	01121	CB 1011	
A2R34	0757-0449		3	R: fxd prec met flm 20K ±1% 1/8 W	19701	MF5C T-O	obd
A2R35	0698-4473		1	R: fxd prec met flm 8.06K ±1% 1/8 W	75042	CEA T-O	obd
A2R36	0757-0442			R: fxd prec met flm 10K ±1% 1/8 W	75042	CEA T-O	obd
A2R37	0757-0436			R: fxd prec met flm 4320Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R38	0698-4488			R: fxd prec met flm 26.7K ±1% 1/8 W	75042	CEA T-O	obd
A2R39	0684-1021		3	R: fxd comp 1000Ω ±10% 1/4 W	01121	CB 1021	
A2R40	0757-0412			R: fxd prec met flm 365Ω ±1% 1/8 W	75042	CEA T-O	obd
A2R41	0757-0442			R: fxd prec met flm 10K ±1% 1/8 W	75042	CEA T-O	obd
A2R42	0698-3157		1	R: fxd prec met flm 19.6K ±1% 1/8 W	75042	CEA T-O	obd
A2R43	0757-0449			R: fxd prec met flm 20K ±1% 1/8 W	19701	MF5C T-O	obd
A2R44	2100-1617		1	R: var comp 1000Ω ±20% 1/5 W	71590	Model 1	obd
A2R45	0698-4488			R: fxd prec met flm 26.7K ±1% 1/8 W	75042	CEA T-O	obd
A2R46				Not assigned			
A2R47	0757-0412			R: fxd prec met flm 365Ω ±1% 1/8 W	75042	CEA T-O	obd
A2R48, A2R49				Not assigned			
A2R50	0684-2211		3	R: fxd comp 220Ω ±10% 1/4 W	01121	CB 2211	
A2R51	0684-1041		2	R: fxd comp 100K ±10% 1/4 W	01121	CB 1041	
A2R52	0757-0442			R: fxd prec met flm 10K ±1% 1/8 W	75042	CEA T-O	obd
A2R53	0757-0279		6	R: fxd prec met flm 3160Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R54	0698-4396		2	R: fxd prec met flm 80.6Ω ±1% 1/8 W	91637	MFF-1/8 T-1	
*A2R55	0757-0279			R: fxd prec met flm 3160Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R56	0684-1011			R: fxd comp 100Ω ±10% 1/4 W	01121	CB 1011	
A2R57				Not assigned			
A2R58	0698-4488			R: fxd prec met flm 26.7K ±1% 1/8 W	75042	CEA T-O	obd
A2R59	0757-0401		1	R: fxd prec met flm 100Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R60	0757-0442			R: fxd prec met flm 10K ±1% 1/8 W	75042	CEA T-O	obd
A2R61				Not assigned			

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2R62	2100-1615		1	R: var comp lin 100Ω ±20% 1/5 W	71590	Model 1
A2R63	0684-1021			R: fxd comp 1000Ω ±10% 1/4 W	01121	CB 1021
A2R64	0757-0277		1	R: fxd prec met flm 49.9Ω ±1% 1/8 W	75042	CEA T-O obd
A2R65	0698-4488			R: fxd prec met flm 26.7K ±1% 1/8 W	75042	CEA T-O obd
A2R66	0757-0446			R: fxd prec met flm 15K ±1% 1/8 W	19701	MF5C T-O obd
A2R67	0698-4123		1	R: fxd prec met flm 499Ω ±1% 1/8 W	19701	MF5C T-O obd
A2R68				Not assigned		
A2R69	0684-1041			R: fxd comp 100K ±10% 1/4 W	01121	CB 1041
A2R70	0757-0279			R: fxd prec met flm 3160Ω ±1% 1/8 W	19701	MF5C T-O obd
A2R71	0757-0455		3	R: fxd prec met flm 36.5K ±1% 1/8 W	19701	MF5C T-O obd
A2R72	0698-4441		1	R: fxd prec met flm 3740Ω ±1% 1/8 W	75042	CEA T-O obd
A2R73	0757-0455			R: fxd prec met flm 36.5K ±1% 1/8 W	19701	MF5C T-O obd
A2R74	0757-0462			R: fxd prec met flm 75K ±1% 1/8 W	19701	MF5C T-O obd
A2R75	0684-1021			R: fxd comp 1000Ω ±10% 1/4 W	01121	CB 1021
A2R76	0684-2211			R: fxd comp 220Ω ±10% 1/4 W	01121	CB 2211
A2R77				Not assigned		
A2R78, A2R79	0684-4721		2	R: fxd comp 4700Ω ±10% 1/4 W	01121	CB 4721
A2R80	0757-0403		1	R: fxd prec met flm 121Ω ±1% 1/8 W	91637	MFF-1/8 T-1
A2R81	0684-2231			R: fxd comp 22K ±10% 1/4 W	01121	CB 2231
*A2R82	0698-5097		1	R: fxd comp 1.5M ±10% 1/4 W	01121	CB 1551
A2R83	0684-1841		1	R: fxd comp 180K ±10% 1/4 W	01121	CB 1841
A2R84	0698-6679		1	R: fxd prec met flm 42.2K ±1% 1/8 W	91637	MFF 1/8 T-1
A3	03555-66503		1	P.C. Assembly Function Switch	-hp-	
A3C1	0170-0055		1	C: fxd my 0.1 μF ±20% 200 vdcw	56289	192P10402-PTS
A3C2	0180-0137		1	C: fxd Ta elect 100 μF ±20± 10 vdcw	56289	150D107X0010R2-DYS
A3R1	0698-4467		1	R: fxd prec met flm 1050Ω ±1% 1/8 W	75042	CEA T-O obd
A3R2	0698-4509		1	R: fxd prec met flm 80.6K ±1% 1/8 W	75042	CEA T-O obd
A3R3	0698-4592		3	R: fxd prec met flm 453Ω ±1% 1/4 W	19701	MF6C T-O obd
A3R4	0757-0334			R: fxd prec met flm 301Ω ±1% 1/4 W	19701	MF6C T-O obd
A3R5, A3R6	0698-4592			R: fxd prec met flm 453Ω ±1% 1/4 W	19701	MF6C T-O obd
A3R7, A3R8	0757-0334			R: fxd prec met flm 301Ω ±1% 1/4 W	19701	MF6C T-O obd
A3R9, A3R10	0757-0710		2	R: fxd prec met flm 75Ω ±1% 1/4 W	19701	MF6C T-O obd
A3R11, A3R12	0757-0709		2	R: fxd prec met flm 68.1Ω ±1% 1/4 W	19701	MF6C T-O obd
A3R13, A3R14	0698-6213		2	R: fxd prec met flm 37.4Ω ±1% 1/4 W	91637	MFF-1/4 T-1
A3R15, A3R16	0698-3450		2	R: fxd prec met flm 42.2K ±1% 1/8 W	91637	MFF-1/8 T-1
A3R17	2100-2520		2	R: var lin trim 50Ω ±30% 1/2 W	73138	62-91-0
A3R18	0757-0399		1	R: fxd prec met flm 82.5Ω ±1% 1/8 W	91637	MFF-1/8 T-1
A3R19	0698-4415		1	R: fxd prec met flm 165Ω ±1% 1/8 W	91637	MFF-1/8 T-1
A3R20	2100-2520			R: var lin trim 50Ω ±30% 1/2 W	73138	62-91-0
A3R21	0683-0825		1	R: fxd comp 8.2Ω ±5% 1/4 W	01121	CB 82G5
A3R22	0698-4377		1	R: fxd prec met flm 37.4Ω ±1% 1/8 W	91637	MFF-1/8 T-1
A4	03555-66504		1	P. C. Assembly Filter Board	-hp-	
A4C1	0160-0127			C: fxd cer 1 μF ±20% 25 vdcw	56289	5C13C
A4C2	0150-0093		4	C: fxd cer 0.01 μF +80% -20% 100 vdcw	91418	TA obd
A4C3, A4C4	0160-2373		2	C: fxd mica 4700 pF ±2% 300 vdcw	04062	RDM19F472G3S
A4C5	0160-0163		2	C: fxd my 0.033 μF ±10% 200 vdcw	56289	192P33392-PTS
A4C6	0180-0228			C: fxd Ta elect 22 μF ±10% 15 vdcw	56289	150D226X9015B2-DYS
A4C7				Not assigned		
A4C8	0140-0179		7	C: fxd mica 1000 pF ±2%	04062	RDM19F102G3C
A4C9	0150-0093			C: fxd cer 0.01 pF +80% -20% 100 vdcw	91418	TA obd
A4C10				Not assigned		
A4C11	0140-0179			C: fxd mica 1000 pF ±2%	04062	RDM19F102G3C

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A4C12	0150-0093			C: fxd cer 0.01 μF +80% -20% 100 vdcw	91418	TA obd
A4C13				Not assigned		
A4C14, A4C15	0140-0179			C: fxd mica 1000 pF ±2%	04062	RDM19F102G3C
A4C16	0150-0093			C: fxd cer 0.01 μF +80% -20% 100 vdcw	91418	TA obd
A4C17	0180-1735		1	C: fxd Ta elect 0.22 μF ±10% 35 vdcw	56289	150D224X9035A2-DYS
A4C18	0140-0179			C: fxd mica 1000 pF ±2%	04062	RDM19F102G3C
A4C19	0160-0163			C: fxd my 0.033 μF ±10% 200 vdcw	56289	192P33392-PTS
A4Q1, A4Q2	1854-0071			TSTR: Si NPN 2N3391	01295	SK 1124
A4Q3	1853-0069			TSTR: Si PNP 2N4122	07263	obd
A4Q4, A4Q5	1854-0071			TSTR: Si NPN 2N3391	01295	SK 1124
A4Q6	1853-0069		TS	TSTR: Si PNP 2N4122	07263	obd
A4Q7, A4Q8	1854-0071			TSTR: Si NPN 2N3391	01295	SK 1124
A4Q9	1853-0069			TSTR: Si PNP 2N4122	07263	obd
A4Q10, A4Q11	1854-0071			TSTR: Si NPN 2N3391	01295	SK 1124
A4Q12	1853-0069			TSTR: Si PNP 2N4122	07263	obd
A4Q13	1854-0071			TSTR: Si NPN 2N3391	01295	SK 1124
A4R1	0684-1051		4	R: fxd comp 1M ±10% 1/4 W	01121	CB 1051
A4R2	0698-4515		1	R: fxd prec met flm 107K ±1% 1/8 W	75042	CEA T-O obd
A4R3	0698-3265		1	R: fxd prec met flm 118K ±1% 1/8 W	75042	CEA T-O obd
A4R4	2100-2464		2	R: var ww 20 kΩ ±10% 1 W	02660	2600 Series obd
A4R5	0684-1031		4	R: fxd comp 10K ±10% 1/4 W	01121	CB 1031
A4R6	0757-0456		2	R: fxd prec met flm 43.2K ±1% 1/8 W	19701	MF5C T-O obd
A4R7	0757-0444		1	R: fxd prec met flm 12.1K ±1% 1/8 W	19701	MF5C T-O obd
A4R8	0757-0280		1	R: fxd prec met flm 1000Ω ±1% 1/8 W	75042	CEA T-O obd
A4R9	2100-1799		1	R: var ww 500Ω ±10% 1 W	02660	2600 Series obd
A4R10	0757-0456			R: fxd prec met flm 43.2K ±1% 1/8 W	19701	MF5C T-O obd
A4R11	0684-1541		9	R: fxd comp 150K ±10% 1/4 W	01121	CB 1541
A4R12, A4R13	0757-0442			R: fxd prec met flm 10K ±1% 1/8 W	75042	CEA T-O obd
A4R14	0684-1541			R: fxd comp 150K ±10% 1/4 W	01121	CB 1541
A4R15	0757-0457		4	R: fxd prec met flm 47.5K ±1% 1/8 W	75042	CEA T-O obd
A4R16	0684-1051			R: fxd comp 1M ±10% 1/4 W	01121	CB 1051
A4R17	0757-0279			R: fxd prec met flm 3116Ω ±1% 1/8 W	19701	MF5C T-O obd
A4R18	0757-0442			R: fxd prec met flm 10K ±1% 1/8 W	75042	CEA T-O obd
A4R19	2100-2464			R: var ww 20 kΩ ±10% 1 W	02660	2600 Series obd
A4R20	0757-0449		1	R: fxd prec met flm 20K ±1% 1/8 W	75042	CEA T-O obd
A4R21				Not assigned		
A4R22	0684-1031			R: fxd comp 10K ±10% 1/4 W	01121	CB 1031
A4R23	0684-1541		R	R: fxd comp 150K ±10% 1/4 W	01121	CB 1541
A4R24	0698-3540			R: fxd prec met flm 15.4K ±1% 1/8 W	75042	CEA T-O obd
A4R25	0684-6831		1	R: fxd comp 68K ±10% 1/4 W	01121	CB 6831
A4R26	0757-0442			R: fxd prec met flm 10K ±1% 1/8 W	75042	CEA T-O obd
A4R27	0684-1541			R: fxd comp 150K ±10% 1/4 W	01121	CB 1541
A4R28, A4R29				Not assigned		
A4R30	0684-1031			R: fxd comp 10K ±10% 1/4 W	01121	CB 1031
A4R31	0684-1541			R: fxd comp 150K ±10% 1/4 W	01121	CB 1541
A4R32	0698-4473		1	R: fxd prec met flm 8060Ω ±1% 1/8 W	91637	MFF-1/8 T-1
A4R33	0757-0442			R: fxd prec met flm 10K ±1% 1/8 W	75042	CEA T-O obd
A4R34	0684-1541			R: fxd comp 150K ±10% 1/4 W	01121	CB 1541
A4R35, A4R36				Not assigned		
A4R37, A4R38	0698-3162		2	R: fxd prec met flm 46.4K ±1% 1/8 W	75042	CEA T-O obd
A4R39	0684-1031			R: fxd comp 10K ±10% 1/4 W	01121	CB 1031
A4R40	0684-1541			R: fxd comp 150K ±10% 1/4 W	01121	CB 1541

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A4R41	0698-4470		1	R: fxd prec met flm 6.98K ±1% 1/8 W	75042	CEA T-O obd
A4R42	0757-0442			R: fxd prec met flm 10K ±1% 1/8 W	75042	CEA T-O obd
A4R43	0684-1541			R: fxd comp 150K ±10% 1/4 W	01121	CB 1541
A4R44	0757-0271		1	R: fxd prec met flm 124K ±1% 1/8 W	75042	CEA T-O obd
A4R45	0684-1541			R: fxd comp 150K ±10% 1/4 W	01121	CB 1541
A4R46	0684-1051			R: fxd comp 1M ±10% 1/4 W	01121	CB 1051
A5	03555-61903		1	Switch Assembly: Weighting	-hp-	
A5C1	0132-0003		2	C: var trim: 0.7-3.0 pF	72982	535-016-4R
A5C2, A5C3	0140-0205		2	C: fxd mica 62 pF ±5%	04062	RDM15E620J3C
A5C4	0132-0003			C: var trim 0.7-3	72982	535-016-4R
A5R1	0698-4513		2	R: fxd prec met flm 97.6K ±1% 1/8 W	91637	MFF 1/8 T-1
A5R2, A5R3	0757-0279			R: fxd prec met flm 3160Ω ±1% 1/8 W	19701	MF5C T-O obd
A5R4	0698-4513			R: fxd prec met flm 97.6K ±1% 1/8 W	91637	MFF 1/8 T-1
A5R5	0757-0346		1	R: fxd prec met flm 10Ω ±1% 1/8 W	91637	MFF 1/8 T-1
A5R6	0698-4369		1	R: fxd prec met flm 23.2Ω ±1% 1/8 W	75042	CEA T-O obd
A5R7	0698-4396		1	R: fxd prec met flm 80.6Ω ±1% 1/8 W	91637	MFF 1/8 T-1 obd
A5R8	0698-3242		1	R: fxd prec met flm 357Ω ±1% 1/8 W	19701	MF5C T-O obd
A5R9	0698-4457		1	R: fxd prec met flm 576Ω ±1% 1/8 W	19701	MF5C T-O obd
A5R10	0698-6081		4	R: fxd prec met flm 1641.1Ω ±0.25% 1/4 W	91637	MFF 1/4 T-1 obd
A5R11	0698-6083		3	R: fxd prec met flm 1109.9Ω ±0.25% 1/4 W	91637	MFF 1/4 T-1 obd
A5R12	0698-4385		1	R: fxd prec met flm 57.6Ω ±1% 1/8 W	91637	MFF 1/8 T-1 obd
A5R13	0698-6081			R: fxd prec met flm 1641.1Ω ±0.25% 1/4 W	91637	MFF 1/4 T-1 obd
A5R14	0698-6083			R: fxd prec met flm 1109.9Ω ±0.25% 1/4 W	91637	MFF 1/4 T-1 obd
A5R15	0698-6081			R: fxd prec met flm 1641.1Ω ±0.25% 1/4 W	91637	MFF 1/4 T-1 obd
A5R16	0698-6083			R: fxd prec met flm 1109.9Ω ±0.25% 1/4 W	91637	MFF 1/4 T-1 obd
A5R17	0698-6081			R: fxd prec met flm 1641.1Ω ±0.25% 1/4 W	91637	MFF 1/4 T-1 obd
A5R18	0698-6082		1	R: fxd prec met flm 758.95Ω ±0.25% 1/4 W	19701	MF6C T-O obd
*A5R19	0683-6815		1	R: fxd comp 680Ω ±5% 1/4 W	01121	CB 6815
BT1	1420-0026		1	Battery: 45 volt dry cell	83740	No. 482 obd
C1	0180-0372		1	C: fxd Al elect 50 μF +75% -10% 200 vdcw	56289	Type 62D obd
C2	0140-0179			C: fxd mica 1000 pF ±2%	04062	RDM19F102G3C
C3	0160-0170		1	C: fxd cer 0.22 μF +80% -20% 25 vdcw	56289	5C9B obd
C4	0140-0179			C: fxd mica 1000 pF ±2%	04062	RDM19F102G3C
C5	0160-0160		1	C: fxd my 0.0082 μF ±10% 200 vdcw	56289	192P82292-PTS
C6	0180-0228			C: fxd Ta elect 22 μF ±10% 15 vdcw	56289	150D226X9015B2-DYS
C7, C8	0140-0208			C: fxd mica 680 pF ±5%	04062	RDM15F681J3C
F1	2110-0017		2	Fuse: cartridge 0.15 amp 125 V slow-blow	75915	313.150 obd
J1	1251-1009		1	Connector: A.C. power cord receptacle	82389	AC-3 obd
J2	1251-1900		1	Connector: telephone type	82389	22A obd
J3	1251-1144		2	Jack: telephone 2 circuit 1D x 1/2Ω long bushing	82389	MT-342B obd
J4	1251-1143		2	Jack: telephone 2 circuit 0.250 ID x 9/16"	82389	MT-332B obd
J5, J6	1251-0065		2	Jack: telephone single open circuit	82389	MT-331 obd
J7, J8	1510-0010		2	Binding Post: red insulator brass	-hp-	
J9	1510-0011			Binding Post: black insulator brass	-hp-	
J10	5060-0627		1	Binding Post: black w/strap	-hp-	
J11	1251-1144			Jack: telephone	-hp-	
J12	1251-1143			Jack: telephone	-hp-	
J13, J14	00236-21001		2	Post: clip	-hp-	
L1	9100-1390		1	Inductor: audio	-hp-	
M1	1120-0909		1	Meter: log	-hp-	

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
R1	0698-3572		1	R: fxd prec met flm 60.4K ±1% 1/8 W	91637	MFF-1/8 T-1
R2	0757-0457			R: fxd prec met flm 47.5K ±1% 1/8 W	75042	CEA T-O obd
R3	0698-4485		3	R: fxd prec met flm 23.2K ±1% 1/8 W	91637	MFF-1/8 T-1
R4	0684-1051			R: fxd comp 1 MΩ ±10% 1/4 W	01121	CB 1051
R5, R6	0757-0457			R: fxd prec met flm 47.5K ±1% 1/8 W	75042	CEA T-O obd
R7, R8	0698-4485			R: fxd prec met flm 23.2K ±1% 1/8 W	91637	MFF-1/8 T-1
R9	0698-4434			R: fxd prec met flm 2320Ω ±1% 1/8 W	91637	MFF-1/8 T-1
R10, R11	2100-0412		2	R: var ww 200Ω ±20% 2 W	11236	Type 117
R12				Not assigned		
R13	0684-1231		1	R: fxd comp 12K ±10% 1/4 W	01121	CB 1231
S1	3101-0003		1	Switch: toggle DPST 250 V 3 amp	04009	81024-GB
S2	3101-0045		1	Switch: slide DPDT 125 V	82389	11A-1014
S3	3101-0824		1	Switch: level (input)	76854	Type 187 obd
S4	03555-61903		1	Switch assembly: weighting	-hp-	
S5	3101-0036		1	Switch: toggle SPST 3 amps 250 V	88140	8928K61
				MISCELLANEOUS		
	8120-0078		1	Assembly: cable 7.5 power cord set	70903	KH-4147 obd
	5040-0007		1	Base: connector	-hp-	
	00741-01209		2	Bracket: meter	-hp-	
	8120-0026			Cable: RF miniature coaxial 100Ω	06513	5080-6908
	8120-0097			Cable: special purpose	06513	5080-6932
	8120-0228			Cable: special purpose	06513	5080-6961
	5020-0427		1	Cap: connector	-hp-	
	9211-0305		1	Carton: corrugated	84324	obd
	03555-64501		1	Case assembly	-hp-	
	00236-00102		1	Chassis: power	-hp-	
	1400-0054		1	Clamp: cable steel cadmium plate	73734	1549 obd
	1251-0148		1	Connector: A. C. power	82389	AC obd
	1251-1035		1	Connector: printed circuit	02660	143-015-08 (1158)
	03555-64502		1	Cover assembly	-hp-	
	00236-04102		1	Cover: battery	-hp-	
	03555-04301		1	Decal set: pushbutton	-hp-	
	03555-00101		1	Deck: main	-hp-	
	0510-0002		7	Fastener: #6 Pem cadmium plated		CL-632-2C
	0403-0019		8	Foot: rubber gray	000MM	Type 9102-W
	1440-0002		1	Handle: leather black oxidized finish	0000Z	obd
	525C-49A		2	Handle: machine	-hp-	
	1205-0033		1	Heat dissipator: semiconductor	05820	NF-207 obd
	03555-06401		1	Holder: battery	-hp-	
	1400-0084		2	Holder: fuse extractor post type	75915	342014
	00236-44102		1	Insulator: jack	-hp-	
	0340-0100		2	Insulator: single binding post	-hp-	
	0340-0099		4	Insulator: single binding post	-hp-	
	1251-1900		1	Jack: telephone type	82389	22A obd
	0370-0121		10	Knob: pushbutton rectangular gray plastic	-hp-	
	0370-0035		1	Knob: skirted bar black w/arrow	-hp-	
	0370-0046		2	Knob: small level switch black	-hp-	
	0510-0767		2	Latch: body cabinet nickel plated	98376	ZSP2-220-2
	0510-0766		2	Latch: strike cabinet nickel plated	98376	ZSP2-220-3
	03555-90001		1	Manual: operating and service	-hp-	
	7120-0866		1	Nameplate: aluminum	91345	obd
	7122-0203		1	Nameplate: serial	91345	obd
	0590-0126		4	Nut: anchor 8-32 with red nylon insert	72962	22NA27-22-82
	2820-0002		6	Nut: hex brass nickel plated	73734	8041 obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
	2950-0001		5	Nut: hex brass nickel plated	73734	9002 obd
	2950-0035		2	Nut: hex brass nickel plated switch	73076	obd
	2950-0038		2	Nut: hex fuse post steel	75815	903-12
	2580-0002		4	Nut: hex stainless steel	73734	obd
	2420-0002		6	Nut: hex stainless steel	80120	obd
	0590-0012		2	Nut: knurled switch ring brass	04009	obd
	9220-0168		2	Pad: foam	-hp-	
	03555-00201		1	Panel: front	-hp-	
	1520-0002		1	Plate: capacitor mounting	56137	obd
	1251-1145		1	Plug: battery 3 prong	72825	7364 obd
	1480-0062		9	Pin: connector phosphor bronze	61577	obd
	1200-0162		1	Receptacle	00779	60804-1
	0510-0769		4	Receptacle: clip on cadmium plated	94222	82-47-101-15
	00236-01202		2	Retainer: cord	-hp-	
	1390-0088		4	Retainer: 1/4 turn fastener	94222	82-32-101-17
	03555-00601		1	Shield: P. C. Board (A2)	-hp-	
	03555-00602		1	Shield: plate	-hp-	
	0380-0059		3	Spacer: captive	00866	obd
	0380-0111		3	Standoff: clinch mounting brass	00866	obd
	1390-0047		4	Stud: oval head cadmium plated	94222	2-0-180
	0380-0200		2	Standoff: hinged clear chromate	000LT	Series HS-200-2
	5040-0170		2	Support: board	-hp-	
	03555-61903		1	Switch assembly: weighting	-hp-	
	3101-0827		1	Switch: lever 2 wafers	76854	Type 187 obd
	3101-0822		1	Switch: pushbutton	76854	Type 130
	3100-1752		1	Switch: rotary	76854	obd
	0360-1089		2	Terminal: solder lug switch	79963	379 obd
	3050-0016		5	Washer: #6 flat brass nickel plated	83053	obd
	3050-0001		4	Washer: #8 flat brass nickel plated	74323	#5832 obd
	3050-0066		4	Washer: #6 x 3/8 flat brass nickel plated	73734	obd
	3050-0067		3	Washer: 3/8 flat brass nickel plated	73734	obd
	3050-0257		6	Washer: #10 flat brass nickel plated	77250	Type 10-S obd
	2190-0037		2	Washer: lock fuse post steel	78189	1224-08 obd
	2190-0022		1	Washer: lock tooth type large	78189	1920-00 obd
	2190-0030		2	Washer: lock #4 split ring	000LU	obd
	2190-0018		33	Washer: lock #6 split large	73734	obd
	2190-0017		4	Washer: lock #8 split ring	73734	obd
	2190-0016		2	Washer: lock small tooth type	78189	1920-02
	2190-0046		8	Washer: lock #6 split small	76665	obd
	2190-0102		4	Washer: lock switch tooth type	78189	1922-01
	2190-0007		3	Washer: lock #6 internal tooth type	78189	1906-00
	2190-0034		6	Washer: lock #10 split ring	83385	obd

SECTION VII

CIRCUIT DIAGRAMS

7-1. INTRODUCTION.

7-2. This section of the manual contains circuit diagrams for the Model 3555A Telephone Test Meter. Included is a functional block diagram, schematic diagrams and diagrams showing arrangement of wafers and contacts on the RANGE switch and the filter WTG switch.

7-3. FUNCTIONAL BLOCK DIAGRAM.

7-4. The functional block diagram (Figure 7-1) of the 3555A serves the dual purpose of showing how various circuits are arranged to form the set and at the same time gives voltages and adjustments for use in troubleshooting the set. This functional block diagram should be used in conjunction with the troubleshooting procedure described in Paragraphs 5-25 through 5-37 when troubleshooting the 3555A.

7-5. SCHEMATIC DIAGRAMS.

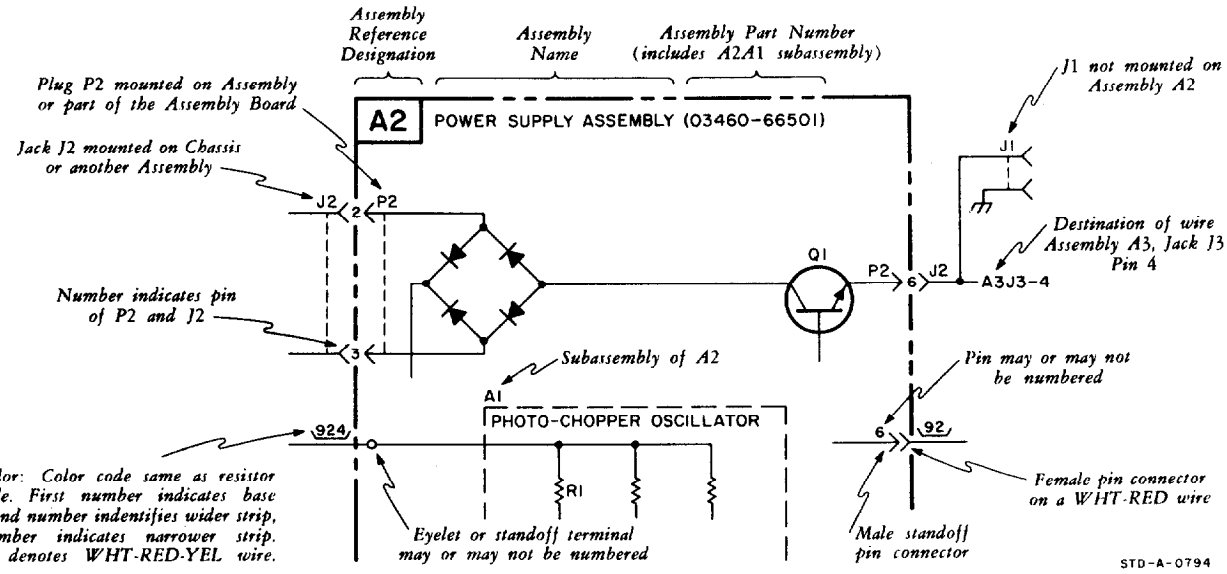
7-6. The schematic diagrams (Figures 7-2 through 7-7) contained in this section show the detailed circuits in the Model 3555A. Components marked with an asterisk are those that are critical in value. The value of these components may vary slightly from one set to another due to variations in transistor Beta etc, and the values shown on the schematic are average. Numbers in parenthesis near the starred value on the schematic indicate the paragraph number in the manual where the method of selecting the optimum value can be found.

7-7. Voltage levels have been included on the schematics which should greatly assist in troubleshooting the set. When measuring these voltages a high input impedance voltmeter (1 megohm or greater) should be used to prevent circuit loading.

REFERENCE DESIGNATIONS

PARTIAL REFERENCE DESIGNATIONS ARE SHOWN: PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.

ASSEMBLY	SUBASSEMBLY	COMPONENT	COMPLETE DESIGNATION
A2	NONE	Q1	A2Q1
A2	A1	R1	A2A1R1
NONE	NONE	J1	J1



GENERAL SCHEMATIC NOTES

1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN. PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.

2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED.

   RESISTANCE IN OHMS

   CAPACITANCE IN MICROFARADS

3. DENOTES ASSEMBLY GROUND.

4. DENOTES CHASSIS GROUND.

5. DENOTES ASSEMBLY.

6. DENOTES MAIN SIGNAL PATH.

7. DENOTES FEEDBACK PATH.

8. DENOTES FRONT PANEL MARKING.

9. DENOTES SIDE AND REAR PANEL MARKING.

10. DENOTES SCREWDRIVER ADJUST.

11. 924 DENOTES WIRE COLOR: COLOR CODE SAME AS RESISTOR COLOR CODE. FIRST NUMBER IDENTIFIES BASE COLOR, SECOND NUMBER IDENTIFIES WIDER STRIP, THIRD NUMBER IDENTIFIES NARROWER STRIP.
    (e. g. 924 = WHITE, RED, YELLOW.)

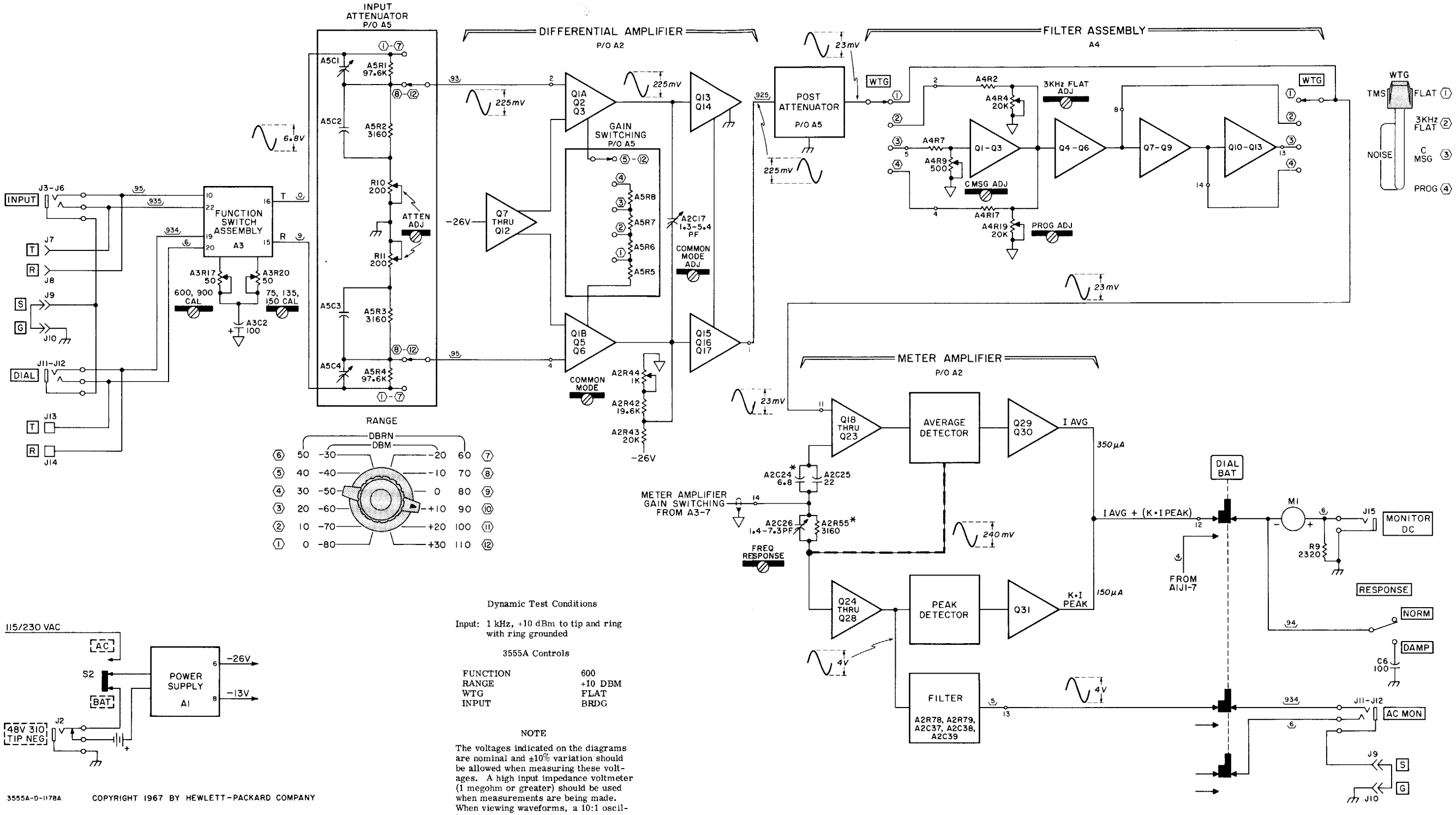
12. * AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY.

13. (0-00) NUMBERS IN PARENTHESIS INDICATE THE PARAGRAPH NUMBER IN MANUAL WHERE METHOD OF SELECTING STARRED VALUES IS FOUND.

14. TRANSISTORS ARE ALL CONNECTED TO CIRCUIT BOARD IN TO-5 CONFIGURATION, ie, 

AS VIEWED FROM THE COMPONENT SIDE OF BOARD.

15. WAVEFORM AND VOLTAGE MEASUREMENTS WERE MADE WITH RESPECT TO CHASSIS GROUND USING A HIGH INPUT IMPEDANCE (> 1 MEGOHM) OSCILLOSCOPE AND TRANSISTOR VOLTMETER. VOLTAGE LEVELS SHOWN ARE NOMINAL AND MAY VARY SOMEWHAT FROM ONE INSTRUMENT TO ANOTHER. A VARIATION OF ± 10% IN MEASUREMENTS SHOULD BE ALLOWED.



Dynamic Test Conditions

Input: 1 kHz, +10 dBm to tip and ring with ring grounded

3555A Controls

FUNCTION	600
RANGE	+10 DBM
WTG	FLAT
INPUT	BRDG

NOTE

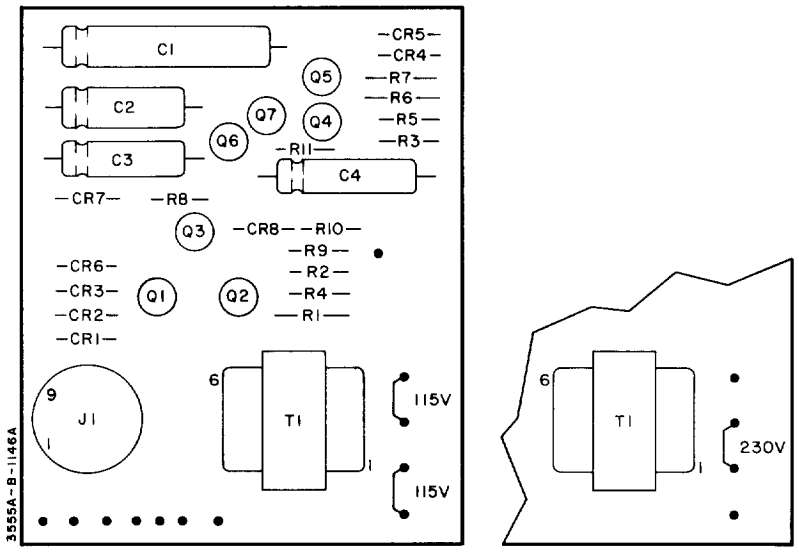
The voltages indicated on the diagrams are nominal and ±10% variation should be allowed when measuring these voltages. A high input impedance voltmeter (1 megohm or greater) should be used when measurements are being made. When viewing waveforms, a 10:1 oscilloscope probe should be used to prevent circuit loading.

3555A-0-1178A COPYRIGHT 1967 BY HEWLETT-PACKARD COMPANY

Figure 7-1. 3555A Functional Block Diagram

NOTE

The voltages indicated on the diagrams are nominal and ± 10% variation should be allowed when measuring these voltages. A high input impedance voltmeter (1 megohm or greater) should be used when measurements are being made. When viewing waveforms, a 10:1 oscilloscope probe should be used to prevent circuit loading.



A1

(*hp* PART NO. 03555-66501)

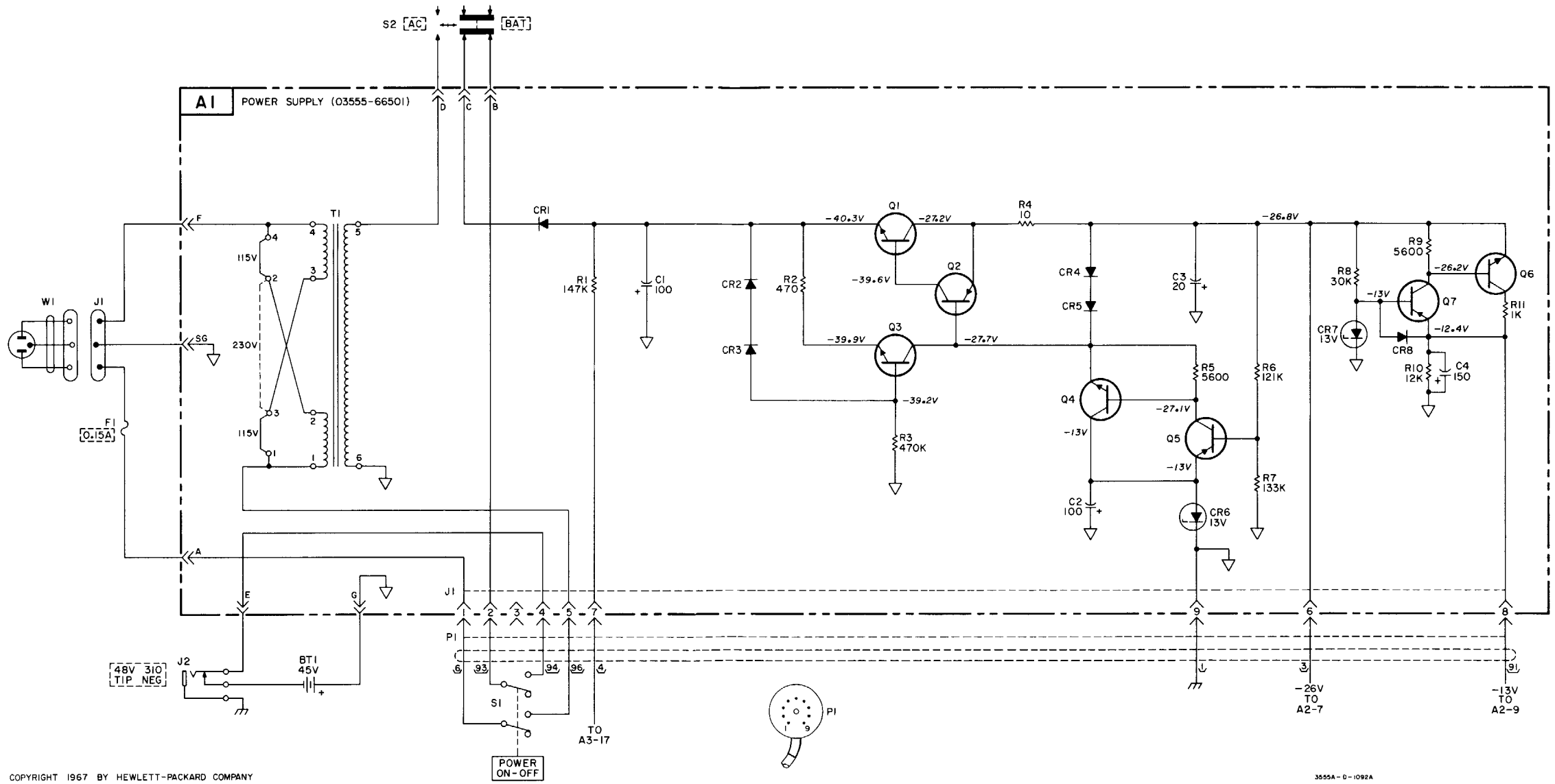
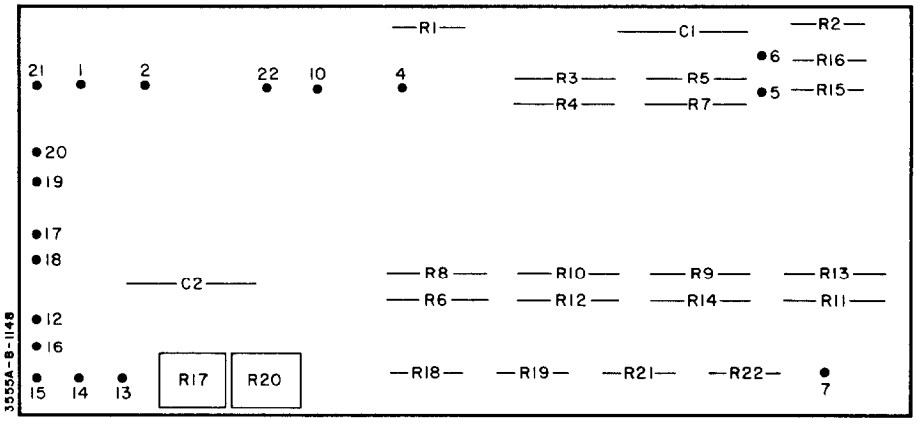


Figure 7-2. Power Supply Assembly Schematic and Component Location



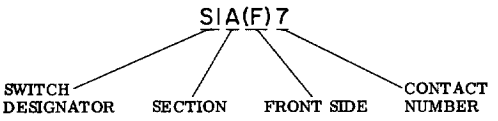
A3
(*hp* PART NO. 03555-66503)

NOTE 1

L1 leads are physically connected to the INPUT jacks and are as shown for schematic simplicity.

NOTE 2

C7 and C8 are physically located on L1 terminals.



NOTE

Both front and rear of switch wafers are shown as viewed from the rear of the switch. Circled numbers (7) indicate contact positions even though some positions may be blank.

RANGE SWITCH SHOWN IN -40 DBM POSITION.

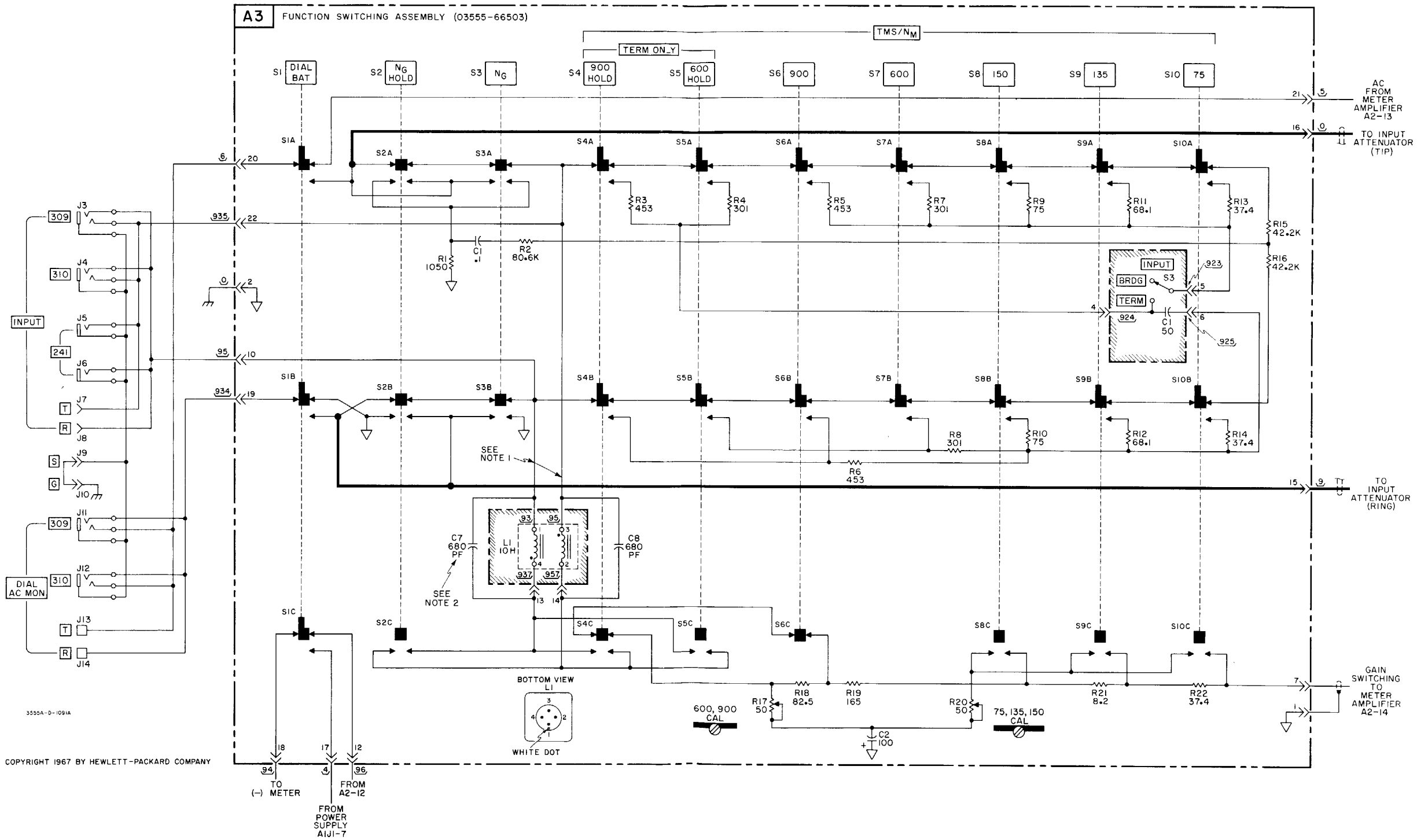
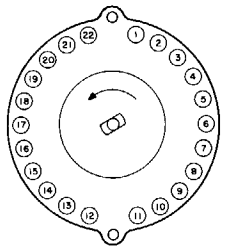
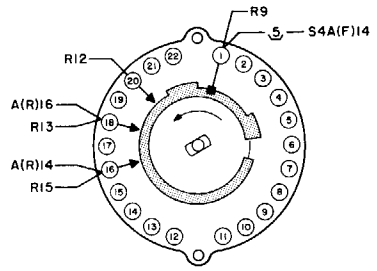


Figure 7-3. Function Switch Assembly Schematic and Component Location

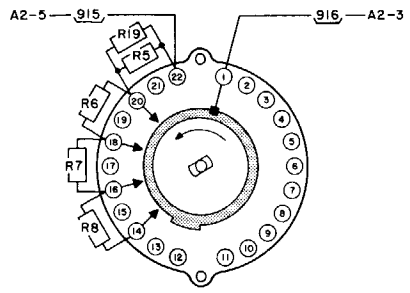
A5 ASSEMBLY



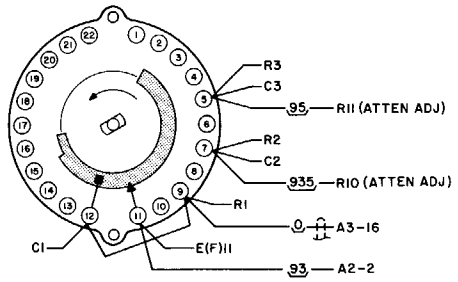
S1A(F)



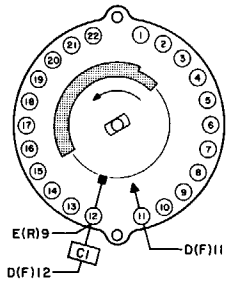
S1B(F)



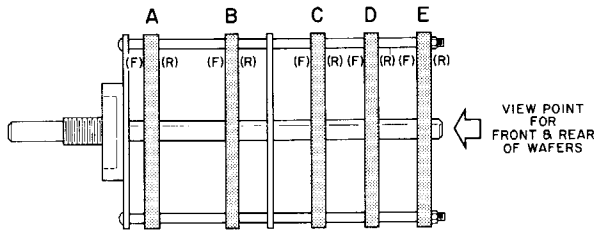
S1C(F)

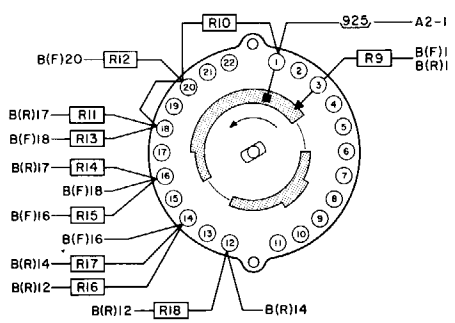


S1D(F)



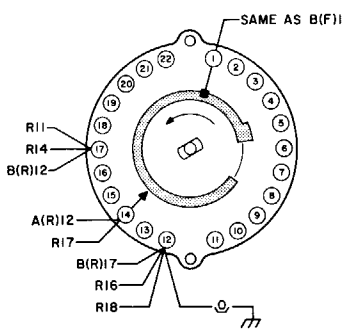
S1E(F)



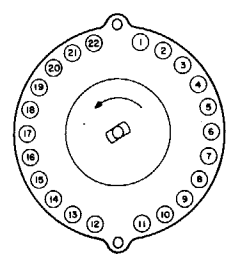


S1A(R)

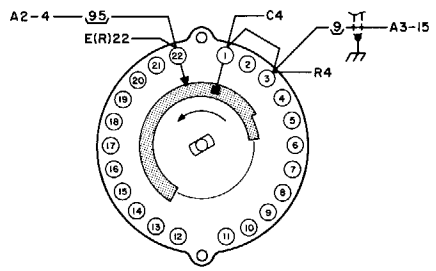
3555A-E-1164A



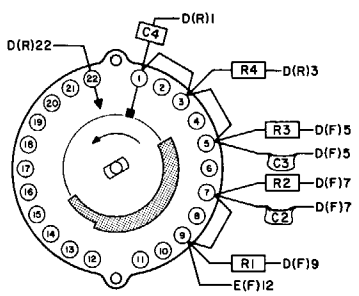
S1B(R)



S1C(R)

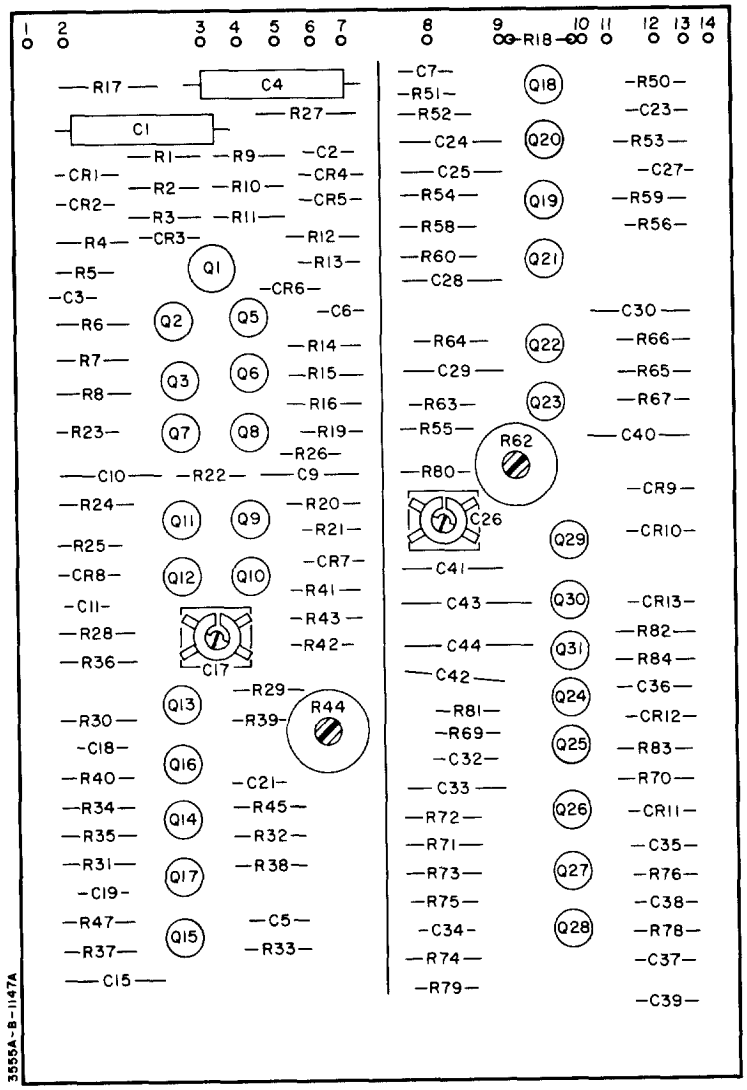


S1D(R)



S1E(R)

Figure 7-4. Range Switch Assembly



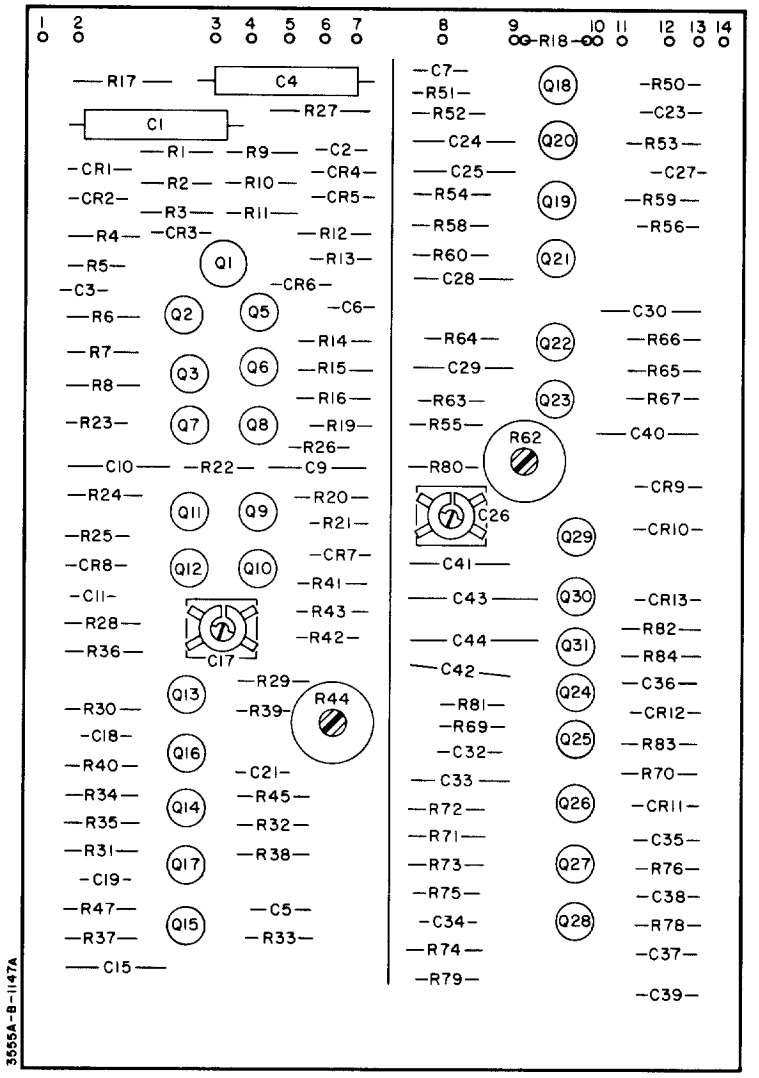
A2
(*hp* PART NO. 03555-66502)

NOTE

The voltages indicated on the diagrams are nominal and ± 10% variation should be allowed when measuring these voltages. A high input impedance voltmeter (1 megohm or greater) should be used when measurements are being made. When viewing waveforms, a 10:1 oscilloscope probe should be used to prevent circuit loading.

DESIGNATORS NOT ASSIGNED
A2 Differential and Meter Amplifier

C8, C12, C13, C14, C16, C20, C22, Q4, R46, R48, R49, R57, R61, R68, R77.



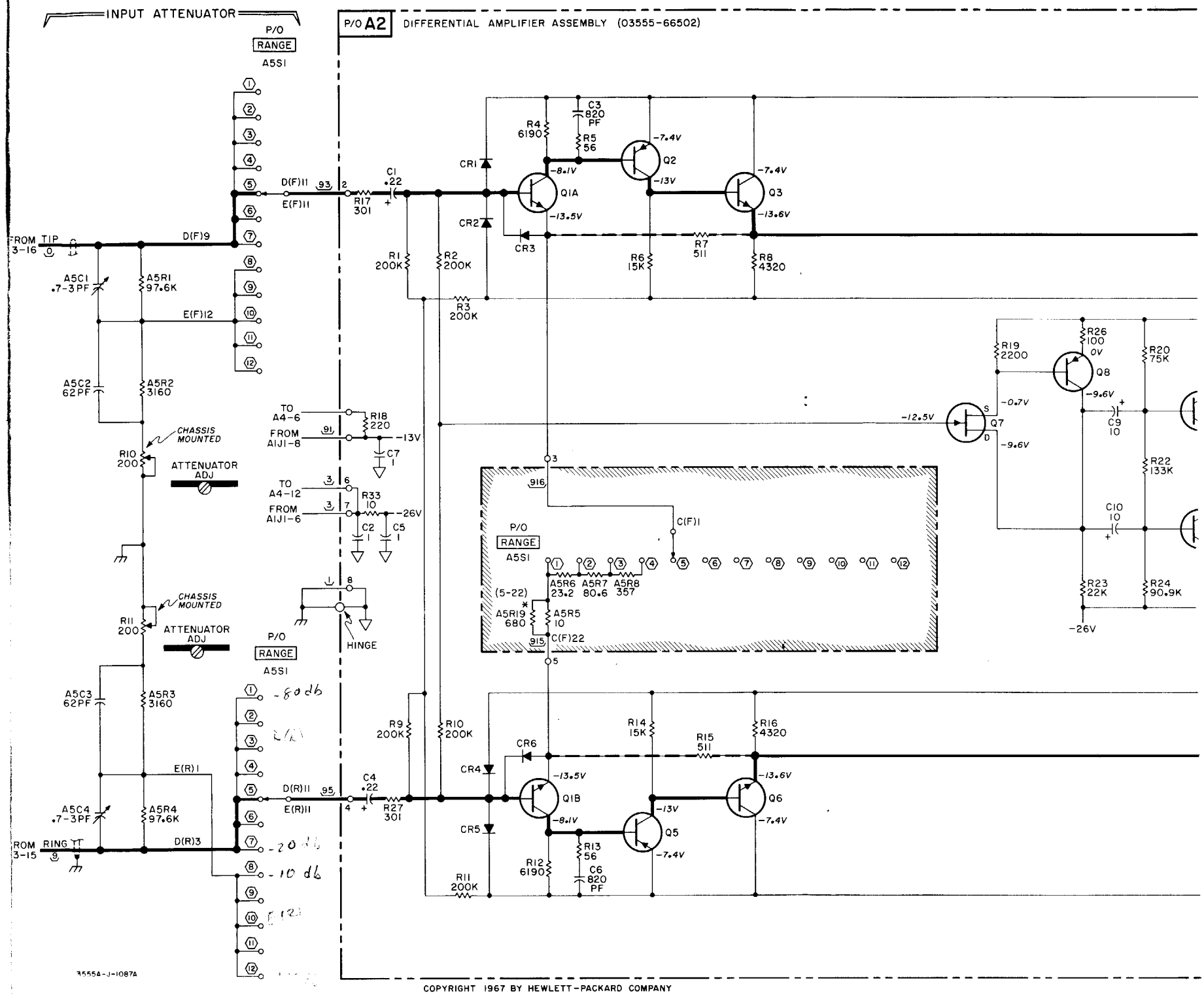
A2
(*hp* PART NO. 03555-66502)

NOTE

The voltages indicated on the diagrams are nominal and ± 10% variation should be allowed when measuring these voltages. A high input impedance voltmeter (1 megohm or greater) should be used when measurements are being made. When viewing waveforms, a 10:1 oscilloscope probe should be used to prevent circuit loading.

DESIGNATORS NOT ASSIGNED
A2 Differential and Meter Amplifier

C8, C12, C13, C14, C16, C20, C22, Q4, R46, R48, R49, R57, R61, R68, R77.



COPYRIGHT 1967 BY HEWLETT-PACKARD COMPANY

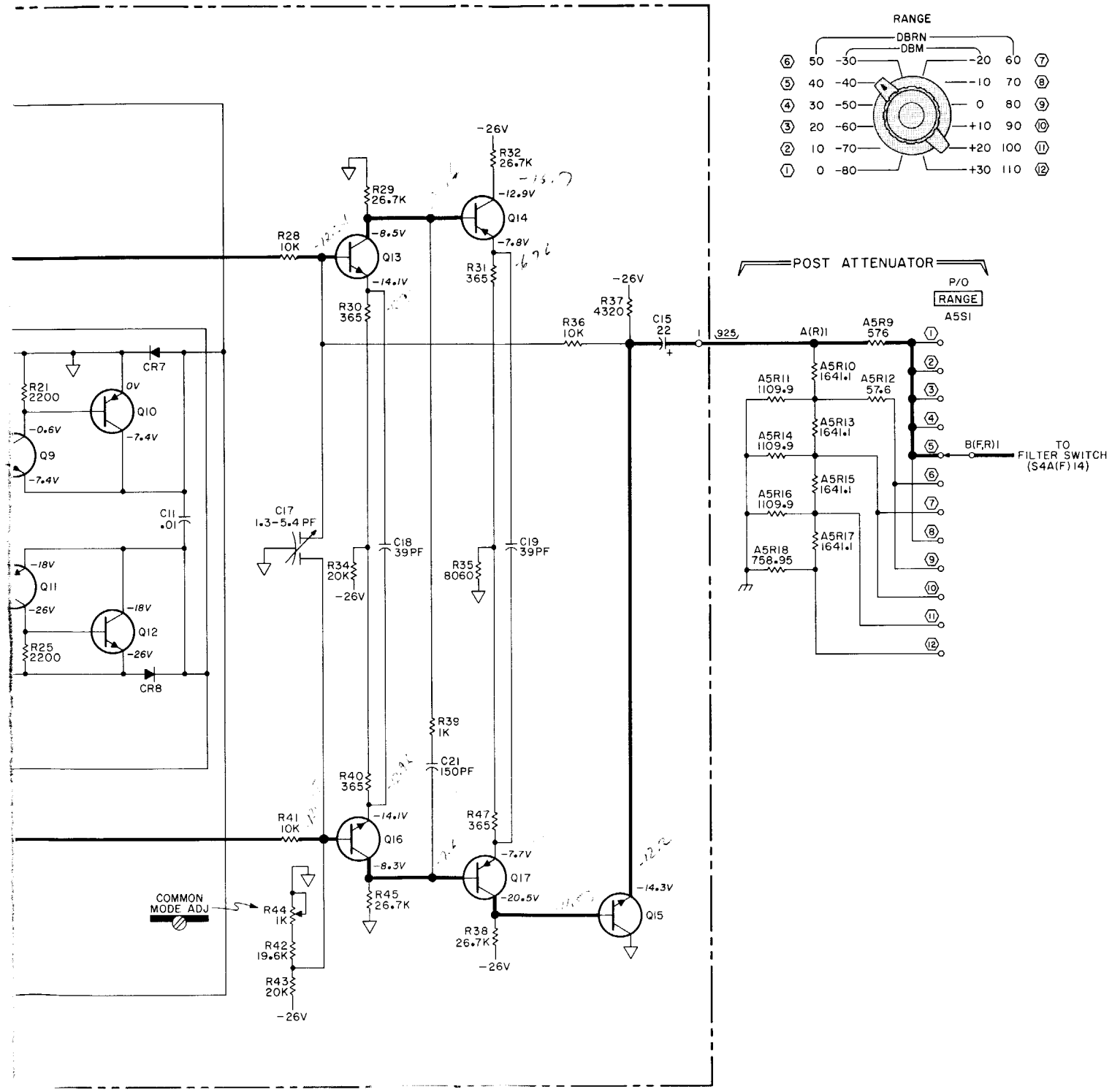
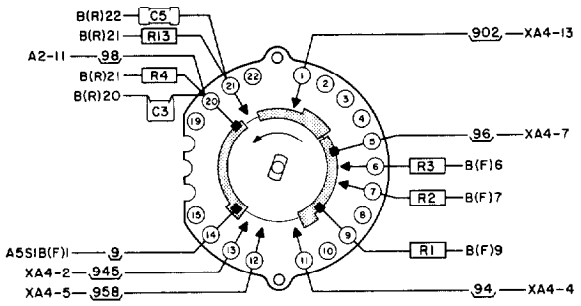
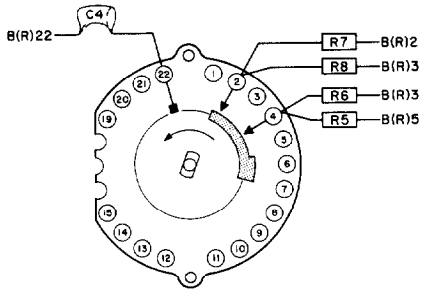


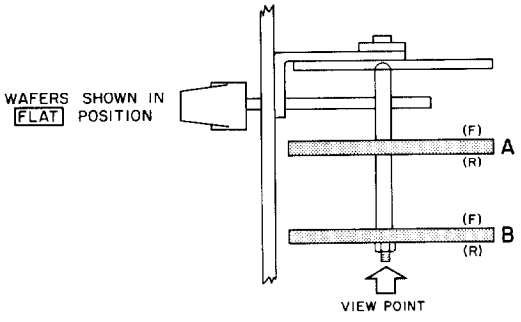
Figure 7-5. Range Switch and Differential Amplifier Schematic; Differential Amplifier Component Location

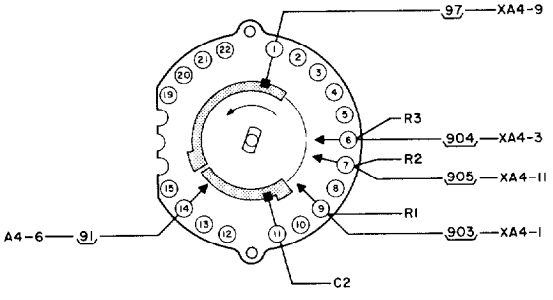


S4A(F)

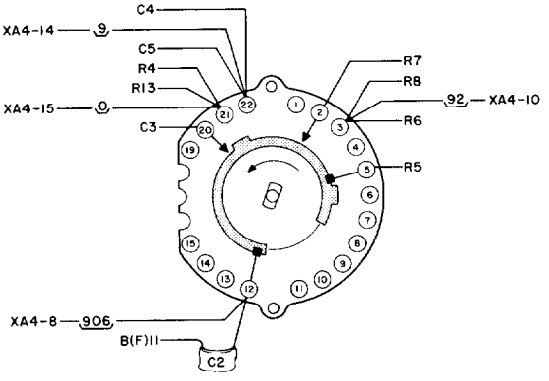


S4A(R)





S4B(F)



S4B(R)

3555A-J-1163

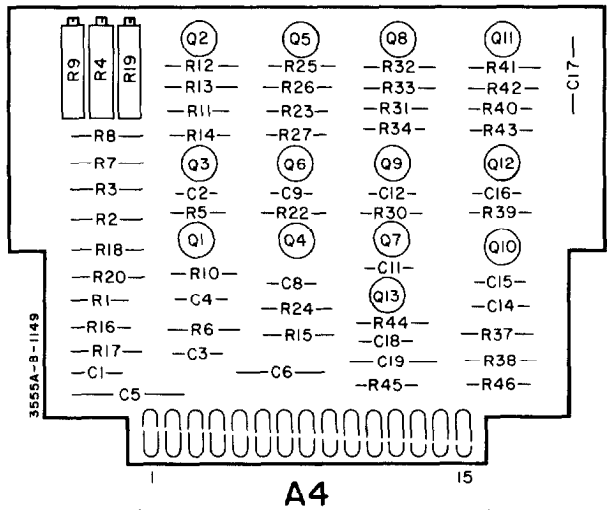
S4A(F) 7

SWITCH DESIGNATOR — SECTION — FRONT SIDE — CONTACT NUMBER

NOTE

Both front and rear of switch wafers are shown as viewed from the rear of the switch. Circled numbers (7) indicate contact positions even though some positions may be blank.

Figure 7-6. Filter Switch Detail



A4

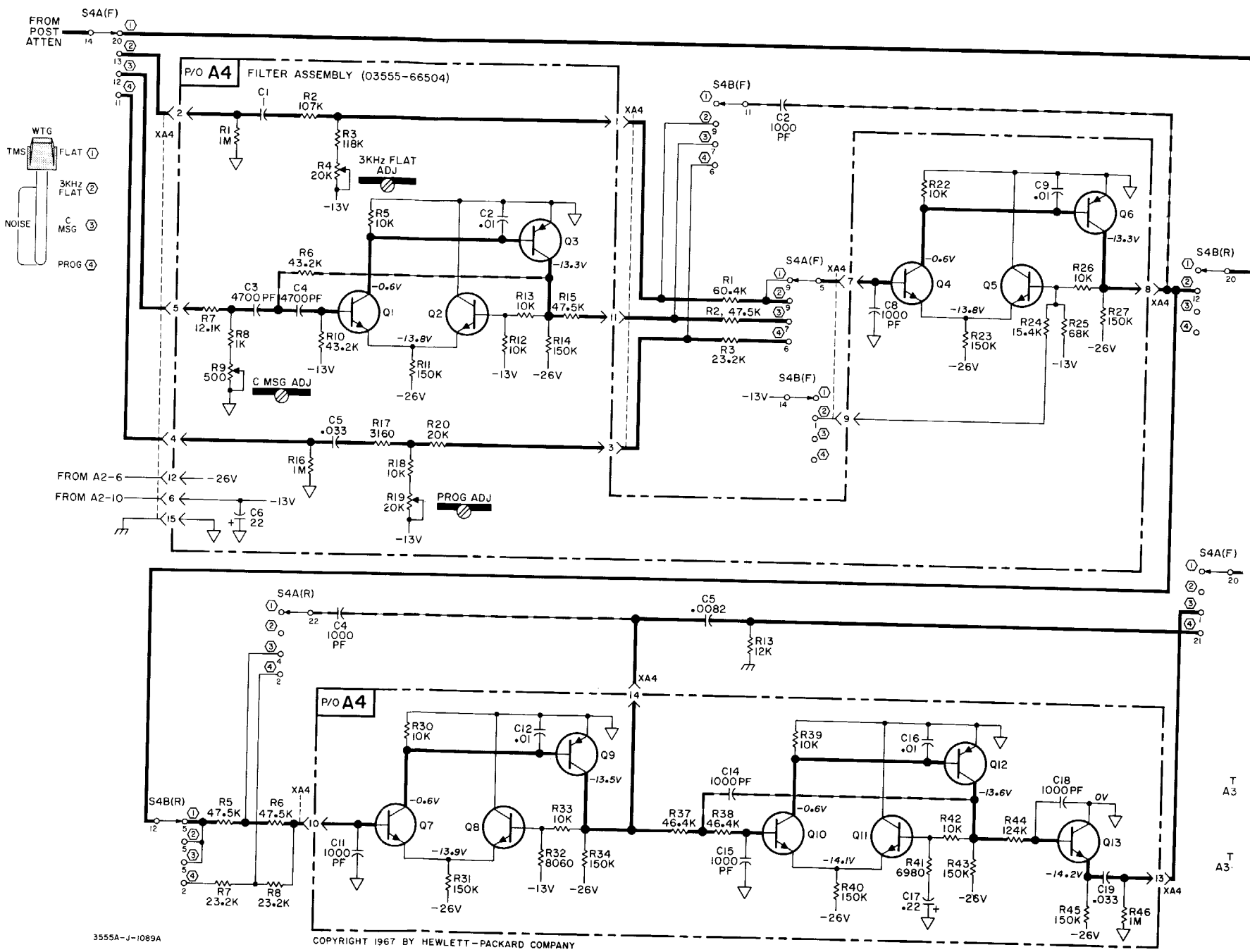
(*hp* PART NO. 03555-66504)

NOTE

The voltages indicated on the diagrams are nominal and ± 10% variation should be allowed when measuring these voltages. A high input impedance voltmeter (1 megohm or greater) should be used when measurements are being made. When viewing waveforms, a 10:1 oscilloscope probe should be used to prevent circuit loading.

DESIGNATORS NOT ASSIGNED
A4 Filter Assembly

C7, C13, C10, R21, R28, R29, R35, R36.


FROM POST ATTEN
S4A(F)
P/O A4 FILTER ASSEMBLY (03555-66504)
WTG
TMS
FLAT
3KHz FLAT
NOISE
C MSG
PROG
C1
R2 107K
R1 1M
R3 118K
R4 20K
3KHz FLAT ADJ
-13V
R5 10K
C2 .01
Q3
-13.3V
R6 43.2K
-0.6V
C3 4700 PF
C4 4700PF
Q1
Q2
R7 12.1K
R8 1K
R9 500
C MSG ADJ
R10 43.2K
-13.8V
R11 150K
-26V
R12 10K
R13 10K
R14 150K
R15 47.5K
XA4
S4B(F)
C2 1000 PF
R1 60.4K
R2, 47.5K
R3 23.2K
S4A(F)
S4B(F)
-13V
R22 10K
C9 .01
Q6
-13.3V
-0.6V
Q4
Q5
C8 1000 PF
-13.8V
R23 150K
-26V
R24 15.4K
R25 68K
-13V
R26 10K
R27 150K
-26V
S4B(R)
C5 .033
R17 3160
R20 20K
R16 1M
R18 10K
R19 20K
PROG ADJ
-13V
FROM A2-6
-26V
FROM A2-10
-13V
C6 22
S4A(R)
C4 1000 PF
C5 .0082
R13 12K
S4B(R)
R5 47.5K
R6 47.5K
R7 23.2K
R8 23.2K
P/O A4
R30 10K
C12 .01
Q9
-13.5V
-0.6V
Q7
Q8
-13.9V
R31 150K
-26V
R33 10K
R32 8060
R34 150K
-13V
-26V
C11 1000 PF
C14 1000PF
R37 46.4K
R38 46.4K
C15 1000 PF
R39 10K
C16 .01
Q12
-13.6V
Q10
Q11
-14.1V
R40 150K
-26V
R41 6980
C17 .22
R42 10K
R43 150K
-26V
C18 1000PF
0V
Q13
-14.2V
R44 124K
R45 150K
-26V
C19 .033
R46 1M
S4A(F)
T A3
T A3
3555A-J-1089A
COPYRIGHT 1967 BY HEWLETT-PACKARD COMPANY

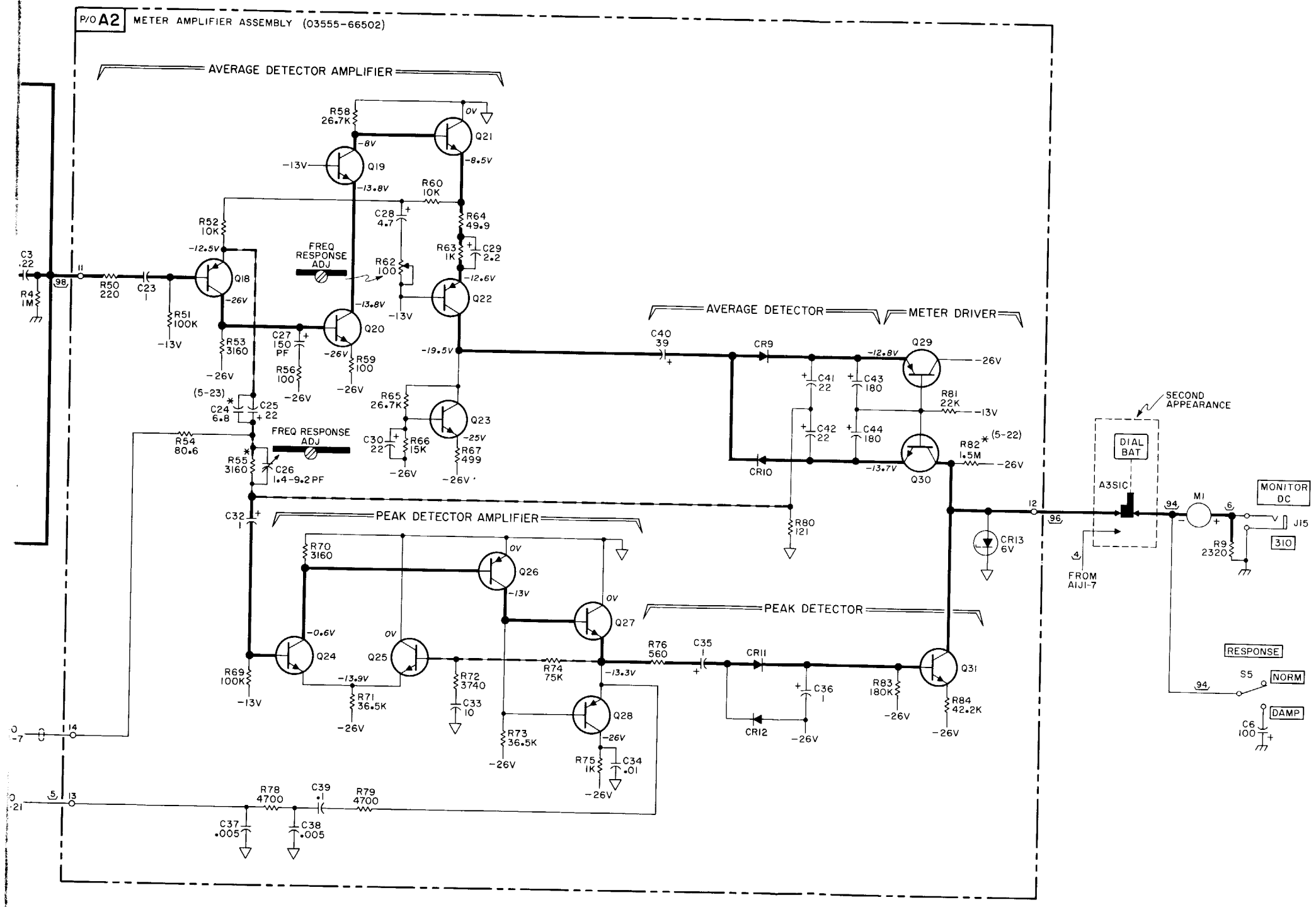


Figure 7-7, Filter and Meter Amplifier Schematic and Component Location Diagram.

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N. Y.
00334	Humidail Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N. J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02285	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N. J.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04354	Precision Paper Tube Co.	Chicago, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc., Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04777	Automatic Electric Sales Corp.	Northlake, Ill.
04796	Sequoia Wire & Cable Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P. M. Motor Company	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (Code Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metropolitan Telecommunications Corp., Metro Cap. Division	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E. T. A. Products Co. of America	Chicago, Ill.
06475	Western Devices, Inc.	Inglewood, Calif.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N. Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06751	U. S. Semcor Division of Nuclear Corp. of America	Phoenix, Arizona
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07358	Kelvin Electric Co.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N. Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	The Birtcher Corp.	Los Angeles, Calif.
07700	Technical Wire Products	Springfield, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert, Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada.
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co., Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S., Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atohm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09664	The Bristol Co.	Waterbury, Conn.
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10545	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronic, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N. J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13103	Thermalloy	Dallas, Texas
13396	Telefunken (G.M.B.H.)	Hannover, Germany
13835	Midland Mfg. Co.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co. Inc.	Brooklyn, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15909	The Daven Co.	Livingston, N.J.
16037	Spruce Pine Mica Co.	Spruce Pine, N. C.
16352	Computer Diode Corp.	Lodi, N. J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
18486	Radio Industries	Des Plaines, Ill.
18583	Curtis Instrument Inc.	Mt. Kisco, N.Y.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21226	Executive, Inc.	New York, N.Y.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fec. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division Nela Park,	Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Globe Fife Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Corp.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Baltimore, Md.
63743	Ward Leonard Electric	Mt. Vernon, N.Y.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
59730	Thomas & Betts Co.	Elizabeth 1, N. J.
60741	Tripplett Electrical Inc.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66295	Wittek Manufacturing Co.	Chicago 23, Ill.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70319	Allmetal Screw Prod. Co., Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72092	Eitel-McCullough, Inc.	San Bruno, Calif.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
71707	Coto Coil Co., Inc.	Providence, R.I.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72699	General Instrument Corp., Semiconductor Div.	Newark, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co, Inc.	Hicksville, N.Y.
73490	Beckman Helipot Corp.	So. Pasadena, Calif.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Prod. Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N. Y.
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77250	Phoell Mfg. Co.	Chicago, Ill.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association. tube meeting EIA standards	Any brand Washington, D.C.
80207	Unimax Switch, Div. of W.L. Maxson Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.

From: FSC. Handbook Supplements
H4-1 Dated DECEMBER 1964
H4-2 Dated MARCH 1962

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

Code No.	Manufacturer	Address
81349	Military Specification	.....
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81541	The Airpax Products Co.	Cambridge, Mass.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs, Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Battery	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronis, Inc.	New York, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A.B. Boyd Co.	San Francisco, Calif.
85474	R.M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven; Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	Seattle, Wash.
87930	Tower Mfg. Corp	Providence, R. I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89462	Waldes Kohinoor, Inc.	Cambridge, Mass.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers', Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Minneapolis-Honeywell Regulator Co., Microswitch Div.	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92196	Universal Metal Prod., Inc.	Bassett Puente, Calif.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tinsolite Insulated Wire Co.	Tarrytown, N.Y.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93788	Howard J. Smith Inc.	Port Monmouth, N. J.
93929	G. V. Controls	Livingston, N. J.
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94222	Southco Div. of S. Chester Corp.	Lester, Pa.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94330	Wire Cloth Products Inc.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95023	Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordas Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
97979	Reon Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98731	General Mills	Minneapolis, Minn.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp of Calif.	Newbury Park, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

J0000	Winchester Electronics, Inc.	Santa Monica, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000AB	ETA	England
000AC	Indiana General Corp., Elect. Div.	Indiana
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Manufacturing Co.	San Jose 27, Calif.
000QQ	Cooltron	Oakland, Calif.
000SS	Control of Elgin Watch Co.	Burbank, Calif.
000WW	California Eastern Lab.	Burlingame, Calif.
000YY	S.K. Smith Co.	Los Angeles 45, Calif.

From: FSC. Handbook Supplements
H4-1 Dated DECEMBER 1964
H4-2 Dated MARCH 1962

HEWLETT hp PACKARD

ELECTRONIC INSTRUMENTATION SALES AND SERVICE

UNITED STATES

ALABAMA
P.O. Box 4207
2003 Byrd Spring Road S.W.
Huntsville 35802
Tel: (205) 881-4591
TWX: 810-726-2204

ARIZONA
3009 North Scottsdale Road
Scottsdale 85251
Tel: (602) 945-7601
TWX: 910-950-1282

232 South Tucson Boulevard
Tucson 85716
Tel: (602) 623-2564
TWX: 910-952-1162

CALIFORNIA
3939 Lankershim Boulevard
North Hollywood 91604
Tel: (213) 877-1282
TWX: 910-499-2170

1101 Embarcadero Road
Palo Alto 94303
Tel: (415) 327-6500
TWX: 910-373-1280

2591 Carlsbad Avenue
Sacramento 95821
Tel: (916) 482-1463
TWX: 910-367-2092

1055 Shafter Street
San Diego 92106
Tel: (714) 223-8103
TWX: 910-335-2000

COLORADO
7965 East Prentice
Englewood 80110
Tel: (303) 771-3455
TWX: 910-935-0705

CONNECTICUT
508 Tolland Street
East Hartford 06108
Tel: (203) 289-9394
TWX: 710-425-3416

111 East Avenue
Norwalk 06851
Tel: (203) 853-1251
TWX: 710-468-3750

DELAWARE
3941 Kennett Pike
Wilmington 19807
Tel: (302) 655-6161
TWX: 510-666-2214

FLORIDA
Suite 106
9999 N.E. 2nd Avenue
Miami Shores 33138
Tel: (305) 758-3626
TWX: 810-848-7262

P.O. Box 20007
Herndon Station 32814
621 Commonwealth Avenue
Orlando
Tel: (305) 841-3970
TWX: 810-850-0113

P.O. Box 8128
Madeira Beach 33708
410 150th Avenue
St. Petersburg
Tel: (813) 391-0211
TWX: 810-863-0366

GEORGIA
P.O. Box 28234
2340 Interstate Parkway
Atlanta 30328
Tel: (404) 436-6181
TWX: 810-766-4890

ILLINOIS
5500 Howard Street
Skokie 60076
Tel: (312) 677-0400
TWX: 910-223-3613

INDIANA
4002 Meadows Drive
Indianapolis 46205
Tel: (317) 546-4891
TWX: 810-341-3263

LOUISIANA
P.O. Box 856
1942 Williams Boulevard
Kenner 70062
Tel: (504) 721-6201
TWX: 810-955-5524

MARYLAND
6707 Whitestone Road
Baltimore 21207
Tel: (301) 944-5400
TWX: 710-862-0850

P.O. Box 727
Twinbrook Station 20851
12303 Twinbrook Parkway
Rockville
Tel: (301) 427-7560
TWX: 710-828-9684

MASSACHUSETTS
Middlesex Turnpike
Burlington 01803
Tel: (617) 272-9000
TWX: 710-332-0382

MICHIGAN
24315 Northwestern Highway
Southfield 48075
Tel: (313) 353-9100
TWX: 810-232-1532

MINNESOTA
2459 University Avenue
St. Paul 55114
Tel: (612) 645-9461
TWX: 910-563-3734

MISSOURI
9208 Wyoming Place
Kansas City 64114
Tel: (816) 333-2445
TWX: 910-771-2087

2812 South Brentwood Blvd.
St. Louis 63144
Tel: (314) 644-0220
TWX: 910-760-1670

NEW JERSEY
391 Grand Avenue
Englewood 07631
Tel: (201) 567-3933
TWX: 710-991-9707

NEW MEXICO
P.O. Box 8366
Station C 87108
6501 Lomas Boulevard N.E.
Albuquerque
Tel: (505) 255-5586
TWX: 910-989-1665

156 Wyatt Drive
Las Cruces 88001
Tel: (505) 526-2485
TWX: 910-983-0550

NEW YORK
1702 Central Avenue
Albany 12205
Tel: (518) 869-8462

1219 Campville Road
Endicott 13760
Tel: (607) 754-0050
TWX: 510-252-0890

236 East 75th Street
New York 10021
Tel: (212) 879-2023
TWX: 710-581-4376

82 Washington Street
Poughkeepsie 12601
Tel: (914) 454-7330
TWX: 510-248-0012

39 Saginaw Drive
Rochester 14623
Tel: (716) 473-9500
TWX: 510-253-5981

1025 Northern Boulevard
Roslyn, Long Island 11576
Tel: (516) 869-8400
TWX: 510-223-0811

5858 East Molloy Road
Syracuse 13211
Tel: (315) 454-2486
TWX: 710-541-0482

NORTH CAROLINA
P.O. Box 5187
1923 North Main Street
High Point 27262
Tel: (919) 882-6873
TWX: 510-926-1516

OHIO
5579 Pearl Road
Cleveland 44129
Tel: (216) 884-9209
TWX: 810-421-8500

2460 South Dixie Drive
Dayton 45439
Tel: (513) 298-0351
TWX: 810-459-1925

OREGON
Westhills Mall, Suite 158
4475 S.W. Scholls Ferry Road
Portland 97225
Tel: (503) 292-9171
TWX: 910-464-6103

PENNSYLVANIA
2500 Moss Side Boulevard
Monroeville 15146
Tel: (412) 271-0724
TWX: 710-797-3650

144 Elizabeth Street
West Conshohocken 19428
Tel: (215) 248-1600, 828-6200
TWX: 510-660-8715

TEXAS
P.O. Box 7166
3605 Inwood Road
Dallas 75209
Tel: (214) 357-1881
TWX: 910-861-4081

P.O. Box 22813
4242 Richmond Avenue
Houston 77027
Tel: (713) 667-2407
TWX: 910-881-2645

GOVERNMENT CONTRACT OFFICE
225 Billy Mitchell Road
San Antonio 78226
Tel: (512) 434-4171
TWX: 910-871-1170

UTAH
2890 South Main Street
Salt Lake City 84115
Tel: (801) 486-8166
TWX: 910-925-5681

VIRGINIA
P.O. Box 6514
2111 Spencer Road
Richmond 23230
Tel: (703) 282-5451
TWX: 710-956-0157

WASHINGTON
11656 N.E. Eighth Street
Bellevue 98004
Tel: (206) 454-3971
TWX: 910-443-2303

FOR AREAS NOT LISTED, CONTACT: Hewlett-Packard; 1501 Page Mill Road; Palo Alto, California 94304; Tel: (415) 326-7000; TWX: 910-373-1267; Telex: 34-8461

CANADA

ALBERTA
10010 - 105th Street
Edmonton
Tel: (403) 424-0718
TWX: 610-831-2431

BRITISH COLUMBIA
Hewlett-Packard (Canada) Ltd.
2184 West Broadway
Vancouver
Tel: (604) 738-7520
TWX: 610-922-5050

NOVA SCOTIA
7001 Mumford Road
Suite 356
Halifax
Tel: (902) 455-0511
TWX: 610-271-4482

ONTARIO
Hewlett-Packard (Canada) Ltd.
880 Lady Ellen Place
Ottawa 3
Tel: (613) 722-4223
TWX: 610-562-1952

Hewlett-Packard (Canada) Ltd.
1415 Lawrence Avenue West
Toronto
Tel: (416) 249-9196
TWX: 610-492-2382

QUEBEC
Hewlett-Packard (Canada) Ltd.
275 Hymus Boulevard
Pointe Claire
Tel: (514) 697-4232
TWX: 610-422-3022
Telex: 01-2819

FOR AREAS NOT LISTED, CONTACT: Hewlett-Packard Inter-Americas; 1501 Page Mill Road; Palo Alto, Calif. 94304; Tel: (415) 326-7000; TWX: 910-373-1267; Telex: 034-8461; Cable: HEWPACK Palo Alto

CENTRAL AND SOUTH AMERICA

ARGENTINA
Mauricio A. Suárez
Telecomunicaciones
Carlos Calvo 224
Buenos Aires
Tel: 30-6312, 34-9087
Cable: TELEPILOT Buenos Aires

BRAZIL
Ciental, Importacao e
Comércio Ltda.
Avenida 13 de Maio, 13-22° andar
Rio de Janeiro G.B.
Tel: 42-9483

Ciental, Importacao e
Comércio Ltda.
Rua Des. Eliseu Guilherme, 52
Sao Paulo 8
Tel: 70-2318
Cable: CIENTALCO, Sao Paulo

CHILE
Héctor Calcagni
Casilla 13942
Santiago
Tel: 490.505, 393.119

COLOMBIA
Instrumentacion
Henrik A. Langebaek & Cia. Ltda.
Cra. 7A N° 48-51/59
Apartado Aereo 6287
Bogota, 1 D.E.
Tel: 45-78-06, 45-55-46
Cable: AARIS Bogota

COSTA RICA
Lic. Alfredo Gallegos Gurdián
Apartado 3243
San José
Tel: 21-86-13
Cable: GALGUR San José

ECUADOR
Laboratorios de Radio-Ingenieria
Calle Guayaquil 1246
Post Office Box 3199
Quito
Tel: 12496
Cable: HORVATH Quito

EL SALVADOR
Electrónica
27 Avenida Norte 1133
Apartado Postal 1589
San Salvador
Tel: 25-74-50
Cable: ELECTRONICA
San Salvador

GUATEMALA
Olander Associates Latin America
Apartado 1226
7a. Calle, 0-22, Zona 1
Guatemala City
Tel: 22812
Cable: OLALA Guatemala City

MEXICO
Hewlett-Packard Mexicana,
S.A. de C.V.
Eugenia 408, Dept. 1
Mexico 12, D.F.
Tel: 43-03-79

NICARAGUA
Roberto Terán G.
Edificio Terán
Apartado Postal 689
Managua
Tel: 3451, 3452
Cable: ROTERAN Managua

PANAMA
Electrónica Balboa, S.A.
P.O. Box 4929
Ave. Manuel Espinosa No. 13-50
Bldg. Alina
Panama City
Tel: 30833
Cable: ELECTRON Panama City

PERU
Fernando Ezeta B.
Av. Petit Thouars 4719
Miraflores
Casilla 3061
Lima
Tel: 50346
Cable: FEPERU Lima

PUERTO RICO
San Juan Electronics, Inc.
P.O. Box 5167
Ponce de León 150, Stop 3
Puerta de Tierra Santa
San Juan 00906
Tel: (809) 725-3342
Cable: SATRONICS San Juan

URUGUAY
Pablo Ferrando
S.A. Comercial e Industrial
Avenida Italia 2877
Casilla de Correo 370
Montevideo
Tel: 40-3102
Cable: RADIUM Montevideo

VENEZUELA
Citec, C.A.
Edif. Arisan-Of. #4
Avda. Francisco de Miranda
Apartado del Este 10934 Chacaito
Caracas
Tel: 71.88.05
Cable: CITECAL Caracas

FOR AREAS NOT LISTED, CONTACT: Hewlett-Packard Inter-Americas; 1501 Page Mill Road; Palo Alto, Calif. 94304; Tel: (415) 326-7000; TWX: 910-373-1267; Telex: 034-8461; Cable: HEWPACK Palo Alto

HEWLETT hp PACKARD

ELECTRONIC INSTRUMENTATION SALES AND SERVICE

EUROPE

AUSTRIA
Unilabor H.m.b.H.
Wissenschaftliche Instrumente
Rummelhardtgasse 6/3
P.O. Box 33
Vienna IX/71
Tel: 426 181
Cable: LABORINSTRUMENT
Vienna

BELGIUM
Hewlett-Packard Benelux S.A.
20-24 rue de l'Hôpital
Brussels
Tel: 11 22 20
Cable: PALOBEN Brussels

DENMARK
Tage Olsen A/S
Ronnegade 1
Copenhagen o
Tel: 29 48 00
Cable: TOCOPEN Copenhagen

FINLAND
INTO O/Y
Meritullinkatu 11
P.O. Box 10153
Helsinki 10
Tel: 61 133
Cable: INTO Helsinki

FRANCE
Hewlett-Packard France
2 rue Tête d'Or
Lyon, 6 - Rhône
Tel: 52 35 66

Hewlett-Packard France
150 Boulevard Massena
Paris 13e
Tel: 707 97 19
Cable: HEWPACK Paris

GERMANY
Hewlett-Packard Vertriebs-GmbH
Lietzenburger Strasse 30
1 **Berlin W** 30
Tel: 24 86 36

Hewlett-Packard Vertriebs-GmbH
Herrenberger Strasse 110
703 **Böblingen,** Württemberg
Tel: 07031-6971
Cable: HEPAG Boblingen

Hewlett-Packard Vertriebs-GmbH
Achenbachstrasse 15
4 **Düsseldorf 1**
Tel: 68 52 58/59

Hewlett-Packard Vertriebs-GmbH
Kurhessenstrasse 95
6 **Frankfurt** 50
Tel: 52 00 36
Cable: HEWPACKSA Frankfurt

Hewlett-Packard Vertriebs-GmbH
Beim Strohhause 26
2 **Hamburg** 1
Tel: 24 05 51/52
Cable: HEWPACKSA Hamburg

Hewlett-Packard Vertriebs-GmbH
Reginfriedstrasse 13
8 **Munich** 9
Tel: 69 51 21/22
Cable: HEWPACKSA Munich

GREECE
Kostos Karayannis
18, Ermou Street
Athens 126
Tel: 230 301
Cable: RAKAR Athens

IRELAND
Hewlett-Packard Ltd.
224 Bath Road
Slough, Bucks, England
Tel: Slough 28406-9, 29486-9
Cable: HEWPIE Slough

ITALY
Hewlett-Packard Italiana S.p.A.
Viale Lunigiana 46
Milan
Tel: 69 15 84
Cable: HEWPACIT Milan

Hewlett-Packard Italiana S.p.A.
Palazzo Italia
Piazza Marconi 25
Rome - Eur
Tel: 591 2544
Cable: HEWPACIT Rome

NETHERLANDS
Hewlett-Packard Benelux, N.V.
de Boelelaan 1043
Amsterdam, Z.2
Tel: 42 77 77
Cable: PALOBEN Amsterdam

NORWAY
Morgenstierne & Co. A/S
Ingeniofirma
6 Wessels Gate
Oslo
Tel: 20 16 35
Cable: MOROF Oslo

PORTUGAL
Telectra
Rua Rodrigo da Fonseca 103
P.O. Box 2531
Lisbon 1
Tel: 68 60 72
Cable: TELECTRA Lisbon

SPAIN
Ataio Ingerieros
Urgel, 259
Barcelona, 11
Tel: 230-69-88

Ataio Ingenieros
Enrique Larreta 12
Madrid, 16
Tel: 235 43 44
Cable: TELEATAIO Madrid

SWEDEN
HP Instrument AB
Hagakersgatan 7
Mölndal
Tel: 031 - 27 68 00

HP Instrument AB
Centralvägen 28
Solna
Tel: 08 - 83 08 30
Cable: MEASUREMENTS
Stockholm

SWITZERLAND
HEWPAK AG
Zurcherstrasse
8952 Schlieren
Zurich
Tel: (051) 98 18 21
Cable: HEWPACKAG Zurich

TURKEY
Telekom Engineering Bureau
P.O. Box 376 - Galata
Istanbul
Tel: 49 40 40
Cable: TELEMATION Istanbul

UNITED KINGDOM
Hewlett-Packard Ltd.
224 Bath Road
Slough, Bucks
Tel: Slough 28406-9, 29486-9
Cable: HEWPIE Slough

YUGOSLAVIA
Belram S.A.
83 avenue des Mimosas
Brussels 15, Belgium
Tel: 35 29 58
Cable: BELRAMEL Brussels

FOR AREAS NOT LISTED, CONTACT: Hewlett-Packard S.A.; 54 Route des Acacias; Geneva, Switzerland; Tel: (022) 42 81 50; Telex: 2.24.86; Cable: HEWPACKSA Geneva

AFRICA, ASIA, AUSTRALIA

AUSTRALIA
Hewlett-Packard Australia
Pty. Ltd.
22-26 Weir Street
Glen Iris, S. E. 6
Victoria
Tel: 20-1371 (4 lines)
Cable: HEWPARD Melbourne

Hewlett-Packard Australia
Pty. Ltd.
4 Grose Street
Glebe, New South Wales
Tel: 211-2235, 211-2888
Cable: HEWPARD Sydney

CEYLON
United Electricals Ltd.
P.O. Box 681
Yahala Building
Staples Street
Colombo 2
Tel: 5496
Cable: HOTPOINT Colombo

ETHIOPIA
African Salespower & Agency
Private Ltd., Co.
P. O. Box 718
Addis Ababa
Tel: 44090
Cable: ASACO Addisababa

HONG KONG
Schmidt & Co. (Hong Kong) Ltd.
P.O. Box 297
1511, Prince's Building
10, Chater Road
Hong Kong
Tel: 240168, 232735
Cable: SCHMIDTCO Hong Kong

INDIA
The Scientific Instrument
Co., Ld.
6, Tej Bahadur Sapru Road
Allahabad 1
Tel: 2451
Cable: SICO Allahbad

The Scientific Instrument
Co., Ld.
240, Dr. Dadabhai Naoroji Road
Bombay 1
Tel: 26-2642
Cable: SICO Bombay

The Scientific Instrument
Co., Ld.
11, Esplanade East
Calcutta 1
Tel: 23-4129
Cable: SICO Calcutta

The Scientific Instrument Co., Ld.
30, Mount Road
Madras 2
Tel: 86339
Cable: SICO Madras

The Scientific Instrument Co., Ld.
B-7, Ajmeri Gate Extn.
New Delhi 1
Tel: 27-1053
Cable: SICO New Delhi

IRAN
Telecom, Ltd.
P. O. Box 1812
Teheran
Tel: 43850, 48111
Cable: BASCOM Teheran

ISRAEL
Electronics & Engineering
Div. of Motorola Israel Ltd.
16, Kremenetski Street
Tel-Aviv
Tel: 35021/2/3
Cable: BASTEL Tel-Aviv

JAPAN
Yokogawa-Hewlett-Packard Ltd.
Shinhankyu Building
No. 8, Umeda
Kita-ku, **Osaka** City
Tel: 0726-23-1641

Yokogawa-Hewlett-Packard Ltd.
Ito Building
No. 59, Kotori-cho
Nakamura-ku, **Nagoya** City
Tel: 551-0215

Yokogawa-Hewlett-Packard Ltd.
Ohashi Building
No. 59, 1-chome, Yoyogi
Shibuya-ku, **Tokyo**
Tel: 370-2281
Cable: YOKOHEWPACK Tokyo
Telex: 232-2034

KENYA
R. J. Tilbury Ltd.
P. O. Box 2754
Suite 517/518
Hotel Ambassadeur
Nairobi
Tel: 25670, 26803, 68206
Cable: ARJAYTEE Nairobi

KOREA
American Trading Co., Korea, Ltd.
Seoul P. O. Box 1103
112-35 Sokong-Dong
Jung-ku, **Seoul**
Tel: 3.7049, 3.7613
Cable: AMTRACO Seoul

LEBANON
Constantin E. Macridis
Clemenceau Street
Clemenceau Center
Beirut
Tel: 220846
Cable: ELECTRONUCLEAR Beirut

MALAYSIA
MECOMB Malaysia Ltd.
2 Lorong 13/6A
Section 13
Petaling Jaya, **Selangor**
Cable: MECOMB Kuala Lumpur

NEW ZEALAND
Sample Electronics (N.Z.) Ltd.
8 Matipo Street
Onehunga S.E. 5
Auckland
Tel: 667-356
Cable: ELPMAS Auckland

PAKISTAN (EAST)
Mushko & Company, Ltd.
31, Jinnah Avenue
Dacca
Tel: 80058
Cable: COOPERATOR Dacca

PAKISTAN (WEST)
Mushko & Company, Ltd.
Oosman Chambers
Victoria Road
Karachi 3
Tel: 51027, 52927
Cable: COOPERATOR Karachi

SINGAPORE
Mechanical and Combustion
Engineering Company Ltd.
9, Jalan Kilang
Singapore, 3
Tel: 642361-3
Cable: MECOMB Singapore

SOUTH AFRICA
F. H. Flanter & Co. (Pty.), Ltd.
Rosella House
Buitencingle Street
Cape Town
Tel: 3-3817
Cable: AUTOPHONE Cape Town

F. H. Flanter & Co. (Pty.), Ltd.
104 Pharmacy House
80 Jorissen Street
Braamfontein, **Johannesburg**
Tel: 724-4172

TAIWAN
Hwa Sheng Electronic Co., Ltd.
P. O. Box 1558
21 Nanking West Road
Taipei
Tel: 46076, 45936
Cable: VICTRONIX Taipei

THAILAND
The International
Engineering Co., Ltd.
P. O. Box 39
614 Sukhumvit Road
Bangkok
Tel: 913460-1-2
Cable: GYSOM Bangkok

VIETNAM
Landis Brothers and Company,
Inc.
P.O. Box H-3
216 Hien-Vuong
Saigon
Tel: 20.805
Cable: LANBROCOMP Saigon

FOR AREAS NOT LISTED, CONTACT: Hewlett-Packard Export Marketing; 1501 Page Mill Road; Palo Alto, California 94304; Tel: (415) 326-7000; Telex: 034-8461; Cable: HEWPACK Palo Alto

HEWLETT hp PACKARD

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

For any assistance contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.