216-1

410C ELECTRONIC VOLTMETER

OPERATING AND SERVICE MANUAL

HEWLETT hp PACKARD

HP 410C

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.

OPERATING AND SERVICE MANUAL

(HP PART NO. 410C-904)

MODEL 410C
ELECTRONIC VOLTMETER

SERIALS PREFIXED: 550-

Appendix C, Manual Backdating Changes adapts this manual to Serials Prefixed:

311, 328, 339, 433, and 532.

P.O. Box 301, Loveland, Colorado, 80537 U.S.A.

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CAUTION

ONE SIDE OF ALMOST ALL POWER DISTRIBUTION SYSTEMS IS GROUNDED. EXTREME CAUTION MUST BE USED IF DIRECT MEASUREMENT OF POWER LINE VOLTAGES IS ATTEMPTED. IF THE GROUND CLIP LEAD IS ACCIDENTALLY CONNECTED TO THE UNGROUNDED SIDE OF THE LINE, SEVERE DAMAGE TO THE 410C IS POSSIBLE BECAUSE OF THE SHORT CIRCUIT CREATED. POWER LINE VOLTAGES CAN BE SAFELY MEASURED BY USING THE PROBE TIP ONLY. CONTACTING THE GROUNDED POWER CONDUCTOR WILL GIVE A READING OF 0 VOLTS WHILE CONTACTING THE UNGROUNDED LEAD WILL GIVE FULL LINE VOLTAGE READING.

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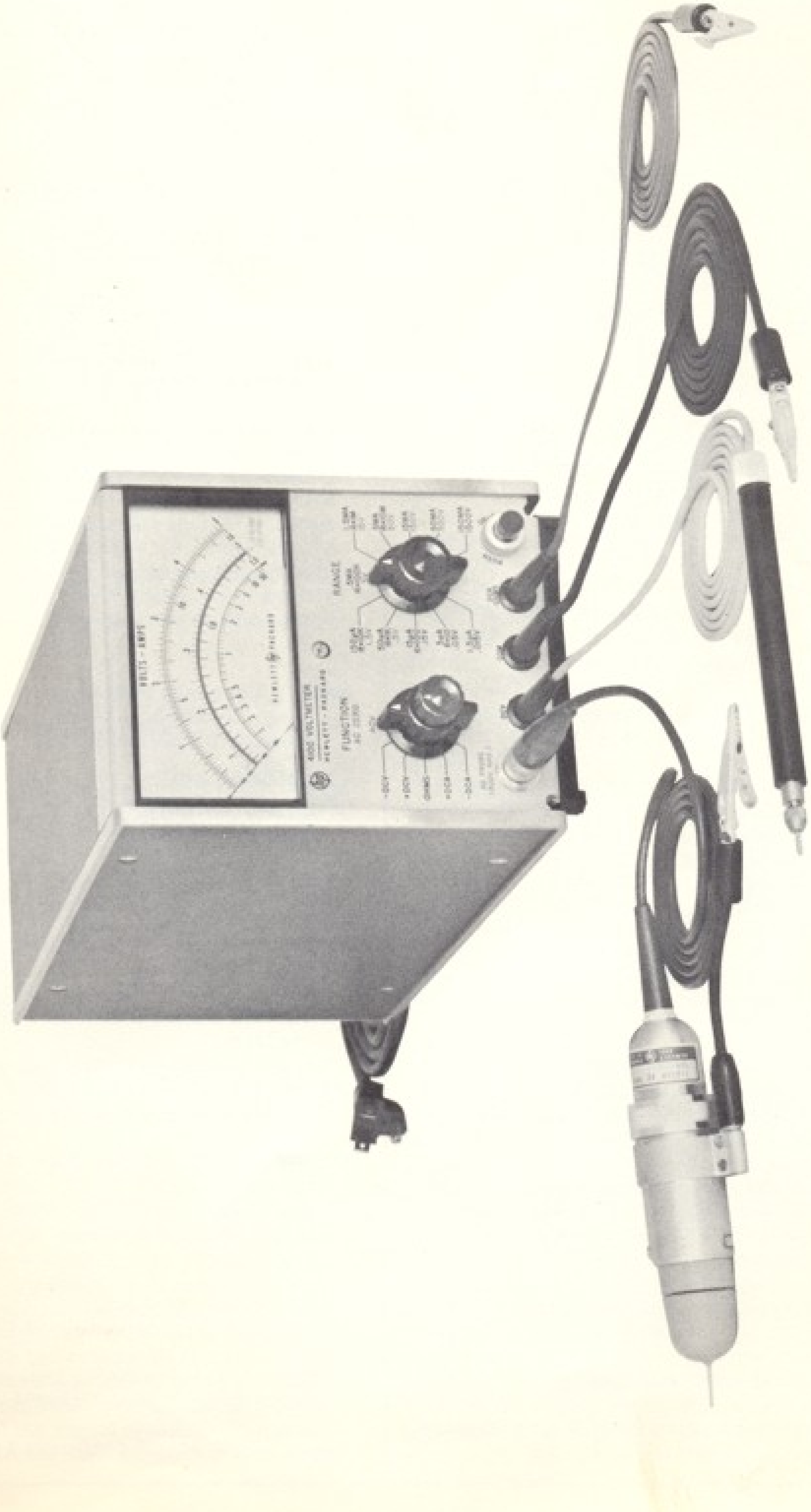


Figure 1-1. The Model 410C Electronic Voltmeter

Table 1-1. Specifications

DC VOLTMETER

Voltage Ranges: ±15 mv to ±1500 v full scale in 15, 50 sequence (11 ranges).

Accuracy: ±2% of full scale on any range.

Input Resistance: 100 megohms ±1% on 500 mv range and above.
10 megohms ±3% on 15 mv, 50 mv, and 150 mv ranges.

DC AMMETER

Current Ranges: ±1.5 μa to ±150 ma full scale in 1.5, 5 sequence (11 ranges).

Accuracy: ±3% of full scale on any range.

Input Resistance: Decreasing from 9 K ohms on 1.5 μa scale to approximately 0.3 Ω on the 150 ma scale.

Special Current Ranges: ±1.5, ±5, and ±15 nanoamps may be measured on the 15, 50, and 150 millivolt ranges using the voltmeter probe, with ±5% accuracy and 10 megohm input resistance.

OHMMETER

Resistance Range: Resistance from 10 ohms to 10 megohm center scale (7 ranges).

Accuracy: Zero to midscale: ±5% of reading or ±2% of midscale, whichever is greater.
±7% from midscale to scale value of 2.
±8% from scale value of 2 to 3.
±9% from scale value of 3 to 5.
±10% from scale value of 5 to 10.

AMPLIFIER

Voltage Gain: 100 maximum.

AC Rejection: 3 db at 1/2 cps; approximately 66 db at 50 cps and higher frequencies for signals less than 1600 v peak or 30 times full scale, whichever is smaller.

Isolation: Impedance between common and chassis is >10 meg in parallel with 0.1 μf. Common may be floated up to 400 v dc above chassis for dc and resistance measurements.

Output: Proportional to meter indication; 1.5 v dc at full scale, maximum current, 1 ma.

Output Impedance: Less than 3 ohms at dc.

Noise: Less than 0.5% of full scale on any range (p-p).

AMPLIFIER (Cont'd)

DC Drift: Less than 0.5% of full scale/year at constant temperature. Less than 0.02% of full scale /°C.

Overload Recovery: Recover from 100:1 overload in <3 sec.

AC VOLTMETER

Ranges: 0.5 v full scale to 300 v in 0.5, 1.5, 5 sequence (7 ranges).

Accuracy: ±3% of full scale at 400 cps for sinusoidal voltages from 0.5 to 300 v rms. The AC Probe responds to the positive peak-above-average value of the applied signal.

Frequency Response: ±2% from 100 cps to 100 Mc (400 cps ref.) ±10% from 20 cps to 100 cps and from 100 Mc to 700 Mc.

Frequency Range: 20 cps to 700 Mc.

Input Impedance: Input capacity 1.5 pf, input resistance >10 megohms at low frequencies. At high frequencies impedance drops off due to dielectric loss.

Safety: The probe body is grounded to chassis at all times for safety. All ac measurements are referenced to chassis ground.

Meter: Individually calibrated taut band meter. Responds to positive peak-above-average. Calibrated in rms volts for sine wave input.

GENERAL

Maximum Input: (see Overload Recovery)
DC: 100 v on 15, 50, and 150 mv ranges; 500 v on 0.5 to 15 v ranges; 1600 v on higher ranges.
AC: 100 times full scale or 450 v peak, whichever is less.

Power: 115 or 230 v ±10%. 50 to 1000 cps, 13 watts (20 watts with 11036A AC Probe).

Dimensions: 6-1/2 in. high (16.5 cm); 5-1/8 in. wide (13.01 cm); 11 in. deep (27.9 cm) behind panel. Fits 5060-0797 Rack Adapter and 1050 series combining cases.

Weight:
Net: 8 lbs. (4,0 kg).
Shipping: approximately 14 lbs. (6,35 kg).

Accessories Furnished: Detachable power cord, NEMA plug; ℎ𝑝 Model 11036A AC Probe.

Option 02: ℎ𝑝 Model 410C less AC Probe.

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The Hewlett-Packard Model 410C Electronic Voltmeter can be used to measure dc voltage and dc current; ac voltage and resistance. Positive and negative dc voltages from 15 millivolts to 1500 volts full scale and positive and negative dc currents from 1.5 microamperes to 150 milliamperes can be measured full scale. Resistance from 10 ohms to 10 megohms mid-scale can be measured with an accuracy of ±5%; resistance from 0.2 ohms to 500 megohms can be measured with reduced accuracy. The Model 410C Electronic Voltmeter is shown in Figure 1-1; the specifications are given in Table 1-1.

1-3. With the Model 11036A detachable AC Probe, the Voltmeter can be used to measure AC voltage from 20 cps to 700 Mc. From 20 cps to 100 Mc, AC voltage from 0.5 to 300 volts can be measured; from 100 Mc to 700 Mc, refer to Figure 3-5 for maximum AC voltage that can be applied to the AC Probe. For additional information on the AC Probe, refer to Paragraph 1-8.

1-4. INSTRUMENT IDENTIFICATION.

1-5. Hewlett-Packard uses a two section, eight-digit serial number (000-00000). The serial number is on a plate attached to the rear panel of the instrument. If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, Appendix C, Backdating Changes will define differences between your instrument and the Model 410C described in this manual.

1-6. ACCESSORIES AVAILABLE.

1-7. Accessories are available that extend the AC and DC measuring capabilities of the Voltmeter. A description of these accessories and their specifications is given below.

1-8. MODEL 11036A AC PROBE. This accessory, when used with the Model 410C, permits AC voltage measurements from 0.5 volts rms to 300 volts rms, full scale over a frequency range of 20 cps to 700 Mc. Reference calibration accuracy at 400 cps (sinusoidal) is ±3% of full scale. Frequency response is ±10% from 20 cps to 700 Mc, with indications obtainable to 3000 Mc. Frequency response at 100 Mc is within ±2%. The Model 11036A responds to the positive-peak-above-average value of the signal applied. The Model 410C is calibrated to read in RMS volts, for sine wave inputs.

1-9. MODEL 11039A CAPACITIVE VOLTAGE DIVIDER. This accessory (formerly the Model 452A) extends the AC voltage range of the Model 410C to 25 kv. The divider permits measurements of extremely high AC voltage such as encountered in dielectric heating equipment, etc., over a frequency range of 25 cps to 20 Mc. A fixed gap is provided so that breakdown will occur if the applied voltage exceeds 28 kv at low frequencies. Voltage division is 1000:1, ±3%, and input capacity is 15 picofarads. A Model 11018A Adapter is also required to connect the Model 11036A AC Probe to the shielded banana plug fitting of the divider.

1-10. MODEL 11040A CAPACITY DIVIDER. This accessory (formerly the Model 453A) extends the AC voltage range of the Voltmeter to 2000 volts RMS. The divider is for use at frequencies above 10 kc. Voltage division is 100:1, ±1%, and input capacity is approximately 2 picofarads.

1-11. MODEL 11042A PROBE T CONNECTOR. This accessory (formerly the Model 455A) is used for connecting the Model 11036A Probe across a 50-ohm transmission line using type N connectors. The T-joint is such that connection of the probe into a transmission line will not cause a standing wave ratio greater than 1.1 at 500 Mc and 1.2 at 1000 Mc. With this device, measurement of power traveling through a transmission line may be made with reasonable accuracy to 1000 Mc. The usual precautions must be taken to provide accurate impedance matching and the elimination of standing waves along the line through which power is floating. By using a dummy load at the receiving end of this T-joint, power output of various devices can be measured. In many applications power going into a real load, such as an antenna, can be conveniently measured up to 1000 Mc with good accuracy.

1-12. MODEL 11043A TYPE N CONNECTOR. This accessory (formerly the Model 458A) allows the AC Probe to be connected to a 50-ohm coaxial line. The connector uses a male type N connector and a receptacle for receiving the probe. Terminating resistor is not included.

1-13. MODEL 11045A DC DIVIDER. This accessory extends the maximum DC voltage range of the Model 410C to 30 kv. Voltage division is 100:1, ±5%, and input resistance is 9900 megohms. When used with the Model 410C, input resistance is 10,000 megohms. This probe offers maximum safety and convenience for measuring high voltages such as in television equipment, etc. The maximum current drain is 2.5 microamperes.

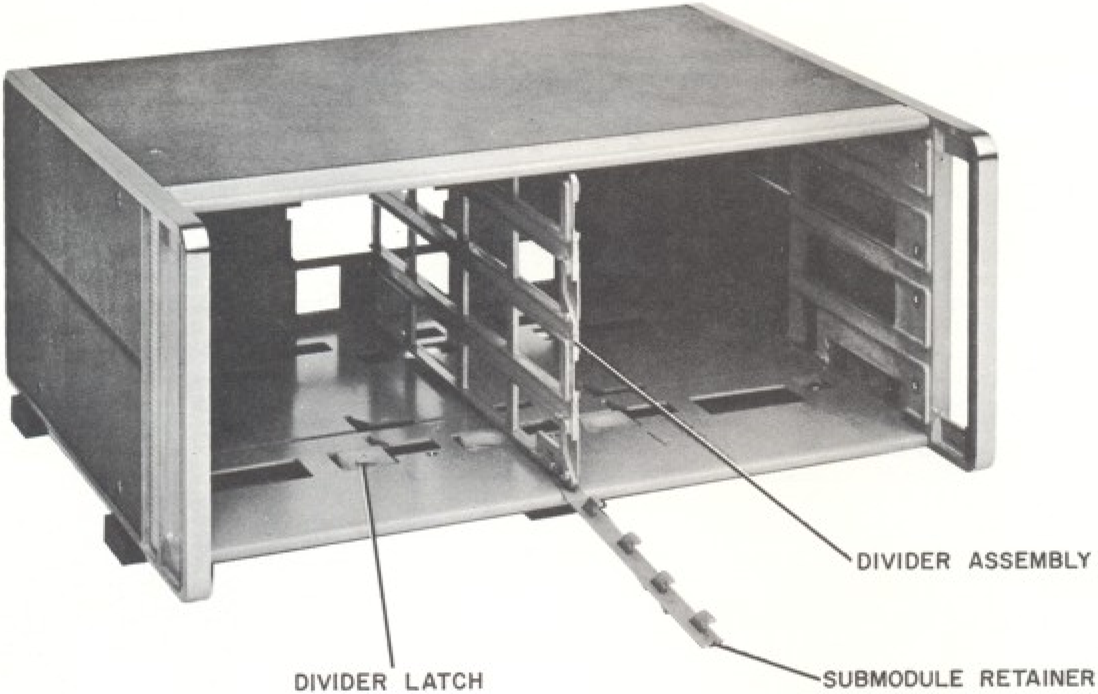


Figure 2-1. The Combining Case

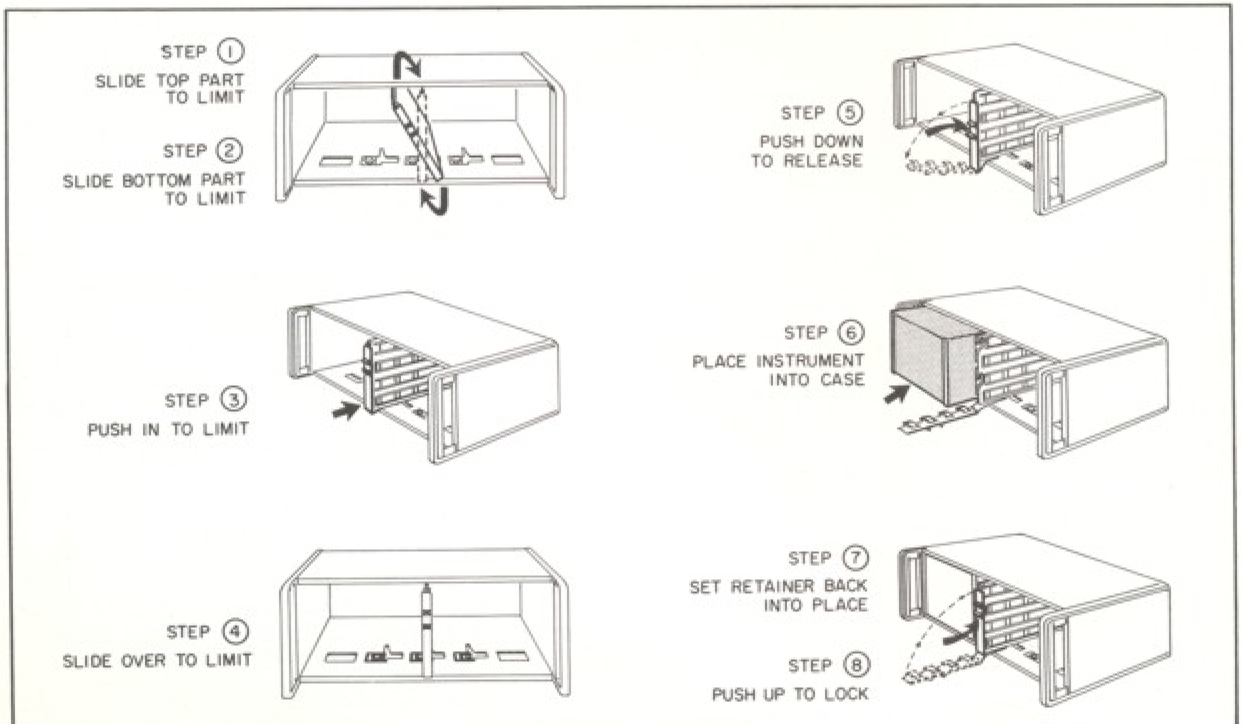


Figure 2-2. Steps to Place Instrument in Combining Case

SECTION II
INSTALLATION

2-1. INSPECTION.

2-2. This instrument was carefully inspected both mechanically and electrically, before shipment. It should be physically free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also, check for supplied accessories, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-5, Performance Checks. If there is damage or deficiency, see the warranty on the inside rear cover of this manual.

2-3. INSTALLATION.

2-4. The ⓗ Model 410C is transistorized except for one vacuum tube and requires no special cooling. However, the instrument should not be operated where the ambient temperature exceeds 55° C (140° F).

2-5. RACK MOUNTING.

2-6. The Model 410C is a submodular unit designed for bench use. However, when used in combination with other submodular units, it can be bench and/or rack mounted. The ⓗ Combining Cases and Adapter Frame are designed specifically for this purpose.

2-7. MODELS 1051A AND 1052A COMBINING CASES. The Combining Cases are full-module units which accept various combinations of submodular units. Being a full width unit, it can either be bench or rack mounted. An illustration of the Combining Case is shown in Figure 2-1. Instructions for installing the Model 410C are shown in Figure 2-2.

2-8. RACK ADAPTER FRAME (ⓗ Part No. 5060-0797). The adapter frame is a rack mounting frame that accepts various combinations of submodular units. It can be rack mounted only. An illustration of the adapter frame is given in Figure 2-3. Instructions are given below.

a. Place the adapter frame on edge of bench as shown in step 1, Figure 2-4.

b. Stack the submodular units in the frame as shown in step 2, Figure 2-4. Place the spacer clamps between instruments as shown in step 3, Figure 2-4.

c. Place spacer clamps on the two end instruments (see step 4, Figure 2-4) and push the combination into the frame.

d. Insert screws on either side of frame, and tighten until submodular instruments are tight in the frame.

e. The complete assembly is ready for rack mounting.

2-9. THREE-CONDUCTOR POWER CABLE.

2-10. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. All Hewlett-Packard instruments are equipped with a three-conductor power cable which grounds the instrument when plugged into an appropriate receptacle.

2-11. To preserve the protection feature when operating the instrument from a two-contact outlet, use three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

2-12. PRIMARY POWER REQUIREMENTS.

2-13. The Model 410C can be operated from either 115 or 230 volts, 50 to 1000 cps. The instrument can be easily converted from 115- to 230- volt operation. The LINE VOLTAGE switch, S4 a two-position slide switch located at the rear of the instrument, selects the mode of AC operation. The line voltage from which the instrument is set to operate appears on the slider of the switch. A 0.25-ampere, slo-blo fuse is used for both 115- and 230-volt operation. If the Model 410C is operated at any frequency other than 60 cps, perform chopper frequency adjust (Paragraph 5-31).

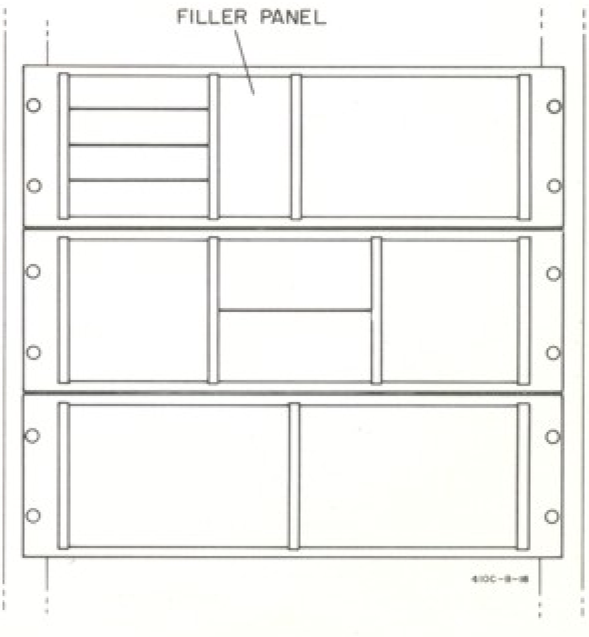


Figure 2-3. Adapter Frame Instrument Combination

CAUTION

DO NOT CHANGE THE SETTING OF THE LINE VOLTAGE SWITCH WHEN THE VOLTMETER IS OPERATING.

2-14. REPACKAGING FOR SHIPMENT.

2-15. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-16 if the original container is to be used; 2-17 if it is not. If you have any questions, contact your local ⓗ Sales and Service Office. (See Appendix B for office locations.)

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicate the service or repair to be performed; include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number, serial number and serial number prefix.

2-16. If the original container is to be used, proceed as follows:

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

b. Ensure that container is well sealed with strong tape or metal bands.

2-17. If original container is not to be used, proceed as follows:

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

b. Place packing material around all sides of instrument and protect panel face with cardboard strips.

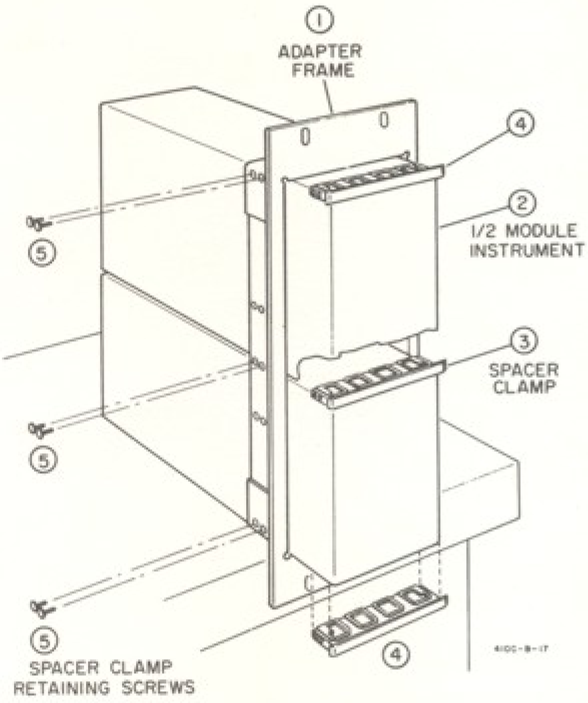


Figure 2-4. Two Half Modules in Rack Adapter

c. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.

d. Mark shipping container with "DELICATE INSTRUMENT", "FRAGILE", etc.

SECTION III

OPERATION

3-1. INTRODUCTION.

3-2. The Model 410C is used to measure AC and DC voltage, DC current, and resistance. All measurement inputs are located on the front panel; a DC output connector is located on the rear panel. Front panel controls and indicators are color coded. DC voltage, DC current and resistance knobs and indicators are in black; AC voltage controls and indicators are in red.

3-3. ADJUSTMENT OF MECHANICAL ZERO.

3-4. The procedure for adjustment of mechanical zero is given in Section V.

3-5. FRONT AND REAR PANEL DESCRIPTION.

3-6. Figure 3-1 describes the function of all front and rear panel controls, connectors and indicators. The description of each control, connector and indicator is keyed to a drawing which accompanies the figure.

3-7. OPERATING PROCEDURES.

3-8. There are five operating procedures: DC Voltage Measurements, Figure 3-2; DC Current Measurements, Figure 3-3; AC Voltage Measurements, Figure 3-4; Resistance Measurements, Figure 3-7; and Measuring DC Current in Nano-amperes, Figure 3-8.

Note

Ageing of the neon lamps in the chopper assembly can cause a change in chopper frequency which produces a slight oscillatory movement of meter pointer. If this oscillatory movement is observed, rotate Osc Freq Adj A3R5 (see Paragraph 5-31) in the ccw direction until oscillation of pointer stops.

3-9. DC VOLTAGE MEASUREMENTS (Figure 3-2).

3-10. The Model 410C is normally floating; however a shorting bar can be connected at the DC AMPLIFIER OUTPUT connector on the rear panel. When the instrument is floating, the COM Lead should not be connected to voltages greater than 400 VDC.

3-11. DC CURRENT MEASUREMENTS (Figure 3-3).

3-12. General instructions for the measurement of DC current are the same as those given for DC voltage measurements, Paragraph 3-9.

3-13. AC VOLTAGE MEASUREMENTS (Figure 3-4).

CAUTION

ONE SIDE OF ALMOST ALL POWER DISTRIBUTION SYSTEMS IS GROUNDED. EXTREME CAUTION MUST BE USED IF DIRECT MEASUREMENT OF POWER LINE VOLTAGES IS ATTEMPTED. IF THE GROUND CLIP LEAD IS ACCIDENTALLY CONNECTED TO THE UNGROUNDED SIDE OF THE LINE. SEVERE DAMAGE TO THE 410C IS POSSIBLE BECAUSE OF THE SHORT CIRCUIT CREATED. POWER LINE VOLTAGES CAN BE SAFELY MEASURED BY USING THE PROBE TIP ONLY. CONTACTING THE GROUNDED POWER CONDUCTOR WILL GIVE A READING OF 0 VOLTS WHILE CONTACTING THE UNGROUNDED LEAD WILL GIVE FULL VOLTAGE READING.

3-14. Although the Model 410C indicates a full scale AC range of 500 volts, the optional Model 11036A AC Probe should not be connected to AC voltages in excess of 300 volts RMS. AC voltage referenced to a DC voltage may be measured, but the AC Probe clip (alligator type) must be connected to the ground (⏚) of the circuit under test.

CAUTION

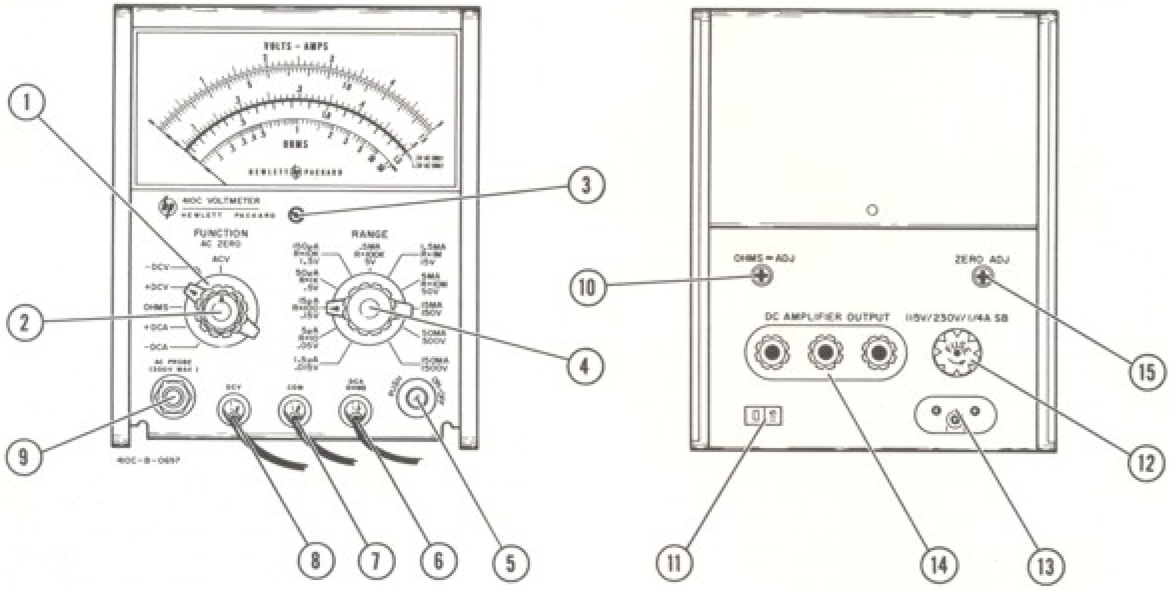
WHEN MEASURING AC REFERENCED TO DC, THE PEAK AC VOLTAGE PLUS DC VOLTAGE CONNECTED TO THE PROBE MUST NOT EXCEED 420 VOLTS.

3-15. PRECAUTIONS WHEN MEASURING AC VOLTAGE.

3-16. Special considerations must be kept in mind when making AC voltage measurements. These considerations are discussed in the following paragraphs.

3-17. GENERAL CONSIDERATION OF COMPLEX WAVEFORMS. Waveforms containing appreciable harmonics or spurious voltages will introduce error in the meter indication since the meter has been calibrated to read RMS values of true sine waves while the Model 11036A Probe is a peak-above-average responding device. The magnitude of error that may be expected when harmonics are present on the measured waveform is indicated in Table 3-1.

3-18. VOLTAGE MEASUREMENTS AT FREQUENCIES BELOW 50 CYCLES/SECOND. Voltage measurements at frequencies as low as 20 cycles per



(1) **FUNCTION SELECTOR:** This control is used for selecting type of measurement to be made. They are: ±DC Voltage, ±DC Current, AC Voltage, and resistance measurements.

(2) **AC ZERO:** This control provides adjustment for zero-setting the meter before making AC voltage measurements.

(3) **MECHANICAL ZERO ADJUST:** This adjustment mechanically zero-sets the meter prior to turning on Voltmeter.

(4) **RANGE:** This control selects the full scale meter range.

(5) **AC POWER SWITCH:** This pushbutton-lamp combination, when depressed, turns the instrument power on or off. The pushbutton glows when the Voltmeter power is on.

(6) **DCA-OHMS:** This lead is used in conjunction with the COM Lead to measure DC current or ohms. The FUNCTION SELECTOR determines which measurement is made.

(7) **COM:** This lead is used with the input leads for DC voltage current, DC voltage, and resistance measurements. The COM Lead is normally floating; however, a shorting bar can be connected from the floating ground terminal to the chassis ground terminal on the DC AMPLIFIER OUTPUT connector. If a shorting bar is not used, the COM Lead is floating except when the FUNCTION SELECTOR is set to ACV.

(8) **DCV:** This lead is used in conjunction with the COM Lead to measure ±DC voltage.

(9) **AC PROBE (300V MAX):** Receptacle for telephone-type plug of Model 11036A AC Probe. With probe connected, the Voltmeter may be used to make AC voltage measurements.

(10) **∞ ADJUST:** This control is used to set meter pointer to ∞ before resistance measurements are made. Only periodic adjustment of this screwdriver adjustment is necessary.

(11) **LINE VOLTAGE:** This two-position slide switch sets the instrument to accept either 115 or 230 volt AC primary power.

(12) **FUSEHOLDER:** The fuseholder contains a 0.25 ampere slow-blow fuse for both 115 vac and 230 vac modes of operation.

(13) **AC POWER CONNECTOR:** Accepts power cable supplied with the instrument.

(14) **DC AMPLIFIER OUTPUT:** Provides DC voltage output proportional to meter indication for driving external recorder. 1.5 volts DC output for full scale meter deflection.

(15) **ZERO ADJUST:** This control is used to set meter pointer to zero when calibrating for DC and resistance measurements.

Figure 3-1. Front and Rear Panel Controls second may be made without loss of accuracy by removing the plastic nose on the Model 11036A and using in its place a 0.25 microfarad blocking capacitor in series with the exposed contact of the probe.

CAUTION

THE GRAY INSULATING MATERIAL AROUND THE AC PROBE IS POLYSTYRENE, A LOW-MELTING POINT MATERIAL. IT IS NOT POSSIBLE TO SOLDER TO THE CONTACT WHICH IS EXPOSED WITH THE PROBE NOSE REMOVED WITHOUT DESTROYING THE POLYSTYRENE.

Table 3-1. Possible Error When Measuring Voltage of Complex Waveforms

% Harmonic	True RMS Value	Voltmeter Indication
0	100	100
10% 2nd	100.5	90 to 110
20% 2nd	102	80 to 120
50% 2nd	112	75 to 150
10% 3rd	100.5	90 to 110
20% 3rd	102	87 to 120
50% 3rd	112	108 to 150

3-19. VOLTAGE MEASUREMENT AT HIGH FREQUENCIES. At frequencies above 100 megacycles the distance between the point of voltage measurement and anode of the probe diode must be made as short as possible. If feasible, substitute a small disc type capacitor of approximately 50 picofarads for the removable tip on the probe. Solder one terminal of the button capacitor to the measurement point in the circuit and not to the probe contact. The probe contact (with tip removed) can then contact the other terminal of the capacitor for the measurement.

3-20. At frequencies above 100 megacycles considerable voltage may be built up across ground leads and along various part of a grounding plane. Consequently, to avoid erroneous readings when measuring medium and high frequency circuits, use the ground clip lead on the shell of the probe to connect the circuit ground. In some cases at the higher frequencies it may be necessary to shorten the grounding lead on the probe.

3-21. For all measurements at higher frequencies, hold the molded nose of the probe as far from the external ground plane or from object at ground potential as can conveniently be done. Under typical conditions, this practice will keep the input capacitance several tenths of a picofarad lower than otherwise.

3-22. For measurements above approximately 250 megacycles it is almost mandatory that measurements be made on voltages which are confined to coaxial transmission line circuits. For applications of this type, the Model 11036A Probe is particularly suitable because the physical configuration of the diode and probe is that of a concentric line, and with a few precautions it can be connected to typical coaxial transmission line circuits with little difficulty.

3-23. To connect the probe into an existing coaxial transmission line, cut the line away so the center conductor of the line is exposed through a hole large enough to clear the body of the probe. The nose of the probe should be removed for this type of measurement. Connect one terminal of a button-type capacitor of approximately 50 picofarads to the center conductor of the coaxial line so that the other terminal of the capacitor will contact the anode connection of the probe. A close-fitting metal shield or bushing should be arranged to ground the outer cylinder of the probe to the outer conductor of the transmission line. This type of connection is likely to cause some increase in the standing wave ratio of the line at higher frequencies. The Model 11042A Probe T Connector is designed to do this job with SWR or less than 1.1 at 500 Mc (see Paragraph 1-11).

3-24. EFFECT OF PARASITICS ON VOLTAGE READINGS. At frequencies above 500 megacycles, leads or portions of circuits often resonate at frequencies two, three, or four times the fundamental of the voltage being measured. These harmonics may cause serious errors in the meter reading. Owning to the resonant rise in the probe circuit at frequencies above 1000 megacycles, the meter may be more sensitive to the harmonics than to the fundamental. To make dependable measurements at these frequencies, the circuits being measured must be free of all parasitics.

3-25. EFFECT OF DC PRESENT WITH AC SIGNAL. When measuring an AC signal at a point where there is a high DC potential, such as at the plate of a vacuum tube, the high DC potential may cause small leakage current through the blocking capacitor in the tip of the Model 11036A AC Probe. When the AC signal under measurement is small, the error introduced into the reading can be significant. To avoid leakage, an additional capacitor with a dielectric such as mylar or polystyrene which has high resistance to leakage is required. (Use 5 picofarads or higher, and insert the capacitor between the point of measurement and the probe tip.)

3-26. PULSE MEASUREMENTS.

3-27. POSITIVE PULSES. The Model 11036A AC Probe is peak-above-average responding and clamps the positive peak value of the applied voltage. This permits the probe to be used to measure the positive-voltage amplitude of a pulse, provided the reading obtained is multiplied by a factor determined from the following expression:

$$1.4\left(1 + \frac{t_1}{t_2} + \frac{K}{PRF}\right)$$

t_1 is the duration of the positive portion of the voltage in microseconds.

t_2 is the duration of the negative portion of the voltage in microseconds.

K is a factor determined from the expression R_0/t_1 and the graph shown in Figure 3-6, where R_0 is the source impedance of the pulse generator in kilohms, and t_1 is the duration of the positive portion of the pulse in microseconds.

PRF is the pulse repetition frequency in pulses per second (pps).

Suppose, for example:

t_1 = 10 microseconds

t_2 = 990 microseconds

K = 0.55

PRF = 1000 pps

To find K, assuming R_o = 2 kilohms and t_1 = 10 microseconds: R_o/t_1 = 2/10° = 0.2. Location 0.2 on the X axis of the graph shown as Figure 3-6, and reading K where X and Y axes intersect the unmarked curve. If the ratio of R_o/t_1 were greater than 1, multiply the X and Y axes by 10, and use the curve marked "R_o/t_1 and K each X10".

Solving the expression for the multiplying factor,

$$1.4 \quad 1 + \left(\frac{10}{990} + \frac{0.55}{1000}\right) =$$

$$1.4 \; (1 + 0.01 + 0.00055) =$$

$$1.4 \; (1.01055) =$$

$$1.41477$$

3-28. NEGATIVE PULSES.

3-29. In the case of a 10 microsecond negative pulse (t_2) and a pulse repetition frequency (PRF) of 1000 pps, t_1 would be 990 microseconds. Thus T_o/t_1 would be approximately 0, and from the graph it is seen that K is approximately 0. The expression would then reduce to

$$1.4 \quad (1 + \frac{990}{10})$$

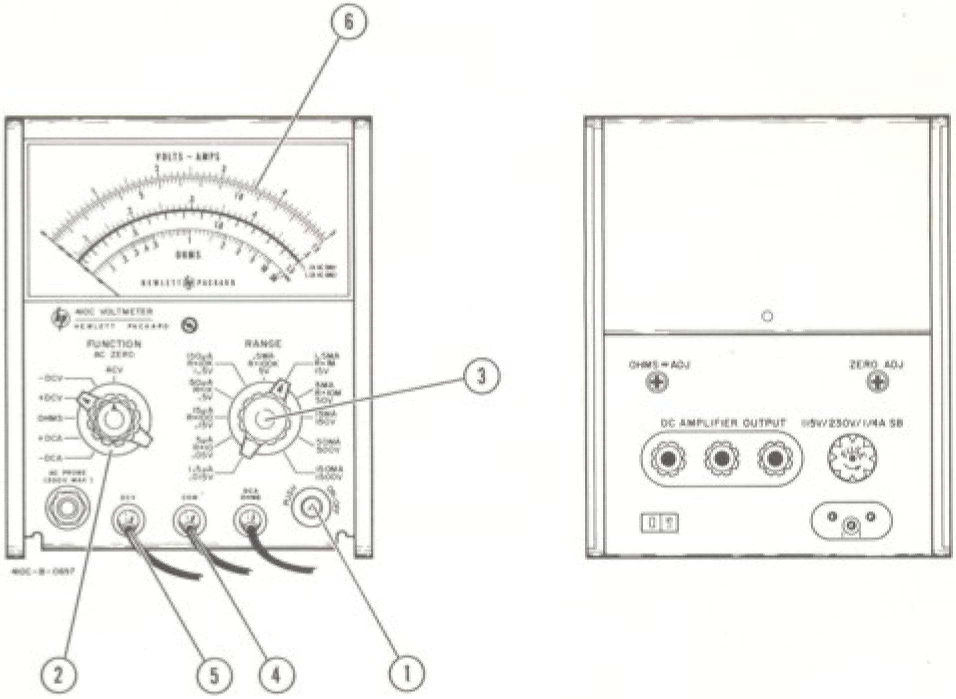
3-30. It can be seen that in the case of negative pulses of short duration much smaller readings will be obtained for an equivalent positive pulse. As a result, large multiplying factors must be used and unless the pulse voltage is large, these measurements may be impractical.

3-31. MEASURING RESISTANCE (Figure 3-7).

3-32. Before making resistance measurements, power must be removed from the circuit to be tested. Also, make sure capacitors are discharged to eliminate any residual voltage.

3-33. MEASURING DC NANO-AMPERE CURRENT (Figure 3-8).

3-34. The Model 410C can be used to measure nano-ampere leakage current in transistors and diodes. The three most sensitive DC voltage measurement ranges are used to measure DC nano-ampere currents.



(1) Depress the AC power switch (neon - switch combination).

(2) Set FUNCTION SELECTOR to polarity desired (+DCV or -DCV).

(3) Set RANGE to desired voltage position.

(4) Connect COM Lead to the ground of circuit under test.

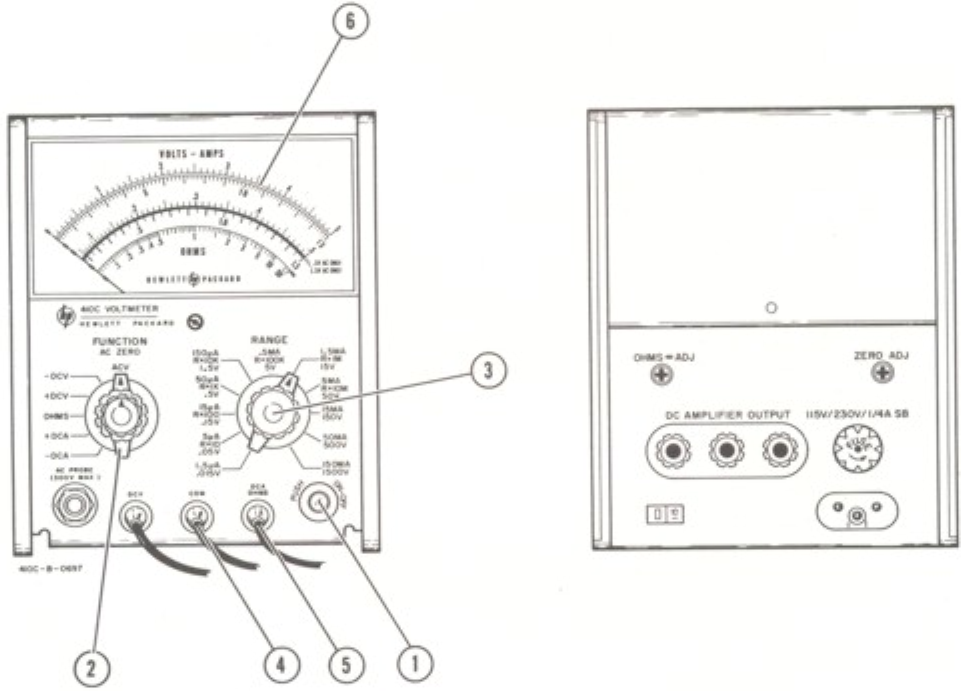
(5) Touch DCV probe to test point.

(6) Read voltage on the VOLTS-AMPS scale.

Note

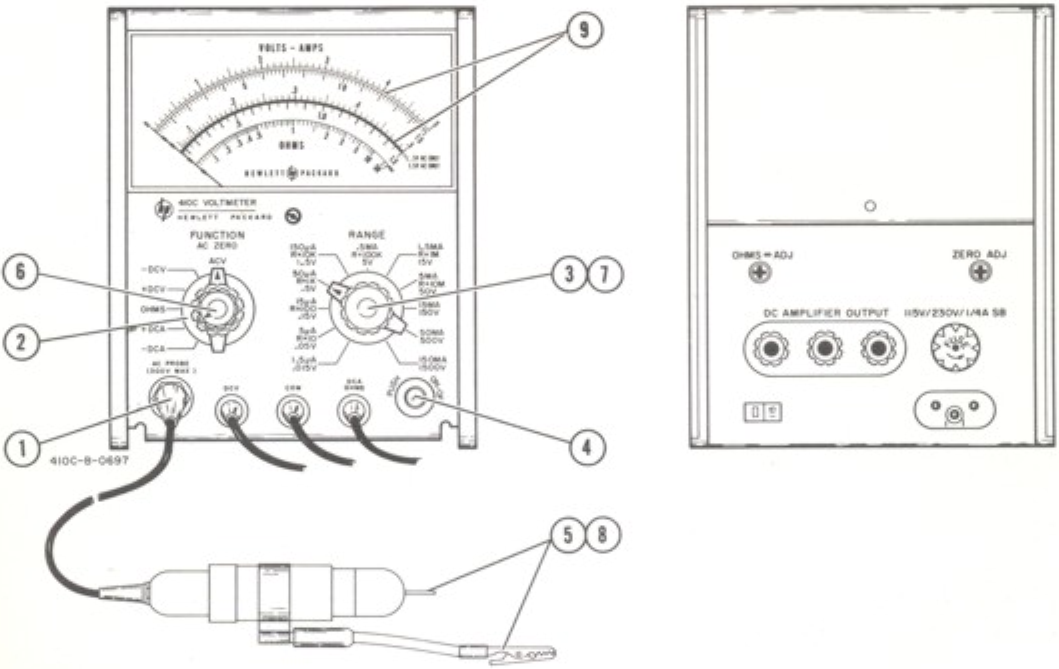
Aging of the neon lamps in the chopper assembly can cause a change in chopper frequency which produces a low amplitude oscillatory movement of the meter pointer. If the meter pointer oscillates, rotate A3R5 ccw until oscillation stops.

Figure 3-2. DC Voltage Measurements



1. Depress the AC power switch (neon-switch combination).
2. Set FUNCTION SELECTOR to the polarity desired (+DCA or -DCA).
3. Set range to desired current position.
4. Connect COM Lead to the ground of circuit under test.
5. Connect the DCA ohms probe to the circuit to be tested.
6. Read the current on the VOLTS-AMPS scale.

Figure 3-3. DC Current Measurements



CAUTION

CONNECT AC GROUND CLIP AND COM LEAD TO EARTH GROUND ONLY WHEN IN AC FUNCTION.

(1) Connect the ⓗⓟ Model 11036A AC Probe to the Model 410C at the AC PROBE receptacle.

(2) Set FUNCTION SELECTOR to ACV. NOTE: COM and chassis are internally connected when the FUNCTION SELECTOR is set to ACV.

(3) Set RANGE to 0. 5 V.

(4) Depress the AC power button (neon-switch combination) and allow 5 minute warmup.

(5) Short AC Probe Tip with Ground Clip.

(6) Adjust AC ZERO for a zero indication on the meter.

(7) Set RANGE to the desired voltage range.

(8) Connect AC Probe clip (alligator) to ground of circuit to be tested, and touch probe tip to test point. At lower frequencies COM Lead can be substituted for the AC probe clip.

CAUTION

BEFORE MEASURING VOLTAGES AT FREQUENCIES ABOVE 100 MC, REFER TO FIGURE 3-5 TO DETERMINE THE MAXIMUM AMOUNT OF VOLTAGE THAT CAN BE APPLIED AT THAT FREQUENCY.

(9) Read AC voltage on the VOLTS-AMPS scale. NOTE: When RANGE is on the 0. 5 V and 1. 5 V positions, use red meter scale.

Figure 3-4. AC Voltage Measurements

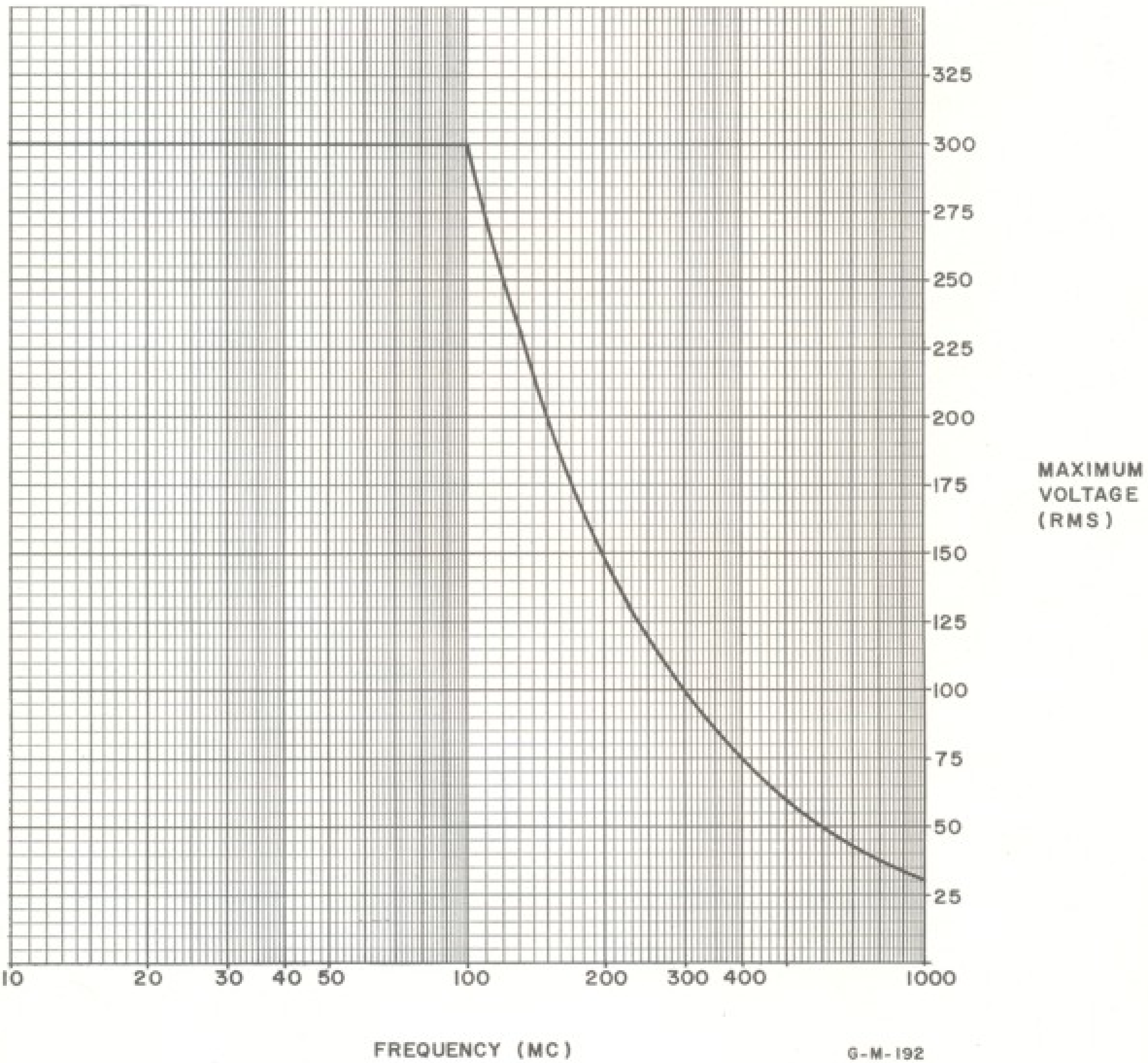


Figure 3-5. Maximum AC Voltage Chart for 11036A AC Probe

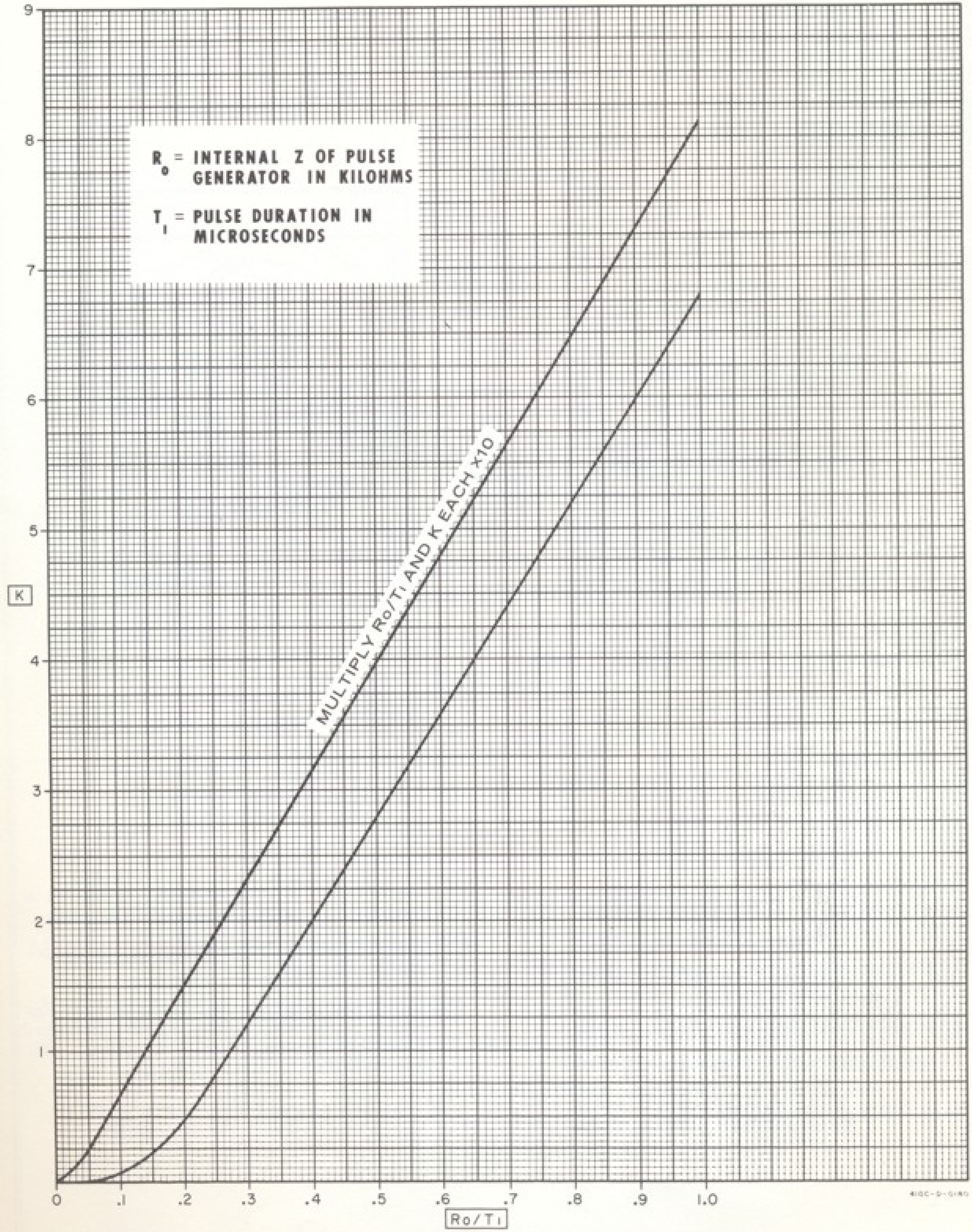
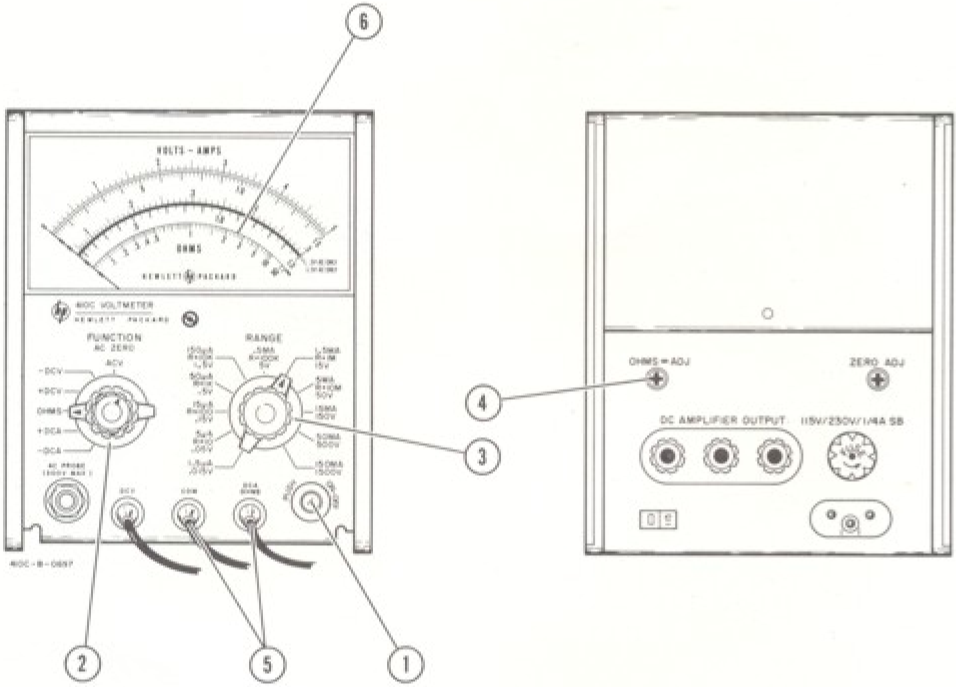


Figure 3-6. Graph Used in Calculation of Pulse Voltage Readings



Before making resistance measurements, remove power from circuit to be tested. Be sure to discharge capacitors to eliminate any residual voltage.

(1) Depress AC power switch (neon-switch combination).

(2) Set the FUNCTION SELECTOR to OHMS.

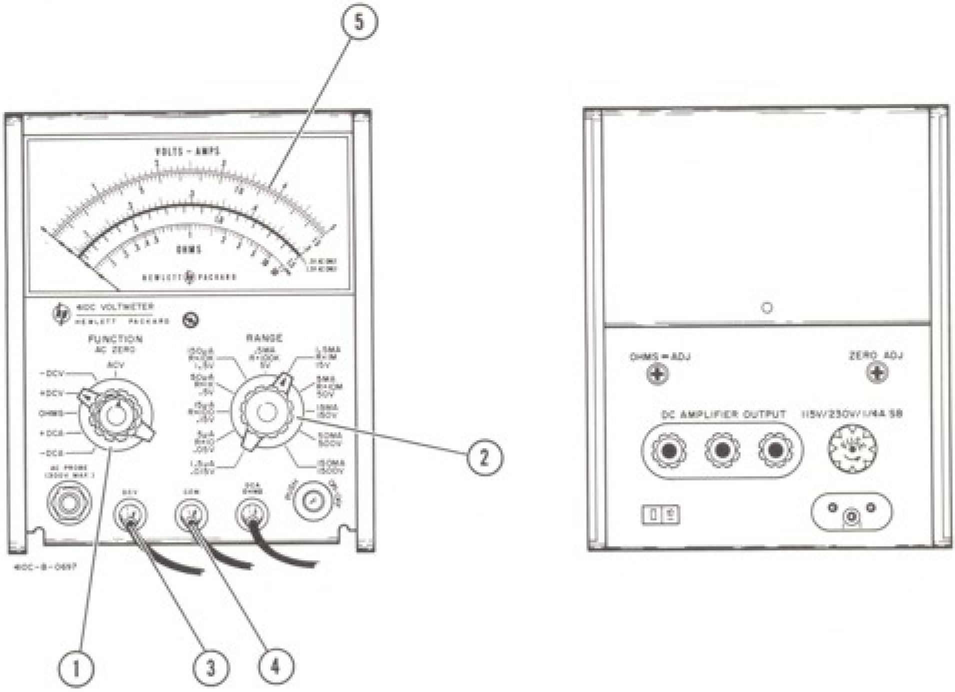
(3) Set RANGE to desired position.

(4) Adjust OHMS ∞ ADJ. control on rear panel to obtain an ∞ reading on the meter if necessary.

(5) Connect COM and DCA OHMS leads across circuit to component to be tested.

(6) Resistance is determined by multiplying the reading on the OHMS scale by the RANGE factor. EXAMPLE: If reading is 1. 5 and factor is 10K, then resistance equals 15K ohms.

Figure 3-7. Resistance Measurements



(1) Set the **FUNCTION SELECTOR** to +DCV or -DCV (depending on direction of current flow).

(2) Set RANGE to desired range (0.015 V, 0.05 V, or 0.15 V range.

Note

0.015 V range = 1.5 nano-amperes range

0.05 V range = 5.0 nano-amperes range

0.15 V range = 15 nano-amperes range

(3) Connect the DCV lead to the circuit under test.

(4) Connect the COM lead to the circuit under test.

(5) Read nano-amperes from the meter on the VOLTS-AMPS scale (top two on meter) which corresponds to the range selected.

Figure 3-8. DC Nano-Ampere Current Measurements

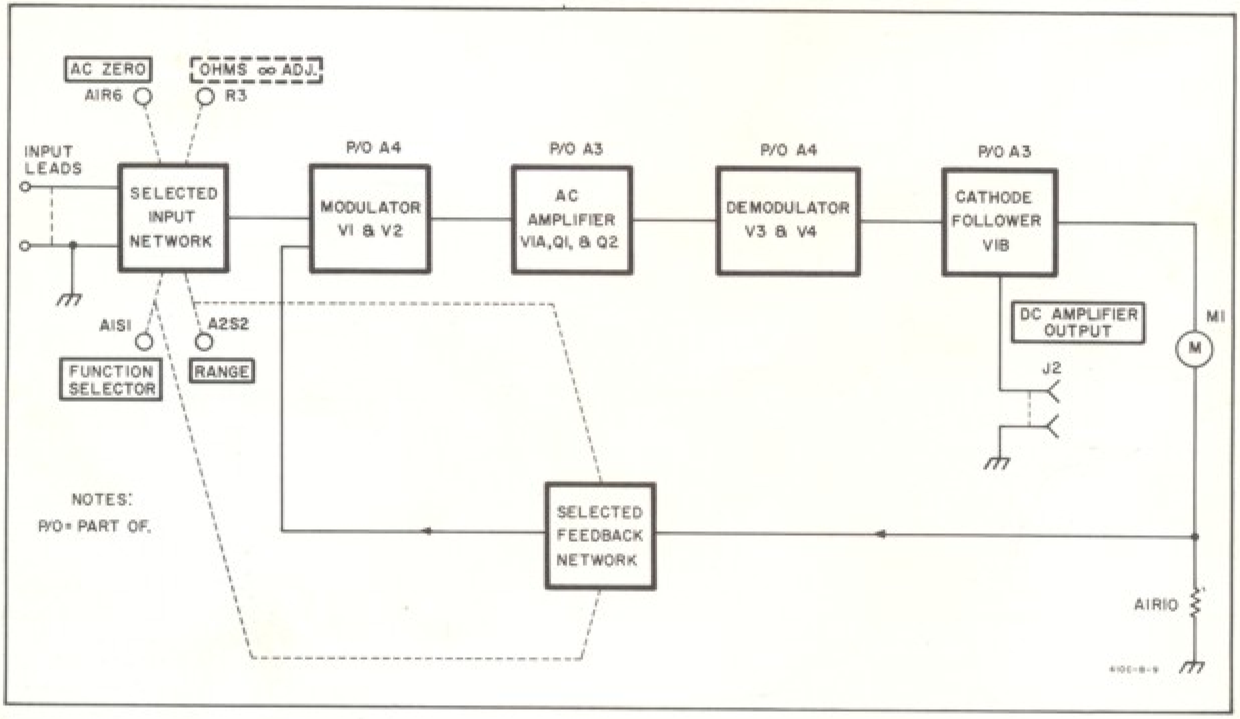


Figure 4-1. Block Diagram, Model 410C

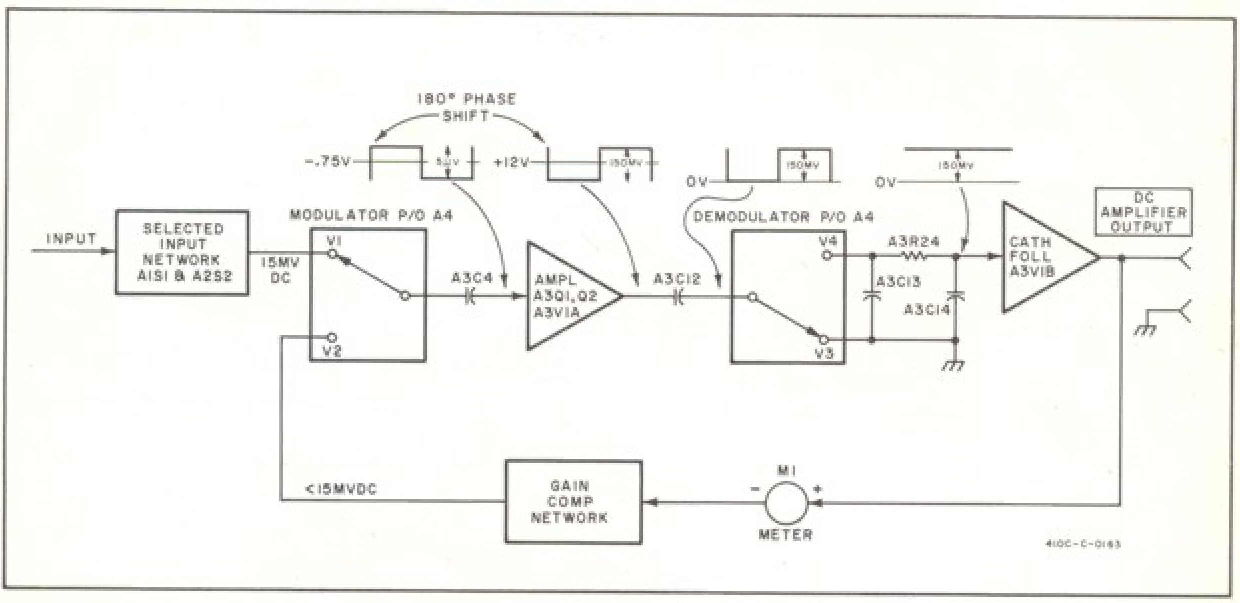


Figure 4-2. Modulator-Demodulator Mechanical Analogy

SECTION IV
THEORY OF OPERATION

4-1. OVERALL DESCRIPTION.

4-2. The Model 410C includes an input network, a modulator-amplifier-demodulator, and a meter circuit. A block diagram of the Model 410C is shown in Figure 4-1.

4-3. Signals to be measured are applied through the appropriate input lead to the input network. AC voltages are detected in the AC probe, and therefore all signals to the input network are DC. The input network attenuates the DC signal to a level determined by RANGE and FUNCTION SELECTOR settings. The attenuated DC voltage is applied to the modulator which converts the DC to AC for amplification. The amplified AC signal is converted back to DC voltage in the demodulator and coupled to cathode follower V1B. The cathode follower output to the DC AMPLIFIER OUTPUT connector and meter circuit is a DC voltage proportional to the amplitude of the signal applied to the input. A portion of the voltage to the meter circuit is returned to the modulator as feedback. When the feedback voltage and attenuated DC voltage are nearly equal, the meter stabilizes.

4-4. CIRCUIT DESCRIPTION.

4-5. INPUT NETWORK.

4-6. The input network includes a precision voltage divider, which by means of the FUNCTION SELECTOR and RANGE switches, provides a maximum of 15 millivolts at the modulator input regardless of the range set and signal applied. The ±DCA, ±DCV, OHMS, and ACV modes of operation are discussed below.

4-7. DC CURRENT MEASUREMENTS: Refer to Figure 4-3, throughout this explanation. The purpose of the input network is to provide proper attenuation of currents applied. Currents from 1.5 μa to 150 ma full scale are applied with input impedance decreasing from 9K ohms on the 1.5 μa range to approximately 0.3 ohms on the 150 ma range.

4-8. The change in input impedance is varied by using DC current shunts in conjunction with RANGE switch A2S2. The DC voltage developed across these shunt resistors, when applied through the modulator-amplifier-demodulator network to the meter, provide a deflection on the meter proportional to the DC current being measured.

4-9. DC VOLTAGE MEASUREMENTS. Refer to Figure 4-4 throughout this explanation. The purpose of the input network is to accurately attenuate the input signal to a maximum of 15 millivolts at the modulator input. The network presents an input impedance of 10 megohms on the three most sensitive ranges and 100 megohms on all other ranges.

4-10. The resistor R1 (located in the DCV probe) in conjunction with resistors A2R10 through A2R26, provides the 10 megohm input impedance required for the three most sensitive DCV ranges. Resistors A2R4 and A3R30 are shunted out of the circuit by the RANGE switch on the three most sensitive DCV ranges.

4-11. When using the eight less sensitive ranges, A2R4 and A3R30 are placed in series with R1 and A2R10 through A2R26 to present more than 100 megohm impedance to the input.

4-12. A3R30 is used to calibrate full scale on the 1500 volt range. (See Paragraph 5-35.)

4-13. RESISTANCE MEASUREMENTS. The purpose of the input network shown in Figure 4-5 is to place approximately 0.6 volt DC source in series with a known (reference) resistance. The resistance to be measured is placed in parallel with the known resistance, which changes the voltage proportionally. The maximum changes in voltage applied to the modulator is 15 mv because of attenuation provided by A2R4, A3R30, and A1R2.

4-14. A DC current of approximately 60 ma is supplied at the junction of A2R22 and A2R23 through A7R10, R3, A2R2 and A2R1 to the input network. The OHMS ∞ ADJ., R3, sets the meter for full scale (∞). Resistor A2R1 is shorted out in the X1M position of the RANGE switch; resistors A2R1 and A2R2 are shorted out in the X10M range. The resistors A2R2 and/or A2R1 are electrically removed from the circuit to increase the voltage at the junction of A2R22 and A2R23. This is done to compensate for the loading of the attenuator (A2R4, A3R30, and A1R2) on these ranges.

4-15. AC VOLTAGE MEASUREMENTS. Refer to Figure 4-6 throughout this explanation. Voltage at the AC probe is converted to DC and applied to the input network. The input signal is attenuated to produce a maximum of about 15 millivolts at the modulator input. AC zero adjustment of meter pointer is made with the AC ZERO control.

4-16. MODULATOR-DEMODULATOR.

4-17. Refer to the Amplifier Schematic, Figure 5-11, and to the Mechanical Analogy Schematic, Figure 4-2 throughout this explanation.

4-18. The input network applies approximately 15 millivolts DC, for full scale meter deflection (positive or negative, depending on the polarity of the voltage or current being measured) to the neon-photoconductor chopper. Also applied to the opposite side of the chopper is the amplifier feedback voltage, which is of the same polarity and approximately 5 microvolts lower in amplitude than the input voltage. The modulator-chopper consists of two photoconductors, A4V1 and A4V2, which are alternately illuminated by two neon lamps, A4DS1 and A4DS2, respectively. The neon lamps are part of a relaxation oscillator, whose frequency is controlled by A3R5. The oscillator frequency is nominally set to 100 cps for operation from 60 cps power line, or to 85 cps for 50 cps line. This frequency is selected so that it is not harmonically related to the power line frequency, precluding possible beat indications on the meter.

4-19. As the photoconductors are alternately illuminated by the neons, their respective resistances are low (conductive) when illuminated and high (non-conductive) when darkened. Therefore the input voltage and feedback voltage are alternately applied to the input amplifier. The amplitude of the resultant signal to the amplifier is the voltage difference between the input and feedback voltages.

4-20. The chopped DC signal is amplified by a three stage RC amplifier, consisting of A3V1A, A3Q1 and A3Q2. The amplified signal to the input of the demodulator-chopper is 180° out of phase with the output of the modulator-chopper.

4-21. The demodulator - chopper consists of two photoconductors, A4V3 and A4V4, which are alternately illuminated by neon lamps A4DS1 and A4DS2, respectively. Approximately 150 millivolts square-wave is applied to the demodulator from the amplifier. Since the same neon lamps illuminate both the modulator and demodulator photoconductors, operation of the two chopper is synchronous. Therefore, when A4V1 is sampling the input voltage, A4V3 is clamping the amplified and inverted difference voltage to ground. Alternately, when A4V2 is sampling the feedback voltage, A4V4 is charging capacitors A3C13 and A3C14 to the peak value of the square-wave. These capacitors maintain this charge so long as the input voltage remains constant by virtue of having no discharge path and because they are being repetitively recharged by the demodulator.

4-22. Therefore, a DC potential, proportional to the difference between the input and feedback voltages, is applied to the grid of the cathode follower and subsequently to meter circuit and DC AMPLIFIER OUTPUT connector. A portion of the meter circuit voltage is fed back to the modulator. The meter stabilizes when the feedback voltage and input voltages are nearly equal.

4-23. THE FEEDBACK NETWORK.

4-24. The feedback network drives the meter and determines the DC gain of the amplifier. The feedback is varied depending on the position of the FUNCTION and RANGE selectors. The different feedback configurations are discussed below.

4-25. FEEDBACK NETWORK FOR ±DCA, OHMS, AND ±DCV. Figures 4-3, 4-4 and 4-5 show the feedback configuration for all positions of the FUNCTION SELECTOR except ACV. The meter is electrically inverted for ±DCV and ±DCA modes of operation. The DC OUTPUT ADJ., A6R20 sets the output voltage. The DC pot, A6R18 determines the amount of feedback to the modulator. The resistor A2R30 is in the circuit in the ±.015 DCV and ±1.5 μa modes of operation, to decrease feedback and thus increase amplifier gain to compensate for the decrease in input signal to the modulator on these ranges.

4-26. FEEDBACK CIRCUIT FOR AC VOLTAGE MEASUREMENTS: Figure 4-6 shows the feedback configuration for the ACV position of the FUNCTION SELECTOR switch, A2S2. The resistors that are placed in the circuit by the RANGE switch program the amplifier gain to compensate for the non-linear response of the AC probe. A6R16 and A6CR1 compensate the non-linear response of the AC probe to the linear calibration of the upper meter scale on the 5 volt range.

4-27. POWER SUPPLY.

4-28. PRIMARY POWER. Refer to Figure 5-9 throughout this explanation. Either 115 or 230 volt ac power is connected through fuse F1 (0.25 amp slow-blow) and switch S3 to the primary of power transformer T1. Switch S4 connects T1 primaries in parallel for 115 volt operation of in series for 230 volt operation.

4-29. UNREGULATED AND ZENER REGULATED POWER SUPPLY. Full wave rectifier CR1 and CR2 produces unregulated +270 volts, which is used to drive the photochopper neons. Unregulated +175 volts and +140 volts are tapped off and are used to provide B+ to the plates of A4V1B and A4V1A, respectively. Zener regulators A7CR6 and CR7 provide regulated +38 volts and -9 volts to bias A3Q1 and A3Q2. Filtering of the outputs is provided by the RC network consisting of A7R1 through A7R3 and C5A through C5D.

4-30. SERIES REGULATED POWER SUPPLY. The output of the full wave rectifier CR3 and CR4 is regulated by transistor Q1, which is connected in series with the output. Zener diode A7CR8 provides reference voltage to the base of Q1. Regulated +6 volts is supplied to the filaments of A3V1A/B and the AC Probe diode A8V1. +0.6 volts is provided through A7R10 to R3, the OHMS ∞ ADJ. control. Filtering of the outputs is provided by C6A and C6B.

4-31. STANDBY FILAMENT SUPPLY. The filament tap (T1, Pins 1 and 2) provides 6.0 volts ac to the filament of the AC probe diode, A8V1, so that the filament remains warm when the Model 410C is being used in modes of operation other than ACV. When FUNCTION selector A1S1 is switched to ACV, 6.0 volts AC is removed from the filament and 6 volts DC is applied. Therefore, the ACV mode is ready for immediate use, without waiting for the filament to warm up.

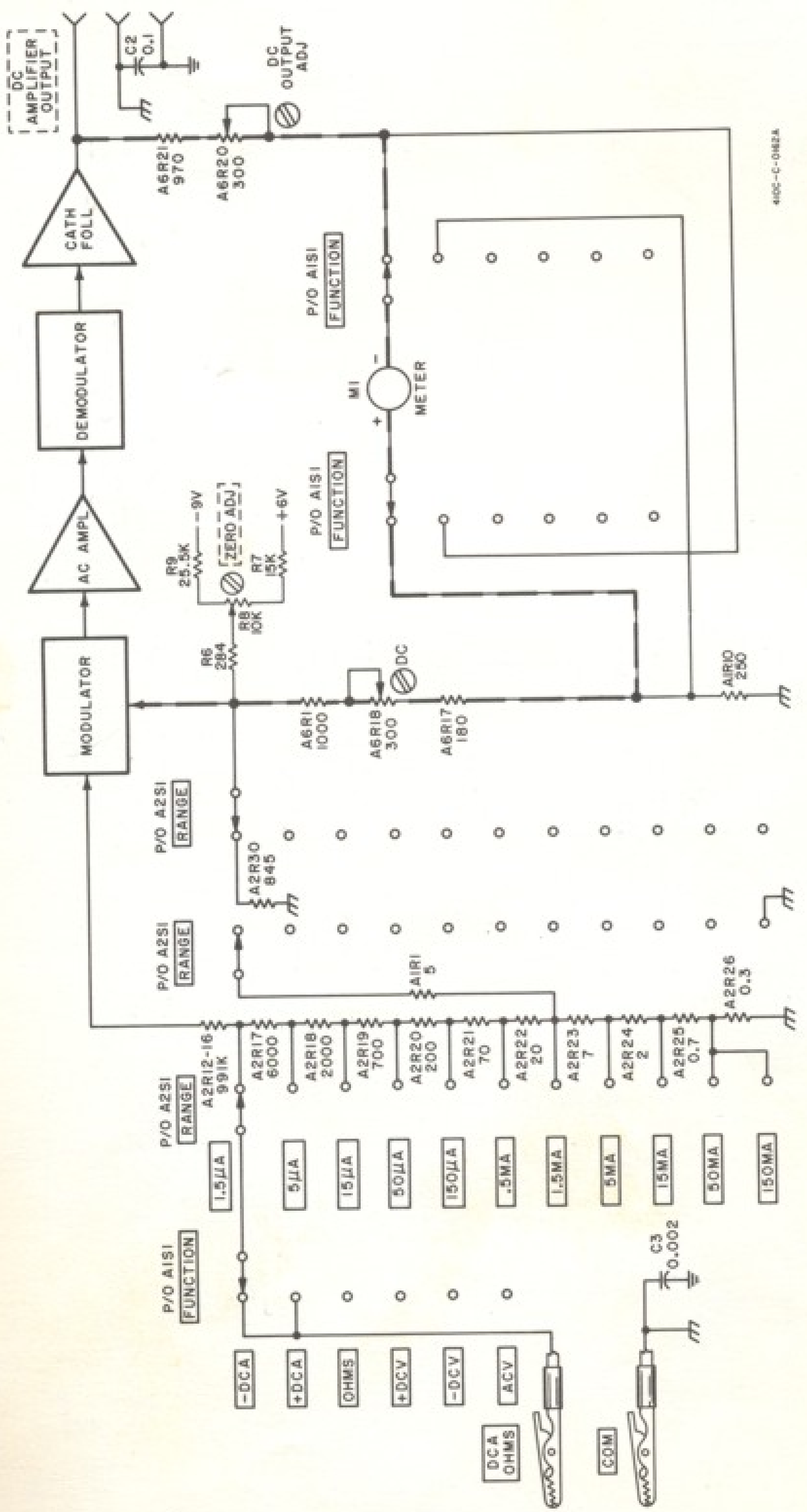


Figure 4-3. Simplified Schematic, DC Current Measurement

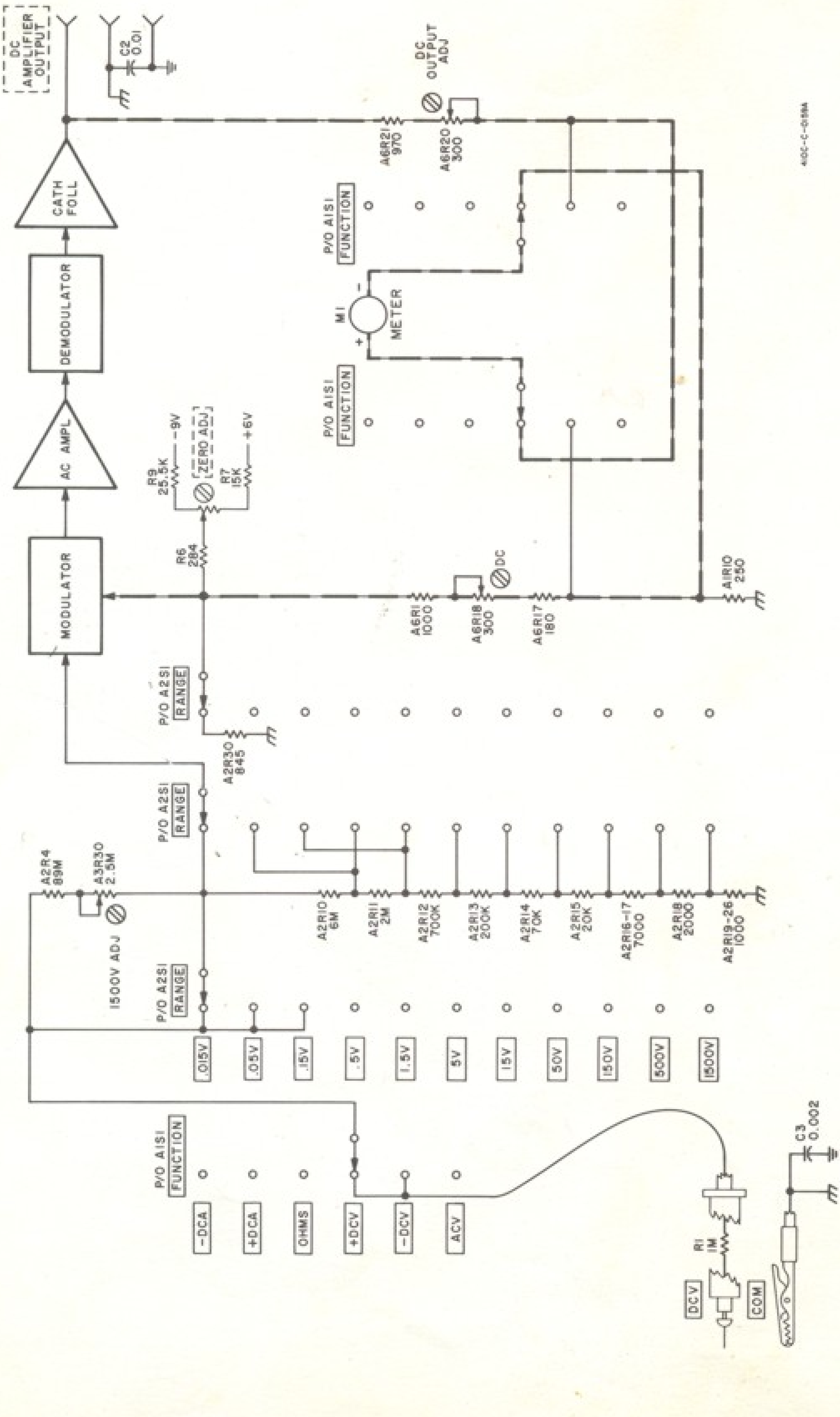


Figure 4-4. Simplified Schematic, DC Voltage Measurements

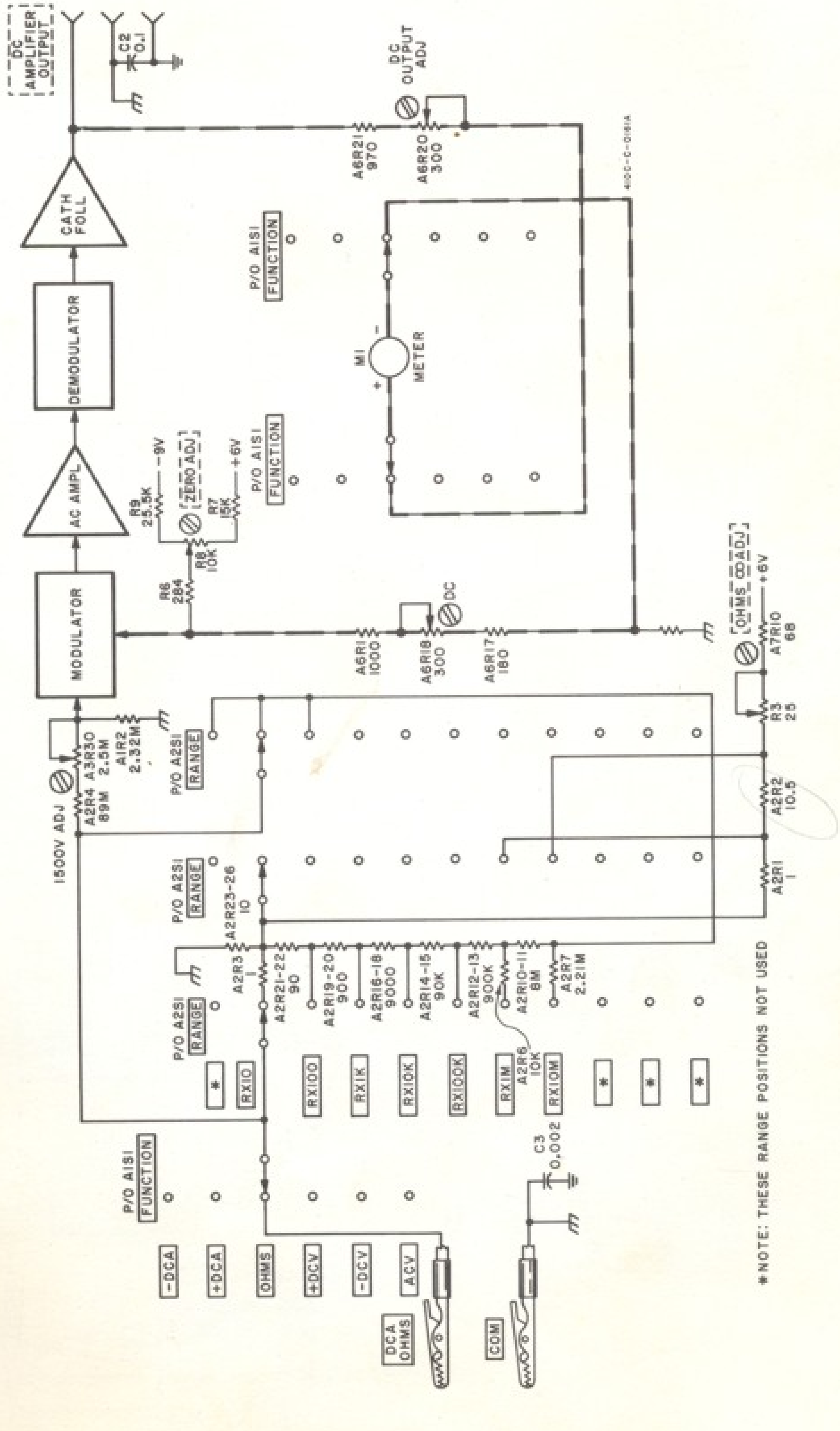


Figure 4-5. Simplified Schematic, Resistance Measurement

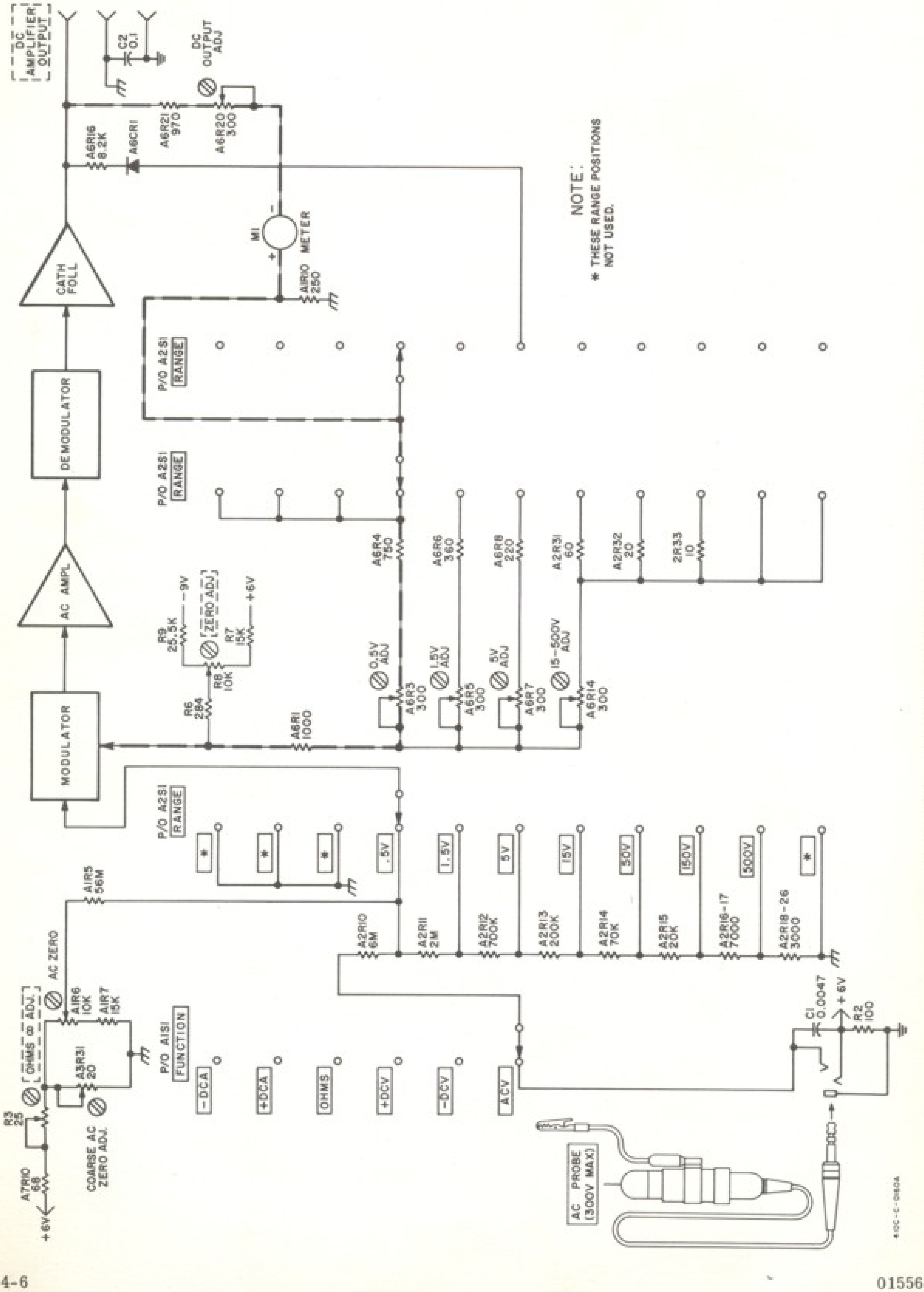


Figure 4-6. Simplified Schematic, AC Voltage Measurement

Table 5-1. Recommended Test Equipment

Instrument Type	Required Characteristics	Use	Recommended Model
Voltmeter Calibrator	Range: 0.015 to 300 v Frequency: Dc and 400 cps Accuracy: ±0.3% ac ±0.2% dc	AC and DC Accuracy Checks and Calibration Adjustments	ⓗ Model 738BR Voltmeter Calibrator
Frequency Response Test Set	Frequency: 20 cps to 10 Mc with external oscillator Output: 2 v into 50 ohms	Frequency Response Test	ⓗ Model 739AR Frequency Response Test Set
Oscillator	Frequency: 20 cps to 10 Mc Output: 2.0 v	Frequency Response Test	ⓗ Model 200SR Oscillator
DC Power Supply	Range: 0 to 10 v continuous	DC Ammeter Accuracy Checks	ⓗ Model 723A DC Power Supply
DC Voltmeter	Range: 10 v Accuracy: ±0.2%	Accuracy Checks; Power Supply Measurements; Troubleshooting	ⓗ Model 3440A/3441A/3443A Digital Voltmeter
VHF Signal Generator	Frequency: 10 Mc to 480 Mc Output: 1.0 v	Frequency Response Test	ⓗ Model 608 VHF Signal Generator
UHF Signal Generator	Frequency: 480 Mc to 700 Mc	Frequency Response Test	ⓗ Model 612A UHF Signal Generator
AC Voltmeter	Range: 120 v	Power Supply Measurements (ripple)	ⓗ Model 3400A RMS Voltmeter
Electronic Counter	Frequency Range: to at least 102 cps	Chopper Frequency Adjust	ⓗ Model 5211A Electronic Counter
Ohmmeter	Range: 100 M Ω Accuracy: ±5%	Troubleshooting	ⓗ Model 412A DC VTVM
Micro-Potentiometer	Frequency Range: 10 Mc to 700 Mc Output Voltage: 0.44 v rms Accuracy: NBS calibrated	Frequency Response Test	Ballantine Model 440 Micro-Potentiometer
Probe-T-Connector	For use with 50 ohm transmission line	Frequency Response Test	ⓗ Model 11042A Probe-T-Connector
Connector Adapter	Type N male to BNC female	Frequency Response Test	ⓗ Part No. 1250-0067
Connector Adapter	BNC to binding post	Frequency Response Test	ⓗ Part No. 10110A
Connector Adapter	Type "N" male to Type "N" female	Frequency Response Test	ⓗ Part No. 11501A
50 Ω termination	Frequency Range: 10 Mc to 700 Mc Low reflection	Frequency Response Test	ⓗ Part No. 908A
50 ohm feed-thru	Male BNC to female BNC	Performance Checks	ⓗ Model 11048B
Resistors:			
10 M Ω	Accuracy: ±1%	Performance Checks	ⓗ Part No. 0730-0168
56 K	Accuracy: ±1%	Performance Checks	ⓗ Part No. 0730-0053
10 K	Accuracy: ±1%	Performance Checks	ⓗ Part No. 0727-0157
1 K	Accuracy: ±1%	Chopper Frequency Adjust	ⓗ Part No. 0727-0751
1.5 K	Accuracy: ±1%	Performance Checks	ⓗ Part No. 0730-0017
56 ohms	Accuracy: ±1%	Performance Checks	ⓗ Part No. 0811-0341
10 ohms	Accuracy: ±1%	Performance Checks	ⓗ Part No. 0727-0335

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains maintenance procedures for the Model 410C Electronic Voltmeter.

5-3. TEST EQUIPMENT REQUIRED.

5-4. The test equipment required to maintain and adjust the Model 410C is listed in Table 5-1. Equipment having similar characteristics may be substituted for items listed.

5-5. PERFORMANCE CHECKS.

5-6. The performance checks presented in this section are front panel operations designed to compare the Model 410C with its published specifications. These operations may be incorporated in periodic maintenance, post repair and incoming quality control checks. These operations should be conducted before any attempt is made at instrument calibration or adjustment. During performance checks, periodically vary the line voltage to the Model 410C, ±10% on either 115 v or 230 v operation. A 1/2 hour warm-up period should be allowed before these tests are conducted.

5-7. ALTERNATE CALIBRATION VOLTAGE SOURCE.

5-8. Should it be necessary to use the ⓗ Model 738AR Voltmeter Calibrator to conduct these Performance Checks, the arrangement described in Figure 5-1 will provide the necessary voltage values required. However, the ⓗ Model 738BR Voltmeter Calibrator is the preferred instrument for these operations.

5-9. MECHANICAL METER ZERO.

a. Turn instrument on. Allow at least a 20 minute warm-up period.

b. Turn voltmeter off, and allow 30 seconds for all capacitors to discharge.

c. Rotate mechanical zero-adjustment screw on front panel clockwise until pointer reaches zero, moving up scale.

d. If for some reason the pointer should overshoot zero, repeat step c until desired results are obtained.

e. When pointer has been positioned at zero, rotate zero-adjust screw slightly counterclockwise to free it. If meter pointer moves to the left during this action, repeat steps c and e.

5-10. DC VOLTMETER OPERATION.

5-11. ACCURACY CHECK (DCV).

a. Short Model 410C DCV probe to COM lead; set pointer to zero using rear panel adjustment (ZERO ADJ).

VER APÊNDICE

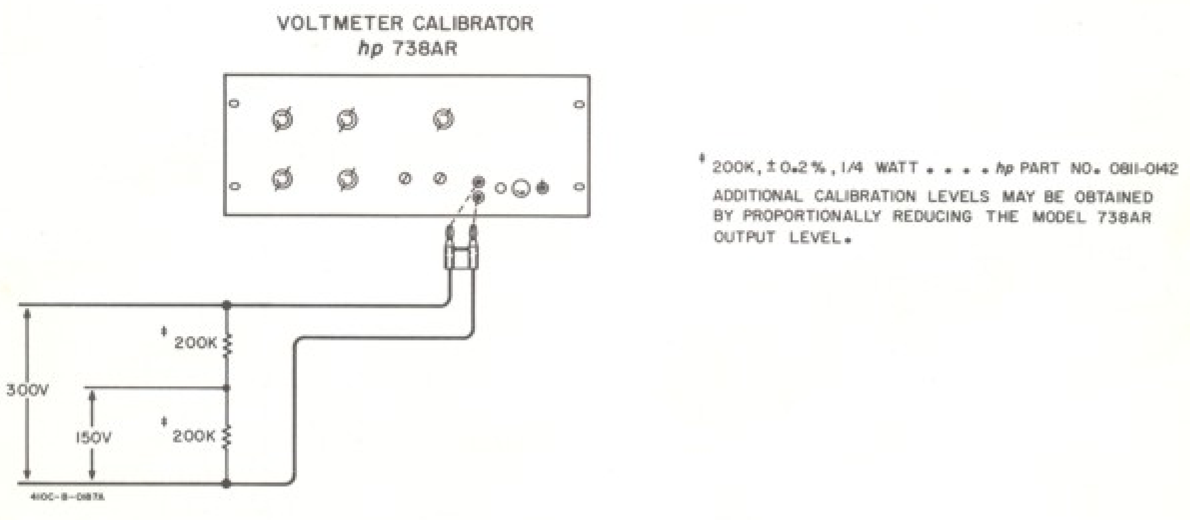


Figure 5-1. Alternate Calibration Voltage Source

b. Set the Model 410C FUNCTION SELECTOR to the +DCV position; RANGE switch to .015 V. Connect Model 410C DCV and COM cables to the Voltmeter Calibrator (hp Model 738BR) output terminals.

c. Adjust voltmeter calibrator and Model 410C to settings listed in Table 5-2.

d. Model 410C should indicate readings within limits specified. If not, refer to Paragraph 5-33 for adjustment procedure.

Table 5-2. DCV Accuracy Test

Model 410C Range Settings	Voltmeter Calibrator Settings Voltage	Model 410C Meter Readings
.015 V	±.015	.0147 to .0153 V
.05 V	±.05	.049 to .051 V
.15 V	±.15	.147 to .153 V
.5 V	±.5	.49 to .51 V
1.5 V	±1.5	1.47 to 1.53 V
5 V	±5	4.9 to 5.1 V
15 V	±15	14.7 to 15.3 V
50 V	±50	49 to 51 V
150 V	±150	147 to 153 V
500 V	±300	290 to 310 V
1500 V	±300	270 to 330 V

5-12. INPUT RESISTANCE CHECK (DCV).

a. Connect an external resistor, R_{series}, of 10 M ohms ±1% (hp Part No. 0370-0168) in series between the voltmeter calibrator and the DCV cable of the Model 410C.

b. Set Model 410C FUNCTION selector to +DCV; RANGE to .015 V.

c. Adjust voltmeter calibrator and Model 410C to settings listed in Table 5-3.

d. Model 410C should read within limits specified. If not, refer to Paragraph 5-35 for adjustment procedure.

NOTE

This method of input resistance measurement is a result of a voltage divider:

$$R_{in} = \left(\frac{E_{meter}}{E_{input} - E_{meter}} \right) R_{series}$$

5-13. DC AMMETER OPERATION.

5-14. ACCURACY CHECK (DCA).

a. Figure 5-2 describes the test arrangement required for this operation. The following additional equipment will also be required:

DC Power Supply (hp Model 723A)

DC Voltmeter (hp Model 3440A/3442A)

10 Ω, 1%, 1 w resistor (hp Part No. 0727-0335)

56 Ω, 1%, 1/2 w resistor (hp Part No. 0811-0341)

10 K, 1%, 1 w resistor (hp Part No. 0727-0157)

56 K, 1%, 1 w resistor (hp Part No. 0730-0053)

b. Connect the Model 410C as shown in Figure 5-2; FUNCTION SELECTOR to +DCA; RANGE to 150 MA.

c. Use 56 ohm resistor for R1 and 10 ohm resistor for R2.

d. Adjust dc power supply to obtain reading on dc voltmeter specified in Table 5-4; change R_1 and R_2 according to Table 5-4.

e. Model 410C should read within limits specified in Table 5-4. If not, refer to Paragraph 5-33 for adjustment procedure.

5-15. OHMMETER OPERATION.

5-16. OHMMETER ACCURACY CHECK.

a. A 10 ohm ±1% resistor (hp Part No. 0727-0335) and a 10 M ±1% resistor (hp Part No. 0730-0168) will be required for this test.

Table 5-3. DCV Input Resistance Test

Model 410C Range Settings	Voltmeter Calibrator Settings Voltage	Model 410C Meter Readings	Model 410C R_{in}
.015 V	.015	.00715 to .00765 V	10 MΩ ±3%
.05 V	.05	.0238 to .0255 V	10 MΩ ±3%
.15 V	.15	.0715 to .0765 V	10 MΩ ±3%
.5 V	.5	.453 to .455 V	100 MΩ ±1%
1.5 V	1.5	1.360 to 1.365 V	100 MΩ ±1%
5 V	5	4.53 to 4.55 V	100 MΩ ±1%
15 V	15	13.60 to 13.65 V	100 MΩ ±1%
50 V	50	45.3 to 45.5 V	100 MΩ ±1%
150 V	150	136.0 to 136.5 V	100 MΩ ±1%
500 V	300	272.0 to 272.5 V	100 MΩ ±1%
1500 V	300	272.0 to 272.7 V	100 MΩ ±1%

NOTE: Input resistance test is dependent on calibration of Model 410C.

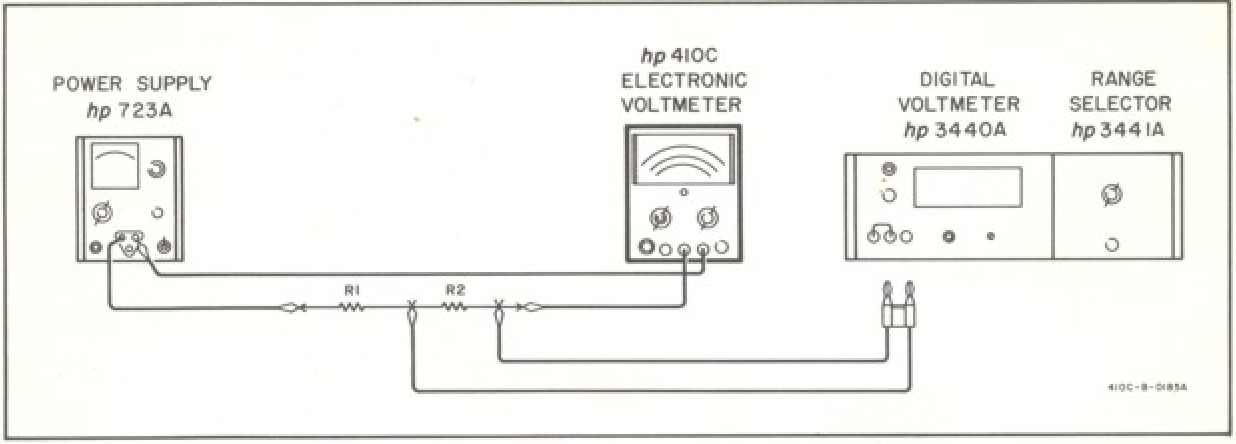


Figure 5-2. DC Ammeter Operation

Table 5-4. DCA Accuracy Test

Model 410C Range Settings	DC Voltmeter Readings	Model 410C Meter Readings	R_1 Ω	R_2 Ω
150 MA	1.4 V	135.5 to 144.5 MA	56	10
50 MA	.4 V	38.5 to 41.5 MA	56	10
15 MA	.14 V	13.55 to 14.55 MA	56	10
5 MA	.04 V	3.85 to 4.15 MA	56	10
1.5 MA	.014 V	1.35 to 1.45 MA	56	10
.5 MA	.004 V	0.385 to 0.415 MA	56	10
150 μa	1.38 V	133.5 to 142.5 μa	56 K	10 K
50 μa	0.46 V	44.5 to 47.5 μa	56 K	10 K
15 μa	0.138 V	13.35 to 14.25 μa	56 K	10 K
5 μa	0.046 V	4.45 to 4.75 μa	56 K	10 K
1.5 μa	0.014 V	1.36 to 1.45 μa	56 K	10 K

b. Set Model 410C FUNCTION SELECTOR to OHMS; RANGE to RX10.

c. Set pointer to ∞ using rear panel adjustment (OHMS ADJ) if required.

d. Connect COM and DCA OHMS cables across 10 ohm resistor.

e. Meter should read 10 ohms (±5%).

f. Set Model 410C RANGE to RX10M. Replace 10 ohm resistor with 10 M ohm resistor.

g. Meter should read 10 M ohms (±5%).

h. If both of these ranges function properly, it can be assumed that the remainder will also. If meter does not function properly, refer to Paragraph 5-36 for adjustment procedure.

5-17. AMPLIFIER OPERATION.

5-18. AMPLIFIER GAIN CHECK.

a. Connect Voltmeter Calibrator (hp Model 738BR) output to Model 410C DCV and COM cables.

b. Connect DC Voltmeter (hp Model 3440A/ 3441A) to DC AMPLIFIER OUTPUT on rear panel of Model 410C. Set DC Voltmeter RANGE to 10 V.

c. Set Model 410C FUNCTION SELECTOR to +DCV; RANGE to .015 V.

d. Adjust voltmeter calibrator for +.015 VDC output.

e. The dc voltmeter should read +1.5 v. This will verify a gain of 100, where the gain equals $E_{DC\ out} / E_{DC\ in}$.

f. If dc voltmeter does not read at least 1.5 v, refer to Paragraph 5-37 for proper adjustment procedure.

5-19. AC REJECTION CHECK.

a. An Oscillator (hp Model 200SR) and an RMS Voltmeter (hp Model 3400A) are required for this check.

b. Set 410C FUNCTION SELECTOR to -DCV; RANGE to .015 V.

c. Connect Oscillator output to Model 410C DCV and COM cables and input of rms voltmeter. Set rms voltmeter to read 10 v.

d. Adjust test oscillator to provide 3.18 v (4.5 v peak) reading on rms voltmeter at 50 cps.

e. Model 410C should not read more than 2.25 mv verifying 66 db ac rejection at 50 cps.

f. Increase frequency to check ac rejection above 50 cps.

g. Switch Model 410C FUNCTION SWITCH to +DCV and repeat steps e and f.

5-20. OUTPUT LEVEL CHECK.

a. A Voltmeter Calibrator (hp Model 738BR) and a DC Voltmeter (hp Model 3440A/3441A) will be required for this check.

b. Connect dc voltmeter to dc amplifier OUTPUT on Model 410C rear panel. Place ground lead between Model 410C circuit ground and earth ground terminals. Set dc voltmeter RANGE to 10 V.

c. Set Model 410C FUNCTION SELECTOR to +DCV; RANGE to 1.5 V.

d. Adjust Voltmeter Calibrator to provide +1.5 v.

e. Model 410C and dc voltmeter should read 1.5 v.

f. If dc voltmeter does not read at least 1.5 v, refer to Paragraph 5-37 for proper adjustment procedure.

5-21. AMPLIFIER OUTPUT IMPEDANCE CHECK.

a. Connect an external DC Voltmeter (hp Model 3440A/3441A) to Model 410C DC AMPLIFIER OUTPUT terminals on rear panel.

b. Set Model 410C FUNCTION SELECTOR to OHMS position; RANGE to RX10K.

c. Record voltage indicated on external dc voltmeter for use as a reference.

d. Connect a 1.5 K ohm ±1% resistor (hp Part No. 0730-0017) across Model 410C DC AMPLIFIER OUTPUT terminals. Dc voltage recorded in step c above should not change more than 3 mv, indicating that dc amplifier output impedance is within the 3 ohm specification at dc.

5-22. AMPLIFIER NOISE CHECK.

a. Connect external DC Voltmeter (hp Model 3440A/3441A) to the DC AMPLIFIER OUTPUT of Model 410C.

b. Set the Model 410C FUNCTION SELECTOR to +DCV; RANGE to 1500 V.

c. Short the Model 410C DCV and COM cables. External dc voltmeter reading should be less than 7.5 mv.

d. Reset Model 410C RANGE to 1.5 V. DC Voltmeter should read less than 7.5 mv.

NOTE

If Model 410C DC OUTPUT is used for recording, the chopper frequency can be adjusted to minimize output noise. Refer to Paragraph 5-31.

5-23. OVERLOAD RECOVERY CHECK.

a. Connect Voltmeter Calibrator (hp Model 738BR) output to Model 410C DCV and COM cables.

b. Set Model 410C FUNCTION SELECTOR to +DCV; RANGE to .15 V.

c. Adjust voltmeter calibrator for +0.15 vdc; note reading on Model 410C.

d. Readjust voltmeter calibrator for +15 VDC output; wait 5 seconds for complete saturation; then switch voltmeter calibrator back to +.15 VDC output. Note time required for meter to return to original position.

e. Recovery time should be less than 3 sec.

5-24. AC VOLTMETER OPERATION.

CAUTION

WHEN MEASURING AC VOLTAGES, DO NOT PERMIT AC GROUND JUMPER OF MODEL 410C AC PROBE TO CONTACT UNGROUNDED SIDE OF AC SOURCE OR SERIOUS DAMAGE TO 410C WILL RESULT.

5-25. AC VOLTMETER ACCURACY CHECK.

a. Connect ACV probe to the Voltmeter Calibrator (hp Model 738BR).

b. Adjust voltmeter calibrator for 400 cps-rms output.

c. Set Model 410C FUNCTION SELECTOR to ACV; RANGE to 500 V; adjust AC ZERO vernier for zero pointer deflection.

d. Adjust the voltmeter calibrator to settings listed in Table 5-5. Model 410C should indicate readings within limits specified. If not, refer to Paragraph 5-38 for corrective action. Record Model 410C readings with 3 v and .3 v inputs.

NOTE

The frequency response tests are performed using reference voltages obtained with 3 v and .3 v inputs.

Table 5-5. AC Accuracy Test

Model 410C Range	Voltmeter Calibrator 400 cps Voltage Selector	Model 410C Readings
500 V	300	285 to 315 V
150 V	150	140.5 to 154.5 V
50 V	50	48.5 to 51.5 V
15 V	15	14.05 to 15.45 V
5 V	5	4.85 to 5.15 V
3 V	3	2.85 to 3.15 V
1.5 V	1.5	1.405 to 1.545 V
.5 V	.5	.485 to .515 V
.5 V	.3	.285 to .515 V

5-26. AC VOLTMETER LOW FREQUENCY RESPONSE CHECK.

a. A Frequency Response Test Set (hp Model 739AR), an Oscillator (hp Model 200SR), a BNC-to-Binding Post Adapter (hp Part No. 10110A), and a 50 ohm Feed-thru Resistor (hp Part No. 11048B) are required for this operation.

b. Connect Model 410C as shown in Figure 5-3.

NOTE

The 50 ohm feed-thru resistor is used to load frequency response test set for impedance match to give accurate frequency response test.

c. Set Model 410C FUNCTION SELECTOR to ACV; RANGE to 5 V.

d. Adjust frequency response test set-oscillator combination to give at 400 cps Model 410C reading recorded in Paragraph 5-25, step d with 3 v input.

e. Set frequency response test set METER SET to convenient SET LEVEL.

f. Vary frequency of frequency response test set-oscillator combination from 20 cps to 10 Mc maintaining reference SET LEVEL on frequency response test set by readjusting test set or oscillator AMPLITUDE. Model 410C should read between 2.7 and 3.3 v at 20 cps and between 2.94 and 3.06 v from 100 cps to 10 Mc.

5-27. AC VOLTMETER HIGH FREQUENCY RESPONSE CHECK.

a. A VHF Signal Generator (hp Model 608C), a UHF Signal Generator (hp Model 612A), a Probe-T-Connector (hp Model 11042A), a Micropotentiometer (Ballantine Model 440), and a DC Voltmeter (hp Model 3440A/3441A) are required for this check. Figure 5-4 describes test arrangement to be used.

NOTE

The micropotentiometer must have the proper radial resistance and current rating to deliver 0.30 v at its output.

b. Set UHF oscillator output to provide output to Model 410C reading recorded in Paragraph 5-25, step c, with .3 v input; frequency to 10 Mc. Record dc voltmeter reading for reference.

c. Vary VHF oscillator frequency from 10 Mc to 480 Mc maintaining reference dc voltmeter reading by readjusting VHF oscillator output. Model 410C should read between .441 and .459 v at frequencies to 100 Mc and between .40 and .50 v at all higher frequencies.

d. Replace VHF oscillator with UHF oscillator in Figure 5-3. Repeat steps b and c for UHF oscillator output frequencies from 480 Mc to 700 Mc.

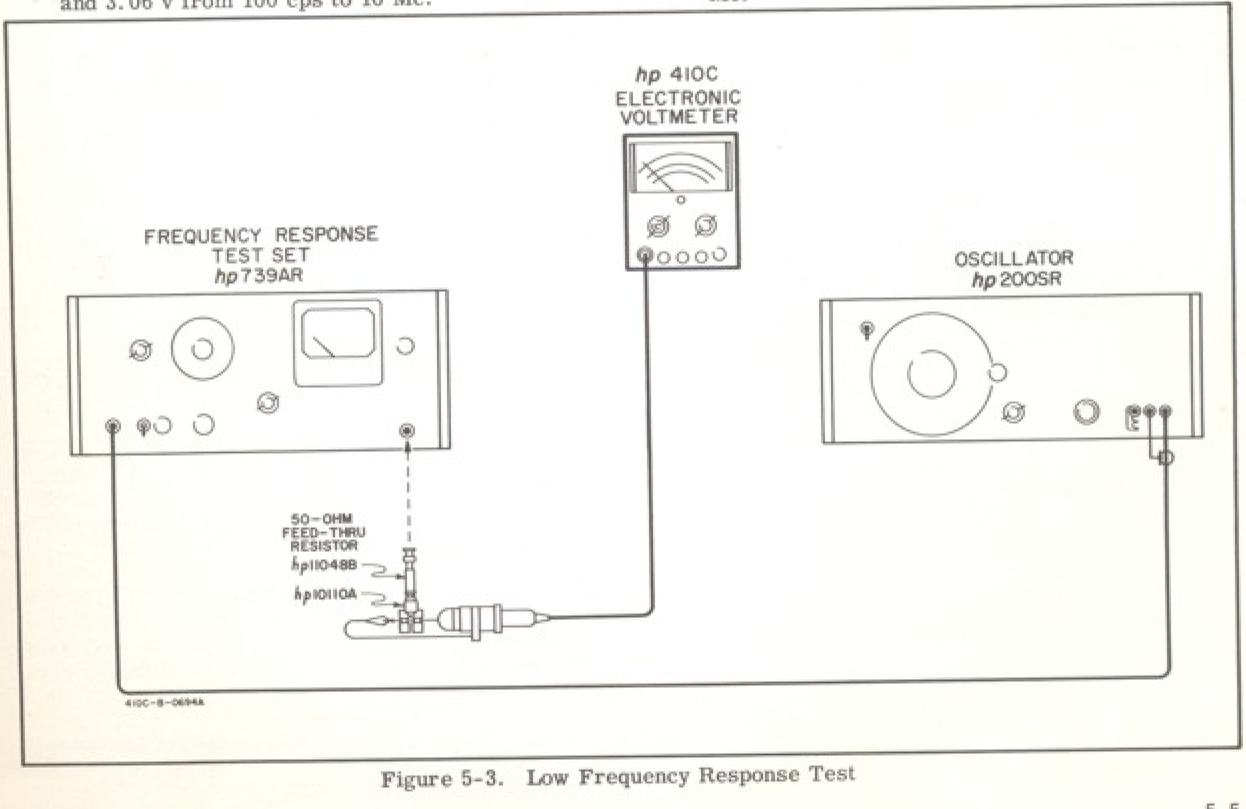


Figure 5-3. Low Frequency Response Test

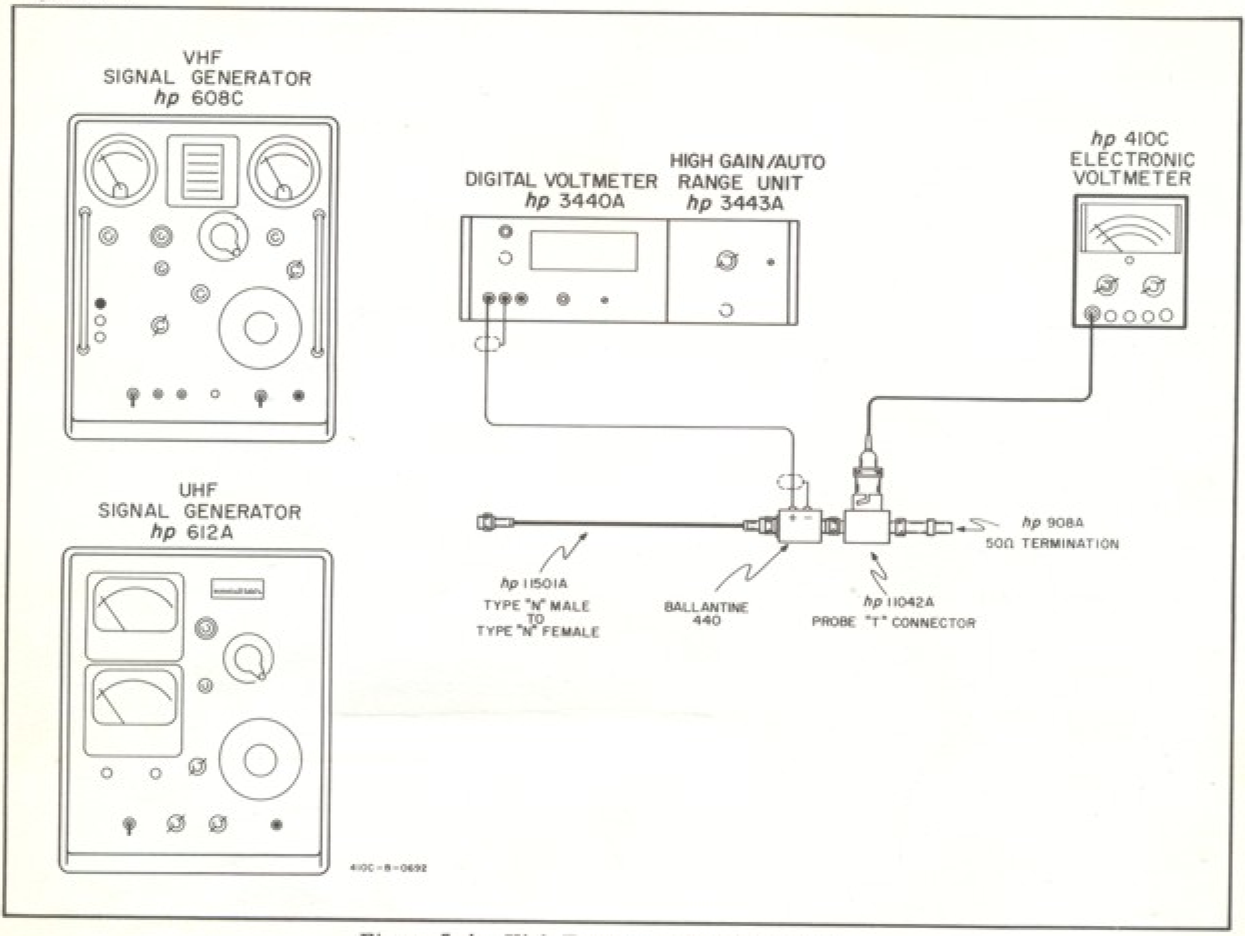


Figure 5-4. High Frequency Response Test

5-28. ADJUSTMENT AND CALIBRATION PROCEDURE.

5-29. The following is a complete adjustment and calibration procedure for the Model 410C. These operations should be conducted only if it has previously been established by Performance Checks, Paragraph 5-5, that the Model 410C is out of adjustment. Indiscriminate adjustment of the internal controls to "refine" settings may actually cause more difficulty. If the procedures outlined do not rectify any discrepancy that may exist, and all connections and settings have been rechecked, refer to Paragraph 5-41, Troubleshooting, for possible cause and recommended corrective action.

5-30. Remove top and bottom covers and two side panels; refer to Figure 5-5 throughout this procedure for location of adjustments.

5-31. CHOPPER FREQUENCY ADJUST.

a. A Voltmeter Calibrator (hp Model 738BR), an Electronic Counter (hp Model 5211A), and an AC Voltmeter (hp Model 3400A) will be required for this operation.

b. Use ac voltmeter to verify Model 410C line voltage of 115 v. Chopper frequency will vary with line voltage variations.

c. Connect Model 410C, electronic counter, and voltmeter calibrator as shown in Figure 5-6.

d. Set Model 410C FUNCTION SELECTOR to +DCV; RANGE to 1.5 V.

e. Adjust voltmeter calibrator to supply +5 v dc to the Model 410C.

f. Observe counter, and adjust A3R5 for a chopper frequency of 100 cps (±2 cps) if operated on a 60 cps line. If operated on 50 cps line, adjust A3R5 for a chopper frequency of 85 cps (±2 cps

g. If line frequency is other than 50 or 60 cps or if fine adjustment of chopper frequency is desired to minimize noise, connect ac voltmeter with RANGE for 0.01 V to Model 410C DC Amplifier OUTPUT.

h. Adjust A3R5 to give minimum voltage reading on ac voltmeter.

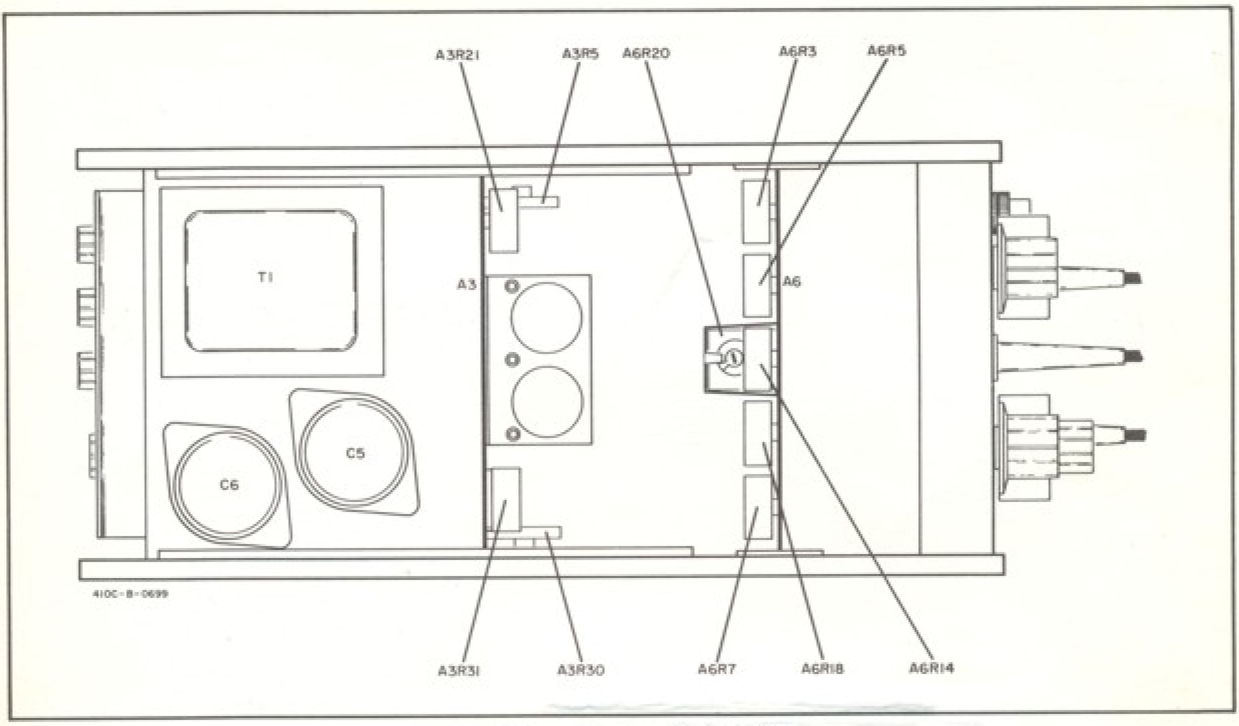


Figure 5-5. Adjustment Location

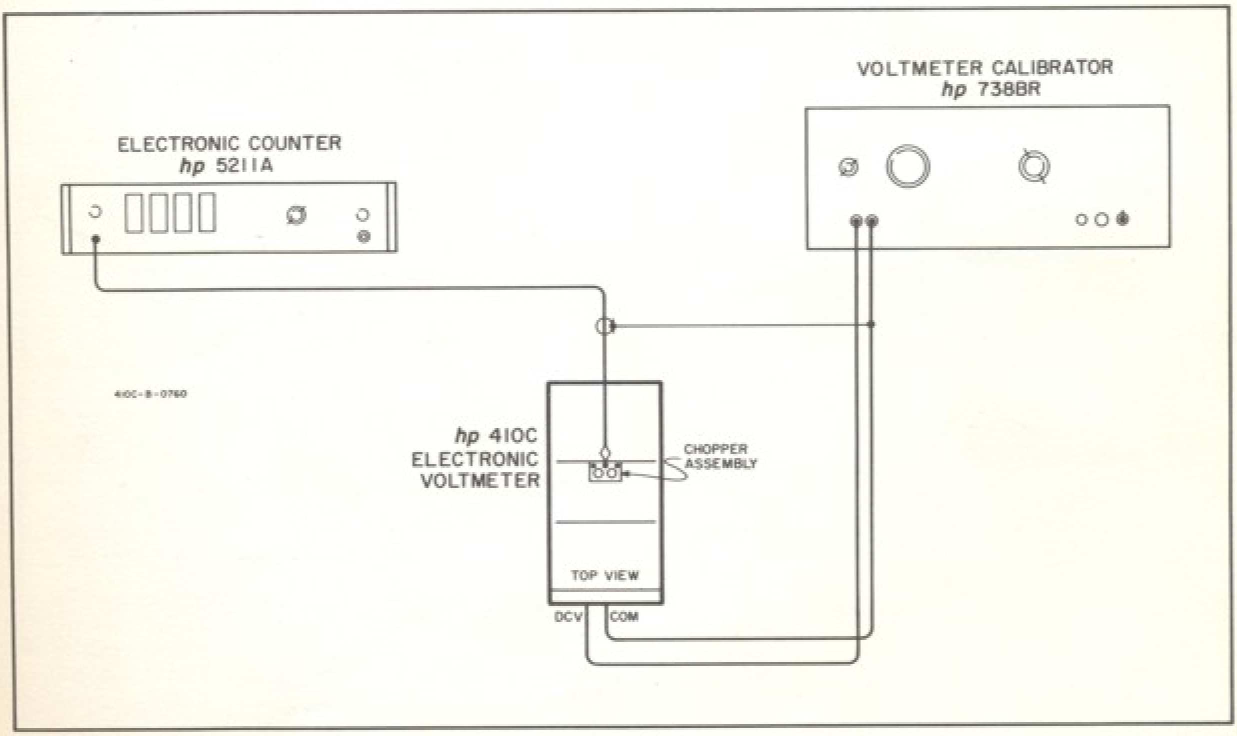


Figure 5-6. Chopper Frequency Adjust Setup

5-32. POWER SUPPLY CHECK.

a. Refer to Table 5-6 and Figure 5-8 for Power Supply check points and typical voltage values. Measure dc voltages between COM lead and designated location on A7.

Table 5-6. Power Supply Test

Voltage	Location on A7 (Figure 5-8)	Tolerance
+175 V	903	±30 V
+38 V	Junction of CR6 and R4	±8.0 V
+6 V	926	±0.6 V
-9 V	Junction of CR7 and R7	±1.8 V

b. Measure +175 volt ac ripple across 903 and COM with ac voltmeter (hp Model 3400A). RMS value of ripple should not exceed 5.0 mv.

5-33. DC VOLTMETER CALIBRATION.

5-34. DC ZERO ADJUSTMENT AND BIAS.

a. Set Model 410C Function Selector to +DCV and Range Switch to 0.5 V.

b. Short DCV Cable to COM Cable.

c. Adjust A3R21 ~~fully counterclockwise, then rotate about 20 degrees clockwise~~. FOR ZERO METER

d. ~~Adjust ZERO ADJ on rear panel for zero meter deflection~~. Switch to -DCV. If any deflection is observed, adjust ZERO ADJ to return meter pointer halfway back to zero. Check zero setting on all ranges for both +DCV and -DCV. Zero offset shall not exceed 1% in any case.

5-35. DC FULL SCALE ADJUST.

a. Connect Model 410C DCV and COM cables to Voltmeter Calibrator (hp Model 738BR) output terminals.

b. Set Model 410C FUNCTION SELECTOR to the +DCV position; RANGE switch to 0.015 V.

c. Adjust voltmeter calibrator to settings listed in Table 5-7.

d. Select proper A6R18 setting which will provide best overall full scale readings for 0.015 V, 0.05 V, and 0.15 V ranges. Adjust A3R30 for best overall full scale readings for ranges above 0.15 V.

NOTE

A6R18 must be adjusted before A3R30, because A6R18 affects all ranges and A3R30 only affects ranges above 0.15 V.

5-36. OHMMETER CALIBRATION.

a. Set Model 410C FUNCTION SELECTOR to OHMS; RANGE to RX10M.

b. Short OHMS and COM cables. Model 410C should read zero.

c. Vary Model 410C RANGE switch through remainder of OHMS settings. Meter should read zero, except at RX10 when meter should read about 0.1 ohms (resistance of leads).

d. Disconnect OHMS and COM cables. Set OHMS ADJ (rear panel) for ∞ reading. Check ∞ reading on all OHMS RANGE settings.

5-37. AMPLIFIER OUTPUT CALIBRATION.

a. A Voltmeter Calibrator (hp Model 738BR) and a DC Voltmeter (hp Model 3440A/3441A) is required for this calibration.

b. Set Model 410C FUNCTION SELECTOR to +DCV; RANGE to 5 V.

c. Adjust voltmeter calibrator to provide 5 V. Set dc voltmeter RANGE to 10 V.

d. Connect Model 410C DCV probe and COM lead to output of voltmeter calibrator. Connect dc voltmeter to dc amplifier OUTPUT on Model 410C rear panel.

e. Adjust A6R20 to give 1.5 v reading on dc voltmeter.

NOTE

Amplifier output will provide a negative voltage for all negative dc and ac inputs. The AC Probe is designed to provide a negative dc voltage to Model 410C.

Table 5-7. DCV Calibration Procedure

Model 410C Range Settings	Voltmeter Calibrator Settings Voltage	Model 410C Meter Readings	Adjustment
.015 V	.015	.0147 to .0153 V	A6R18
.05 V	.05	.049 to .051 V	A6R18
.15 V	.15	.147 to .153 V	A6R18
.5 V	.5	.49 to .51 V	A3R30
1.5 V	1.5	1.47 to 1.53 V	A3R30
5 V	5	4.9 to 5.1 V	A3R30
15 V	15	14.7 to 15.3 V	A3R30
50 V	50	49 to 51 V	A3R30
150 V	150	147 to 153 V	A3R30
500 V	300	290 to 310 V	A3R30
1500 V	300	270 to 330 V	A3R30

5-38. AC VOLTMETER CALIBRATION.

5-39. AC ZERO ADJUST.

a. Set Model 410C FUNCTION SELECTOR to ACV; RANGE to 0.5 V. Ensure full insertion of telephone plug from ac probe into Model 410C.

b. Set AC ZERO vernier on front panel to center of rotation.

c. Short Model 410C ac probe and ac probe common (short lead).

d. Adjust A3R31 for Model 410C approximately zero deflection.

e. Fine adjust AC ZERO vernier for Model 410C zero deflection.

5-40. AC FULL SCALE ADJUST.

CAUTION

WHEN MEASURING AC VOLTAGES, DO NOT PERMIT AC GROUND JUMPER OF MODEL 410C AC PROBE TO CONTACT UNGROUNDED SIDE OF AC SOURCE OR SERIOUS DAMAGE TO 410C WILL RESULT.

a. Connect Model 410C ac probe to voltmeter calibrator output terminals. Set Model 410C FUNCTION SELECTOR to ACV; RANGE to 0.5 V.

b. Adjust voltmeter calibrator to settings listed in Table 5-8 at 400 cps-rms output.

c. Adjust potentiometers called for under "Adjustment" to provide Model 410C readings listed.

Table 5-8. AC Full Scale Adjust

Model 410C Range	Voltmeter Calibrator AC Voltage Settings	Model 410C Reading ±3%	Adjustment
.5 V	.50	.5 V	A6R3
1.5 V	1.5	1.5 V	A6R5
5 V	5	5 V	A6R7
* 15 V	15	15 V	A6R14
* 50 V	50	50 V	A6R14
* 150 V	150	150 V	A6R14
* 500 V	300	300 V	A6R14

* A6R14 is proper adjustment of Model 410C for RANGE settings from 15 vac to 500 vac. Select proper A6R14 setting which will provide best overall results for these ranges.

5-41. TROUBLESHOOTING PROCEDURE.

5-42. This section contains procedures designed to assist in the isolation of malfunctions. These procedures are based on a systematic analysis of the instrument circuitry in an effort to localize the problem. These operations should be undertaken only after it has been established that the difficulty cannot be eliminated by the Adjustment and Calibration Procedures, Paragraph 5-28. An investigation should also be made to insure that the trouble is not a result of conditions external to the Model 410C.

5-43. Conduct a visual check of the Model 410C for possible burned or loose components, loose connections, or any other obvious conditions which might suggest a source of trouble.

5-44. Table 5-9 contains a summary of the front-panel symptoms that may be encountered. It should be used in initial efforts to select a starting point for troubleshooting operations.

5-45. Figure 5-7 contains procedures which may be used as a guide in isolating malfunctions.

5-46. The checks outlined in Figure 5-7 are not designed to measure all circuit parameters, rather only to localize the malfunction. Therefore, it is quite possible that additional measurements will be required to completely isolate the problem. Amplifier gain may also vary slightly between instruments; therefore it should not be necessary to precisely duplicate waveforms or values described.

5-47. Refer to Figure 5-10 for typical waveforms encountered in the Model 410C. Waveforms represent signals which occur when instrument is operating during overdriven conditions (0.5 vdc input to 0.015 v RANGE).

5-48. SERVICING ETCHED CIRCUIT BOARDS.

5-49. The ⓗ Model 410C has three etched circuit boards. Use caution when removing them to avoid damaging mounted components. The ⓗ Part Number for the assembly is silk screened on the interior of the circuit board to identify it. Refer to Section VI for parts replacement and ⓗ Part Number information.

5-50. The etched circuit boards are a plated-through type. The electrical connection between sides of the board is made by a layer of metal plated through the component holes. When working on these boards, observe the following general rules.

a. Use a low-heat (25 to 50 watts) small-tip soldering iron, and a small diameter rosin core solder.

b. Circuit components can be removed by placing the soldering iron on the component lead on either side of the board, and pulling up on lead. If a component is obviously damaged, clip leads as close to component as possible and then remove. Excess heat can cause the circuit and board to separate, or cause damage to the component.

c. Component lead hole should be cleaned before inserting new lead.

d. To replace components, shape new leads and insert them in holes. Reheat with iron and add solder as required to insure a good electrical connection.

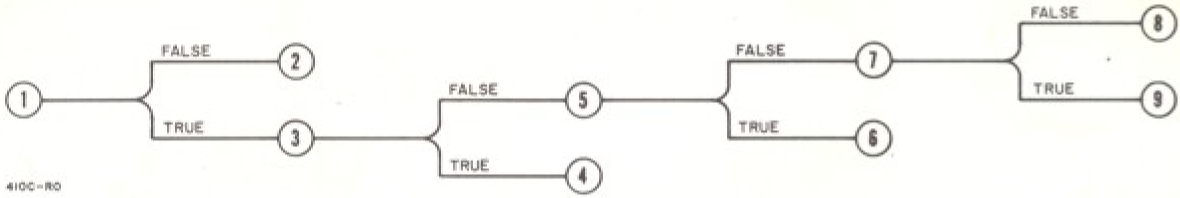
e. Clean excess flux from the connection and adjoining area.

f. To avoid surface contamination of the printed circuit, clean with weak solution of warm water and mild detergent after repair. Rinse thoroughly with clean water. When completely dry, spray lightly with Krylon (#1302 or equivalent).

Table 5-9. Front Panel Troubleshooting Procedure

FRONT PANEL SYMPTOM	POSSIBLE CAUSE
No meter deflection with input. ON - OFF lamp not glowing.	Check fuse (F1) on back panel.
In -DCV, pointer deflects 1/2 scale. In +DCV, pointer pegs downscale.	Check A3C5 (Figure 5-11).
In +DCV, pointer pegs downscale. In -DCV, pointer pegs upscale.	Check A3Q1, A3C6 or A3C12 (Figure 5-11).
Excessive jitter. Ohms function; all ranges except RX10M.	Check A2R2 (Figure 4-5).
*DCA mode out on 50 ma and 150 ma ranges.	Check A2R25 and A2R26 (Figure 4-3).
*If ∞ ADJ is effective in ranges from RX10 to RX1M, then shifts when RANGE switch is set to RX10M.	Check A2R2 (Figure 4-5).
*AC ZERO will not adjust properly. Pointer responds to input variations.	Check A1R5, A1R6, A1R7 and A3R31 (Figure 4-6).
*Operates in DCV mode on ranges 0.015 v to 0.15 v, but fails on higher ranges.	Check A2R2 and A3R30.
Dc amplifier output is +1.5 v. Meter will not deflect full scale in DCV or DCA mode.	Check A6R21, A6R20, A6R1, A6R18 and A6R17 (Figure 4-4).
*Meter pegs upscale on all ranges. +DC Amplifier output is high regardless of mode of operation.	Check for open resistor in amplifier feedback loop or shorted A1R10 (Figure 5-11).
In ACV mode, pointer will not deflect full scale with proper input applied.	Refer to Paragraph 5-38.
Operates on all ranges in ACV mode except 5 v ac position.	Check A6R16 and A6CR1 (Figure 4-6).
Instrument inoperative in all modes. Meter has slight random drift pattern.	Check chopper assembly. Connect 1 M ohm resistor across A4V1. If photocell were open, meter will now respond to input. Use 100 K resistor across A4V3 to check DC - Modulator (Figure 5-10).
Meter oscillates full scale at rate of 5 - 10 cps.	Check chopper assembly. Connect 1 M ohm resistor across A4V2. If photocell were open, instrument will now respond to input. Use 100 K resistor across A4V2 to check DC - Modulator (Figure 5-10).
No ac zero.	Check C1 for short to chassis (Figure 4-6). Check ac probe.
No deflection on OHMS; dc ranges operative.	Check OHMS and DCA lead for short to common at alligator clip.
0.5 and 1.5 VAC range will not track.	Check A8V1 (Figure 5-13). Substitute known good ac probe.
5 VAC range will not track.	Check A6CR1.

* Refer to ⑥, Table 5-11.



(1) Check power supply voltage values using the procedure outlined in Paragraph 5-29. If voltages are correct, proceed to (3). If voltages are incorrect, proceed to (2).

(2) If malfunction appears in the power supply, and adjustment of the chopper frequency to 100 cps does not reduce the error, refer to Figure 5-8 for further investigation. Check voltage and resistance values listed with Model 410C FUNCTION +DCV; RANGE 0.015 v; INPUT +0.015 v. When deviation is noted, trace circuit investigating for faulty component.

(3) With Model 410C FUNCTION SELECTOR to +DCV; RANGE 0.015 v; overdrive with a +0.5 v input. Measure the dc voltage at the DC AMPLIFIER OUTPUT on Model 410C rear panel. Output should be approximately +4.0 v. If this measurement is correct, disconnect source and short DCV probe and COM lead. If output is zero, proceed to (5); if not, proceed to (4).

(4) Trace circuit from Pin 11, A3 to Pin 2, A6. Use ohmmeter to check values of A6R21, A6R20, A6R17 and A6R1. Refer to Figure 5-11 for pertinent component values. Check pertinent dc voltages under conditions listed in NOTE No. 11.

(5) Measure the dc voltage at Pin 1, A3. This voltage is typically 13-15 mv. If this voltage is correct, proceed to (7); if not, proceed to (6).

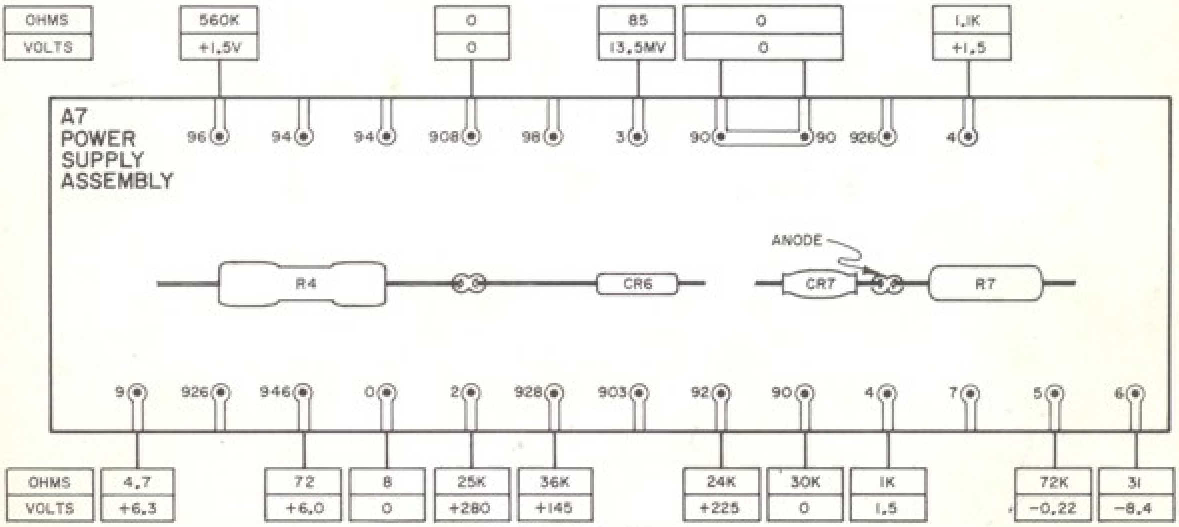
(6) Investigate switch circuit. Refer to asterisks in Table 5-10 for hints on how to troubleshoot switch circuit.

(7) Observe input voltage to demodulator (5) using an oscilloscope. Refer to Figure 5-4 for normal waveform under overdriven conditions specified. If waveform is normal, proceed to (9); if not, proceed to (8).

(8) Investigate the demodulator and cathode follower A1V3B. Refer to Figure 5-11 for typical voltage and parameter values under conditions listed in NOTE No. 11. Refer to Table 5-10 for method to check for open demodulator.

(9) Investigate the modulator and amplifier to include A1V1A, Q1 and Q2. Refer to Figure 5-11 for typical voltage and parameter values under conditions listed in NOTE No. 11. Refer to Table 5-10 for method to check for open modulator.

Figure 5-7. Troubleshooting Procedures



TEST CONDITIONS

VOLTAGE	RESISTANCE	NOTE
FUNCTION: +DCV RANGE: .015 V INPUT: +.015 V REFERENCE: Circuit ground (⏚)	Instrument: OFF FUNCTION: +DCV RANGE: .015 V INPUT: DCV Shorted to COM	Voltage and resistance values listed are approximate values for a typical instrument. Deviations should be in the most significant figure before circuit tracing is warranted.

Figure 5-8. Power Supply Measurements

NOTES

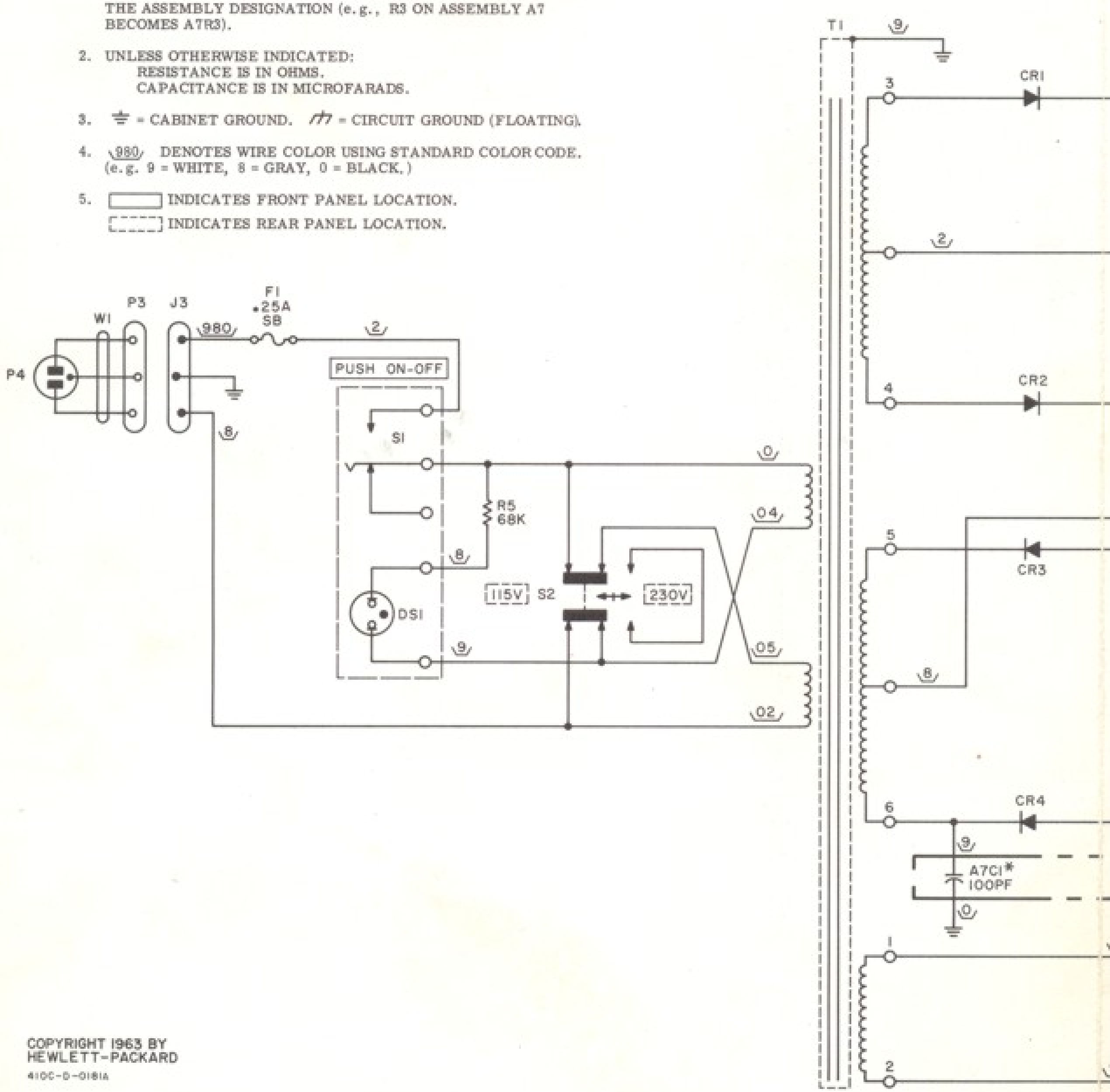
1. ———— — — ———— INDICATES AN ASSEMBLY. ALL COMPONENTS LOCATED ON AN ASSEMBLY ARE PREFIXED BY THE ASSEMBLY DESIGNATION (e.g., R3 ON ASSEMBLY A7 BECOMES A7R3).

2. UNLESS OTHERWISE INDICATED:
   RESISTANCE IS IN OHMS.
   CAPACITANCE IS IN MICROFARADS.

3. ⏚ = CABINET GROUND. ⫽⫽ = CIRCUIT GROUND (FLOATING).

4. \980/ DENOTES WIRE COLOR USING STANDARD COLOR CODE. (e.g. 9 = WHITE, 8 = GRAY, 0 = BLACK.)

5. ▭ INDICATES FRONT PANEL LOCATION.
   ⬚ INDICATES REAR PANEL LOCATION.



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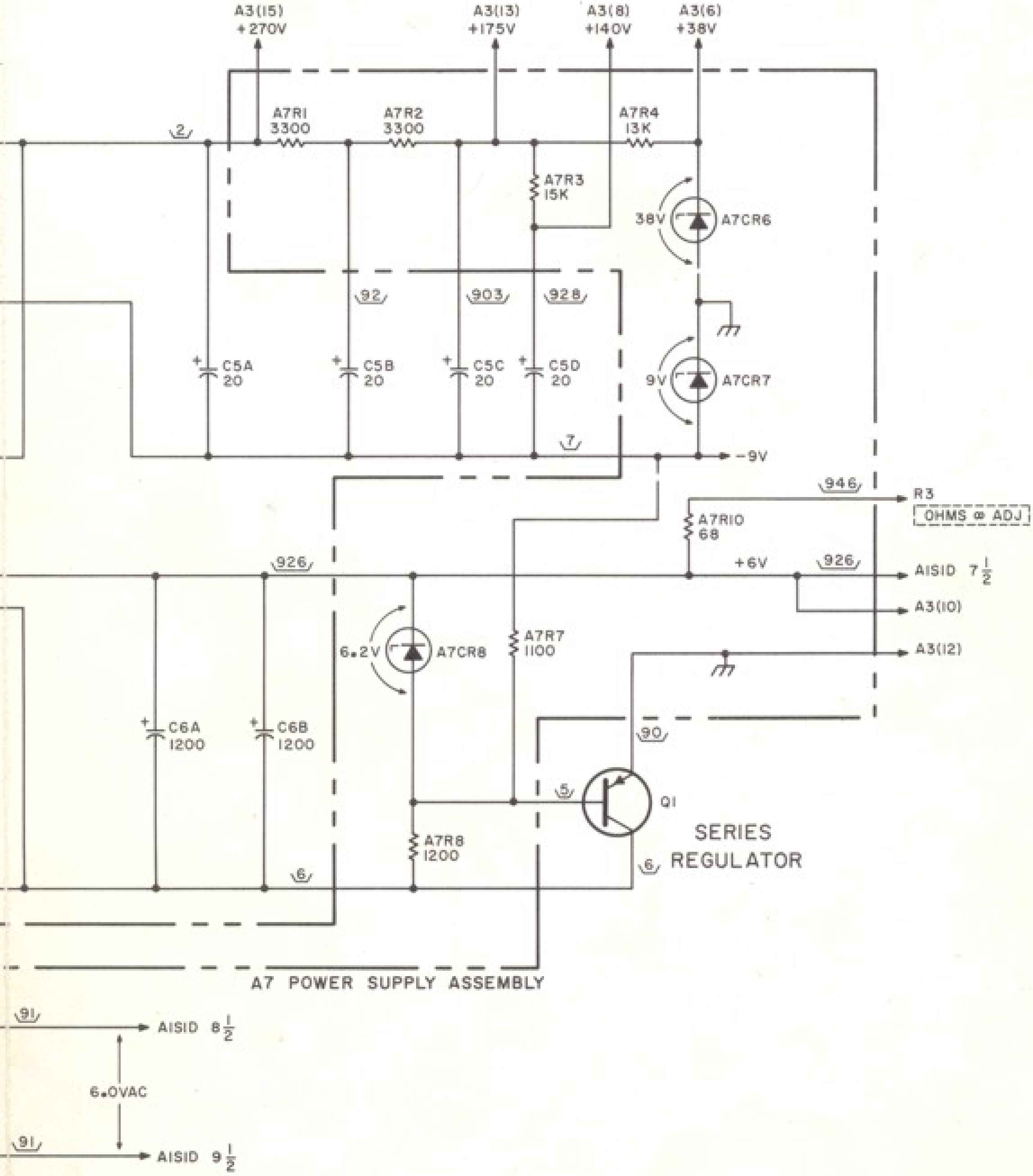


Figure 5-9. Power Supply Schematic

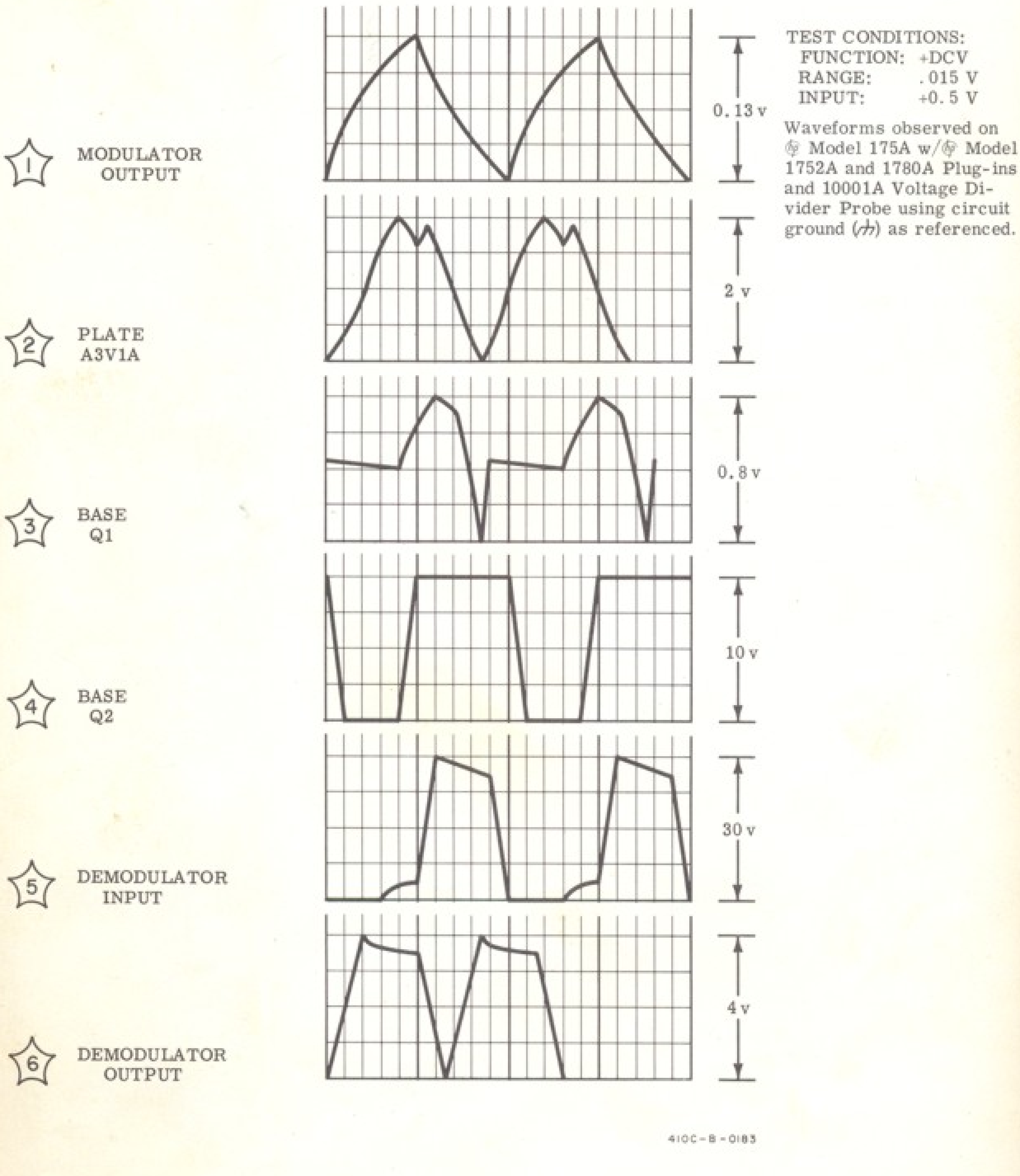


Figure 5-10. Typical Amplifier Waveforms

NOTES

1. A4V1 AND A4V3 ARE LIGHTED SIMULTANEOUSLY BY A4DS1, AND A4V2 AND A4V4 ARE LIGHTED BY A4DS2.

2. UNLESS OTHERWISE NOTED:

   RESISTANCE IS IN OHMS.

   CAPACITANCE IS IN MICROFARADS.

3. SWITCHES ARE SHOWN IN FULL CCW POSITIONS.

4. DC VOLTAGES SHOWN ARE TYPICAL UNDER THE FOLLOWING CONDITIONS:

   FUNCTION: +DCV

   RANGE: 1.5 V

   INPUT: +1.5 V

5. ——— – – ——— INDICATES AN ASSEMBLY. ALL COMPONENTS LOCATED ON AN ASSEMBLY ARE PREFIXED BY THE ASSEMBLY DESIGNATION (e.g., R3 ON ASSEMBLY A7 BECOMES A7R3.)

6. — — — — — — — INDICATES SUBASSEMBLY.

7. ▬ ▬ ▬ ▬ ▬ ▬ ▬ INDICATES DC FEEDBACK.

8. P/O = PART OF.

9. ☐ INDICATES FRONT PANEL LOCATION.

   ⬚ INDICATES REAR PANEL LOCATION.

10. ○ INDICATES PANEL ADJUST.

    ⊘ INDICATES SCREWDRIVER ADJUST.

11. ⏚ = CABINET GROUND.

    ⏚ = CIRCUIT GROUND (FLOATING).

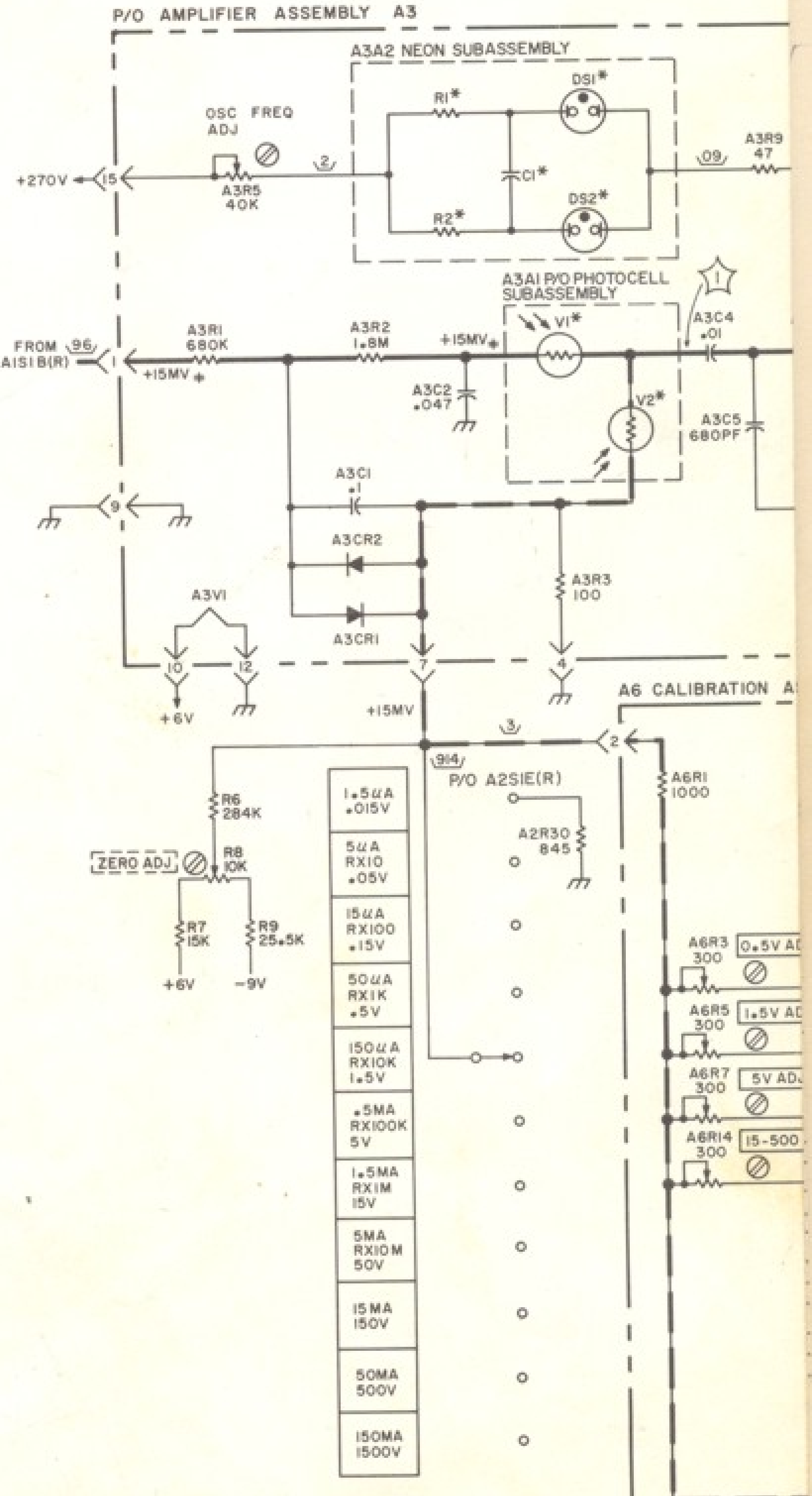
12. \935/ DENOTES WIRE COLOR USING STANDARD COLOR CODE. (e.g. 9 = WHITE, 3 = ORANGE, 5 = GREEN.)

13. * = OPTIMUM VALUE SELECTED AT FACTORY.

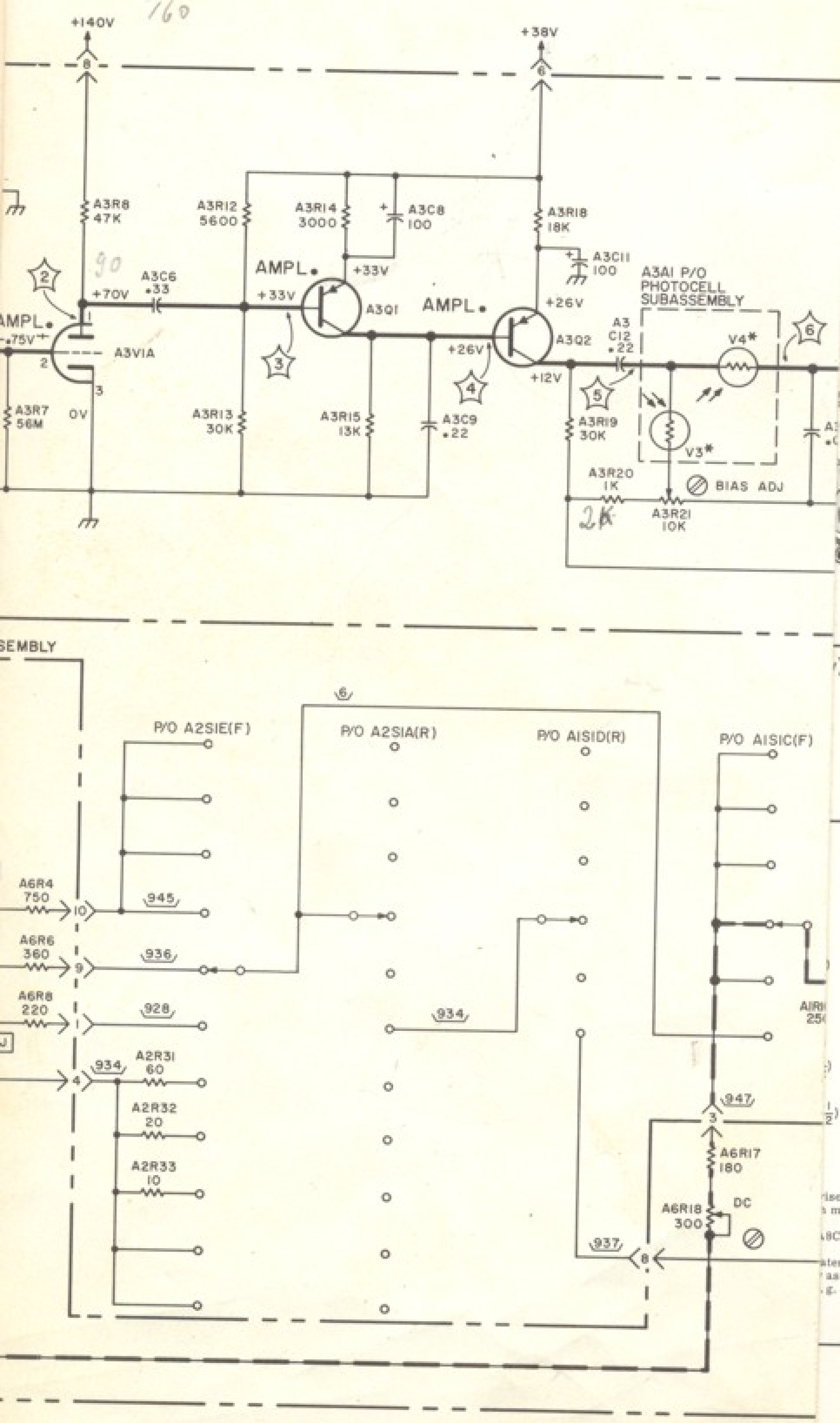
14. ⧺ VOLTAGE IS DEPENDENT ON LOAD INTRODUCED BY EXTERNAL VOLTMETER.

15. + VOLTAGE VARIES ACCORDING TO INDIVIDUAL TUBE.

16. ⫲ PIN 8 IS REFERENCE. VOLTAGE VARIES ACCORDING TO INDIVIDUAL TUBE.


P/O AMPLIFIER ASSEMBLY A3
A3A2 NEON SUBASSEMBLY
OSC FREQ ADJ
+270V
A3R5 40K
R1*
R2*
C1*
DS1*
DS2*
A3R9 47
A3A1 P/O PHOTOCELL SUBASSEMBLY
FROM A1S1 B(R)
A3R1 680K
A3R2 1.8M
+15MV
A3C2 .047
V1*
V2*
A3C4 .01
A3C5 680PF
A3C1 .1
A3CR2
A3CR1
A3R3 100
A3V1
+6V
+15MV
A6 CALIBRATION A
A6R1 1000
P/O A2S1E(R)
A2R30 845
R6 284K
ZERO ADJ
R8 10K
R7 15K
R9 25.5K
+6V
-9V
1.5μA .015V
5μA RX10 .05V
15μA RX100 .15V
50μA RX1K .5V
150μA RX10K 1.5V
.5MA RX100K 5V
1.5MA RX1M 15V
5MA RX10M 50V
15MA 150V
50MA 500V
150MA 1500V
A6R3 300
0.5V AD
A6R5 300
1.5V AD
A6R7 300
5V ADJ
A6R14 300
15-500

410C-D-0181A



+140V
160
+38V
A3R8
47K
A3R12
5600
A3R14
3000
A3C8
100
A3R18
18K
A3C11
100
90
A3C6
.33
+70V
AMPL.
+33V
A3Q1
AMPL.
+26V
A3Q2
+12V
A3
C12
.22
A3A1 P/O
PHOTOCELL
SUBASSEMBLY
V4*
V3*
A3V1A
.75V
0V
A3R7
56M
A3R13
30K
A3R15
13K
A3C9
.22
A3R19
30K
A3R20
1K
2K
A3R21
10K
BIAS ADJ
SEMBLY
P/O A2S1E(F)
P/O A2S1A(R)
P/O A1S1D(R)
P/O A1S1C(F)
A6R4
750
945
A6R6
360
936
A6R8
220
928
934
A2R31
60
A2R32
20
A2R33
10
934
947
A6R17
180
A6R18
300
DC
937

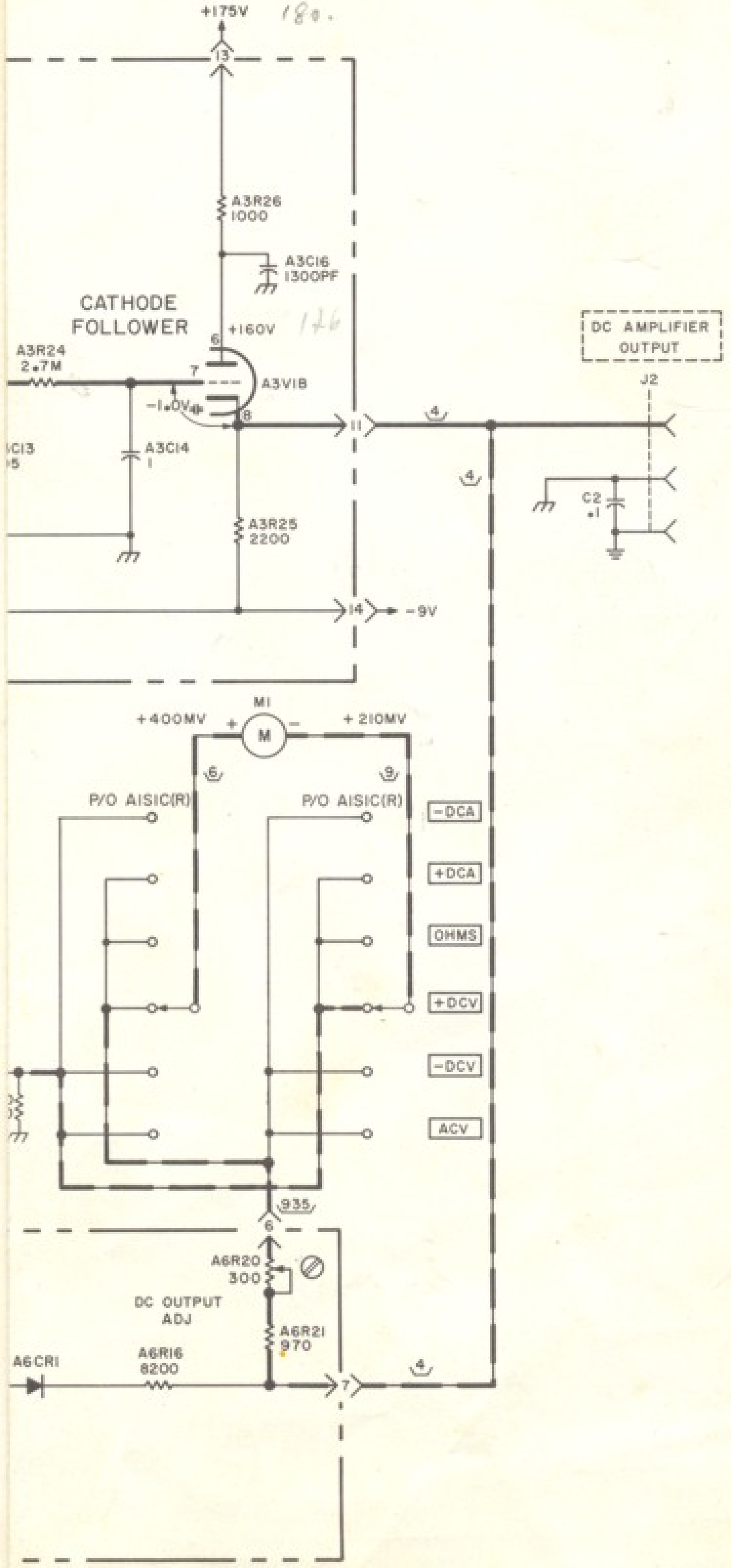


Figure 5-11. Amplifier Schematic

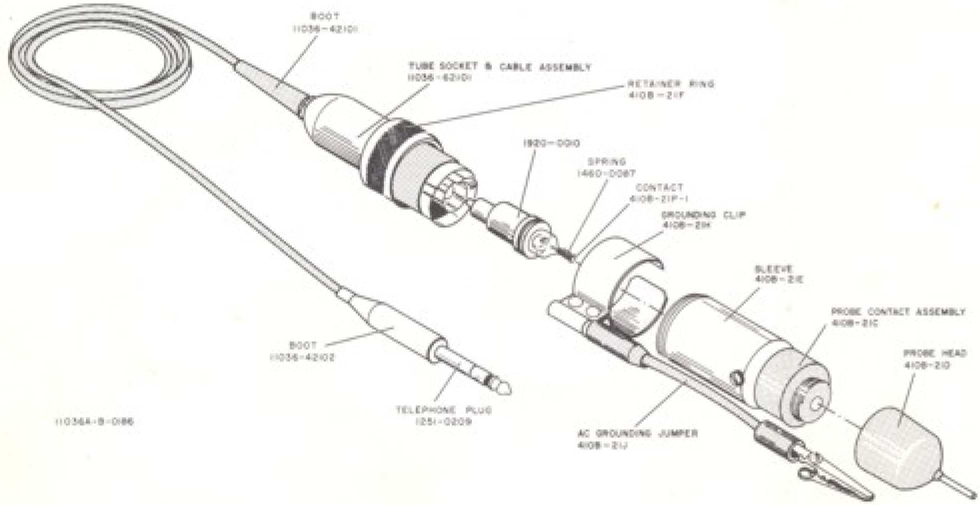


Figure 5-12. Model 11036A AC Probe (Exploded View)

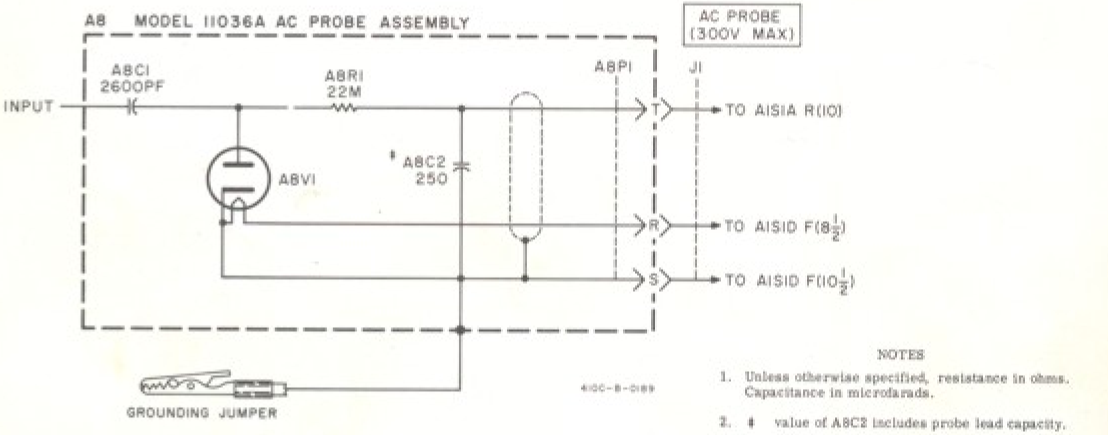
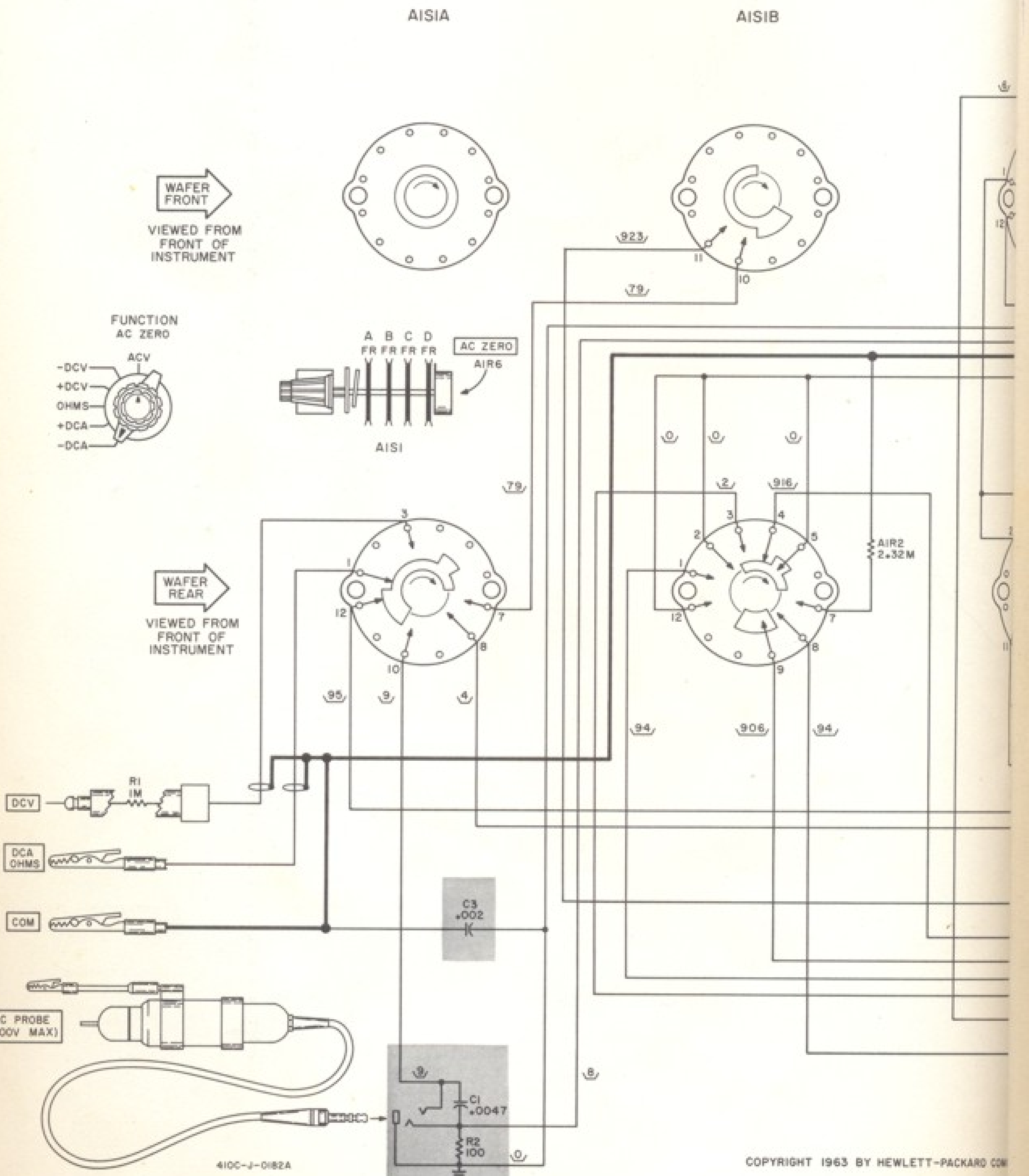


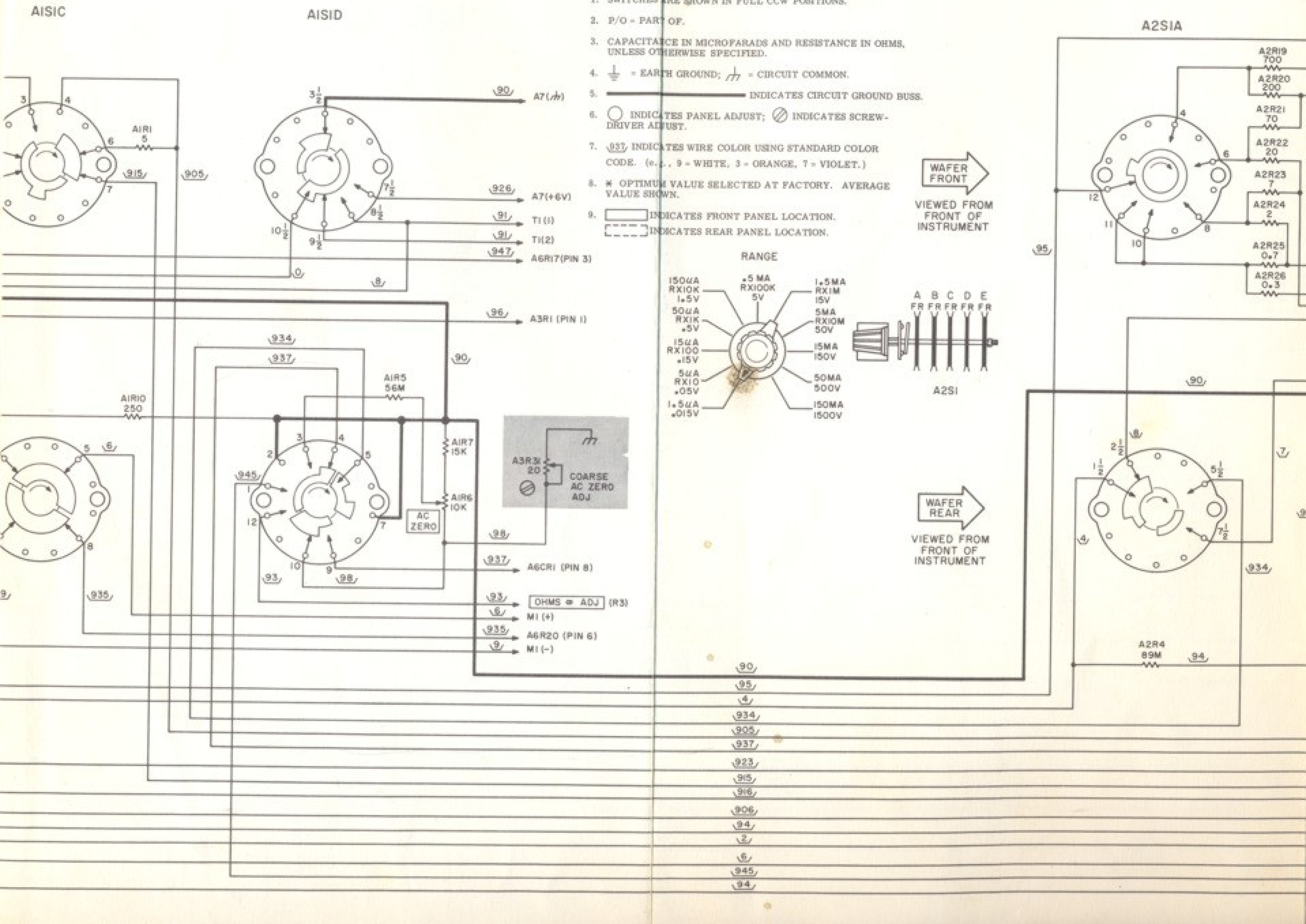
Figure 5-13. Model 11036A AC Probe Schematic

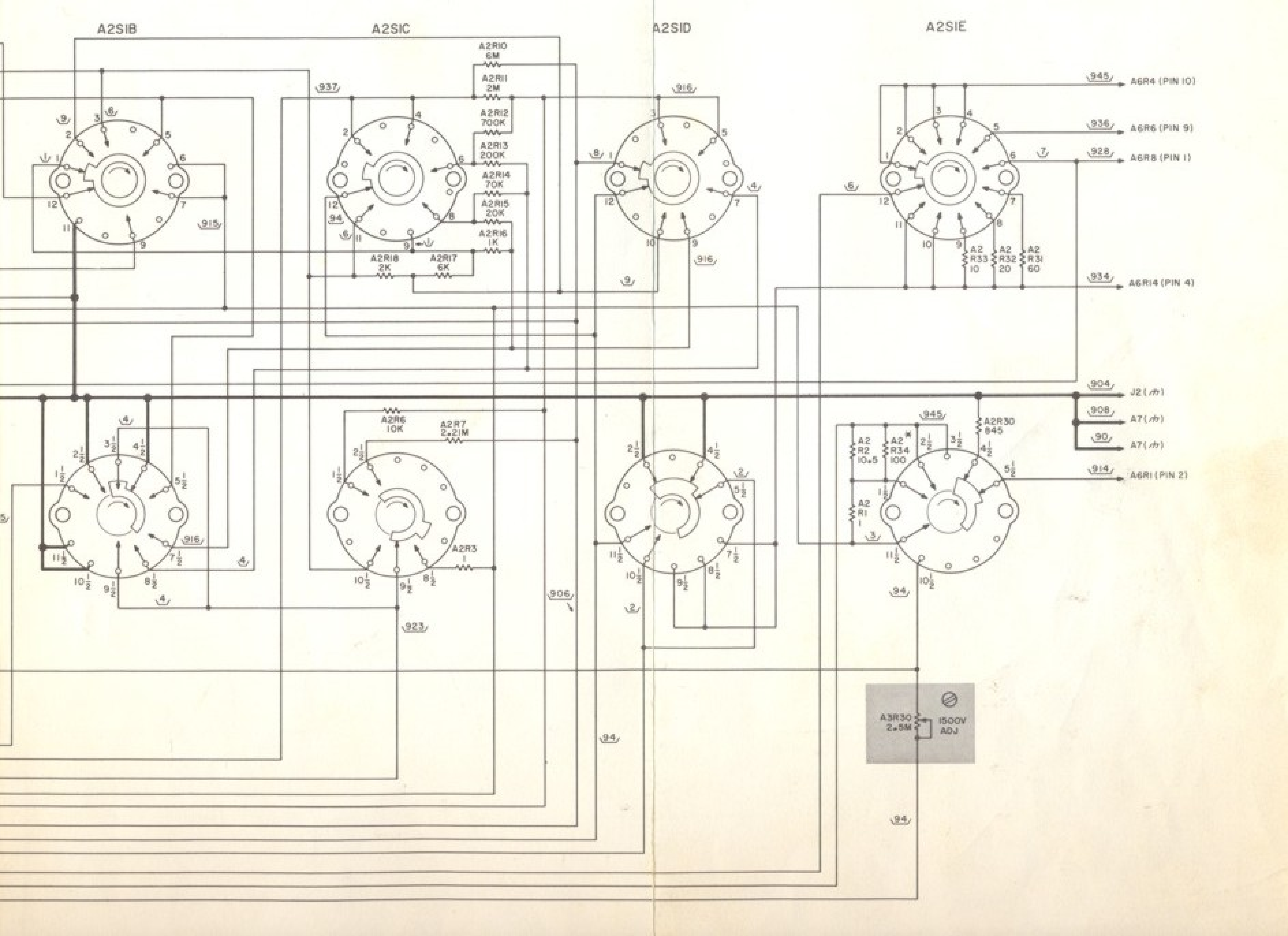


AISIA
AISIB
WAFER FRONT
VIEWED FROM FRONT OF INSTRUMENT
FUNCTION
AC ZERO
ACV
-DCV
+DCV
OHMS
+DCA
-DCA
A B C D
FR FR FR FR
AC ZERO
AIR6
AISI
WAFER REAR
VIEWED FROM FRONT OF INSTRUMENT
AIR2
2.32M
DCV
RI
IM
DCA
OHMS
COM
C3
.002
AC PROBE
(300V MAX)
CI
.0047
R2
100
410C-J-0182A

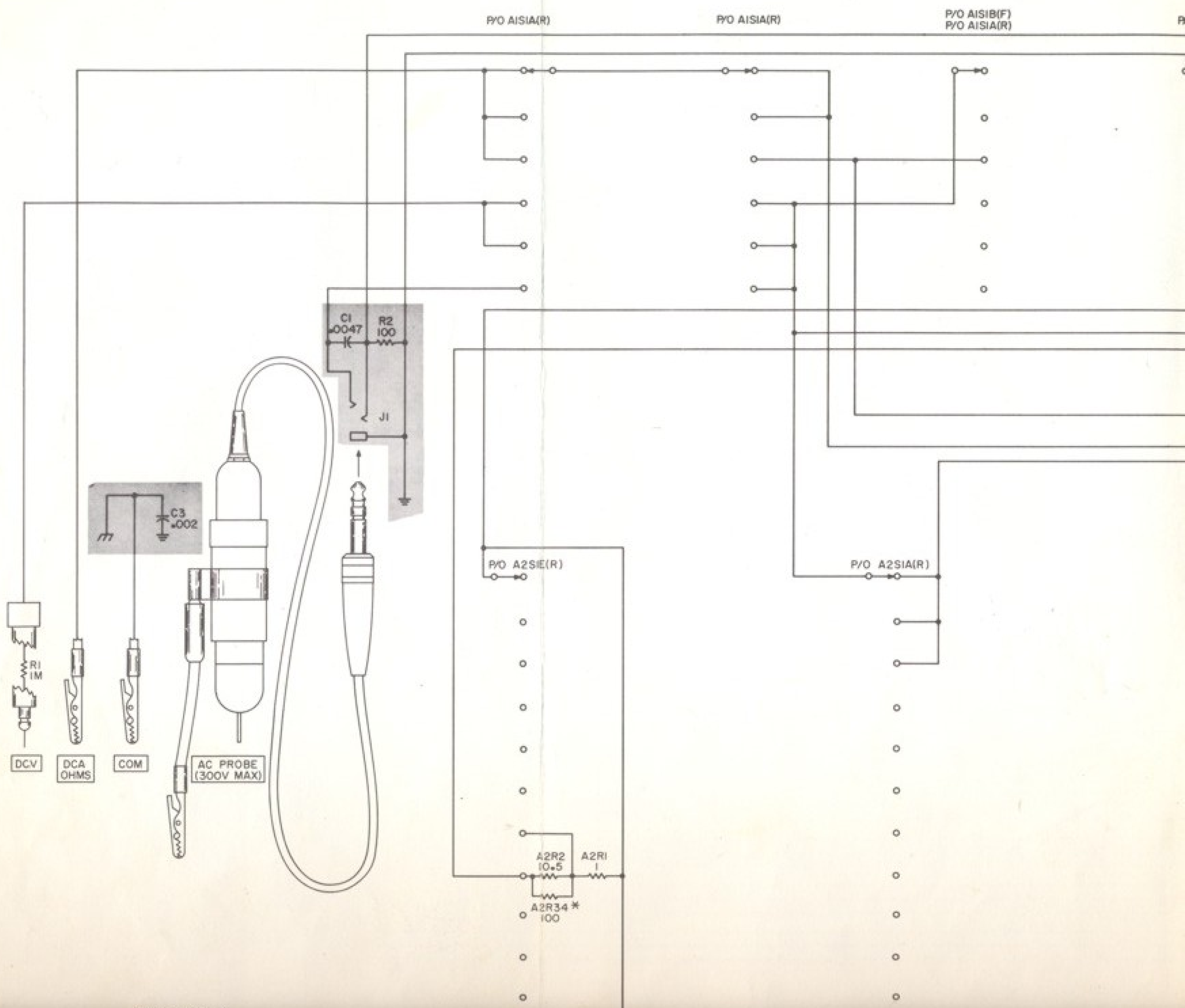
NOTES

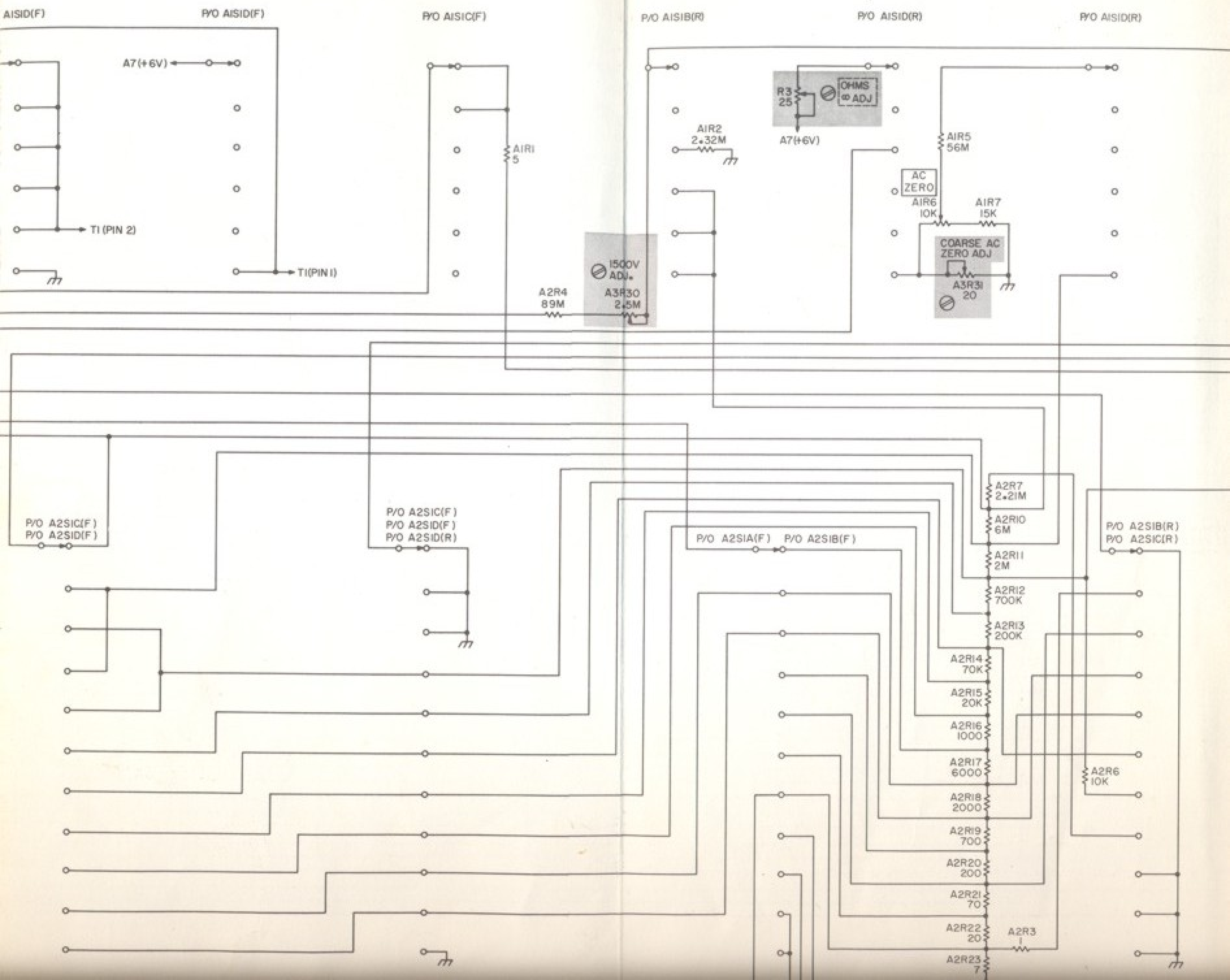
1. SWITCHES ARE SHOWN IN FULL CCW POSITIONS.
2. P/O = PART OF.
3. CAPACITANCE IN MICROFARADS AND RESISTANCE IN OHMS, UNLESS OTHERWISE SPECIFIED.
4. ⏚ = EARTH GROUND; ⊥ = CIRCUIT COMMON.
5. ▬▬ INDICATES CIRCUIT GROUND BUSS.
6. ○ INDICATES PANEL ADJUST; ⊘ INDICATES SCREWDRIVER ADJUST.
7. 937 INDICATES WIRE COLOR USING STANDARD COLOR CODE. (e.g., 9 = WHITE, 3 = ORANGE, 7 = VIOLET.)
8. * OPTIMUM VALUE SELECTED AT FACTORY. AVERAGE VALUE SHOWN.
9. ▭ INDICATES FRONT PANEL LOCATION. ⬚ INDICATES REAR PANEL LOCATION.

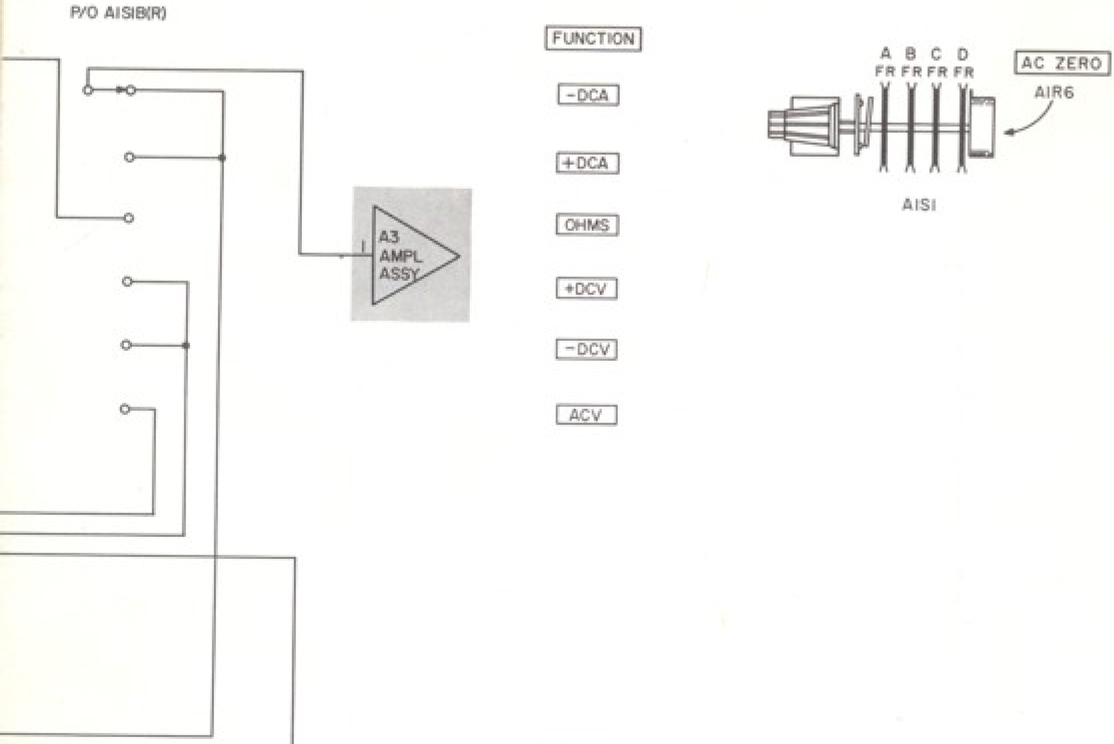


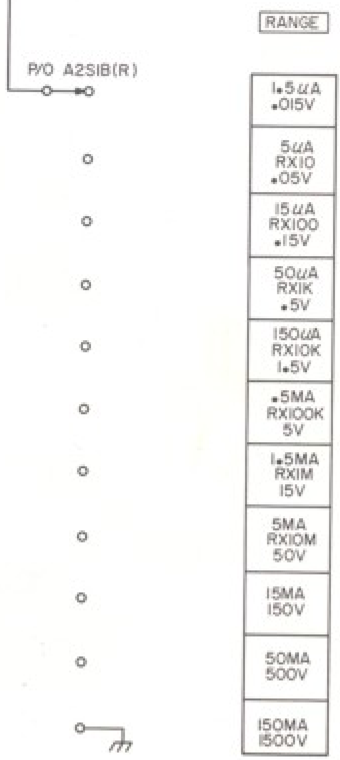


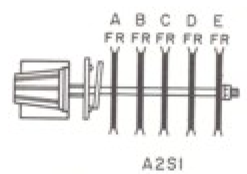
A2S1B
A2S1C
A2S1D
A2S1E
A2R10 6M
A2R11 2M
A2R12 700K
A2R13 200K
A2R14 70K
A2R15 20K
A2R16 1K
A2R18 2K
A2R17 6K
A2 R33 10
A2 R32 20
A2 R31 60
945
A6R4 (PIN 10)
936
A6R6 (PIN 9)
928
A6R8 (PIN 1)
934
A6R14 (PIN 4)
904
J2
908
A7
90
A7
914
A6R1 (PIN 2)
937
916
915
94
923
906
A2R6 10K
A2R7 2.21M
A2R3 1
A2R30 845
A2 R2 10.5
A2 R34 100
A2 R1 1
A3R30 2.5M
1500V ADJ


P/O AISIA(R)
P/O AISIA(R)
P/O AISIB(F)
P/O AISIA(R)
CI
.0047
R2
100
JI
C3
.002
RI
IM
DCV
DCA
OHMS
COM
AC PROBE
(300V MAX)
P/O A2SIE(R)
P/O A2SIA(R)
A2R2
10.5
A2RI
I
A2R34 *
100


AISID(F)
P/O AISID(F)
P/O AISIC(F)
P/O AISIB(R)
P/O AISID(R)
P/O AISID(R)
A7(+6V)
TI (PIN 2)
TI(PIN I)
AIRI
5
AIR2
2.32M
R3
25
OHMS
∞ ADJ
A7(+6V)
AIR5
56M
AC
ZERO
AIR6
IOK
AIR7
I5K
COARSE AC
ZERO ADJ
A3R3I
20
I500V
ADJ.
A3R30
2.5M
A2R4
89M
P/O A2SIC(F)
P/O A2SID(F)
P/O A2SIC(F)
P/O A2SID(F)
P/O A2SID(R)
P/O A2SIA(F)
P/O A2SIB(F)
P/O A2SIB(R)
P/O A2SIC(R)
A2R7
2.2IM
A2RI0
6M
A2RII
2M
A2RI2
700K
A2RI3
200K
A2RI4
70K
A2RI5
20K
A2RI6
I000
A2RI7
6000
A2RI8
2000
A2RI9
700
A2R20
200
A2R21
70
A2R22
20
A2R23
7
A2R3
I
A2R6
IOK







NOTES

1. SWITCHES ARE SHOWN IN FULL CCW POSITIONS.
2. SWITCHES ARE IDENTIFIED AS A1S1 = FUNCTION SELECTOR AND A2S2 = RANGE SELECTOR. WAFERS ARE DESIGNATED BY LETTER SUFFIXES(e.g., A1S1A (R) = FUNCTION SELECTOR, REAR SIDE OF FIRST WAFER; A2S2B (F) = RANGE SELECTOR, FRONT SIDE OF SECOND WAFER).
3. P/O = PART OF.
4. CAPACITANCE IN MICROFARADS AND RESISTANCE IN OHMS, UNLESS OTHERWISE SPECIFIED.
5. ⏚ = EARTH GROUND; ⊥ = CIRCUIT COMMON (FLOATING).
6. ○ INDICATES FRONT PANEL ADJUST; ⊘ INDICATES SCREWDRIVER ADJUST.
7. * OPTIMUM VALUE SELECTED AT FACTORY. AVERAGE VALUE SHOWN.
8. ▭ INDICATES FRONT PANEL LOCATION.
   ⬚ INDICATES REAR PANEL LOCATION.

Figure 5-15. Input RANGE and FUNCTION Switching Schematic

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

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

a. Description of the part (see list of abbreviations below).

b. Typical manufacturer of the part in a five-digit code (see list of manufacturers in Appendix).

c. Manufacturer's part number.

d. Total quantity used in the instrument (TQ column).

6-3. Replaceable hardware parts, not listed in Table 6-1 or 6-2, are listed in Table 6-3 in alphabetical order of description.

6-4. ORDERING INFORMATION.

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office (see lists at rear of this manual for addresses). Identify parts by their Hewlett-Packard stock 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.

REFERENCE DESIGNATORS

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

ABBREVIATIONS

a	= amperes
bp	= bandpass
bwo	= backward wave oscillator
c	= carbon
cer	= ceramic
cmo	= cabinet mount only
coef	= coefficient
com	= common
comp	= composition
conn	= connection
crt	= cathode-ray tube
dep	= deposited
EIA	= Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by ⓗ stock numbers.
elect	= electrolytic
encap	= encapsulated
f	= farads
fxd	= fixed
Ge	= germanium
grd	= ground (ed)
h	= henries
Hg	= mercury
impg	= impregnated
incd	= incandescent
ins	= insulation (ed)
K	= kilo = 1000
lin	= linear taper
log	= logarithmic taper
m	= milli = 10^{-3}
M	= megohms
ma	= milliamperes
μ	= micro = 10^{-6}
minat	= miniature
mfgl	= metal film on glass
mfr	= manufacturer
mtg	= mounting
my	= mylar
NC	= normally closed
Ne	= neon
NO	= normally open
NPO	= negative positive zero (zero temperature coefficient)
nsr	= not separately replaceable
obd	= order by description
p	= peak
pc	= printed circuit board
pf	= picofarads = 10^{-12} farads
pp	= peak to peak
piv	= peak inverse voltage
pos	= position (s)
poly	= polystyrene
pot	= potentiometer
rect	= rectifier
rot	= rotary
rms	= root-mean-square
rmo	= rack mount only
s-b	= slow-blow
Se	= selenium
sect	= section(s)
Si	= silicon
sil	= silver
sl	= slide
td	= time delay
TiO_2	= titanium dioxide
tog	= toggle
tol	= tolerance
trim	= trimmer
twt	= traveling wave tube
var	= variable
w/	= with
W	= watts
ww	= wirewound
w/o	= without
*	= optimum value selected at factory, average value shown (part may be omitted)

Table 6-1 Reference Designation Index

REFERENCE DESIGNATION	⊛ PART NO.	DESCRIPTION	NOTE
A1	410C-19B	Switch ass'y - selector, includes: R1, 2; R5 thru 7; R10; S1	
A1R1	0727-0004	R: fxd, dep c flm, 5 ohms ±1%, 1/2 w	
A1R2	0727-0480	R: fxd, carbon flm, 2.32 megohms ±1%, 0.5 w	
A1R3 and A1R4		Not Assigned	
A1R5	0687-5661	R: fxd, comp, 56 megohms ±10%, 1/2 w	
A1R6	2100-0389	R: var, ww, lin taper, 10 K ohms ±10%, 5 w	
A1R7	0687-1531	R: fxd, comp, 15 K ohms ±10%, 1/2 w	
A1R8 and A1R9		Not Assigned	
A1R10	0727-0479	R: fxd, carbon flm, 250 ohms ±1%, 1/2 w	
A1S1	3100-0383	Switch: rotary, 4-section, 6-position (FUNCTION)	
A2	410C-19A	Switch ass'y - range, includes: R1 thru 4; R6, 7; R10 thru 26; R30 thru 33; S2	
A2R1	0728-0004	R: fxd, carbon flm, 1 ohm ±1%, 1/2 w	
A2R2	0727-0955	R: fxd, carbon flm, 10.5 ohms ±1%, 1/2 w	
A2R3	0728-0004	R: fxd, carbon flm, 1 ohm ±1%, 1/2 w	
A2R4	0733-0018	R: fxd, carbon flm, 89 megohms ±1%, 2 w	
A2R5		Not Assigned	
A2R6	0687-1031	R: fxd, comp, 10 K ohms ±10%, 1/2 w	
A2R7	0727-0478	R: fxd, carbon flm, 2.21 megohms ±1%, 1/2 w	
A2R8 and A2R9		Not Assigned	
A2R10	0730-0176	R: fxd, 6 megohms ±0.5%, 1 w	
A2R11	0727-0459	R: fxd, carbon flm, 2 megohms ±0.5%, 1 w	
A2R12	0727-0458	R: fxd, carbon flm, 700 K ohms ±0.5%, 1/2 w	
A2R13	0727-0457	R: fxd, carbon flm, 200 K ohms ±1%, 1/2 w	
A2R14	0727-0456	R: fxd, carbon flm, 70 K ohms ±0.5%, 1/2 w	
A2R15	0727-0455	R: fxd, carbon flm, 20 K ohms ±0.5%, 1/2 w	
A2R16	0727-0451	R: fxd, carbon flm, 1 K ohm ±0.5%, 1/2 w	
A2R17	0727-0454	R: fxd, carbon flm, 6 K ohms ±0.5%, 1/2 w	
A2R18	0727-0453	R: fxd, carbon flm, 2 K ohms ±0.5%, 1/2 w	
A2R19	0727-0452	R: fxd, carbon flm, 700 ohms ±0.5%, 1/2 w	
A2R20	0727-0450	R: fxd, carbon flm, 200 ohms ±0.5%, 1/2 w	
A2R21	0727-0449	R: fxd, carbon flm,70 ohms ±1%, 1/2 w	
A2R22	0727-0448	R: fxd, carbon flm, 20 ohms ±1%, 1/2 w	
A2R23	0727-0446	R: fxd, carbon flm, 7 ohms ±1%, 1/2 w	
A2R24	0727-0445	R: fxd, carbon flm, 2 ohms ±1%, 1/2 w	
A2R25	410C-26B	R: fxd, 0.7 ohms	
A2R26	410C-26A	R: fxd, 0.3 ohms	
A2R27 thru A2R29		Not Assigned	
A2R30	0727-0701	R: fxd, carbon flm, 845 ohms ±1%, 1/2 w	
A2R31	0727-0031	R: fxd, carbon flm, 60 ohms ±1%, 1/2 w	
A2R32	0727-0448	R: fxd, carbon flm, 20 ohms ±1%, 1/2 w	
A2R33	0727-0948	R: fxd, carbon flm, 10 ohms ±1%, 1/2 w	
A2R34*	0687-1011	R: fxd, comp, 100 ohms ±10%, 1/2 w	
A2S1	3100-0382	Switch: rotary, 5-section, 11-position (RANGE)	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	ⓗ PART NO.	DESCRIPTION	NOTE
A3	410C-65A	Board ass'y - amplifier, includes: C1, 2 R1 thru 3 C4 thru 6 R5 C8, 9 R7 thru 9 C11 thru 14 R12 thru 15 C16 R18 thru 21 CR1, 2 R24 thru 26 Q1, 2 R30, 31 V1	
A3A1	1990-0020	Ass'y - chopper, includes: A3A1V1 thru A3A1V4	
A3A1V1 thru A3A1V4		Not separately replaceable, part of chopper ass'y (1990-0020)	
A3A2	1990-0207	Lamp ass'y, includes: A3A2C1 A3A2R1, 2 A3A2DS1, 2	
A3A2C1		Not separately replaceable, part of lamp ass'y (1990-0207)	
A3A2DS1 and A3A2DS2		Not separately replaceable, part of lamp ass'y (1990-0207)	
A3A2R1 and A3A2R2		Not separately replaceable, part of lamp ass'y (1990-0207)	
A3C1	0170-0030	C: fxd, poly, 0.1 µf ±10%, 50 vdcw	
A3C2	0170-0077	C: fxd, poly, 0.047 µf ±10%, 50 vdcw	
A3C3		Not Assigned	
A3C4	0160-0161	C: fxd, my, 0.01 µf, 200 vdcw	
A3C5	0140-0208	C: fxd, mica, 680 pf ±5%, 300 vdcw	
A3C6	0160-0209	C: fxd, my, 0.33 µf ±20%, 200 vdcw	
A3C7		Not Assigned	
A3C8	0180-0039	C: fxd, elect, 100 µf, 12 vdcw	
A3C9	0160-0200	C: fxd, my, 0.22 µf ±20%, 200 vdcw	
A3C10		Not Assigned	
A3C11	0180-1819	C: fxd, elect, 100 µf, 50 vdcw	
A3C12	0160-0200	C: fxd, my, 0.22 µf ±20%, 200 vdcw	
A3C13	0150-0096	C: fxd, cer, 0.05 µf, 100 vdcw	
A3C14	0170-0018	C: fxd, my, 1 µf ±5%, 200 vdcw	
A3C15		Not Assigned	
A3C16	0140-0154	C: fxd, mica, 1300 pf ±5%, 500 vdcw	
A3CR1 and A3CR2	1901-0156	Diode: si, 50 ma	
A3Q1	1850-0013	Transistor: germanium, PNP	
A3Q2	1850-0040	Transistor: germanium, PNP	
A3R1	0687-6841	R: fxd, comp, 680 K ohms ±10%, 1/2 w	
A3R2	0687-1851	R: fxd, comp, 1.8 megohms ±10%, 1/2 w	
A3R3	0811-0998	R: fxd, comp, 100 ohms ±1%, 1/4 w	
A3R4		Not Assigned	
A3R5	2100-0442	R: var, comp, lin taper, 40 K ohms ±30%, 1/4 w	
A3R6		Not Assigned	
A3R7	0687-5661	R: fxd, comp, 56 megohms ±10%, 1/2 w	
A3R8	0687-4731	R: fxd, comp 47 K ohms ±10%, 1/2 w	
A3R9	0687-4701	R: fxd, comp, 47 ohms ±10%, 1/2 w	
A3R10 and A3R11		Not Assigned	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	ⓗ PART NO.	DESCRIPTION	NOTE
A3R12	0757-0164	R: fxd, met flm, 5.6 K ohms ±2%, 1/2 w	
A3R13	0757-0166	R: fxd, met flm, 30 K ohms ±2%, 1/2 w	
A3R14	0757-0163	R: fxd, met flm, 3 K ohms ±2%, 1/2 w	
A3R15	0757-0165	R: fxd, met flm, 13 K ohms ±2%, 1/2 w	
A3R16 and A3R17		Not Assigned	
A3R18	0757-0091	R: fxd, met flm, 18 K ohms ±2%, 1/2 w	
A3R19	0757-0166	R: fxd, met flm, 30 K ohms ±2%, 1/2 w	
A3R20	0687-1021	R: fxd, comp, 1 K ohm ±10%, 1/2 w	
A3R21	2100-0396	R: var, ww, lin taper, 10 K ohms ±20%, 1 w	
A3R22 and A3R23		Not Assigned	
A3R24	0687-2751	R: fxd, comp, 2.7 megohms ±10%, 1/2 w	
A3R25	0687-2221	R: fxd, comp, 2.2 K ohms ±10%, 1/2 w	
A3R26	0687-1021	R: fxd, comp, 1 K ohm ±10%, 1/2 w	
A3R27 thru A3R29		Not Assigned	
A3R30	2100-0413	R: var, comp, lin taper, 2.5 megohms ±20%, 1/4 w	
A3R31	2100-0227	R: var, ww, lin taper, 20 ohms ±10%, 1 w	
A3V1	1932-0027	Tube: electron, dual triode, 12AT7	
A4 and A5		Not Assigned	
A6	410C-65B	Board ass'y - calibration, includes: CR1 R14 R1 R16 thru 18 R3 thru 8 R20, 21	
A6CR1	1901-0025	Diode: si, 50 ma	
A6R1	0727-0751	R: fxd, carbon flm, 1 K ohm ±1%, 1/2 w	
A6R2		Not Assigned	
A6R3	2100-0394	R: var, ww, lin taper, 300 ohms ±20%, 1 w	
A6R4	0727-0747	R: fxd, carbon flm, 750 ohms ±1%, 1/2 w	
A6R5	2100-0394	R: var, ww, lin taper, 300 ohms ±20%, 1 w	
A6R6	0728-0011	R: fxd, carbon flm, 360 ohms ±1%, 1/2 w	
A6R7	2100-0394	R: var, ww, lin taper, 300 ohms ±20%, 1 w	
A6R8	0728-0010	R: fxd, carbon flm, 220 ohms ±1%, 1/2 w	
A6R9 thru A6R13		Not Assigned	
A6R14	2100-0394	R: var, ww, lin taper, 300 ohms ±20%, 1 w	
A6R15		Not Assigned	
A6R16	0758-0048	R: fxd, met flm, 8.2 K ohms ±5%, 1/2 w	
A6R17	0727-0866	R: fxd, carbon flm, 180 ohms ±1%, 1/2 w	
A6R18	2100-0394	R: var, ww, lin taper, 300 ohms ±20%, 1 w	
A6R19		Not Assigned	
A6R20	2100-0395	R: var, comp, lin taper, 300 ohms ±20%, 1/4 w	
A6R21	0727-0475	R: fxd, deposit carbon, 970 ohms ±0.5%, 1/2 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	⊕ PART NO.	DESCRIPTION	NOTE
A7	410C-65C	Board ass'y - power supply, includes: C1 R1 thru 4 CR6, 8 R7, 8, 10	
A7C1*	0140-0041	C: fxd, mica, 100 pf ±5%, 500 vdcw	
A7CR1 thru A7CR5		Not Assigned	
A7CR6	1902-0026	Diode: breakdown junction, 36.5 v ±10%, 0.4 w	
A7CR7	1902-0567	Diode: breakdown junction, 9.09 v ±10%, 500 mw	
A7CR8	1902-0049	Diode: breakdown junction, 6.19 v ±5%, 0.4 w	
A7R1 and A7R2	0764-0003	R: fxd, met flm, 3.3 K ohms ±5%, 2 w	
A7R3	0758-0018	R: fxd, met flm, 15 K ohms ±5%, 1/2 w	
A7R4	0764-0026	R: fxd, met flm, 13 K ohms ±5%, 2 w	
A7R5 and A7R6		Not Assigned	
A7R7	0758-0069	R: fxd, met flm, 1.1 K ohm ±5%, 1/2 w	
A7R8	0758-0070	R: fxd, met flm, 1.2 K ohms ±5%, 1/2 w	
A7R9		Not Assigned	
A7R10	0758-0083	R: fxd, met flm, 68 ohms ±5%, 1/2 w	
A8	11036A	AC Probe ass'y (⊕ Model 11036A, complete) C1, 2 R1 P1 V1	
A8C1		Not separately replaceable, part of AC Probe ass'y (11036A)	
A8C2		Not separately replaceable, part of AC Probe ass'y (11036A)	
A8P1	1251-0209	Plug: telephone, 3 conductor	
A8R1		Not separately replaceable, part of AC Probe ass'y (11036A)	
A8V1	1920-0010	Tube: electron, EA53, diode	
C1	0170-0021	C: fxd, my, 4700 pf ±10%, 400 vdcw	
C2	0170-0022	C: fxd, my, 0.1 μf ±10%, 600 vdcw	
C3	0150-0023	C: fxd, ceramic, 2000 pf ±20%, 1000 vdcw	
C4		Not Assigned	
C5	0180-0125	C: fxd, elect, 4 sect, 4 x 20 μf, 450 vdcw	
C6	0180-0153	C: fxd, elect, 2 sect, 2 x 1200 μf, 20 vdcw	
CR1 and CR2	1901-0036	Diode: si, 300 ma	
CR3 and CR4	1901-0049	Diode: si, 500 ma	
CR5 and CR6		Not Assigned	
DS1	1450-0106	Light Indicator: A1C neon (p/o S3)	
F1	2110-0018	Fuse: cartridge, slo-blo, 0.25 amp, 125 v	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	⊕ PART NO.	DESCRIPTION	NOTE
J1	1251-0200	Jack: telephone, 3 conductor, AC PROBE	
J2		Assembly: DC AMPLIFIER OUTPUT (See MISCELLANEOUS for Part Nos.)	
J3	1251-0148	Connector: power cord receptacle	
M1	1120-0317	Meter: 0-1 ma	
Q1	1850-0098	Transistor: germanium, PNP	
R1	0727-0274	R: fxd, carbon flm, 1 megohm ±1%, 1/2 w	
R2	0758-0086	R: fxd, met flm, 100 ohms ±5%, 1/4 w	
R3	2100-0415	R: var, ww, lin taper, 25 ohms ±10%, 2 w	
R4		Not Assigned	
R5	0687-6831	R: fxd, comp, 68 K ohms ±10%, 1/2 w	
R6	0727-0231	R: fxd, carbon flm, 284 K ohms ±0.5%, 1/2 w	
R7	0727-0168	R: fxd, carbon flm, 15 K ohms ±1%, 1/2 w	
R8	2100-1567	R: var, ww, 10 K ohms ±10%, 2 w	
R9	0727-0180	R: fxd, carbon flm, 25.5 K ohms ±1%, 1/2 w	
S1	3101-0100	Switch: SPST, pushbutton, w/pilot light	
S2	3101-0033	Switch: DPDT, slide	
T1	9100-0174	Transformer: power	
W1	8120-0078	Cable, Power: 3 conductor, 7-1/2 ft. long, w/NEMA plug	
XQ1	1200-0044	Socket, transistor: TO-3	
		MISCELLANEOUS	
	1220-0066	Shield: tube	
	1490-0088	Clip: ground	
	1510-0006	Binding Post, black, p/o J2	
	1510-0007	Binding Post assembly, red, p/o J2	

See introduction to this section

Table 6-2. Replaceable Parts

ⓗⓟ PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	
410C-19A	Switch ass'y - range, includes: R1 thru 4; R6, 7; R10 thru 26; R30 thru 33; S2	28480	410C-19A	1	
410C-19B	Switch ass'y - selector, includes: R1, 2; R5 thru 7; R10; S1	28480	410C-19B	1	
410C-26A	R: fxd, 0.3 ohms	28480	410C-26A	1	
410C-26B	R: fxd, 0.7 ohms	28480	410C-26B	1	
410C-65A	Board ass'y-amplifier, includes: C1, 2; C4 thru 6; C8, 9; C11 thru 14; C16; CR1, 2; R1 thru 3; * R5; R7 thru 9; R12 thru 15; R18 thru 21; R24 thru 26; R30; Q1, 2; V1	28480	410C-65A	1	
410C-65B	Board ass'y - calibration, includes: CR1; R1; R3 thru 8; R14; R16 thru 18; R20, 21	28480	410C-65B	1	
410C-65D	Board ass'y - power supply, includes: C1; CR6, 8; R1 thru 4; R7, 8, 10	28480	410C-65D	1	
0140-0041*	C: fxd, mica, 100 pf ±5%, 500 vdcw	04062	RCM15E101J	1	
0140-0154	C: fxd, mica, 1300 pf ±5%, 500 vdcw	14655	RCM15E101K	1	
0140-0208	C: fxd, mica, 680 pf ±5%, 300 vdcw	00853	obd #	1	
0150-0023	C: fxd, ceramic, 2000 pf ±20%, 100 vdcw	56289	19C203A	1	
0150-0096	C: fxd, ceramic, 0.05 µf, 100 vdcw	72982	845-X5V-5032	1	
0160-0161	C: fxd, my, 0.01 µf, 200 vdcw	56289	192P10392	1	
0160-0200	C: fxd, my, 0.22 µf ±20%, 200 vdcw	72354	F307C224M	2	
0160-0209	C: fxd, my, 0.33 µf ±20%, 200 vdcw	72354	F307C334M	1	
0170-0018	C: fxd, my, 1 µf ±5%, 200 vdcw	84411	Hew 4/	1	
0170-0021	C: fxd, my, 4700 pf ±10%, 400 vdcw	84411	620SJ0047	1	
0170-0022	C: fxd, my 0.1 µf ±10%, 600 vdcw	59875	HEW-17	1	
0170-0030	C: fxd, poly, 0.1 µf ±10%, 50 vdcw	56289	P136072	1	
0170-0077	C: fxd, poly, 0.047 µf ±10%, 50 vdcw	56289	P130649	1	
0180-0039	C: fxd, elect, 100 µf, 12 vdcw	56289	D32697	1	
0180-0125	C: fxd, elect, 4 sect, 4 x 20 µf, 450 vdcw	00853	Type PLI	1	
0180-0153	C: fxd, elect, 2 sect, 2 x 1200 µf, 20 vdcw	00853	4S4039	1	
0180-1819	C: fxd, elect, 100 µf, 50 vdcw	56289	30D107G0500H2	1	
0687-1011*	R: fxd, comp, 100 ohms ±10%, 1/2 w	01121	EB1011	1	
0687-1021	R: fxd, comp, 1 K ohm ±10%, 1/2 w	01121	EB1021	2	

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

⊕ PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	
0687-1031	R: fxd, comp, 10 K ohms ±10%, 1/2 w	01121	EB1031	1	
0687-1531	R: fxd, comp, 15 K ohms ±10%, 1/2 w	01121	EB1531	1	
0687-1851	R: fxd, comp, 1.8 megohms ±10%, 1/2 w	01121	EB1851	1	
0687-2221	R: fxd, comp, 2.2 K ohms ±10%, 1/2 w	01121	EB2221	1	
0687-2751	R: fxd, 2.7 megohms ±10%, 1/2 w	01121	EB2751	1	
0687-4701	R: fxd, comp, 47 ohms ±10%, 1/2 w	01121	EB4701	1	
0687-4731	R: fxd, comp, 47 K ohms ±10%, 1/2 w	01121	EB4731	1	
0687-5661	R: fxd, comp, 56 megohms ±10%, 1/2 w	01121	EB5661	2	
0687-6831	R: fxd, comp, 68 K ohms ±10%, 1/2 w	01121	EB6831	1	
0687-6841	R: fxd, comp, 680 K ohms ±10%, 1/2 w	01121	EB6841	1	
0727-0004	R: fxd, deposit carbon flm, 5 ohms ±1%, 1/2 w	94459	CVS	1	
0727-0031	R: fxd, carbon flm, 60 ohms ±1%, 1/2 w	01295	DC1/2PR	1	
0727-0168	R: fxd, carbon flm, 15 K ohms ±1%, 1/2 w	91637	DCS1/2-15	1	
0727-0180	R: fxd, carbon flm, 25.5 K ohms ±1%, 1/2 w	91637	DCS1/2-15	1	
0727-0231	R: fxd, carbon flm, 284 K ohms ±0.5%, 1/2 w	91637	DCS1/2	1	
0727-0274	R: fxd, carbon flm, 1 megohm ±1%, 1/2 w	94459	CVF	1	
0727-0445	R: fxd, carbon flm, 2 ohms ±1%, 1/2 w	94459	CVS	1	
0727-0446	R: fxd, carbon flm, 7 ohms ±1%, 1/2 w	94459	CVS	1	
0727-0448	R: fxd, carbon flm, 20 ohms ±1%, 1/2 w	94459	CVF	1	
0727-0449	R: fxd, carbon flm, 70 ohms ±1%, 1/2 w	94459	CVF	2	
0727-0450	R: fxd, carbon flm, 200 ohms ±0.5%, 1/2 w	94459	CVF	1	
0727-0451	R: fxd, carbon flm, 1 K ohms ±0.5%, 1/2 w	94459	CVF	1	
0727-0452	R: fxd, carbon flm, 700 ohms ±0.5%, 1/2 w	94459	CVF	1	
0727-0453	R: fxd, carbon flm, 2 K ohms ±0.5%, 1/2 w	94459	CVF	1	
0727-0454	R: fxd, carbon flm, 6 K ohms ±0.5%, 1/2 w	94459	CVF	1	
0727-0455	R: fxd, carbon flm, 20 K ohms ±0.5%, 1/2 w	94459	CVF	1	
0727-0456	R: fxd, carbon flm, 70 K ohms ±0.5%, 1/2 w	94459	CVF	1	
0727-0457	R: fxd, carbon flm, 200 K ohms ±1%, 1/2 w	94459	CVF	1	
0727-0458	R: fxd, carbon flm, 700 K ohms ±0.5%, 1/2 w	94459	CVF	1	
0727-0459	R: fxd, carbon flm, 2 megohms ±0.5%, 1 w	01295	CD1R	1	
0727-0475	R: fxd, deposit carbon, 970 ohms ±0.5%, 1/2 w	94459	CD1/2MR	1	
0727-0478	R: fxd, carbon flm, 2.21 megohms ±1%, 1/2 w	94459	CVF	1	
0727-0479	R: fxd, carbon flm, 250 ohms ±1%, 1/2 w	94459	CVF	1	
0727-0480	R: fxd, carbon flm, 2.32 megohms ±1%, 0.5 w	94459	CVF	1	
0727-0701	R: fxd, carbon flm, 845 ohms ±1%, 1/2 w	94459	CVF	1	
0727-0747	R: fxd, carbon flm, 750 ohms ±1%, 1/2 w	94459	CVF	2	
0727-0751	R: fxd, carbon flm, 1 K ohm ±1%, 1/2 w	94459	CVF	1	
0727-0866	R: fxd, carbon flm, 180 ohms ±1%, 1/2 w	94459	CVF	1	
0727-0948	R: fxd, carbon flm, 10 ohms ±1%, 1/2 w	94459	CVF	1	
0727-0955	R: fxd, carbon flm, 10.5 ohms ±1%, 1/2 w	94459	CVF	1	
0728-0004	R: fxd, carbon flm, 1 ohm ±1%, 1/2 w	94459	CVF	2	
0728-0010	R: fxd, carbon flm, 220 ohms ±1%, 1/2 w	94459	CVS	1	
0728-0011	R: fxd, carbon flm, 360 ohms ±1%, 1/2 w	94459	CVF	1	
0730-0176	R: fxd, 6 megohms ±0.5%, 1 w	94459	CVC	1	
0733-0018	R: fxd, carbon flm, 89 megohms ±1%, 2 w	03888	HV2000	1	
0757-0091	R: fxd, met flm, 18 K ohms ±2%, 1/2 w	07115	C20	1	
0757-0163	R: fxd, met flm, 3 K ohms ±2%, 1/2 w	07115	C20	1	
0757-0164	R: fxd, met flm, 5.6 K ohms ±2%, 1/2 w	07115	C20	1	
0757-0165	R: fxd, met flm, 13 K ohms ±2%, 1/2 w	07115	C20	1	
0757-0166	R: fxd, met flm, 30 K ohms ±2%, 1/2 w	07115	C20	2	
0758-0018	R: fxd, met flm, 15 K ohms ±5%, 1/2 w	07115	C20	1	
0758-0048	R: fxd, met flm, 8.2 K ohms ±5%, 1/2 w	07115	C20	1	

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

℗ PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	
0758-0069	R: fxd, met flm, 1.1 K ohm ±5%, 1/2 w	07115	C20	1	
0758-0070	R: fxd, met flm, 1.2 K ohms ±5%, 1/2 w	07115	C20	1	
0758-0083	R: fxd, met flm, 68 ohms ±5%, 1/2 w	07115	C20	1	
0758-0086	R: fxd, met flm, 100 ohms ±5%, 1/4 w	07115	C07	1	
0764-0003	R: fxd, met flm, 3.3 K ohms ±5%, 2 w	07115	C42S	1	
0764-0026	R: fxd, met flm, 13 K ohms ±5%, 2 w	07115	C42S	1	
0811-0998	R: fxd, comp, 100 ohms ±1%, 1/4 w	28480	0811-0998	1	
1120-0317	Meter: 0 - 1 ma	28480	1120-0317	1	
1200-0044	Socket, transistor: TO-3	97913	M7 (PB)	1	
1251-0148	Connector, power cord receptacle	82389	AC3G	1	
1251-0200	Jack: telephone, 3 conductor	82389	3J-1291	1	
1251-0209	Plug: telephone, 3 conductor	82389	2P-1297	1	
1450-0106	Light Indicator: A1C neon (p/o S3)	87034	A1C	1	
1850-0013	Transistor: germanium, PNP	86684	CP2366	1	
1850-0040	Transistor: germanium, PNP	04713	SA591	1	
1850-0098	Transistor: germanium, PNP	83298	B-1493	1	
1901-0025	Diode: si, 50 ma	93332	D3C72	1	
1901-0036	Diode: si, 300 ma	01841	obd #	1	
1901-0049	Diode: si, 500 ma	86684	34934	1	
1901-0156	Diode: si, 50 ma	03877	SG3288	1	
1902-0026	Diode: breakdown, junction, 36.5 v ±10%, 0.4 w	04713	SZ10939-343	1	
1902-0049	Diode: breakdown, junction, 6.19 v ±5%, 0.4 w	04713	SZ10939-122	1	
1902-0567	Diode: breakdown, junction, 9.09 v ±10%, 1.5 w	59875	PS18256A	1	
1920-0010	Tube electron, EA53, diode	73445	EA53	1	
1932-0027	Tube: electron, 12AT7, dual triode	000I1	2AT7	1	
1990-0020	Ass'y - chopper block, includes: C1 R1, 2 DS1, 2 V1 thru 4	28480	1990-0020	1	
1990-0207	Lamp ass'y	28480	1990-0207	1	
2100-0227	R: var, ww, lin taper, 20 ohms ±10%, 1 w	28480	2100-0227	1	
2100-0389	R: var, ww, lin taper, 10 K ohms ±10%, 5 w	28480	2100-0389	1	
2100-0394	R: var, ww, lin taper, 300 ohms ±20%, 1 w	11236	Series 110	6	
2100-0395	R: var, comp, lin taper, 300 ohms ±20%, 1/4 w	71590	Series 5, Type 70-1	1	
2100-0396	R: var, ww, lin taper, 10 K ohms ±20%, 1 w	79727	E870PAB	1	
2100-0413	R: var, comp, lin taper, 2.5 megohms ±20%, 1/4 w	71590	Series 5, Type 70-1	1	
2100-0415	R: var, comp, lin taper, 25 ohms ±10%, 2 w	08984	FFF-1, Term. X, Y, Z	1	
2100-0442	R: var, comp, lin taper, 40 K ohms ±30%, 1/4 w	71590	Series 5, Type 70-1	1	
2100-1567	R: var, ww, 10 K ohms ±10%, 2 w	11236	117	1	
2110-0018	Fuse: cartridge, slow-blow, 0.25 amp, 125 v	71400	MDL1/4	1	
3100-0382	Switch: rotary, 5-section, 11-position	76854	obd #	1	
3100-0383	Switch: rotary, 4-section, 6-position	76854	obd #	1	
3101-0033	Switch: slide, DPDT	79727	G-326, 6510 Rev. D	1	
3101-0100	Switch: SPST, pushbutton, w/pilot light				
3101-0100	Switch: SPST, pushbutton, w/pilot light	87034	SW-624-109	1	
8120-0078	Cable, Power: 3 conductor, 7-1/2 ft. long, w/NEMA plug	70903	KH-4147	1	
9100-0174	Transformer: power	28480	9100-0174	1	

See introduction to this section

Table 6-3. Replaceable Hardware

⊕ PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	
1510-0006	Binding post, black (p/o J2)	28480	1510-0006	1	
1510-0007	Binding post, red (p/o J2)	28480	1510-0007	2	
11036-42102	Boot, AC plug (p/o 11036A)	28480	11036-42102	1	
11036-42101	Boot, AC probe (p/o 11036A)	28480	11036-42101	1	
412A-83A	Boot, cable	28480	412A-83A	3	
410C-12A	Bracket, connector (used with A3 connector)	28480	410C-12A	1	
410C-12B	Bracket, switch (used with A6 connector)	28480	410C-12B	1	
1200-0081	Bushing, insulator (used with Q1)	26365	974 Special	2	
1410-0091	Bushing, panel (used with A1S1 and A2S2)	28520	SB-437-4	2	
0400-0019	Bushing, strain relief	28480	0400-0019	3	
410C-1A	Chassis, xfmr	28480	410C-1A	1	
410B-21H	Clip, grounding (p/o 11036A)	28480	410B-21H	1	
1251-0195	Connector, 10 pin P. C.	02660	143-010-09 (109)	1	
1251-0213	Connector, 15 pin P. C.	000XX	SD-615W (125)	1	
410B-21P	Contact, Diode (p/o 11036A)	28480	410B-21P	1	
3130-0038	Coupler, switch	45255	10X20X1	1	
5000-0703	Cover, side	28480	5000-0703	1	
5000-0712	Cover, top	28480	5000-0712	2	
5060-0714	Cover, bottom	28480	5060-0714	1	
5060-0727	Foot Ass'y	28480	5060-0727	2	
5060-0703	Frame, side	28480	5060-0703	2	
410B-21J	Ground Lead Ass'y (p/o 11036A)	28480	410B-21J	1	
5040-0700	Hinge (used with tilt stand)	28480	5040-0700	2	
1400-0084	Holder, fuse	75915	342014	1	
0340-0086	Insulator, binding post, double	28480	0340-0086	1	
0340-0091	Insulator, binding post, triple	28480	0340-0091	1	
1520-0001	Insulator, capacitor (used with C1 - C2)	56137	XP	2	
0340-0007	Insulator, ceramic standoff	71590	obd#	1	
0370-0112	Knob, black bar, concentric	28480	0370-0112	1	
0370-0113	Knob, black bar, w/arrow	28480	0370-0113	1	
0370-0114	Knob, red, w/arrow	28480	0370-0114	1	
0360-0016	Lug, solder, lock, #4	78452	718	1	
0360-0007	Lug, solder, #10	78189	2501-10-00	4	
0360-0042	Lug, solder, 90°	79963	obd#	2	
2260-0001	Nut, hex, 4-40 x 1/4 in.	28480	2260-0001	4	
2420-0001	Nut, hex, 6-32 x 5/16 in., w/lock	83385	obd#	4	
2820-0001	Nut, hex, 10-32 x 3/8 in.	73743	obd#	3	
2950-0006	Nut, hex, 1/4-32 x 3/8 in.	73734	#9000	3	
2950-0001	Nut, hex, 3/8-32 x 1/2 in.	73743	obd#	3	
2950-0037	Nut, hex, 1/2-16 x 11/16 in.	75915	obd#	1	
2950-0038	Nut, hex, 1/2-24 x 11/16 in.	75915	903-12	1	
0590-0039	Nut, speed, 6-32	78553	C6800-632-1	4	
0590-0052	Nut, speed, 6-32	78553	C8020-632-4	2	
410C-2A	Panel, front	28480	410C-2A	1	
410C-2C	Panel, rear	28480	410C-2C	1	
410C-41A	Plate, insulator (used with A1S1 and A2S2)	28480	410C-41A	1	

See introduction to this section

Table 6-3. Replaceable Hardware (Cont'd)

℗ PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	
1200-0043	Plate, insulator (used with Q1)	71785	294457	1	
1251-0209	Plug, telephone (p/o 11036A)	82389	2P-1297	1	
410B-21C	Probe contact ass'y	28480	410B-21C	1	
410B-21D	Probe head	28480	410B-21D	1	
410B-21F	Ring, retainer (p/o 11036A)	28480	410B-21F	1	
	MISCELLANEOUS				
1490-0088	Clip: ground	71785	422-11-11-095	1	
2200-0006	Screw, machine, 4-40 x 3/8 in. RH	80120	obd#	2	
2200-0014	Screw, machine, 4-40 x 9/16 in. RH	80120	obd#	2	
2370-0001	Screw, machine, 6-32 x 1/4 in. FH	80120	obd#	20	
2390-0007	Screw, machine, 6-32 x 5/16 in. BH, w/lock	83385	obd#	4	
2370-0002	Screw, machine, 6-32 x 3/8 in. FH	80120	obd#	8	
2370-0003	Screw, machine, 6-32 x 1/2 in. FH	80120	obd#	2	
1220-0066	Shield: tube	82252	319A-2	1	
410B-21E	Sleeve (p/o 11036A)	28480	410B-21E	1	
1460-0087	Spring, diode contact (p/o 11036A)	91260	obd#	1	
1490-0031	Stand, tilt	91260	obd#	1	
410C-66A	Support, circuit board (used with A3)	28480	410C-66A	2	
410C-21D	Test lead ass'y, COM	28480	410C-21D	1	
410C-21C	Test lead ass'y, DCA-OHMS	28480	410C-21C	1	
410C-21A	Test lead ass'y, DCV (includes R1)	28480	410C-21A	1	
5020-0704	Trim, meter	28480	5020-0704	1	
11036-62101	Tube, socket and cable ass'y (p/o 11036A)	28480	11036-62101	1	
3050-0066	Washer, flat, #6	73734	obd#	2	
3050-0067	Washer, flat, 3/8 in. ID	73734	obd#	3	
0900-0016	Washer, fuse holder	76680	622710	1	
2190-0005	Washer, lock, #4 external	80120	obd#	2	
2190-0004	Washer, lock, #4 internal	78189	SF1904	2	
2190-0003	Washer, lock, #4 split	83385	obd#	2	
2190-0047	Washer, lock, #6 countersunk	78189	obd#	30	
2190-0011	Washer, lock, #10 internal	78189	1910	2	
2190-0028	Washer, lock, #10 int/ext	78189	4010-18-00	2	
2190-0027	Washer, lock, 1/4 in. internal	78189	1914	3	
2190-0022	Washer, lock, 3/8 in. ID	78189	1920	4	
2190-0037	Washer, lock, 1/2 in. internal	78189	1224-08	2	
1400-0090	Washer, Neoprene	75915	901-2	1	

See introduction to this section

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	Humidial 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.
02286	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 (c/o 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.
07088	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.
10646	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	Thermolloy	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	Executone, Inc.	New York, N.Y.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. 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	Grobet File 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	Sorensen & 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	Triplett 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.
72707	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 Philips 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	Littelfuse 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	Pheoll 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. Any brand tube meeting EIA standards	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.

Code No.	Manufacturer	Address
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.

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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.
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95264	Lerco Electronics, Inc.	Burbank, Calif.
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95987	Weckesser Co.	Chicago, Ill.
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98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
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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.

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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

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MANUAL BACKDATING CHANGES

MODEL 410C

ELECTRONIC VOLTMETER

Manual Serial Prefixed: 433
Part No. 410C-904

This manual backdating sheet makes this manual applicable to earlier instruments. Instrument-component values that differ from those in the manual, yet are not listed in the backdating sheet, should be replaced using the part number given in the manual.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
550-05301 and above	Manual applies	344	1 thru 5
550-05300 and below	1	339	1 thru 6
532	1, 2	328	1 thru 7
443	1 thru 3	311	1 thru 8

CHANGE #1

Under Table of Replaceable Parts:
Delete: A3C11; Capacitor, fixed, 100 μf, 25 vdcw; Part No. 0180-0094.
Add: A3C11; Capacitor, fixed, 100 μf, 50 vdcw; Part No. 0180-1819.

NOTE

Later Models 410C (Serial No. 550-05301 and above use a 50 vdcw capacitor (Part No. 0180-1819) to ensure that the voltage rating of the capacitor is not exceeded. It is recommended that earlier models be modified accordingly in case of failure of the 25 vdcw capacitor.

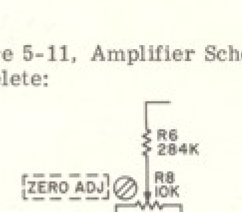
CHANGE #2

Under Table of Replaceable Parts:
Delete: C2; Capacitor, fixed, 0.1 μf; Part No. 0170-0022.
Add: C2; Capacitor, fixed, 0.1 μf; Part No. 0160-0001.
Add: R6; Resistor, fixed, 284 K Ω; Part No. 0727-0231.
Add: R7; Resistor, fixed, 15 K Ω; Part No. 0727-0168.
Add: R8; Resistor, variable, 10 K Ω; Part No. 2100-1567.
Add: R9; Resistor, fixed, 25.5 K Ω; Part No. 0727-0180.

Figures 3-1, 3-2, 3-3, 3-7:
Delete:

Figures 4-3, 4-4, 4-5, 4-6:
Delete:

Figure 5-11, Amplifier Schematic:
Delete:



Manual Backdating Changes Model 410C Page 2

CHANGE #2 (Cont'd)

Page 5-1, Paragraph 5-11 a:
Short Model 410C DCV probe to COM lead; pointer should read zero. If not, refer to Paragraph 5-33 for adjustment procedure.

Page 5-8, Paragraph 5-34 c:
Adjust A3R21 for zero meter deflection.

Page 5-8, Paragraph 5-34 c: d
Switch to -DCV. If any deflection is observed, adjust A3R21 to return meter pointer halfway back to zero. Check zero setting on all ranges for both +DCV and -DCV. Zero offset shall not exceed 1% in any case.

NOTE

Later Models 410C (Serial Prefix 550 and above) use the ZERO ADJUST on the rear panel for increased accuracy for DC ZERO ADJUSTMENT. It is recommended that earlier models be modified accordingly. Refer to hp Service Note 410C-6 for modification instructions.

CHANGE #3

Under Table of Replaceable Parts:
Delete: A3R20; Resistor, fixed, 1 K ohm; hp Part No. 0687-1021.
Add: A3R20; Resistor, fixed, 10 K ohms; hp Part No. 0686-1035.

Figure 5-10, Amplifier Schematic:
Change A3R20 from 1 K ohm to 10 K ohms.

NOTE

Later Models 410C (Serial Prefix 433 and above) use a 1 K ohm resistor for A3R20 to increase the meter zero adjustment (A3R21). It is recommended that earlier models be modified accordingly, in case of zero adjustment problem. Refer to hp Service Note 410C-1 for modification instructions.

CHANGE #4

Under Table of Replaceable Parts:
Delete: Q1; Transistor, PNP Germanium; hp Part No. 1850-0098.
Add: Q1; Transistor, PNP Germanium; hp Part No. 1850-0094.

NOTE

Later Models 410C (Serial Prefix 433 and above) use the hp Part No. 1850-0098 for increased reliability. It is recommended that earlier models be modified accordingly, in case of failure of the earlier type transistor. Refer to hp Service Note 410C-3 for modification instructions.

CHANGE #5

Under Table of Replaceable Parts:
Delete: CR7; Diode, Breakdown Junction, 9 v, 1.5 w; hp Part No. 1902-0327.
Add: A7CR7; Diode, Breakdown Junction, 9 v, 0.4 w; hp Part No. 1902-0037.

Figure 5-8, Power Supply Schematic:
Change CR7 to A7CR7. This designates that this diode is part of the Power Supply Assembly, A7.

NOTE

Later Models 410C (Serial Prefix 433 and above) use the 1.5 watt breakdown diode (hp Part No. 1902-0327) for increased reliability. It is recommended that earlier models be modified accordingly, in case of failure of the 0.4 watt diode.

CHANGE #6

Under Table of Replaceable Parts:
Delete: S3; Switch, pushbutton w/pilot light; hp Part No. 3101-0100.
Delete: DS1; Light, indicator, A1C neon; hp Part No. 1450-0106.
Delete: R5; Resistor, fixed, 68 K ohms; hp Part No. 0687-6831.

Manual Backdating Changes Model 410C Page 3

CHANGE #6 (Cont'd)

Add: S3; Switch, pushbutton; hp Part No. 3130-0054.
Add: DS1; Light, indicator, NE-2H neon; hp Part No. 1450-0048.
Add: Bushing, panel; hp Part No. 5020-0883.
Add: Actuator, AC switch; hp Part No. 5040-0918.
Add: Bracket; AC switch; hp Part No. 410C-12C.
Add: R5; Resistor, fixed, 33 K ohms; hp Part No. 0687-3331.

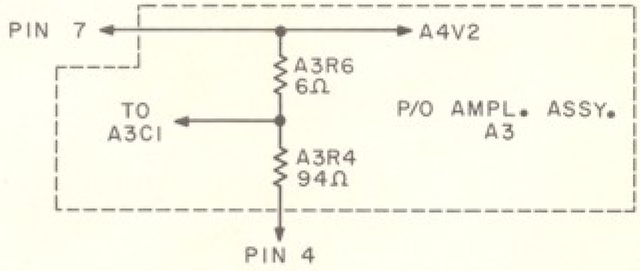
NOTE

Later Models 410C (Serial Prefix 344 and above) use the hp Part No. 3101-0100, pushbutton switch w/pilot light for increased reliability. It is recommended that this improved switch-pilot light assembly be used for replacement, in case of failure of the older type switch. Refer to hp Service Note P-3101-0100 for modification instructions.

CHANGE #7

Under Table of Replaceable Parts:
Delete: A3R3; Resistor, fixed, 100 ohms; hp Part No. 410C-26D.
Add: A3R4; Resistor, fixed, 94 ohms; hp Part No. 0727-0470.
Add: A3R6; Resistor, fixed, 6 ohms; hp Part No. 410C-26C.

Figure 5-10, Amplifier Schematic:
Change:



CHANGE #8

Under Table of Replaceable Parts:
Delete: A1R7; Resistor, fixed, 15 K ohms; hp Part No. 0687-1531.
Add: A1R7; Resistor, fixed, 22 K ohms; hp Part No. 0758-0020.
Delete: A2R2; Resistor, fixed, 10.5 ohms; hp Part No. 0727-0955.
Add: A2R2; Resistor, fixed, 6 megohms; hp Part No. 0727-0460.
Delete: A2R10; Resistor, fixed, 6 megohms; hp Part No. 0730-0176.
Add: A2R10; Resistor, fixed, 10.8 ohms; hp Part No. 0728-0005.

Figure 5-13, RANGE and FUNCTION Switching (Pictorial):
Change A1R7 from 15 K ohms to 22 K ohms.
Change A2R2 from 10.5 ohms to 6 megohms.
Change A2R10 from 6 megohms to 10.8 ohms.