ELECTRONIC VOLTMETER

410C

HEWLETT
PACKARD

HP 410C

HEWLETT
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OPERATING AND SERVICE MANUAL

MODEL 410C
ELECTRONIC VOLTMETER

Prefixed: 0982A

Appendix C, Manual Backdating
Changes adapts this manual to
Serials Prefixed:
311, 328, 339, 433, 532, 550, 807, 844, 952 and 982

WARNING

To help minimize the possibility of electrical fire or shock hazards, do not expose this instrument to rain or excessive moisture.

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

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HEWLETT PACKARD

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard product is warranted against defects in material and workmanship for a period of one year from date of shipment [,except that in the case of certain components listed in Section I of this manual, the warranty shall be for the specified period] . During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by -hp-. Buyer shall prepay shipping charges to -hp- and -hp- shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to -hp- from another country.

Hewlett-Packard warrants that its software and firmware designated by -hp- for use with an instrument will execute its programming instructions when properly installed on that instrument. Hewlett-Packard does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HEWLETT-PACKARD SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HEWLETT-PACKARD SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

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

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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements. This is a Safety Class 1 instrument.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DANGEROUS PROCEDURE WARNINGS

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

WARNING

Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.

SAFETY SYMBOLS

General Definitions of Safety Symbols Used On Equipment or In Manuals.

⚠	Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.
ϟ	Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).
⏚ OR (⏚)	Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating equipment.
(⏚)	Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of a fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating the equipment.
⫽ OR ⊥	Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.
∼	Alternating current (power line).
⎓	Direct current (power line).
≂	Alternating or direct current (power line).
WARNING	The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.
CAUTION	The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, condition or the like, which,if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.
NOTE:	The NOTE sign denotes important information. It calls attention to procedure, practice, condition or the like, which is essential to highlight.

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 mV to 1500 V full scale and positive and negative dc currents from 1.5 μA to 150 mA can be measured full scale. Resistance from 10 Ω to 10 MΩ mid-scale can be measured with an accuracy of ± 5%; resistance from 0.2 Ω to 500 MΩ can be measured with reduced accuracy. The Model 410C Electronic Voltmeter 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 Hz to 700 MHz. From 20 Hz to 100 MHz, ac voltage from 0.5 to 300 V can be measured; from 100 MHz to 700 MHz, 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 1-9.

1-4. INSTRUMENT AND MANUAL IDENTIFICATION.

1-5. Hewlett-Packard uses a two-section serial number consisting of a four-digit prefix and a five-digit suffix. The prefix and suffix are separated by a letter designating the country in which the instrument was manufactured. (A = U.S.A.; G = West Germany; J = Japan; U = United Kingdom.)

1-6. This manual applies to instruments with the serial prefix indicated on the title page. If changes have been made in the instrument since the printing of this manual, a "Manual Changes" supplement supplied with the manual will define these changes. Be sure to record these changes in your manual. Backdating information located in Appendix C adapts the manual to instruments manufactured prior to this printing. The manual part number is indicated on the title page.

1-7. ACCESSORIES AVAILABLE.

1-8. 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.

1-9. Model 11036A AC Probe. This accessory, when used with the Model 410C, permits ac voltage measurements from 0.5 V rms to 300 V rms, full scale over a frequency range of 20 Hz to 700 MHz. Reference calibration accuracy at 400 Hz (sinusoidal) is ± 3% of full scale. Frequency response is ± 10% from 20 Hz to 700 MHz, with indications obtainable to 3000 MHz. Frequency response at 100 MHz 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.

1-10. 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 Hz to 20 MHz. 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 pF. A Model 11018A Adapter is also required to connect the Model 11036A AC Probe to the shielded banana plug fitting of the divider.

1-11. Model 11040A Capacity Divider. This accessory (formerly the Model 453A) extends the ac voltage range of the Voltmeter to 2000 V rms. The divider is for use at frequencies above 10 kHz. Voltage division is 100:1, ± 1%, and input capacity is approximately 2 pF.

1-12. Model 11042A Probe T Connector. This accessory (formerly the Model 455A) is used for connecting the Model 11036A Probe across a 50 Ω 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 MHz and 1.2 at 1000 MHz. With this device, measurement of power traveling through a transmission line may be made with reasonable accuracy to 1000 MHz. 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 MHz with good accuracy.

1-13. Model 11043A Type N Connector. This accessory (formerly the Model 458A) allows the AC Probe to be connected to a 50 Ω coaxial line. The connector uses a male type N connector and a receptacle for receiving the probe. Terminating resistor is not included.

1-14. 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 MΩ. When used with the Model 410C input resistance is 10,000 MΩ. This probe offers maximum safety and convenience for measuring high voltages such as in television equipment, etc. The maximum current drain is 2.5 μA.

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 MΩ ± 1% of 500 mV range and above. 10 MΩ ± 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 kΩ on 1.5 µA scale to approximately 0.3 Ω on the 150 mA scale.

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

OHMMETER

Resistance Range: Resistance from 10 Ω to 10 MΩ 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 Hz; approximately 66 dB at 50 Hz 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 MΩ 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 Ω at dc.

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

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 Hz 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 Hz to 50 MHz (400 Hz ref.), 0% to -4% from 50 MHz to 100 MHz ± 10% from 20 Hz to 100 Hz and ± 1.5 dB from 100 MHz to 700 MHz.

Frequency Range: 20 Hz to 700 MHz.

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

Safety: The probe body is grounded to chassis in the AC Function 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%. 48 to 440 Hz, 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 15 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 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 Tests. If there is damage or deficiency, see the warranty on the inside front cover of this manual.

2-3. INSTALLATION.

2-4. The -hp- 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 -hp- 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 (-hp- 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.

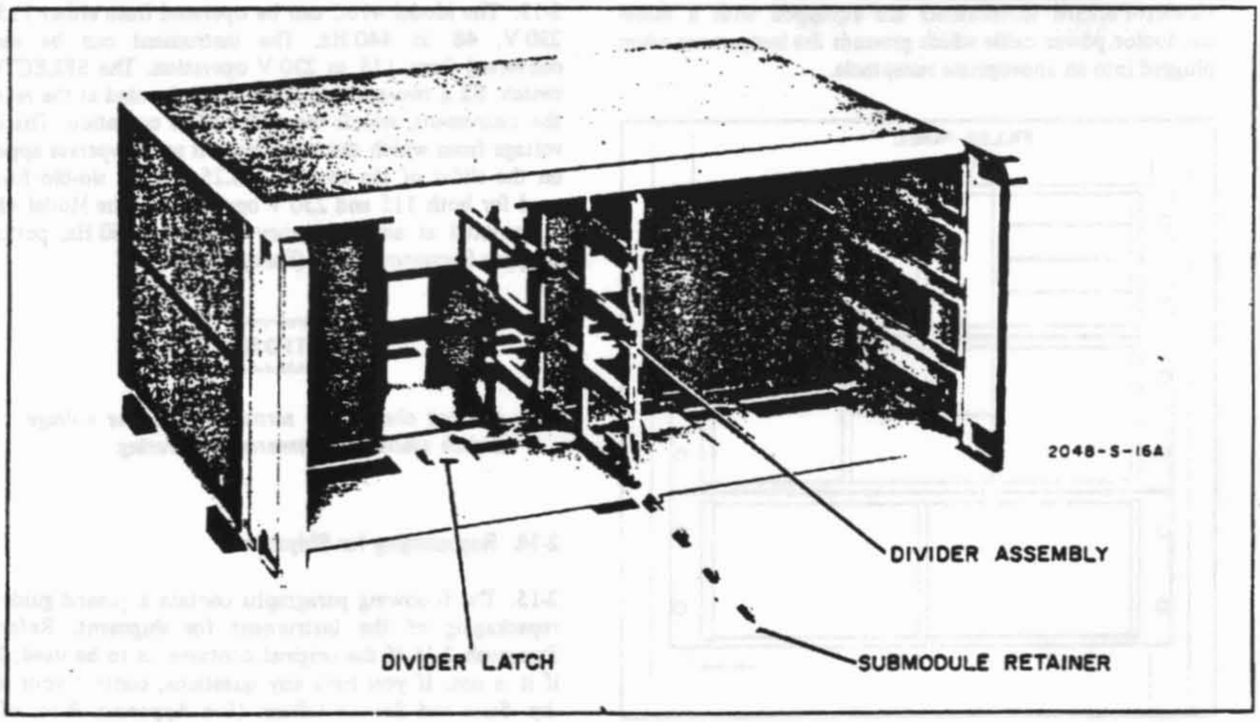


Figure 2-1. The Combining Case.

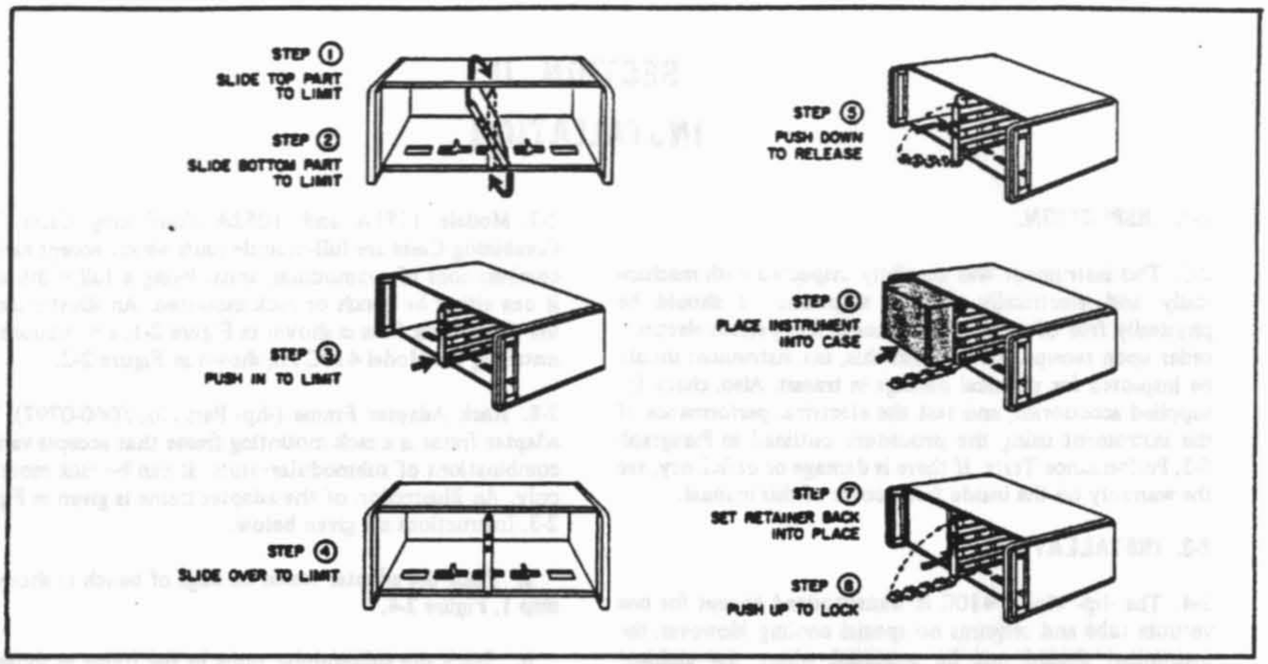


Figure 2-2. Steps to Place Instrument in Combining Case.

e. The complete assembly is ready for rack mounting.

2-9. THREE-CONDUCTOR POWER CABLE.

2-10. To protect operating personnel, the National Electrical Manufacturer's 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.

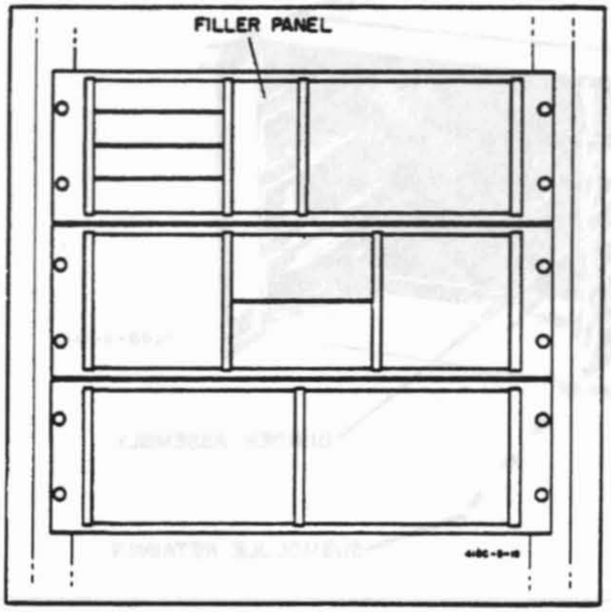


Figure 2-3. Adapter Frame Instrument Combination.

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 V, 48 to 440 Hz. The instrument can be easily converted from 115 to 230 V operation. The SELECTOR switch, S2 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 V operation. If the Model 410C is operated at any frequency other than 60 Hz, perform chopper frequency adjust (Paragraph 5-31).

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 -hp- Sales and Service Office. (See Appendix B for office locations.)

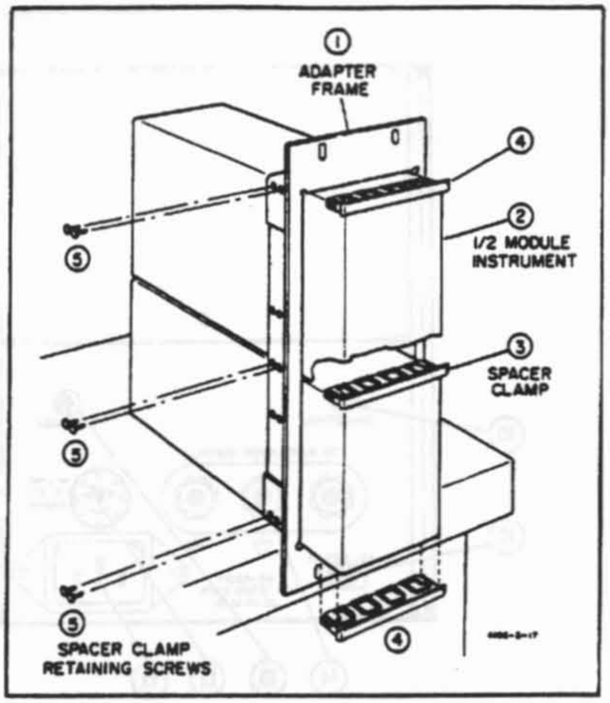


Figure 2-4. Two Half Modules in Rack Adapter.

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 -hp- Sales and Service Office.

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

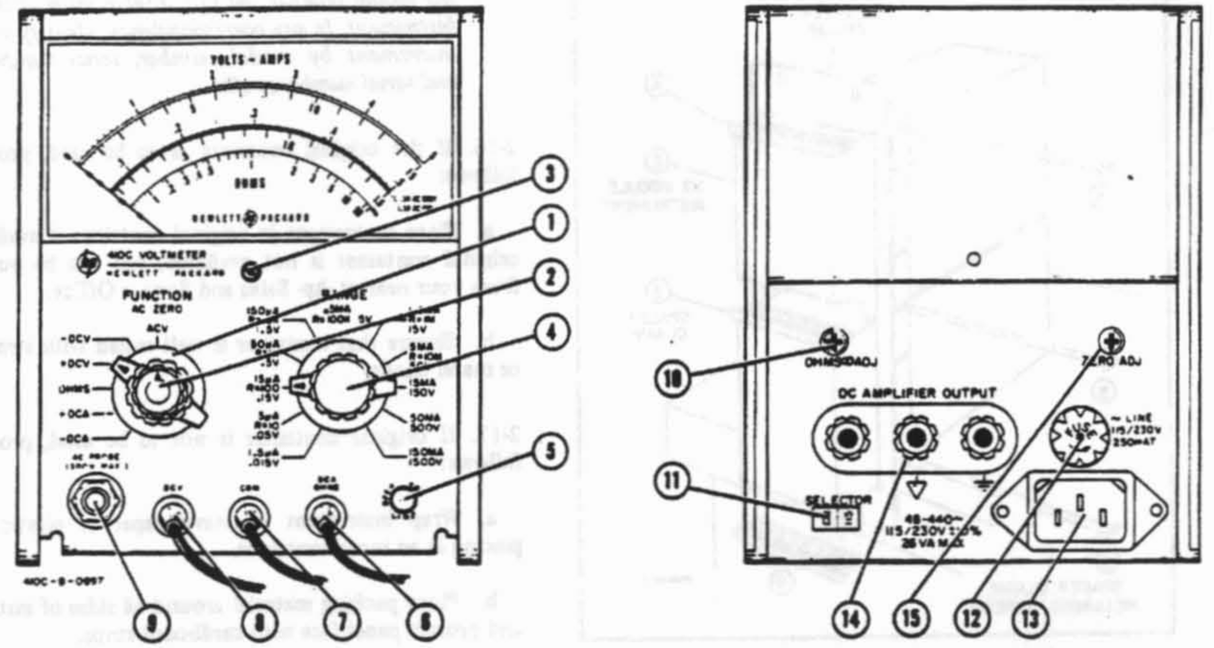
2-17. If original container is not to be used, proceed as follows:

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.

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.



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 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 (300 V 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 adjusment is necessary.

⑪ **LINE VOLTAGE:** This two-position slide switch sets the instrument to accept either 115 or 230 V ac primary power.

⑫ **FUSEHOLDER:** The fuseholder contains a 0.25 ampere slow-blow fuse for both 115 V ac and 230 V ac 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 V 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.

SECTION III
OPERATING INSTRUCTIONS

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.

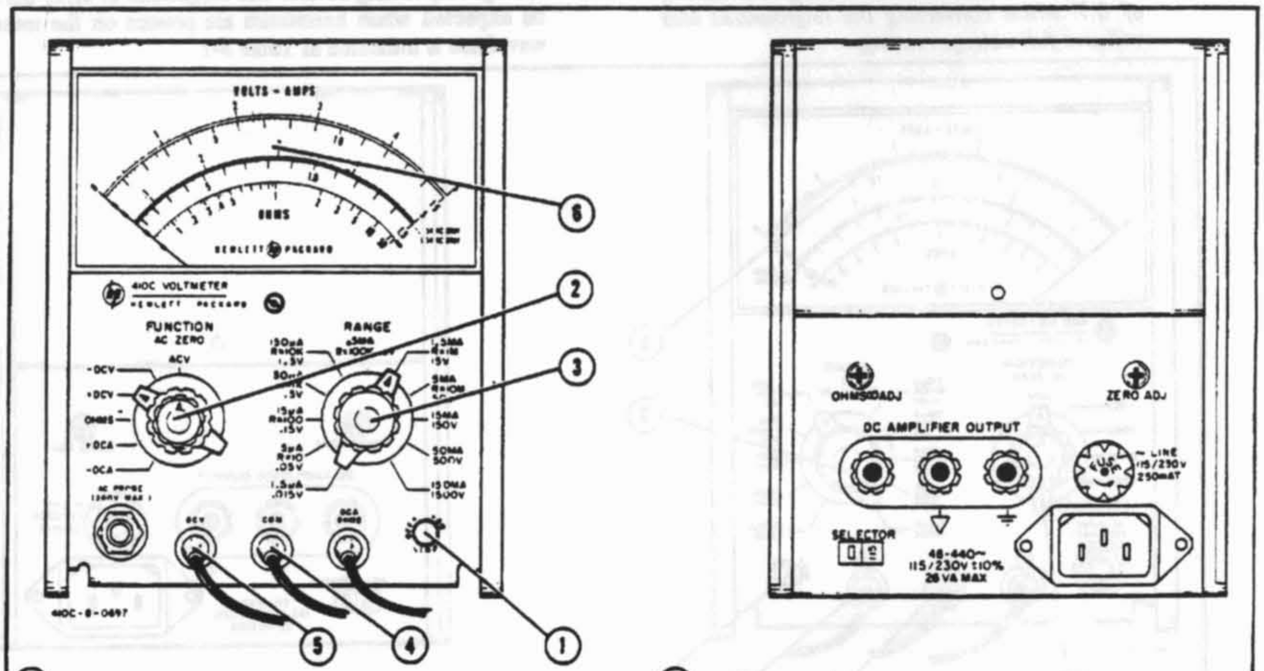
3-6. Figure 3-1 describes the function of all front and rear panel controls, connectors and indicators. The description of each control, connector and indicator is keyed to a drawing which accompanies the figure.

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

Aging 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.



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.

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 V dc.

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 best be measured by using the probe tip only. Contacting the grounded power conductor will give a reading of 0 V while contacting the ungrounded lead will give full voltage reading.

3-14. Although the Model 410C indicates a full scale ac range of 500 V, the optional Model 11036A AC Probe should not be connected to ac voltages in excess of 300 V 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.

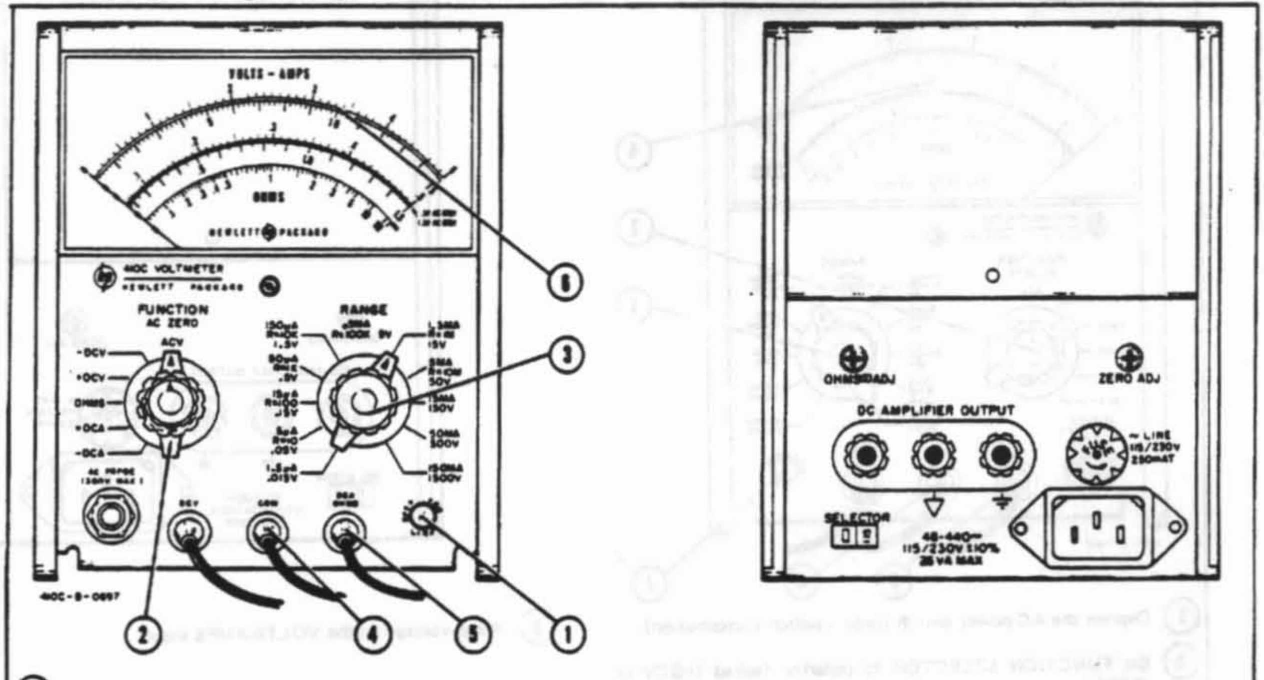
CAUTION

When measuring ac referenced to dc, the peak ac voltage plus dc voltage connected to the probe must not exceed 420 V.

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.



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

② **Set FUNCTION SELECTOR to the polarity desired (+DCA or -DCA).**

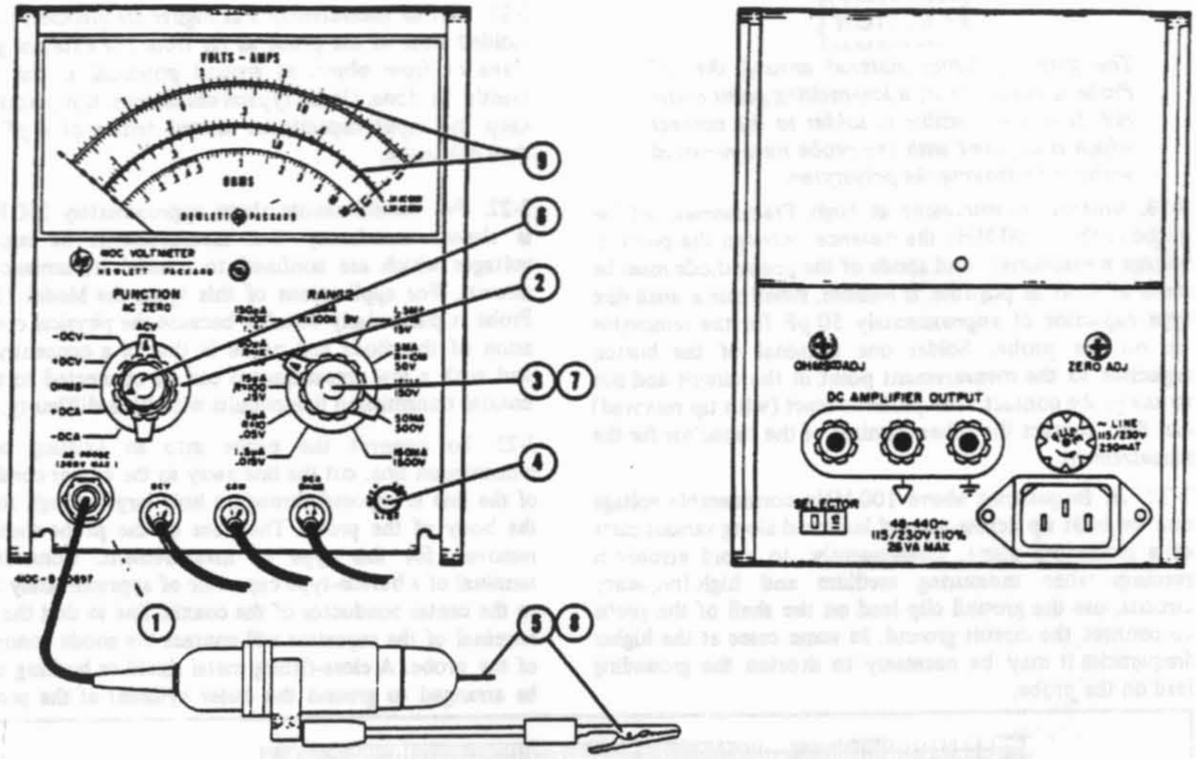
③ **Set RANGE to desired current position.**

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 -hp- 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 MHz, 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.

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

3-18. Voltage Measurements at Frequencies Below 50 Hertz. Voltage measurements at frequencies as low as 20 Hz may be made without loss of accuracy by removing the plastic nose on the Model 11036A and using in its place a 0.25 μF 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.

3-19. Voltage Measurement at High Frequencies. At frequencies above 100 MHz 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 pF 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 MHz considerable voltage may be built up across ground leads and along various parts 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 pF lower than otherwise.

3-22. For measurements above approximately 250 MHz 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 pF 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

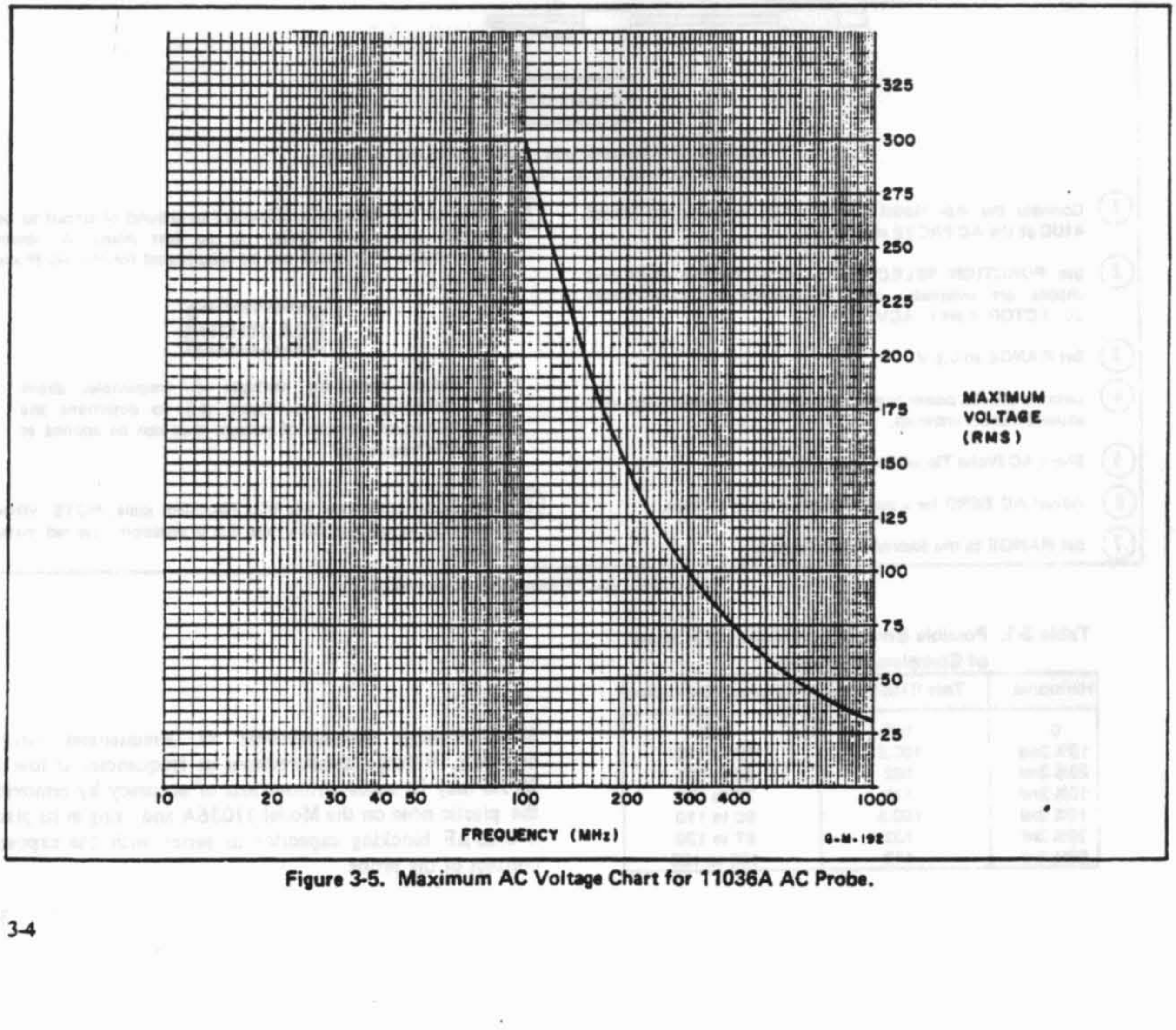


Figure 3-5. Maximum AC Voltage Chart for 11036A AC Probe.

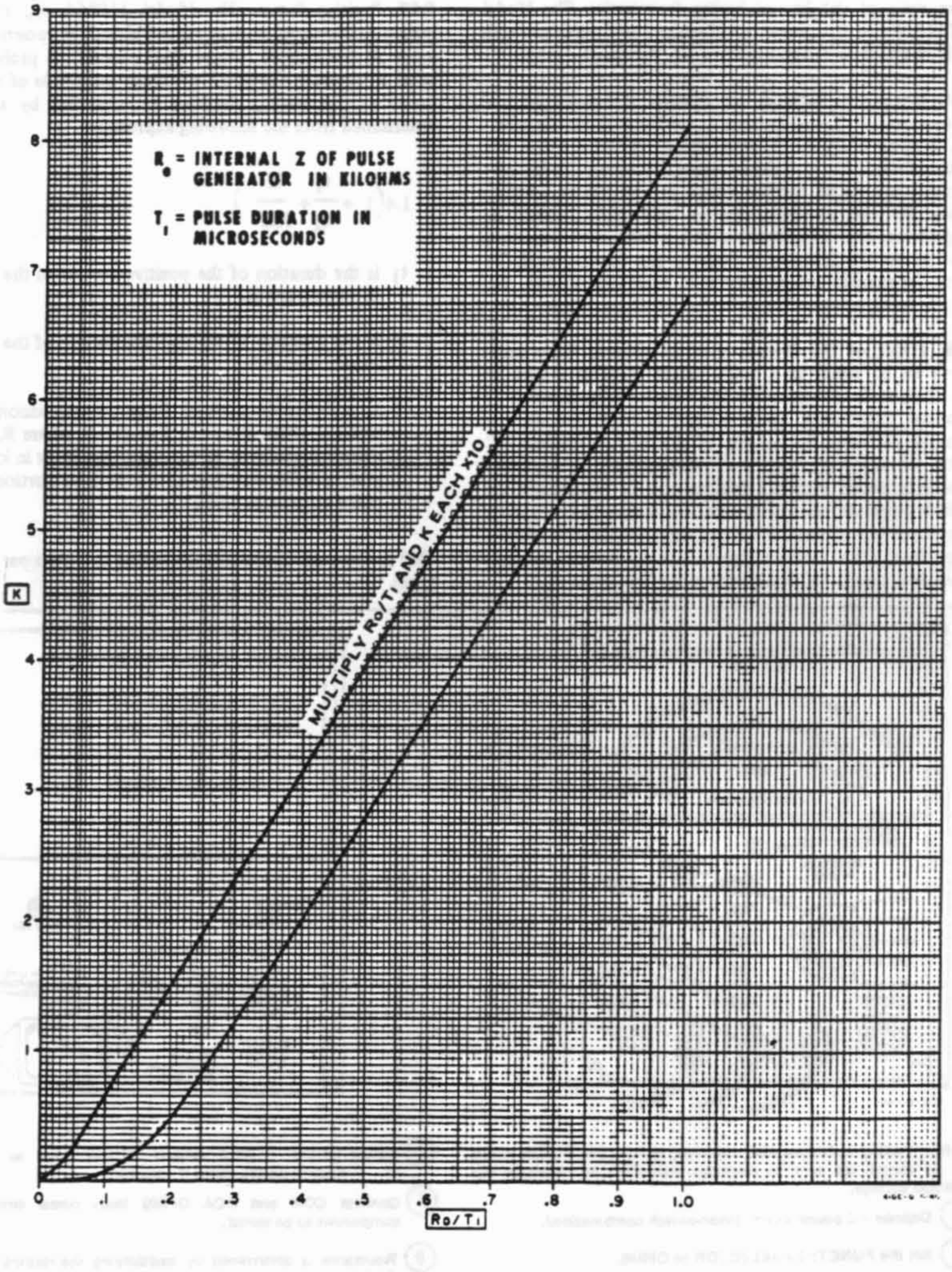


Figure 3-6. Graph Used in Calculation of Pulse Voltage Readings.

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 of less than 1.1 at 500 MHz (see Paragraph 1-12).

3-24. Effect of Parasitics on Voltage Readings. At frequencies above 500 MHz 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. Owing to the resonant rise in the probe circuit at frequencies above 1000 MHz, 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 pF 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:

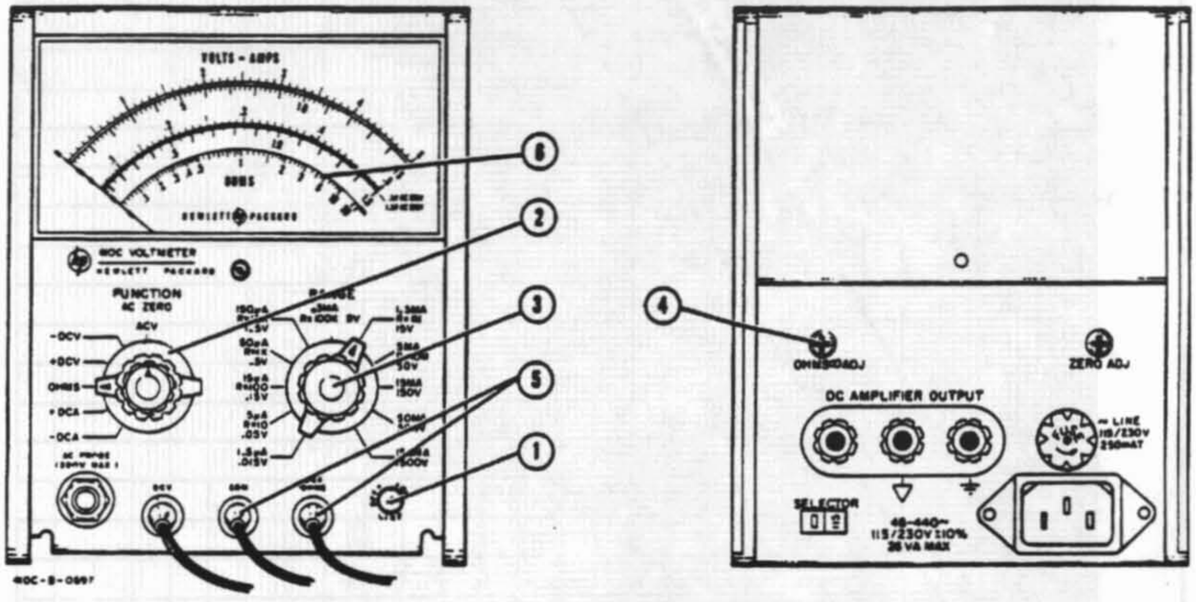
$$1.4\left(1+\frac{t_1}{t_2}+\frac{K}{PRF}\right)$$

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_o/t_1 and the graph shown in Figure 3-6, where R_o 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).



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 10 K, then resistance equals 15 kΩ.

Figure 3-7. Resistance Measurements.

Suppose for example:

t_1 = 10 microseconds
t_2 = 990 microseconds
K = 0.45
PRF = 1000 pps

To find K, assuming $R_o = 2\ k\Omega$ and t_1 = 10 microseconds: $R_o/t_1 = 2/10 = 0.2$. Locate 0.2 on the X axis of the graph shown as Figure 3-6, and read K where X and Y axes intersect the unmarked curve. If the ratio of R_o/t_1 were greater than 1, you would 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,

$$1.4\left(1 + \frac{10}{990} + \frac{0.45}{1000}\right) =$$

$$1.4\ (1 + 0.01 + 0.00045) =$$

$$1.4\ (1.01045) =$$

$$1.41463$$

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 R_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

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

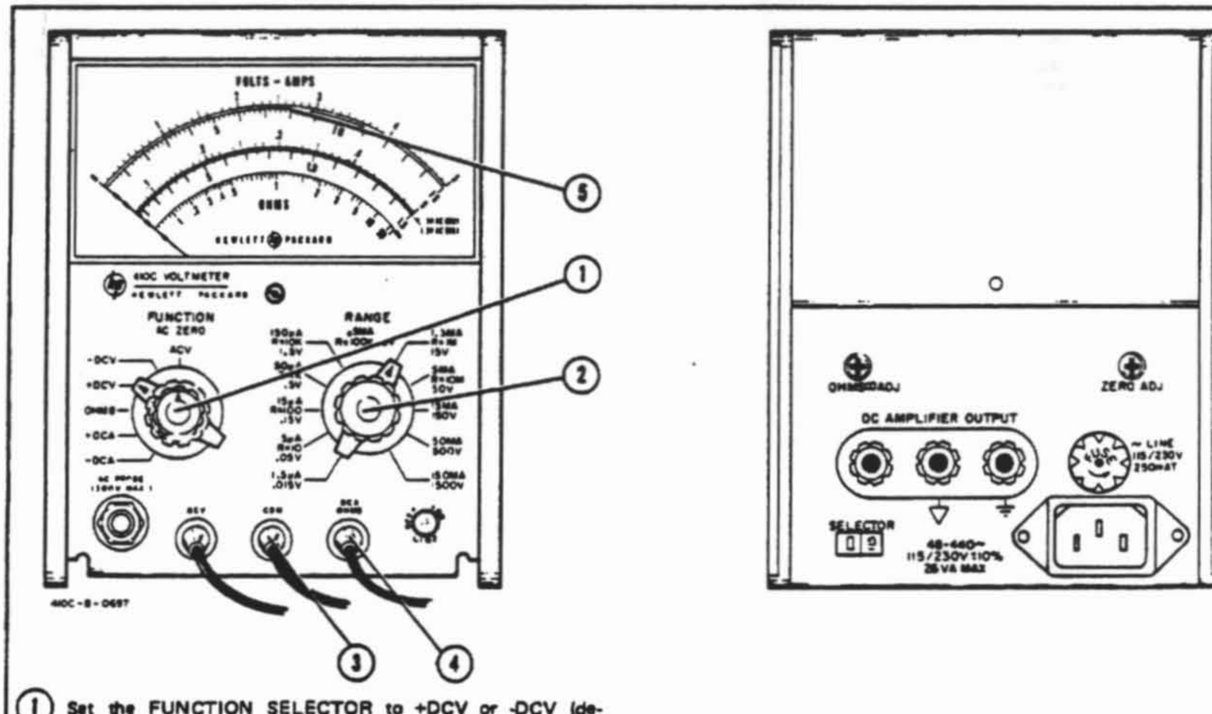
3-30. It can be seen that in the case of negative pulses of short duration much smaller readings will be obtained for an equivalent positive pulse. As a result, large multiplying factors must be used and unless the pulse voltage is large, these measurements may be impractical.

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 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.

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 mV 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 5-16, 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 9 kΩ on the 1.5 µA range to approximately 0.3 Ω on the 150 mA range.

4-8. The change in input impedance is varied by using dc current shunts in conjunction with RANGE switch A2S1. 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.

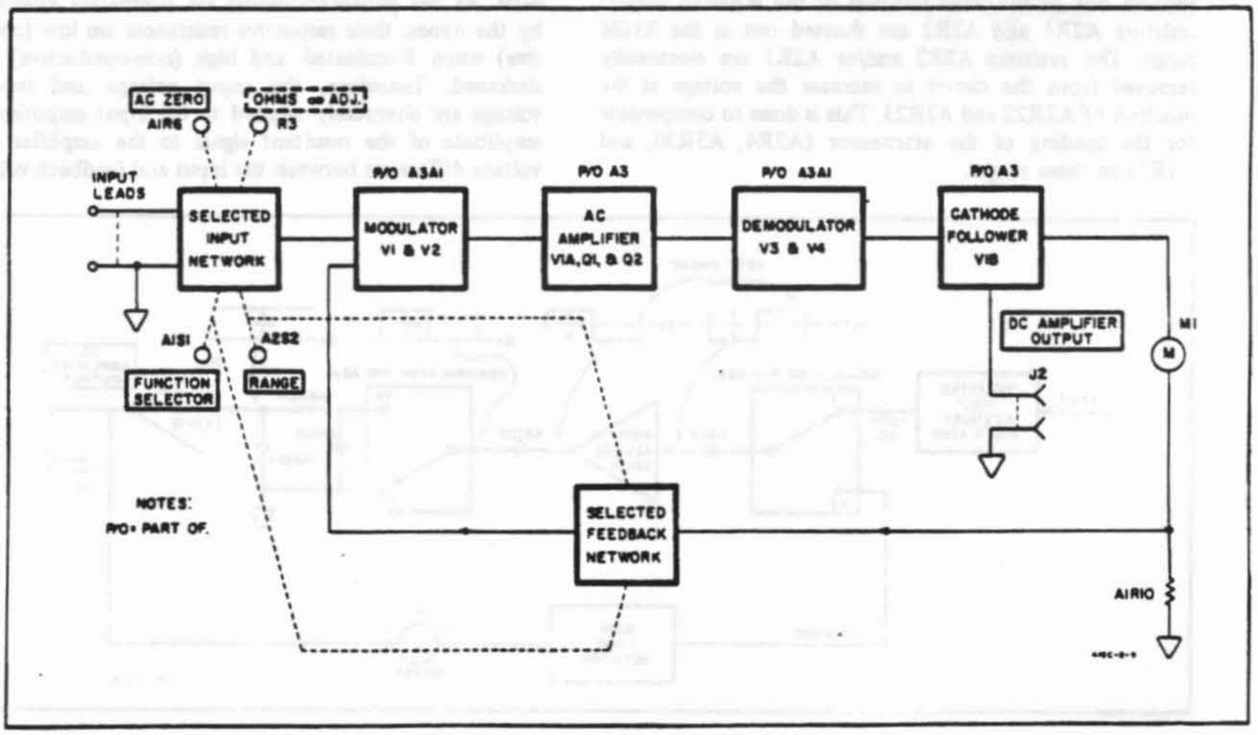


Figure 4-1. Block Diagram, Model 410C.

4-9. DC Voltage Measurements. Refer to Figure 5-17 throughout this explanation. The purpose of the input network is to accurately attenuate the input signal to a maximum of 15 mV at the modulator input. The network presents an input impedance of 10 MΩ on the three most sensitive ranges and 100 MΩ on all other ranges.

4-10. The resistor R1 (located in the DCV probe) in conjunction with resistors A2R10 through A2R26, provides the 10 MΩ 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 MΩ impedance to the input.

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

4-13. Resistance Measurements. The purpose of the input network shown in Figure 5-18 is to place approximately 0.6 V 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 5-19 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 mV 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 mV dc, for full scale meter deflection (positive or negative, depending on the polarity of the voltage or current being measured) to the neon-photo-conductor chopper. Also applied to the opposite side of the chopper is the amplifier feedback voltage, which is of the same polarity and approximately 5 μV lower in amplitude than the input voltage. The modulator-chopper consists of two photoconductors, A3A1V1 and A3A1V2, which are alternately illuminated by two neon lamps, A3A1DS1 and A3A1DS2, respectively. The neon lamps are part of a relaxation oscillator whose frequency is controlled by A3R5. The oscillator frequency is nominally set to 100 Hz for operation from 60 Hz power line, or to 85 Hz for 50 Hz 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.

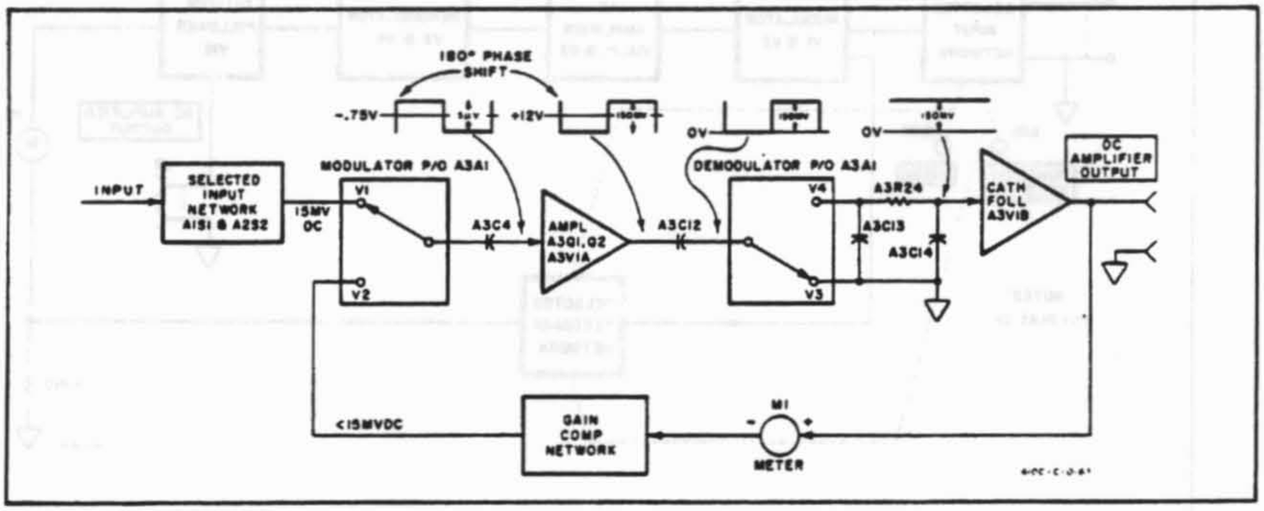


Figure 4-2. Modulator-Demodulator Mechanical Analogy.

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, A3A1V3 and A3A1V4, which are alternately illuminated by neon lamps A3A1DS1 and A3A1DS2, respectively. Approximately 150 mV 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 choppers is synchronous. Therefore, when A3A1V1 is sampling the input voltage, A3A1V3 is clamping the amplified and inverted difference voltage to ground. Alternately, when A3A1V2 is sampling the feedback voltage, A3A1V4 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 5-16, 5-17and 5-18 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 5-19 shows the feedback configuration for the ACV position of the FUNCTION SELECTOR switch, A1S1. 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 V range.

4-27. Power Supply.

4-28. Primary Power. Refer to Figure 5-9 throughout this explanation. Either 115 or 230 V ac power is connected through fuse F1 (0.25 amp slow-blow) and switch S1 to the primary of power transformer T1. Switch S2 connects T1 primaries in parallel for 115 V operation or in series for 230 V operation.

4-29. Unregulated and Zener Regulated Power Supply. Full wave rectifier CR1 and CR2 produces unregulated + 270 V, which is used to drive the photochopper neons. Unregulated + 175 V and + 140 V are tapped off and are used to provide B+ to the plates of A3V1B and A3V1A, respectively. Zener regulators A7CR6 and CR7 provide regulated + 38 V and - 9 V 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 V is supplied to the filaments of A3V1A/B and the AC Probe diode A8V1. + 0.6 V 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 V 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 V ac is removed from the filament and 6 V dc is applied. Therefore, the ACV mode is ready for immediate use, without waiting for the filament to warm up.

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 Hz Accuracy: ± 0.3% ac ± 0.2% dc	AC and DC Accuracy Checks and Calibration Adjustments	-hp- Model 738BR Voltmeter Calibrator
Oscillator	Frequency: 20 Hz to 10 MHz Output: 2.0 V	Frequency Response Test	-hp- Model 652A Test Oscillator
DC Power Supply	Range: 0 to 10 V continuous	DC Ammeter Accuracy Tests	-hp- Model 6214A DC Power Supply
DC Voltmeter	Range: 10 V Accuracy: ± 0.2%	Accuracy Tests; Power Supply Measurements; Troubleshooting	-hp- Model 3440A/3443A Digital Voltmeter
Oscilloscope	Bandwidth: DC to 10 MHz Sweep: 0.1 μsec to 1 sec/div Sensitivity: 1 V/div	Amplifier Troubleshooting	-hp- Model 180C/D with 1801A and 1820C plug-ins
VHF Signal Generator	Frequency: 10 MHz to 400 MHz Output: 1.0 V	Frequency Response Test	-hp- Model 608E VHF Signal Generator
UHF Signal Generator	Frequency: 480 MHz to 700 MHz	Frequency Response Test	-hp- Model 612A UHF Signal Generator
AC Voltmeter	Range: 120 V	Power Supply Measurements (ripple)	-hp- Model 3400A RMS Voltmeter
Electronic Counter	Frequency Range: to at least 102 Hz	Chopper Frequency Adjust	-hp- Model 5300A/5301A Electronic Counter
Ohmmeter	Range: 100 MΩ Accuracy: ± 5%	Troubleshooting	-hp- Model 412A DC VTVM
Micro-Potentiometer	Frequency Range: 10 MHz to 700 MHz 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	-hp- Model 11042A Probe-T-Connector
Connector Adapter	Type N male to BNC female	Frequency Response Test	-hp- Part No. 1250-0067
Connector Adapter	BNC to binding post	Frequency Response Test	-hp- Part No. 10110A
Connector Adapter	Type "N" male to Type "N" female	Frequency Response Test	-hp- Part No. 11501A
50 Ω termination	Frequency Range: 10 MHz to 700 MHz Low reflection	Frequency Response Test	-hp- Part No. 908A
50 Ω feed-thru	Male BNC to female BNC	Performance Tests	-hp- Model 11048C
Resistors:			
10 MΩ	Accuracy: ± 1%	Performance Tests	-hp- Part No. 0730-0168
56 K	Accuracy: ± 1%	Performance Tests	-hp- Part No. 0730-0053
10 K	Accuracy: ± 1%	Performance Tests	-hp- Part No. 0727-0157
1 K	Accuracy: ± 1%	Chopper Frequency Adjust	-hp- Part No. 0727-0751
1.5 K	Accuracy: ± 1%	Performance Tests	-hp- Part No. 0730-0017
56 Ω	Accuracy: ± 1%	Performance Tests	-hp- Part No. 0811-0341
10 Ω	Accuracy: ± 1%	Performance Tests	-hp- Part No. 0727-0335

SECTION V

MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains performance test procedures, adjustment and calibration procedures, troubleshooting procedures, circuit schematics and simplified schematics of each measurement function to aid in the troubleshooting process of 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 TESTS.

5-6. The performance tests 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 tests, 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 -hp- Model 738AR Voltmeter Calibrator to conduct these Performance Tests, the arrangement described in Figure 5-1 will provide the necessary voltage values required. However, the -hp- Model 738BR Voltmeter Calibrator is the preferred instrument for these operations.

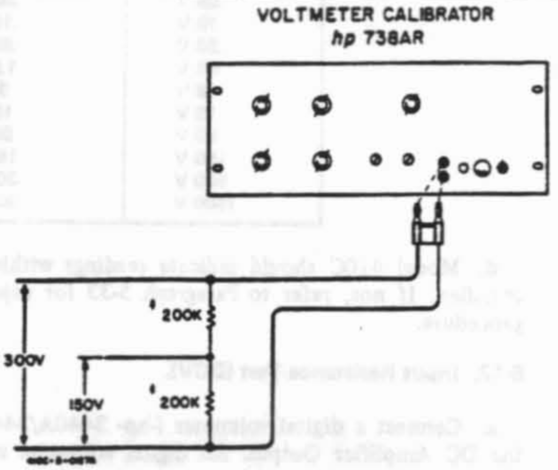
5-9. Mechanical Meter Zero.

a. Instrument must be turned off for two hours or install a short across meter terminals.

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

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

d. 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 b and d.



† 200 K ± 0.2%, 1/4 watt ... -hp- Part No. 0811-0142

Additional calibration levels may be obtained by proportionally reducing the Model 738AR output level.

Figure 5-1. Alternate Calibration Voltage Source.

5-10. DC Voltmeter Operation.

5-11. Accuracy Test (DCV).

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

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.

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

Table 5-3. DCV Input Resistance Test.

Model 410C Range Settings	Voltmeter Calibrator Settings	Model 3440/43A Voltage Readings	Model 410C R_{in}
	Voltage		
.015 V	.015	0.7202 to 0.7801	10 MΩ ± 3%
.05 V	.05	0.7202 to 0.7801	10 MΩ ± 3%
.15 V	.15	0.7202 to 0.7801	10 MΩ ± 3%
.50 V	.50	1.333 to 1.394	100 MΩ ± 1%
1.5 V	1.5	1.333 to 1.394	100 MΩ ± 1%
5 V	5	1.333 to 1.394	100 MΩ ± 1%
15 V	15	1.333 to 1.394	100 MΩ ± 1%
50 V	50	1.333 to 1.394	100 MΩ ± 1%
150 V	150	1.333 to 1.394	100 MΩ ± 1%
500 V	300	0.800 to 0.863	100 MΩ ± 1%
1500 V	300	0.265 to 0.280	100 MΩ ± 1%

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

5-12. Input Resistance Test (DCV).

a. Connect a digital voltmeter (-hp- 3440A/3443A) to the DC Amplifier Output. Set digital voltmeter range to 10 V.

b. Set 410C RANGE to .015 V, FUNCTION to +DCV.

c. Connect a voltmeter calibrator in series with a 10 MΩ ± 1% resistor (-hp- Part No. 0730-0168). Set calibrator output to +.015 V. Connect the calibrator and series resistor to the 410C DCV probe.

d. Adjust the calibrator and 410C to settings listed in Table 5-3. Digital voltmeter readings should be within the limits specified for each setting. If readings are not within limits, refer to Paragraph 5-37, Amplifier Output Calibration; recalibrate amplifier and repeat test.

5-13. DC Ammeter Operation.

5-14. Accuracy Test (DCA).

a. Figure 5-2 describes the test arrangement required for this operation.

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

c. Use 56 Ω resistor for R1 and 10 Ω 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 adjusment procedure.

5-15. Ohmmeter Operation.

5-16. Ohmmeter Accuracy Test.

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

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 Ω resistor.

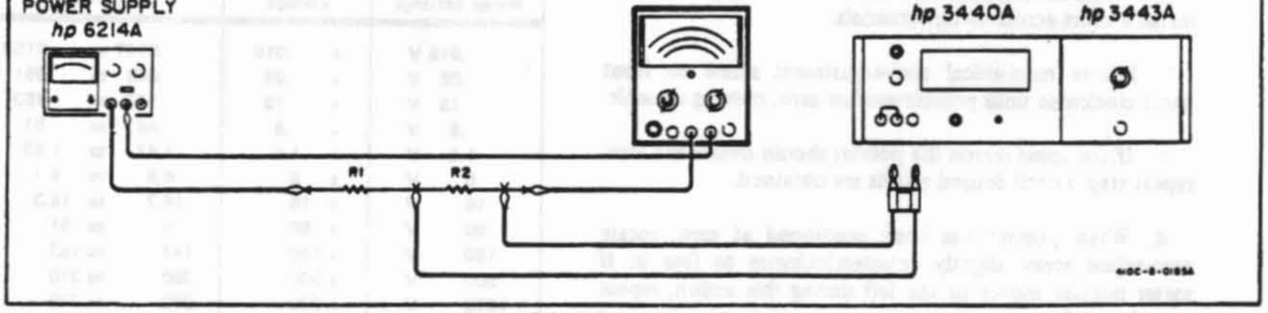


Figure 5-2. DC Ammeter Operation.

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

e. Meter should read 10 Ω (± 5%).

f. Set Model 410C RANGE to RX10M. Replace 10 Ω resistor with 10 MΩ resistor.

g. Meter should read 10 MΩ (± 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 Test.

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

b. Connect DC Voltmeter (-hp- Model 3440A/3443A) 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. Output Level Test.

a. A Voltmeter Calibrator (-hp- Model 738BR) and a DC Voltmeter (-hp- Model 3440A/3443A) will be required for this test.

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.

5-20. Amplifier Output Impedance Test.

a. Connect an external DC Voltmeter (-hp- Model 3440A/3443A) 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 kΩ ± 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 Ω specification at dc.

5-21. Amplifier Noise Test.

a. Connect external DC Voltmeter (-hp- Model 3440A/3443A) 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.

5-22. Overload Recovery Test.

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 V dc; 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.

5-23. AC Rejection Test.

a. An Oscillator (-hp- Model 652A) and an RMS Voltmeter (-hp- Model 3400A) are required for this test.

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 Hz.

e. Model 410C should not read more than 2.25 mV verifying 66 dB ac rejection at 50 Hz.

f. Increase frequency to check ac rejection about 50 Hz.

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

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 Test.

a. Set Model 410C RANGE to 0.5 V. Short the input of the AC Probe. Adjust ZERO vernier for zero pointer deflection.

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

c. Adjust voltmeter calibrator for 400 Hz rms output.

d. Set Model 410C FUNCTION SELECTOR to ACV; RANGE to 500 V.

e. 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 reading with 0.3 V input.

NOTE

The frequency response tests are performed using reference voltage obtained with 0.3 V input.

Table 5-5. AC Accuracy Test.

410C Range	Voltmeter Calibrator 400 Hz	Model 410C Readings
	Voltage Selection	
500 V	300	285 to 315 V
150 V	150	145.5 to 154.5 V
50 V	50	48.5 to 51.5 V
15 V	15	14.55 to 15.45 V
5 V	5	4.85 to 5.15 V
1.5 V	1.5	1.455 to 1.545 V
.5 V	0.5	0.485 to .515 V
.5 V	0.3	0.285 to .315 V

5-26. AC Voltmeter Low Frequency Response Test.

a. A Test Oscillator (-hp- Model 652A), a BNC-to-Binding Post Adaptor (-hp- Part No. 10110A) and a 50 Ω Feed-thru Termination (-hp- Part No. 11048C) are required for this test.

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

c. Set Model 410C FUNCTION SELECTOR to ACV; RANGE to 0.5 V.

d. Set Test Oscillator frequency to 400 Hz, and adjust amplitude to give same 410C reading as recorded in Paragraph 5-25, step e, with 0.3 V input.

e. Set Test Oscillator REF SET to convenient level.

f. Adjust frequency of Test Oscillator to various cardinal points between 20 Hz and 10 MHz, resetting amplitude to reference level set in step c for each frequency. Model 410C readings should be the same as the reading set at 400 Hz in step d ± 10% from 20 Hz to 100 Hz and ± 2% from 100 Hz to 10 MHz.

5-27. AC Voltmeter High Frequency Response Test.

a. A VHF Signal Generator (-hp- Model 608E), 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/3443A) are required for this test. Figure 5-4 describes test arrangement to be used.

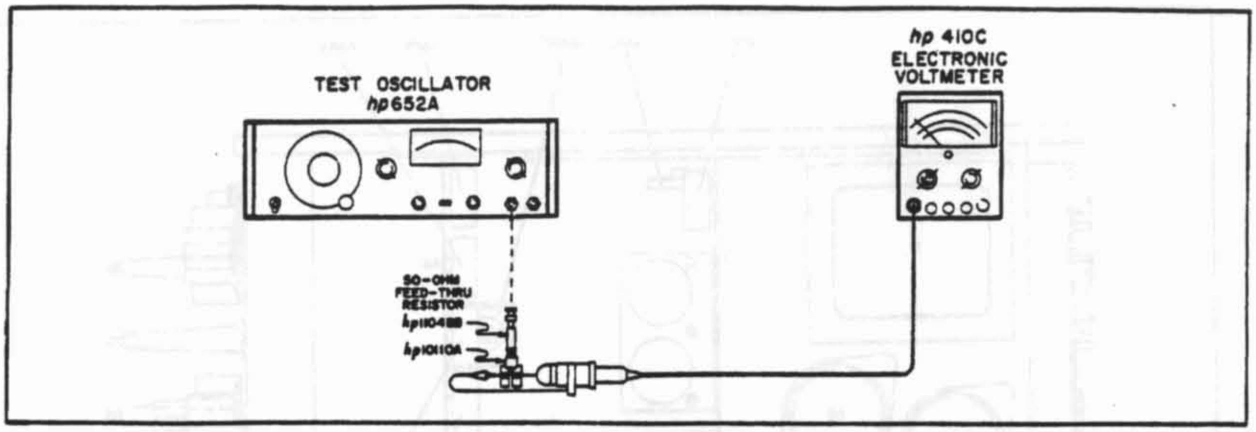


Figure 5-3. Low Frequency Response Test.

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 5-26, step f, with .3 V input; frequency to 10 MHz. Record dc voltmeter reading for reference.

c. Vary VHF oscillator frequency from 10 MHz to 480 MHz maintaining reference dc voltmeter reading by readjusting VHF oscillator output. Model 410C reading should be the same as the reading set at 400 Hz in Paragraph 5-26, step d, ± 2% at frequencies to 50 MHz, 0 to -4% from 50 MHz to 100 MHz and ± 1.5 dB at all higher specified frequencies.

d. Replace VHF oscillator with UHF oscillator in Figure 5-4. Repeat steps b and c for UHF oscillator output frequencies from 480 MHz to 700 MHz.

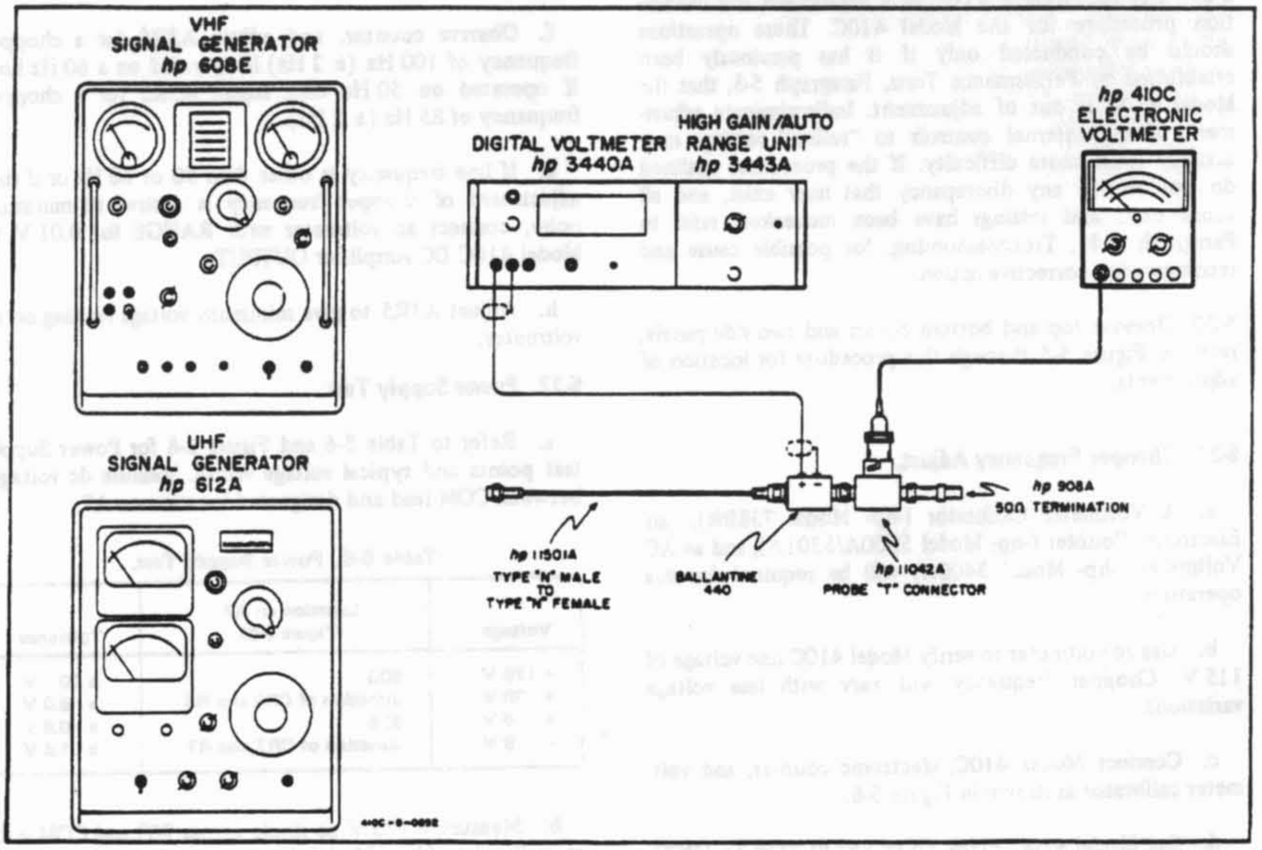


Figure 5-4. High Frequency Response Test.

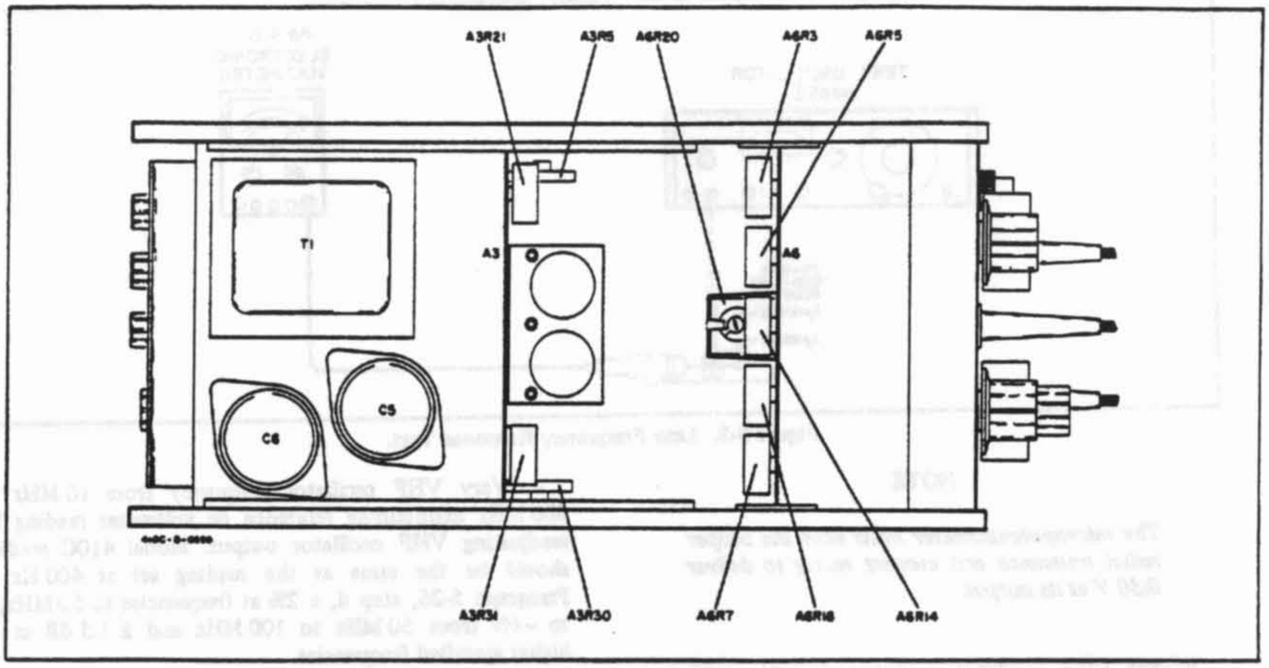


Figure 5-5. Adjustment Location.

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 Tests, 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 through this procedure for location of adjustments.

5-31. Chopper Frequency Adjust.

a. A Voltmeter Calibrator (-hp- Model 738BR), an Electronic Counter (-hp- Model 5300A/5301A), 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 Hz (± 2 Hz) if operated on a 60 Hz line. If operated on 50 Hz line, adjust A3R5 for a chopper frequency of 85 Hz (± 2 Hz).

g. If line frequency is other than 50 or 60 Hz 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.

5-32. Power Supply Test.

a. Refer to Table 5-6 and Figure 5-8 for Power Supply test 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 V ac ripple across 903 and COM with ac voltmeter (-hp- Model 3400A). RMS value of ripple should not exceed 5.0 mV.

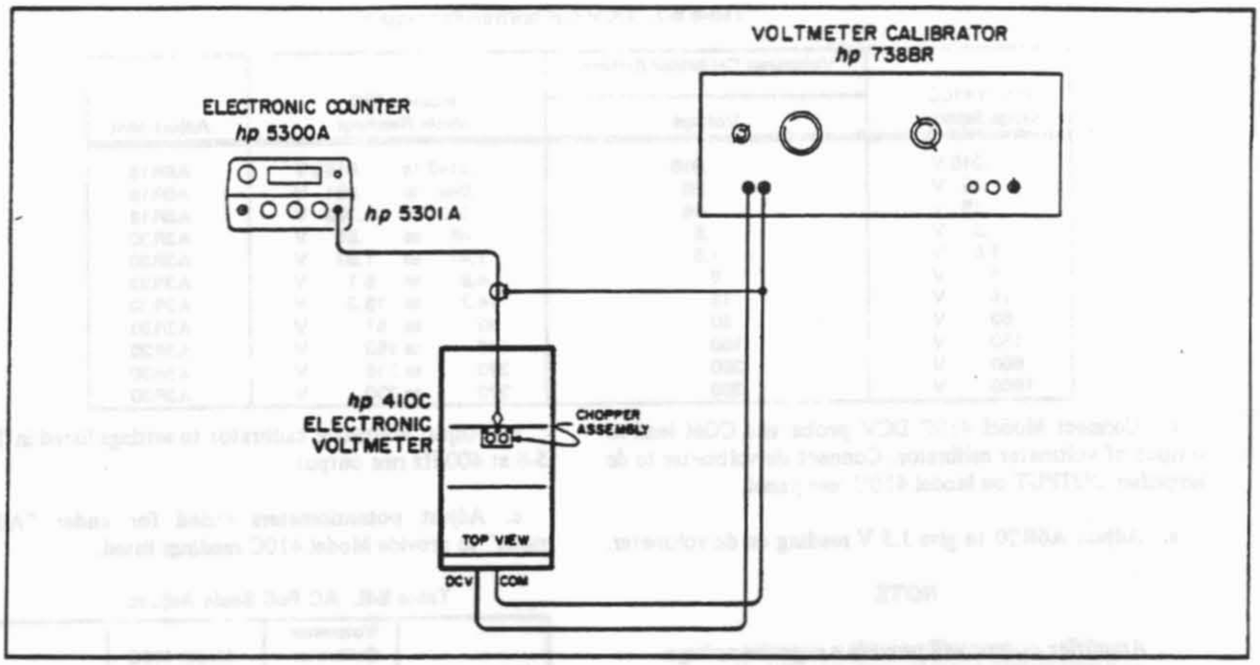


Figure 5-6. Chopper Frequency Adjust Setup.

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.

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 Ω (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/3443A) are 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.

Table 5-7. DCV Calibration Procedure.

Model 410C Range Settings	Voltmeter Calibrator Settings	Model 410C Meter Readings	Adjustment
	Voltage		
.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

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.

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 Hz 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 V ac to 500 V ac. 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.

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).
DC ZERO shifts, range to range.	A3CR1, CR2 light sensitive.
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 MΩ resistor across A3A1V1. If photocell were open, meter will now respond to input. Use 100 K resistor across A3A1V3 to check DC - Modulator (Figure 5-10).
Meter oscillates full scale at rate of 5 - 10 Hz.	Check chopper assembly. Connect 1 MΩ resistor across A3A1V2. If photocell were open, instrument will now respond to input. Use 100 K resistor across A3A1V2 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, Figure 5-7.

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 V dc input to 0.015 V RANGE).

5-48. Servicing Etched Circuit Boards.

5-49. The -hp- Model 410C has three etched circuit boards. Use caution when removing them to avoid damaging mounted components. The -hp- 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 -hp- 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.

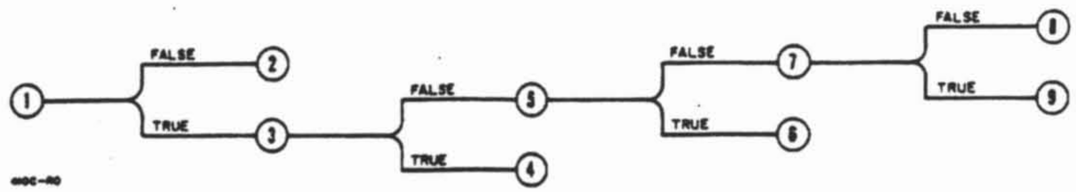
b. Circuit components can be removed by placing the soldering iron on the component lead on either side of the board and pulling up on lead. If a component is obviously damaged, clip leads as close to component as possible and then remove. Excess heat can cause the circuit and board to separate or cause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



① Check power supply voltage values using the procedure outlined in Paragraph 5-32. 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 Hz 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. 4.

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 .

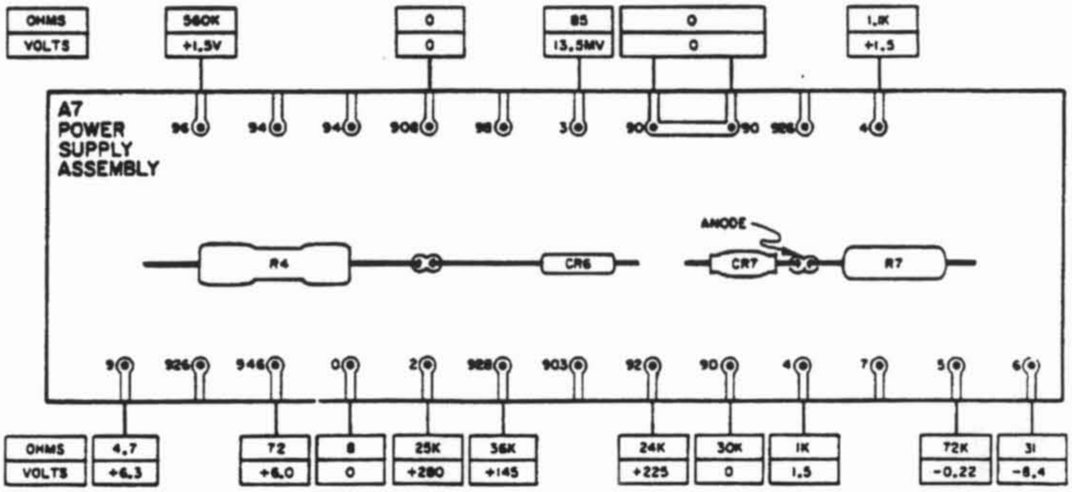
⑥ Investigate switch circuit. Refer to asterisks in Table 5-9 for hints on how to troubleshoot switch circuit.

⑦ Observe input voltage to demodulator ① using an oscilloscope. Refer to Figure 5-10 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. 4. Refer to Table 5-9 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. 4. Refer to Table 5-9 for method to check for open modulator.

Figure 5-7. Troubleshooting Procedures.



TEST CONDITIONS

VOLTAGE

FUNCTION: +DCV
RANGE: .015 V
INPUT: + .015 V
REFERENCE: Circuit ground (▽)

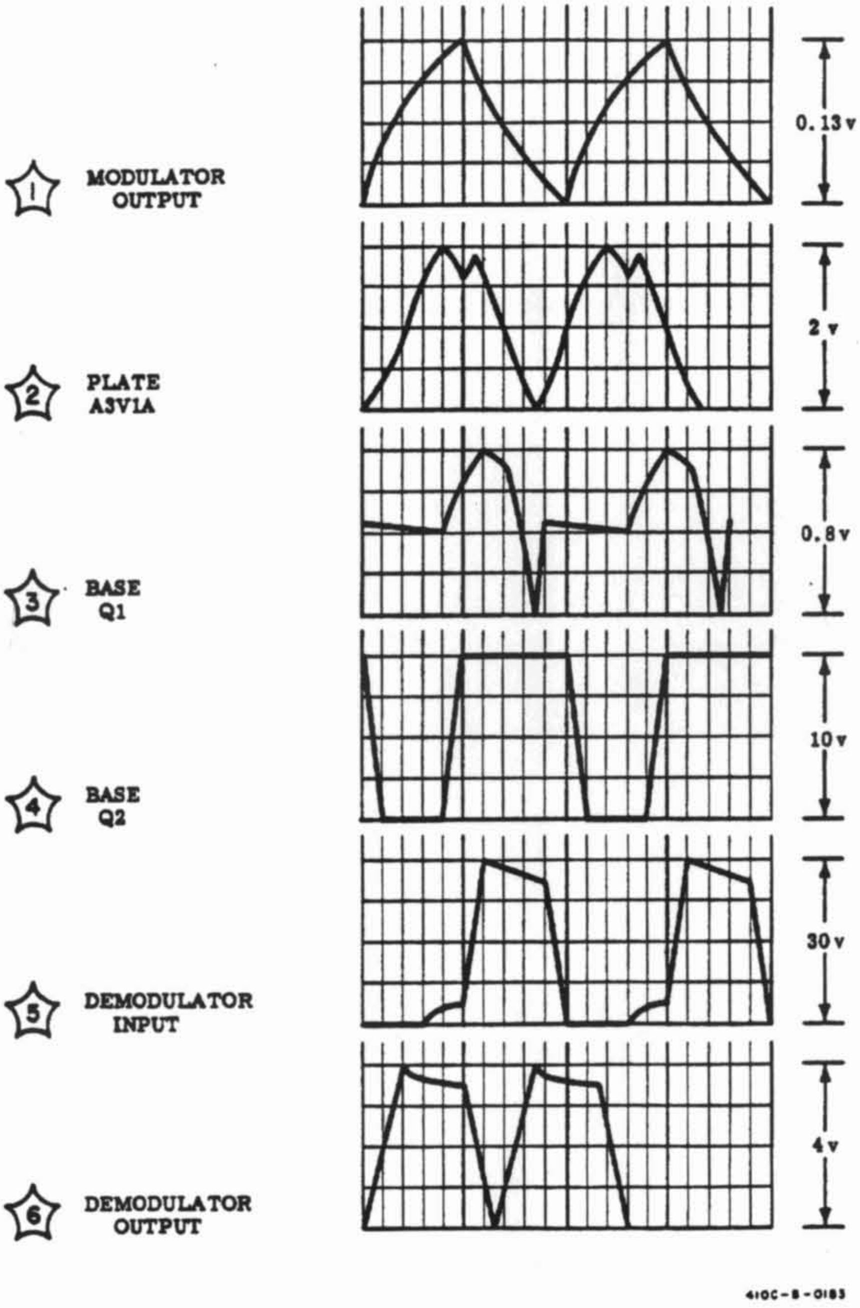
RESISTANCE

Instrument: OFF
FUNCTION: +DCV
RANGE: .015 V
INPUT: DCV Shorted to COM

NOTE

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.



TEST CONDITIONS:

FUNCTION: +DCV
RANGE: .015 V
INPUT: + 0.5 V

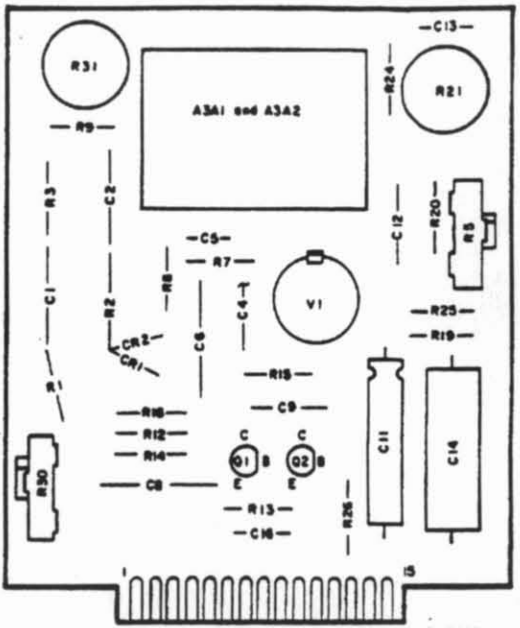
Waveforms observed on -hp- Model 180C w/-hp- Model 1801A and 1820C Plug-ins and 10001A Voltage Divider Probe using circuit ground (☆) are referenced.

Figure 5-10. Typical Amplifier Waveforms.

NOTES

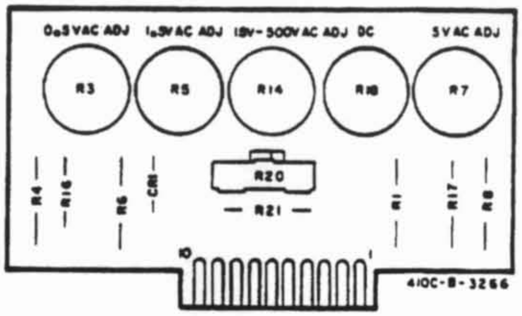
1. A3A1V1 AND A3A1V3 ARE LIGHTED SIMULTANEOUSLY BY A3A1DS1, AND A3A1V2 AND A3A1V4 ARE LIGHTED BY A3A1DS2.
2. UNLESS OTHERWISE NOTED:
   RESISTANCE IS IN OHMS.
   CAPACITANCE IS IN MICROFARADS.
3. SWITCHES ARE SHOWN IN FULLY CCW POSITIONS.
4. DC VOLTAGES SHOWN ARE TYPICAL UNDER THE FOLLOWING CONDITIONS:

   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 SCREWDRIVER ADJUST.
10. ○ INDICATES PANEL ADJUST.
    ⊘ INDICATES SCREWDRIVER ADJUST.
11. ⏚ = EARTH GROUND, ⊥ = CHASSIS GROUND,
    ▽ = CIRCUIT COMMON (FLOATING GROUND)
12. 935 DENOTES WIRE COLOR USING STANDARD COLOR CODE. (e.g. 9 = WHITE, 3 = ORANGE, 5 = GREEN.)
13. ✱ = OPTIMUM VALUE SELECTED AT FACTORY, AVERAGE VALUE SHOWN.
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.



A3

hp Part No. 410C-65A



A6

hp Part No. 410C-65B

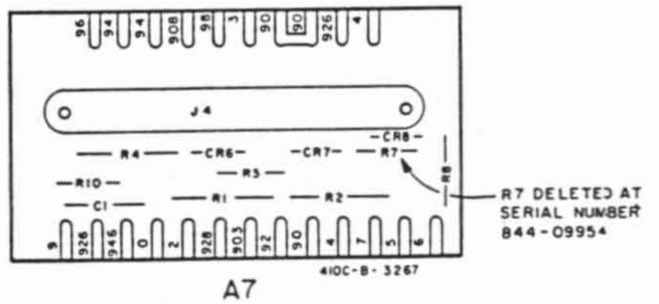
1. ———— — — — INDICATES AN ASSEMBLY. ALL COMPONENTS LOCATED ON AN ASSEMBLY ARE PREFIXED BY THE ASSEMBLY DESIGNATION (e.g., R3 ON ASSEMBLY A7 BECOMES A7R3).

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

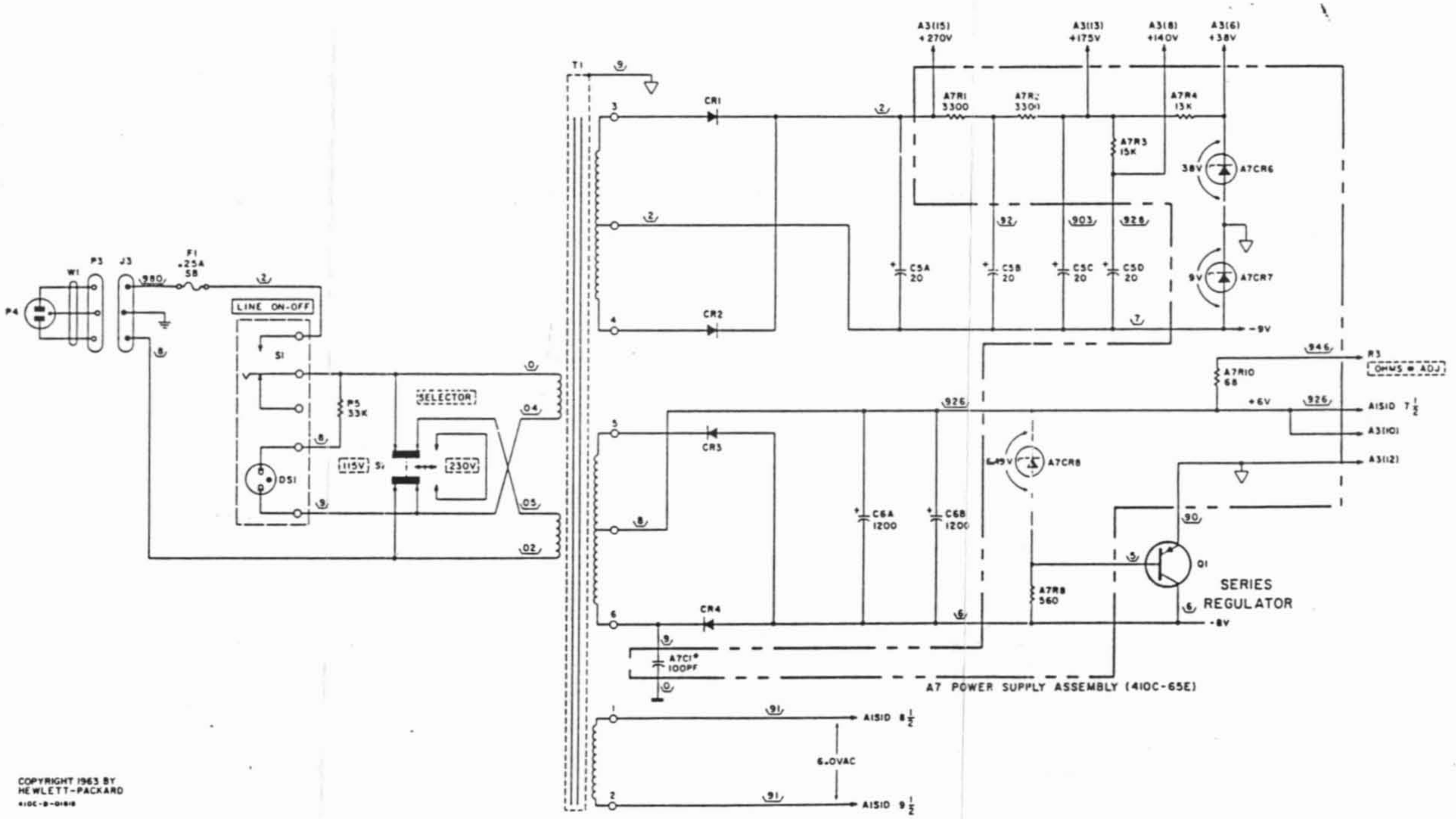
3. ⏚ = EARTH GROUND, ⊥ = CHASSIS GROUND,
   ▽ = CIRCUIT COMMON (FLOATING GROUND)

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.



A7
hp Part No 410C-65E



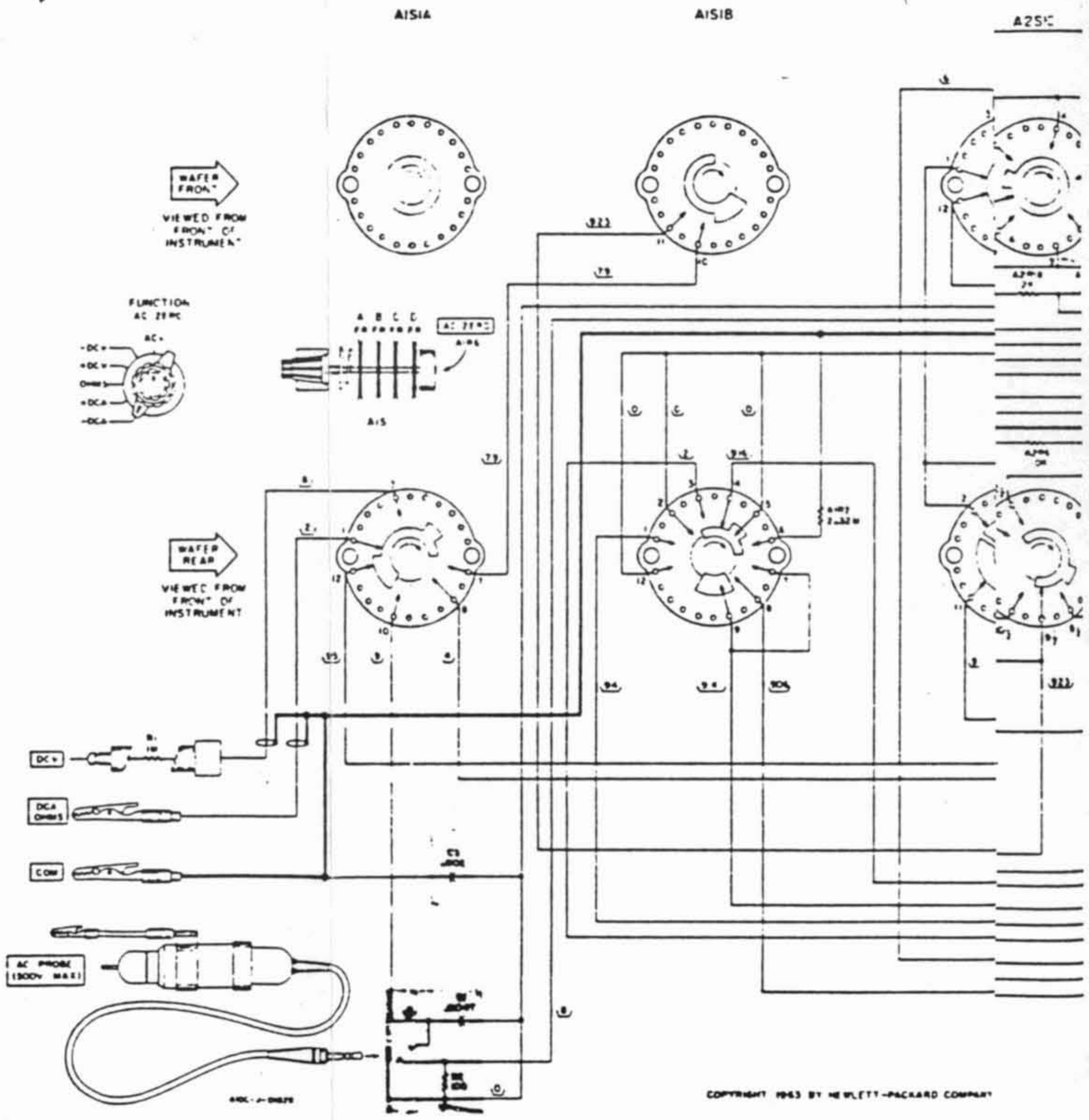
410C-B-01616

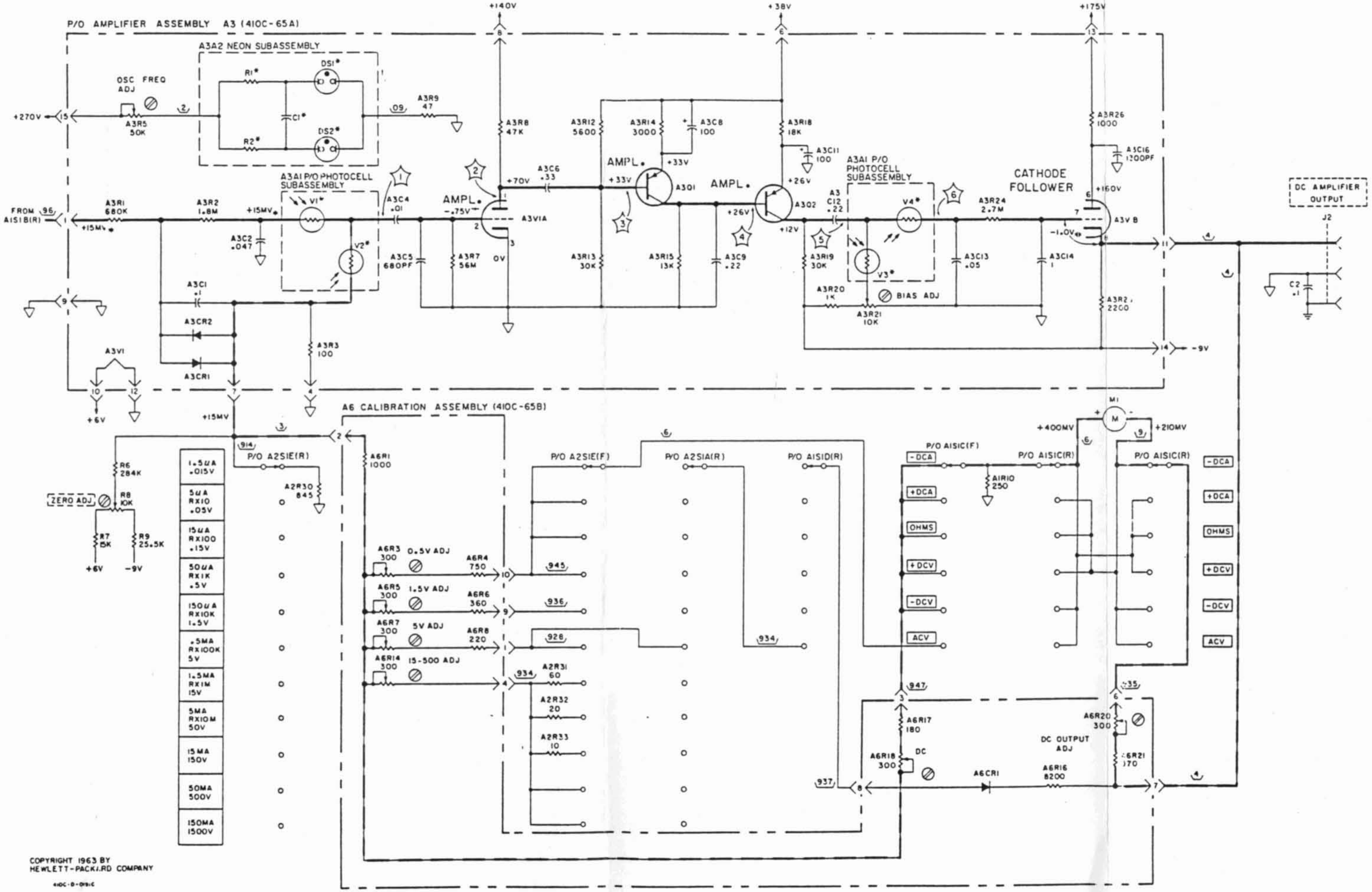
Figure 5-9. Power Supply Schematic.

410C-L-001A

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, ▬ = CHASSIS GROUND, ▽ = CIRCUIT COMMON (FLOATING GROUND).
5. ━━━━━━━━ INDICATES CIRCUIT GROUND BUS.
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.





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410C-D-0151C

Figure 5-11. Amplifier Schematic.

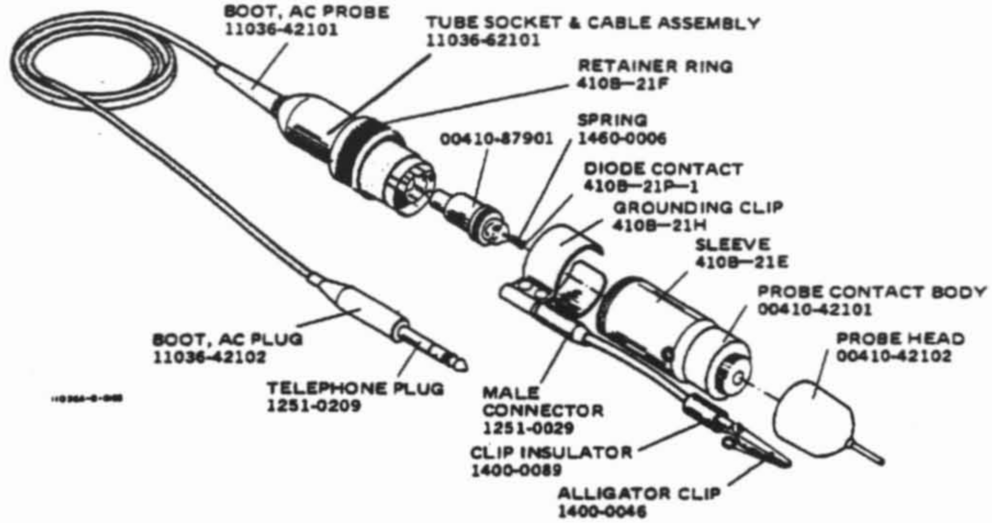
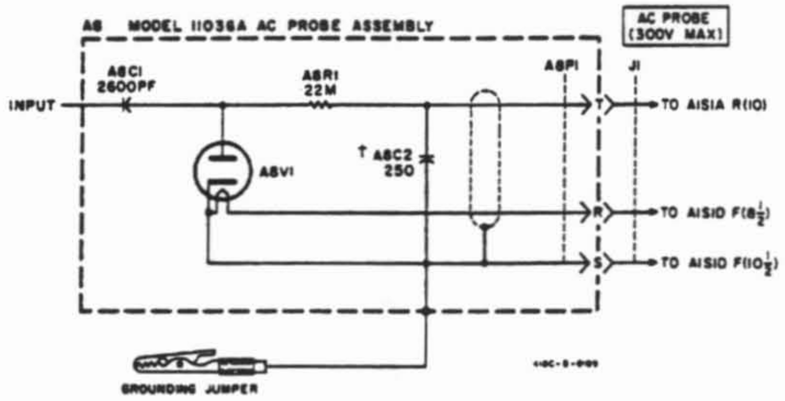


Figure 5-12. Model 11036A AC Probe (Exploded View).



NOTES

1. Unless otherwise specified, resistance in ohms. Capacitance in microfarads.

2. † value of A8C2 includes probe lead capacity.

3. – – – – indicates an assembly. All components located on any assembly are prefixed by the assembly designation (e.g., R1 on assembly A8 becomes A8R 1).

Figure 5-13. Model 11036A AC Probe Schematic.

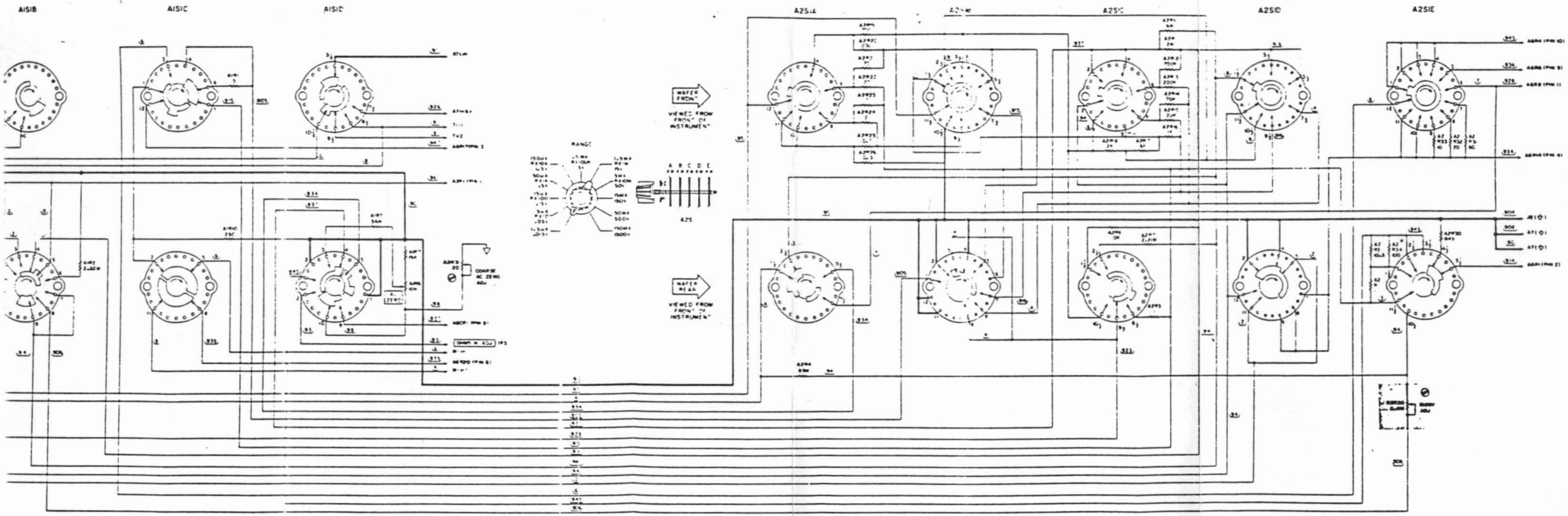


Figure 5-14. Range and Function Switching (Pictorial).

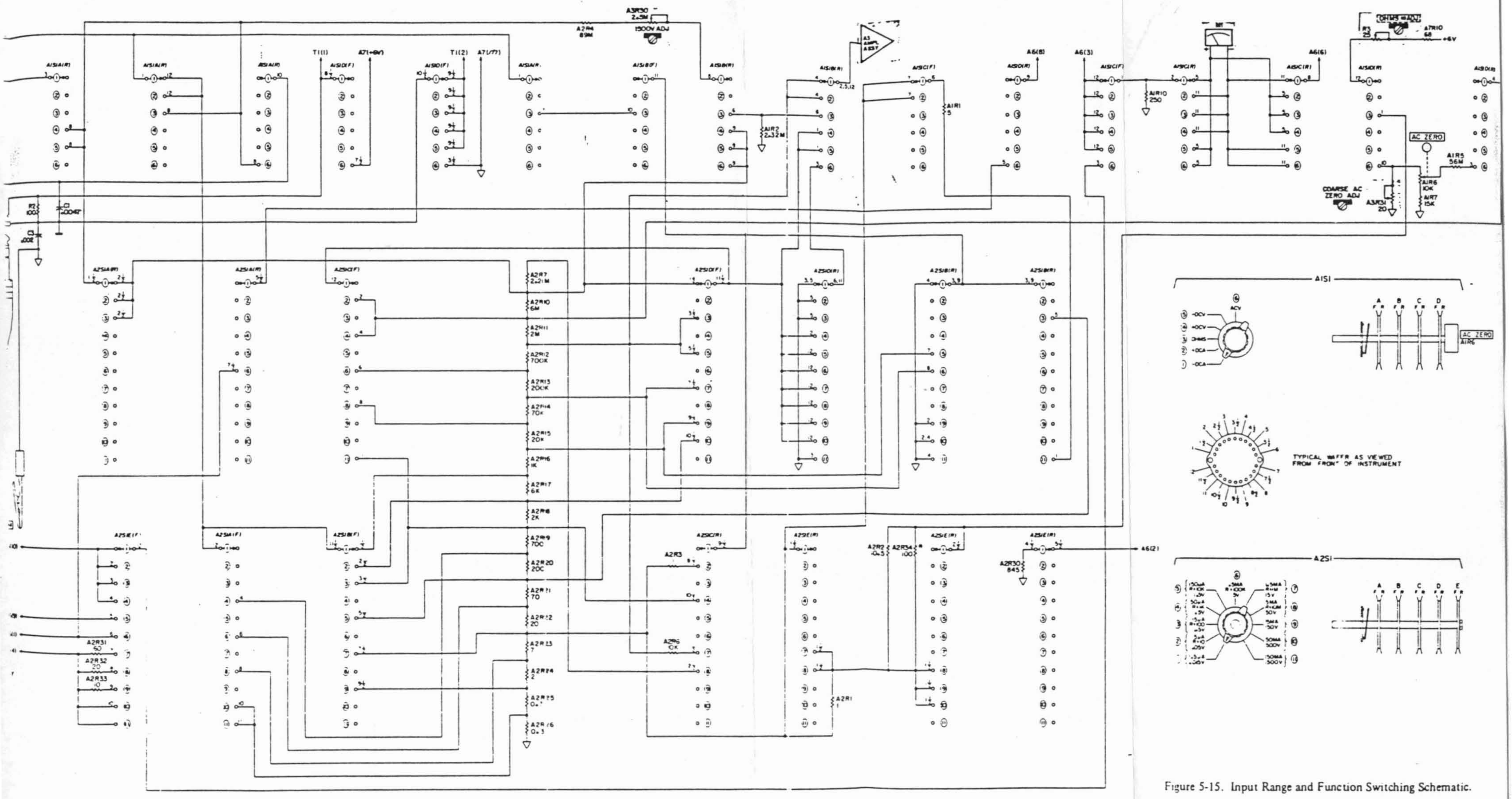


Figure 5-15. Input Range and Function Switching Schematic.

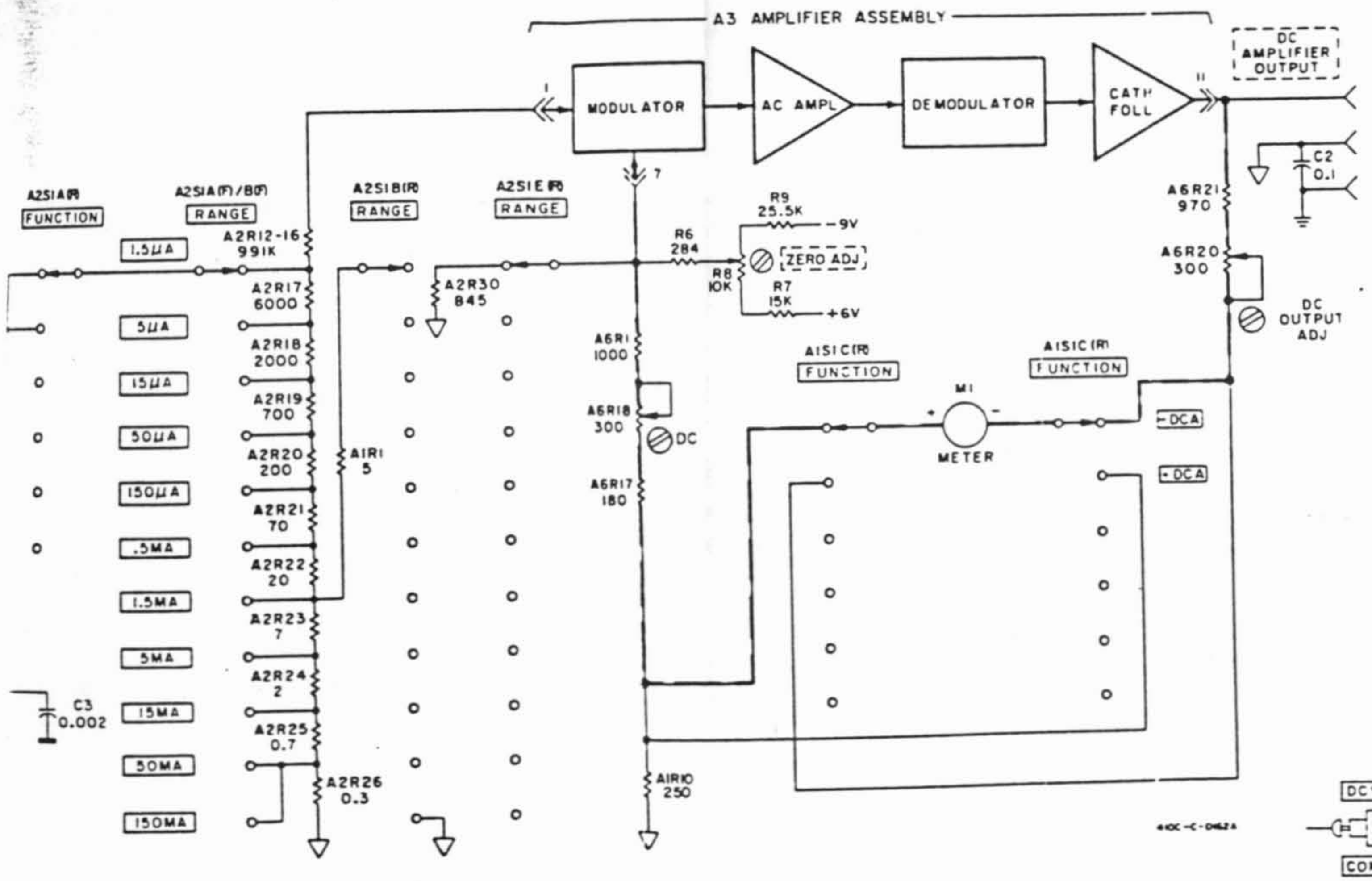


Figure 5-16. Simplified Schematic, DC Current Measurement.

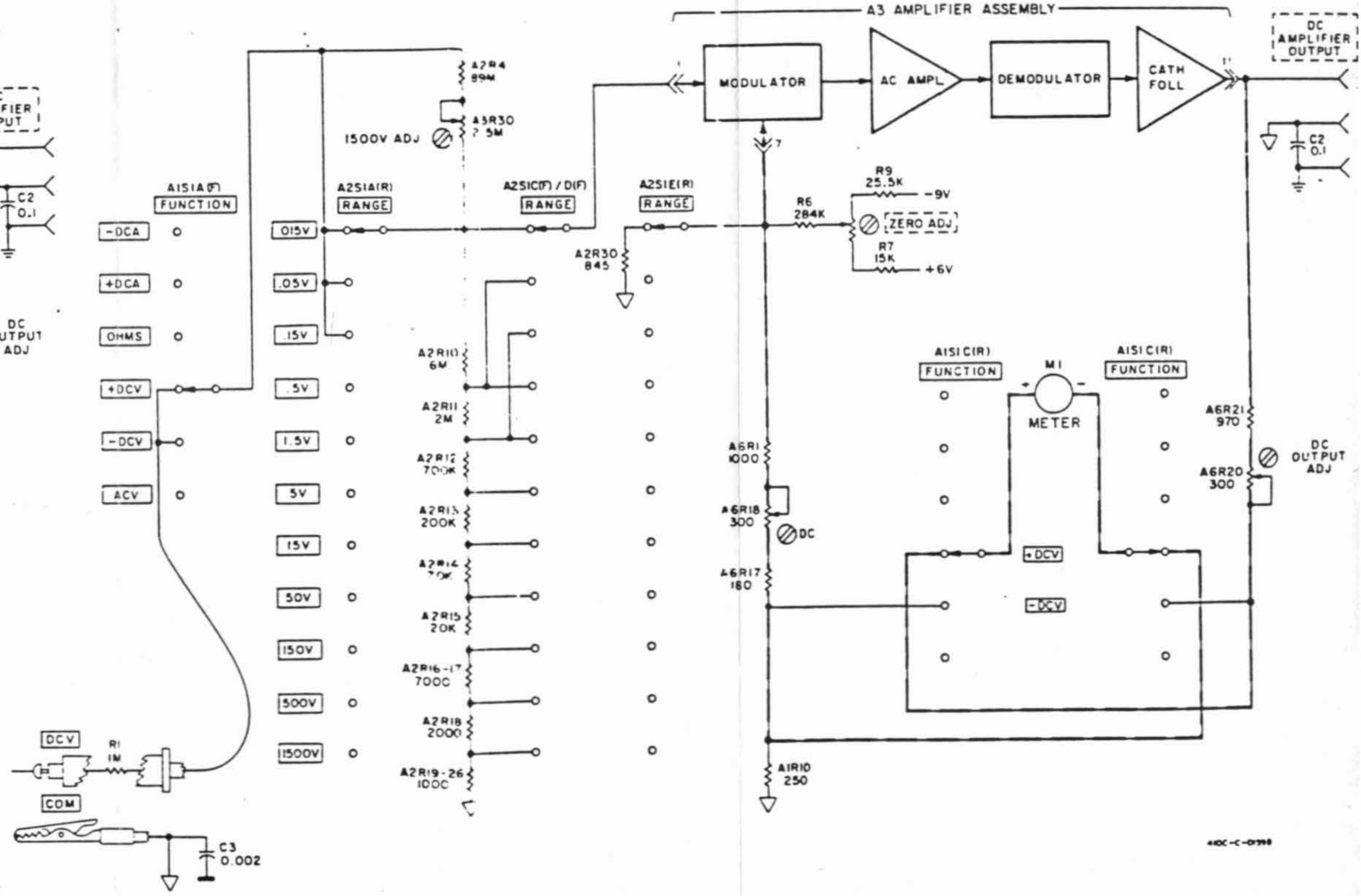


Figure 5-17. Simplified Schematic, DC Voltage Measurements.

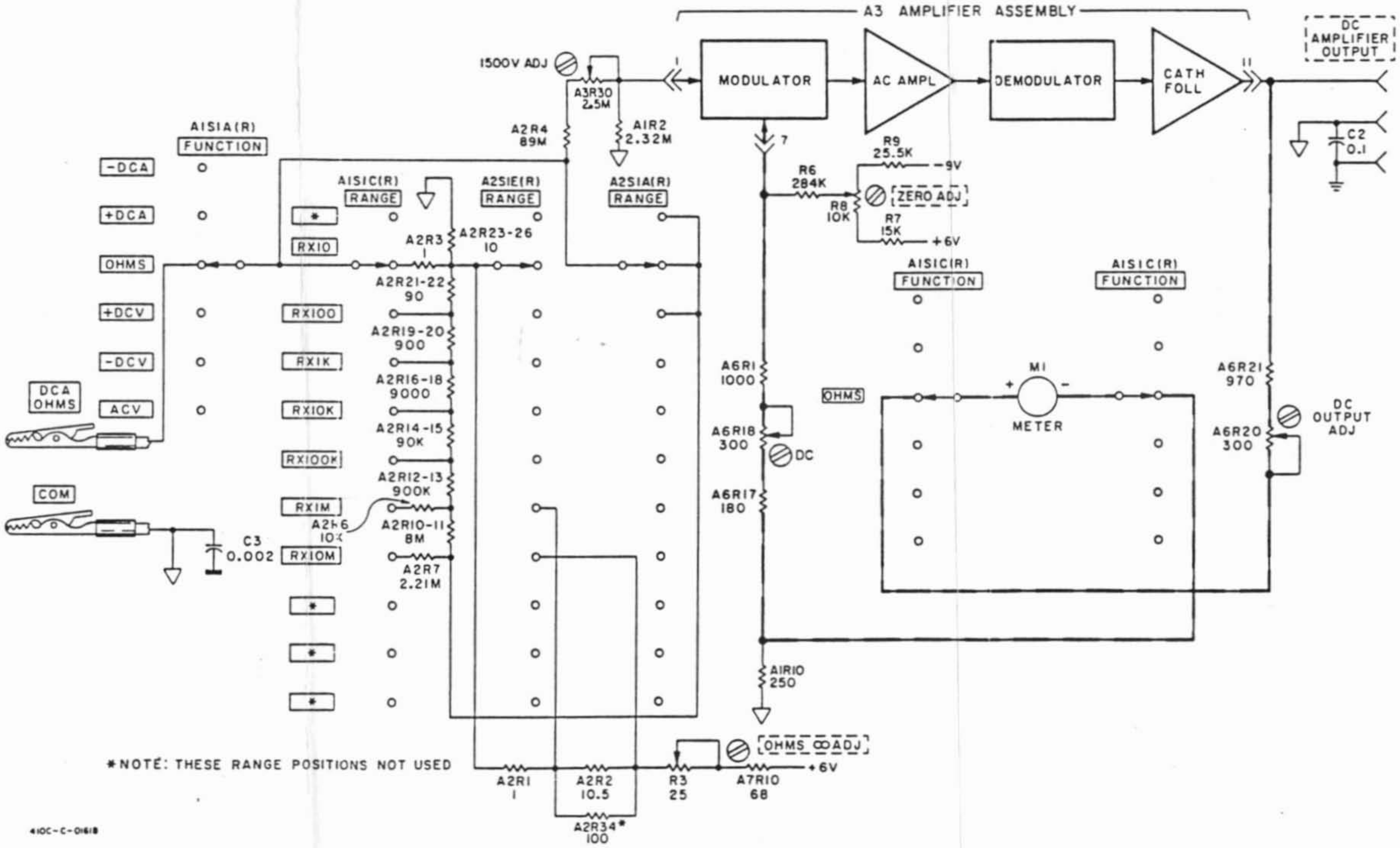
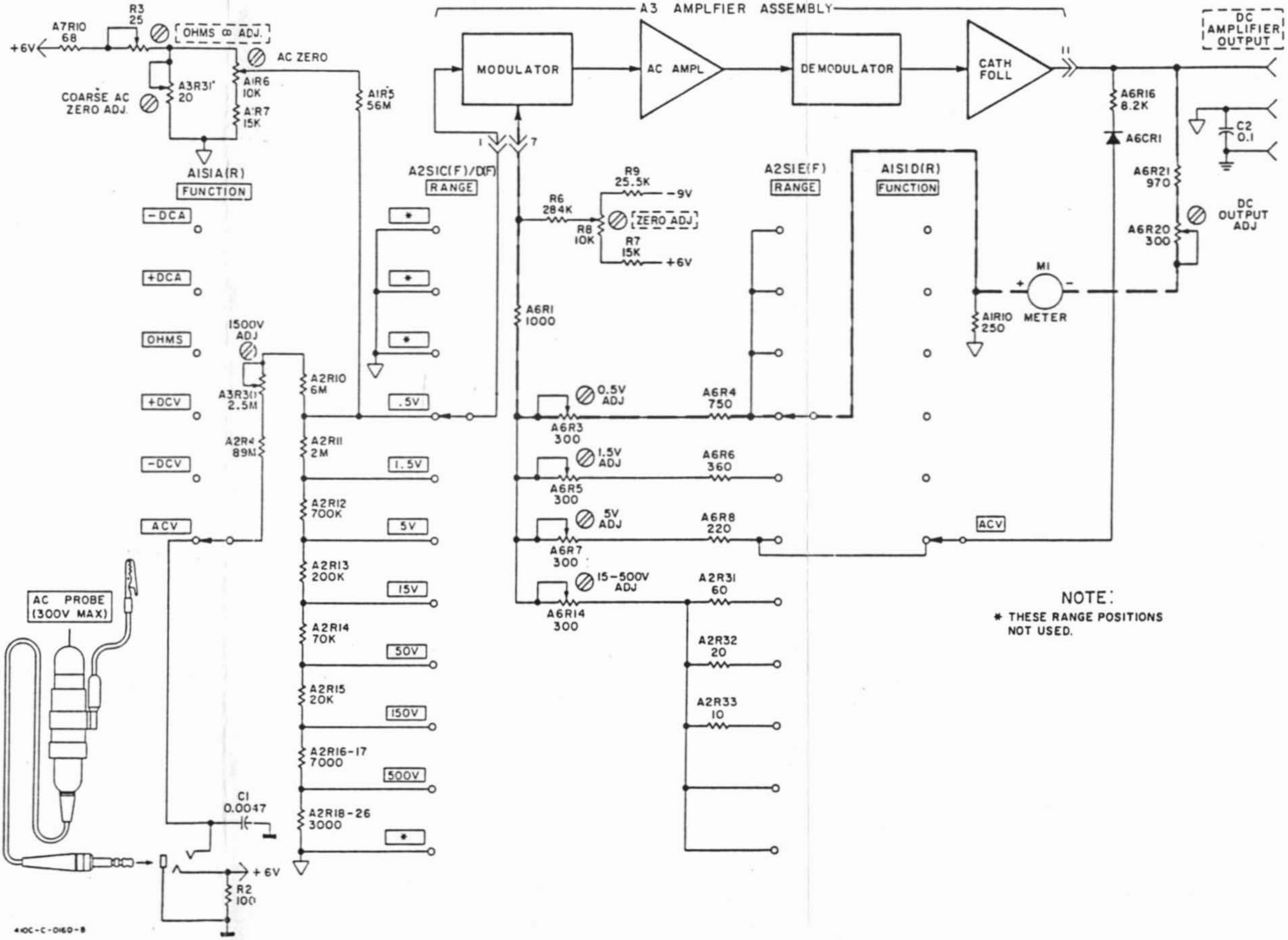


Figure 5-18. Simplified Schematic, Resistance Measurement.



NOTE:
* THESE RANGE POSITIONS NOT USED.

Figure 5-19. Simplified Schematic, AC Voltage Measurement.

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 -hp- part number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their -hp- part 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. ORDERING INFORMATION.

6-4. 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 part numbers.

6-5. Non-Listed Parts.

6-6. 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.

ABBREVIATIONS

Ag	silver
Al	aluminum
A	ampere(s)
Au	gold
C	capacitor
cer	ceramic
coef	coefficient
com	common
comp	composition
conn	connection
dep	deposited
DPDT	double-pole double-throw
DPST	double-pole single-throw
elect	electrolytic
encap	encapsulated
F	farad(s)
FET	field effect transistor
fxd	fixed
GaAs	gallium arsenide
GHz	gigahertz = 10^{+9} hertz
gd	guard(ed)
Ge	germanium
grnd	ground(ed)
H	henry(ies)
Hg	mercury
Hz	hertz (cycle(s) per second)
ID	inside diameter
impg	impregnated
incd	incandescent
ins	insulation(ed)
kΩ	kilohm(s) = 10^{+3} ohms
kHz	kilohertz = 10^{+3} hertz
L	inductor
lin	linear taper
log	logarithmic taper
mA	milliampere(s) = 10^{-3} amperes
MHz	megahertz = 10^{+6} hertz
MΩ	megohm(s) - 10^{+6} ohms
met flm	metal film
mfr	manufacturer
ms	millisecond
mtg	mounting
mV	millivolt(s) = 10^{-3} volts
μF	microfarad(s)
μs	microsecond(s)
μV	microvolt(s) = 10^{-6} volts
my	Mylar®
nA	nanoampere(s) = 10^{-9} amperes
NC	normally closed
Ne	neon
NO	normally open
NPO	negative positive zero (zero temperature coefficient)
ns	nanosecond(s) = 10^{-9} seconds
nsr	not separately replaceable
Ω	ohm(s)
obd	order by description
OD	outside diameter
p	peak
pA	picoampere(s)
pc	printed circuit
pF	picofarad(s) 10^{-12} farads
piv	peak inverse voltage
p/o	part of
pos	position(s)
poly	polystyrene
pot	potentiometer
p-p	peak-to-peak
ppm	parts per million
prec	precision (temperature coeffient, long term stability and/or tolerance)
R	resistor
Rh	rhodium
rms	root-mean-square
rot	rotary
Se	selenium
sect	section(s)
Si	silicon
sl	slide
SPDT	single-pole double-throw
SPST	single-pole single-throw
Ta	tantalum
TC	temperature coefficient
TiO₂	titanium dioxide
tog	toggle
tol	tolerance
trim	trimmer
TSTR	transistor
V	volt(s)
vacw	alternating current working voltage
var	variable
vdcw	direct current working voltage
W	watt(s)
w/	with
wiv	working inverse voltage
w/o	without
ww	wirewound
*	optimum value selected at factory, average value shown (part may be omitted)
**	no standard type number assigned selected or special type

® Dupont de Nemours

DECIMAL MULTIPLIERS

Prefix	Symbols	Multiplier	Prefix	Symbols	Multiplier
tera	T	10^{12}	centi	c	10^{-2}
giga	G	10^{9}	milli	m	10^{-3}
mega	M or Meg	10^{6}	micro	μ	10^{-6}
kilo	K or k	10^{3}	nano	n	10^{-9}
hecto	h	10^{2}	pico	p	10^{-12}
deka	da	10	femto	f	10^{-15}
deci	d	10^{-1}	atto	a	10^{-18}

STD-B-2734

DESIGNATORS

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

Table 6-1. Replaceable Parts

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1	410C-19B			Switch Assembly: Selector	-hp-	
R1	0727-0004		1	R: fxd C flm 5 Ω ±1% 1/2 W	94459	CVS
R2	0727-0480		1	R: fxd C flm 2.32 MΩ ±1% 0.5 W	94459	CVF
R3, R4				Not assigned		
R5	0687-5661		2	R: fxd comp 56 MΩ ±10% 1/2 W	01121	EB5661
R6	2100-0389		1	R: var ww lin 10 kΩ ±10% 5 W	-hp-	
R7	0687-1531		1	R: fxd comp 15 kΩ ±10% 1/2 W	01121	EB1531
R8, R9				Not assigned		
R10	0727-0479		1	R: fxd C flm 250 Ω ±1% 1/2 W	94459	CVF
S1	3100-0383		1	Switch: rotary 4-section 6-position (FUNCTION)	76854	obd
A2	410C-19A			Switch Assembly: Range	-hp-	
R1	0728-0004		2	R: fxd C flm 1 Ω ±1% 1/2 W	94459	CVF
R2	0727-0955		1	R: fxd C flm 10.5 Ω ±1% 1/2 W	94459	CVF
R3	0728-0004			R: fxd C flm 1 Ω ±1% 1/2 W	94459	CVF
R4	0733-0018		1	R: fxd C flm 89 MΩ ±1% 2 W	03888	HV2000
R5				Not assigned		
R6	0687-1031		1	R: fxd comp 10 kΩ ±10% 1/2 W	01121	EB1031
R7	0727-0478		1	R: fxd C flm 2.21 MΩ ±1% 1/2 W	94459	CVF
R8, R9				Not assigned		
R10	0730-0176		1	R: fxd 6 MΩ ±0.5% 1 W	94459	CVC
R11	0727-0459		1	R: fxd C flm 2 MΩ ±0.5% 1 W	01295	CD1R
R12	0727-0458		1	R: fxd C flm 700 kΩ ±0.5% 1/2 W	94459	CVF
R13	0727-0457		1	R: fxd C flm 200 kΩ ±1% 1/2 W	94459	CVF
R14	0727-0456		1	R: fxd C flm 70 kΩ ±0.5% 1/2 W	94459	CVF
R15	0727-0455		1	R: fxd C flm 20 kΩ ±0.5% 1/2 W	94459	CVF
R16	0727-0451		1	R: fxd C flm 1000 Ω ±0.5% 1/2 W	94459	CVF
R17	0727-0454		1	R: fxd C flm 6000 Ω ±0.5% 1/2 W	94459	CVF
R18	0727-0453		1	R: fxd C flm 2000 Ω ±0.5% 1/2 W	94459	CVF
R19	0727-0452		1	R: fxd C flm 700 Ω ±0.5% 1/2 W	94459	CVF
R20	0727-0450		1	R: fxd C flm 200 Ω ±0.5% 1/2 W	94459	CVF
R21	0727-0449		1	R: fxd C flm 70 Ω ±1% 1/2 W	94459	CVF
R22	0727-0448		2	R: fxd C flm 20 Ω ±1% 1/2 W	94459	CVF
R23	0727-0446		1	R: fxd C flm 7 Ω ±1% 1/2 W	94459	CVS
R24	0727-0445		1	R: fxd C flm 2 Ω ±1% 1/2 W	94459	CVS
R25	410C-26B		1	R: fxd 0.7 Ω	-hp-	
R26	410C-26A		1	R: fxd 0.3 Ω	-hp-	
R27 thru R29				Not assigned		
R30	0727-0701		1	R: fxd C flm 845 Ω ±1% 1/2 W	94459	CVF
R31	0727-0031		1	R: fxd C flm 60 Ω ±1% 1/2 W	01295	DC1/2PR
R32	0727-0448			R: fxd C flm 20 Ω ±1% 1/2 W	94459	CVF
R33	0727-0948		1	R: fxd C flm 10 Ω ±1% 1/2 W	94459	CVF
R34*	0687-1011		1	R: fxd comp 100 Ω ±10% 1/2 W	01121	EB1011
S1	3100-0382		1	Switch: rotary 5-section 11-position (RANGE)		
A3	410C-65A			Assembly: Amplifier	-hp-	
A1	1990-0020			Assembly: Chopper Block	-hp-	
V1 thru V4				Not separately replaceable, part of Chopper Assembly (1990-0020)		

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A3 (Cont'd)						
A2	1990-0207			Assembly: Lamp	-hp-	
C1				Not separately replaceable, part of Lamp Assembly (1990-0207)		
DS1, DS2				Not separately replaceable, part of Lamp Assembly (1990-0207)		
R1, R2				Not separately replaceable, part of Lamp Assembly (1990-0207)		
C1	0160-2641		1	C: fxd poly 0.1 μF ±10% 50 vdcw	56289	P136072
C2	0160-3116		1	C: fxd poly 0.047 μF ±10% 50 vdcw	56289	P136049
C3				Not assigned		
C4	0160-0161		1	C: fxd my 0.01 μF 200 vdcw	56289	192P10392
C5	0140-0208		1	C: fxd mica 680 pF ±5% 300 vdcw	00853	obd
C6	0160-2128		1	C: fxd my 0.33 μF ±20% 200 vdcw	72354	F307C334M
C7				Not assigned		
C8	0180-0039		1	C: fxd Al elect 100 μF 12 vdcw	56289	D32697
C9	0160-3366		2	C: fxd my 0.22 μF ±20% 100 vdcw	72354	F307C224M
C10				Not assigned		
C11	0180-1819		1	C: fxd Al elect 100 μF 50 vdcw	56289	30D107G0500H2
C12	0160-3366			C: fxd my 0.22 μF ±20% 100 vdcw	72354	F307C224M
C13	0150-0096		1	C: fxd cer 0.05 μF 100 vdcw	72982	845-X5V-5032
C14	0170-0018		1	C: fxd my 1 μF ±5% 200 vdcw	84411	HEW-4
C15				Not assigned		
C16	0140-0154		1	C: fxd mica 1300 pF ±5% 500 vdcw	14655	RCM15E101K
CR1, CR2	1901-0156		1	Diode: Si 50 mA	03877	SG3288
Q1, Q2	1853-0020		2	TSTR: Si PNP	-hp-	
R1	0687-6841		1	R: fxd comp 680 kΩ ±10% 1/2 W	01121	EB6841
R2	0687-1851			R: fxd comp 1.8 MΩ ±10% 1/2 W	01121	EB1851
R3	0811-0998		1	R: fxd comp 100 Ω ±1% 1/4 W	-hp-	
R4				Not assigned		
R5	2100-0760		1	R: var comp lin 50 kΩ ±30% 1/4 W	71590	Series 5 Type 70-1
R6				Not assigned		
R7	0687-5661			R: fxd comp 56 MΩ ±10% 1/2 W	01121	EB5661
R8	0687-4731		1	R: fxd comp 47 kΩ ±10% 1/2 W	01121	EB4731
R9	0687-4701		1	R: fxd comp 47 Ω ±10% 1/2 W	01121	EB4701
R10, R11				Not assigned		
R12	0757-0164		1	R: fxd met flm 5600 Ω ±2% 1/2 W	07115	C20
R13	0757-0166		2	R: fxd met flm 30 kΩ ±2% 1/2 W	07115	C20
R14	0757-0163		1	R: fxd met flm 3000 Ω ±2% 1/2 W	07115	C20
R15	0757-0165		1	R: fxd met flm 13 kΩ ±2% 1/2 W	07115	C20
R16, R17				Not assigned		
R18	0757-0091		1	R: fxd met flm 18 kΩ ±2% 1/2 W	07115	C20
R19	0757-0166			R: fxd met flm 30 kΩ ±2% 1/2 W	07115	C20
R20	0687-1021		3	R: fxd comp 1000 Ω ±10% 1/2 W	01121	EB1021
R21	2100-0396		1	R: var ww lin 10 kΩ ±20% 1 W	79727	E870PAB
R22, R23				Not assigned		
R24	0687-2751		1	R: fxd 2.7 MΩ ±10% 1/2 W	01121	EB2751
R25	0687-2221		1	R: fxd comp 2.2 kΩ ±10% 1/2 W	01121	EB2221
R26	0687-1021			R: fxd comp 1000 Ω ±10% 1/2 W	01121	EB1021
R27 thru R29				Not assigned		
R30	2100-0413		1	R: var comp lin 2.5 MΩ ±20% 1/4 W	71590	Series 5 Type 70-1

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A3 (Cont'd)						
R31	2100-0227		1	R: var ww lin 20 Ω ±10% 1 W	-hp-	
V1	1932-0027		1	Tube: electron 12AT7 dual triode	80131	12AT7
A4, A5				Not assigned		
A6	410C-65B			Assembly: Calibration	-hp-	
CR1	1901-0025		1	Diode: Si 50 mA	93332	D3C72
R1	0727-0751		1	R: fxd C flm 1000 Ω ±1% 1/2 W	94459	CVF
R2				Not assigned		
R3	2100-0394		6	R: var ww lin 300 Ω ±20% 1 W	11236	Series 110
R4	0727-0747		2	R: fxd C flm 750 Ω ±1% 1/2 W	94459	CVF
R5	2100-0394			R: var ww lin 300 Ω ±20% 1 W	11236	Series 110
R6	0728-0011		1	R: fxd C flm 360 Ω ±1% 1/2 W	94459	CVF
R7	2100-0394			R: var ww lin 300 Ω ±20% 1 W	11236	Series 110
R8	0728-0010		1	R: fxd C flm 220 Ω ±1% 1/2 W	94459	CVS
R9 thru R13				Not assigned		
R14	2100-0394			R: var ww lin 300 Ω ±20% 1 W	11236	Series 110
R15				Not assigned		
R16	0758-0048		1	R: fxd met flm 8200 Ω ±5% 1/2 W	07115	C20
R17	0727-0866		1	R: fxd C flm 180 Ω ±1% 1/2 W	94459	CVF
R18	2100-0394			R: var ww lin 300 Ω ±20% 1 W	11236	Series 110
R19				Not assigned		
R20	2100-0395		1	R: var comp lin 300 Ω ±20% 1/4 W	71590	Series 5 Type 70-1
R21	0727-0475		1	R: fxd C 970 Ω ±0.5% 1/2 W	94459	CD1/2MR
A7	410C-65E			Assembly: Power Supply	-hp-	
C1*	0140-0041		1	C: fxd mica 100 pF ±5% 500 vdcw	04062	RCM15E101J
CR1 thru CR5				Not assigned		
CR6	1902-0026		1	Diode: breakdown 36.5 V ±10% 0.4 W	04713	SZ10939-343
CR7	1902-0681		1	Diode: breakdown 9.09 V ±10% 500 mW	04713	SZ12385
CR8	5080-9050		1	Diode: breakdown 6.49 V ±5% 0.4 W	-hp-	
J4	1251-0213		1	Connector: 15 pin PC	95354	SD-615W(125)
R1, R2	0764-0003		2	R: fxd met flm 3300 Ω ±5% 2 W	07115	C42S
R3	0758-0018		1	R: fxd met flm 15 kΩ ±5% 1/2 W	07115	C20
R4	0764-0026		1	R: fxd met flm 13 kΩ ±5% 2 W	07115	C42S
R5, R6				Not assigned		
R7				Deleted in serial number 844-09954 and up		
R8	0758-0002		1	R: fxd met flm 560 Ω ±5% 1/2 W	07115	C20
R9				Not assigned		
R10	0758-0083		1	R: fxd met flm 68 Ω ±5% 1/2 W	07115	C20
A8	11036A			Assembly: AC Probe (-hp- Model 11036A, complete)	-hp-	
C1				Not separately replaceable, part of AC Probe (11036A)		
C2				Not separately replaceable, part of AC Probe (11036A)		
P1	1251-0209		1	Plug: telephone 3 conductor	82389	2P-1297

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A8 (Cont'd)						
R1				Not separately replaceable, part of AC Probe (11036A)		
V1	00410-87901			Tube: electron diode	-hp-	
C1	0170-0021		1	C: fxd my 4700 pF ±10% 400 vdcw	84411	620SJ0047
C2	0170-0022		1	C: fxd my 0.1 μF ±10% 600 vdcw	59875	HEW-17
C3	0150-0023		1	C: fxd cer 2000 pF ±20% 1000 vdcw	56289	19C203A
C4				Not assigned		
C5	0180-0025		1	C: fxd Al elect 4x20 μF +50% -10% 450 vdcw	00853	Type PLI
C6	0180-0153		1	C: fxd Al elect 2x1200 μF +100% -10% 20 vdcw	00853	4S4039
CR1, CR2	1901-0036		1	Diode: Si 300 mA	01841	obd
CR3, CR4	1901-0049		1	Diode: Si 500 mA	86684	34934
DS1	2140-0244		1	Light indicator: A1H neon (p/o S3)	87034	A1H
F1	2110-0201		1	Fuse: cartridge slow-blow 0.25 A 125 V	-hp-	
J1	1251-0200		1	Jack: telephone 3 conductor	82389	3J-1291
J2				Assembly: DC AMPLIFIER OUTPUT (see MISCELLANEOUS for Part Nos.		
J3	1251-2357		1	Connector: power cord receptacle	82389	EAC-301
M1	1120-0317		1	Meter: 0-1 mA	-hp-	
Q1	1853-0063		1	TSTR: Si PNP	04713	SJ1528
R1	0727-0274		1	R: fxd C flm 1 MΩ ±1% 1/2 W	94459	CVF
R2	0758-0086		1	R: fxd met flm 100 Ω ±5% 1/4 W	07115	C07
R3	2100-0415		1	R: var ww lin 25 Ω ±10% 2 W	08984	FFF-1
R4				Not assigned		
R5	0687-3331		1	R: fxd comp 33 kΩ ±10% 1/2 W	01121	EB3331
R6	0727-0231		1	R: fxd C flm 284 kΩ ±0.5% 1/2 W	91637	DCS1/2
R7	0727-0168		1	R: fxd C flm 15 kΩ ±1% 1/2 W	91637	DCS1/2-15
R8	2100-1567		1	R: var ww 10 kΩ ±10% 2 W	11236	117
R9	0727-0180		1	R: fxd C flm 25.5 kΩ ±1% 1/2 W	91637	DCS1/2-15
S1	3101-1248		1	Switch: SPST pushbutton (Line)	29207	53-55480-121-A1H
S2	3101-1234		1	Switch: DPDT slide (Selector)		
T1	9100-0174		1	Transformer: power	-hp-	
W1	8120-1348		1	Cable: power 3 conductor 7-1/2 ft. long w/NEMA plug	-hp-	
XQ1	1200-0044		1	Socket: transistor TO-3	97913	M7(PB)
				MISCELLANEOUS		
	1220-0066		1	Shield: tube	82252	319A-2
	1490-0088		1	Clip: ground	71785	422-11-11-095
	1510-0006		1	Binding post: black (p/o J2)	-hp-	
	1510-0007		2	Binding post: red (p/o J2)	-hp-	

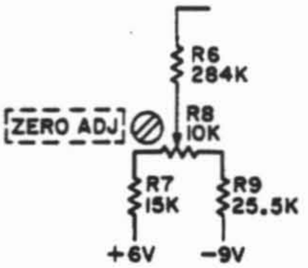
Table 6-2. Replaceable Hardware

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
	11036-42102		1	Boot: AC plug (p/o 11036A)	-hp-	
	11036-42101		1	Boot: AC probe (p/o 11036A)	-hp-	
	412A-83A		3	Boot: cable	-hp-	
	410C-12A		1	Bracket: connector (used with A3 connector)	-hp-	
	410C-12B		1	Bracket: switch (used with A6 connector)	-hp-	
	00410-01202		2	Bracket: cover retainer	-hp-	
	1200-0081		2	Bushing: insulator (used with Q1)	26365	974 Special
	1410-0091		2	Bushing: panel (used with A1S1 and A2S2)	28520	SB-437-4
	0400-0019		3	Bushing: strain relief	-hp-	
	410C-1A		1	Chassis: transformer	-hp-	
	1400-0046		1	Clip: alligator (P/O 11036A)	-hp-	
	410B-21H		1	Clip: grounding (P/O 11036A)	-hp-	
	1251-0029		1	Connector: male (P/O 11036A)	-hp-	
	410B-21P		1	Contact: Diode (p/o 11036A)	-hp-	
	3130-0038		1	Coupler: switch	45255	10X20X1
	5000-8565		1	Cover: side	-hp-	
	00410-64102		1	Cover: top (requires 2 brackets 00410-01202)	-hp-	
	5000-8577		1	Cover: bottom	-hp-	
	5060-0727		2	Foot assembly	-hp-	
	5060-0703		2	Frame: side	-hp-	
	5040-0700		2	Hinge (used with tilt stand)	-hp-	
	1400-0084		1	Holder: fuse	75915	342014
	1400-0089		1	Insulator: clip (P/O 11036A)	-hp-	
	0340-0086		1	Insulator: binding post double	-hp-	
	0340-0091		1	Insulator: binding post triple	-hp-	
	1520-0001		2	Insulator: capacitor (used with C1 - C2)	56137	XP
	0340-0007		1	Insulator: ceramic standoff	71590	obd
	0370-0112		1	Knob: black bar concentric	-hp-	
	0370-0113		1	Knob: black bar w/arrow	-hp-	
	0370-0114		1	Knob: red w/arrow	-hp-	
	0360-0016		1	Lug: solder lock #4	78452	718
	0360-0007		4	Lug: solder #10	78189	2501-10-00
	0360-0042		2	Lug: solder 90°	79963	obd
	2260-0001		4	Nut: hex 4-40 x 1/4 in.	-hp-	
	2420-0001		4	Nut: hex 6-32 x 5/16 in. w/lock	83385	obd
	2820-0001		3	Nut: hex 10-32 x 3/8 in.	73743	obd
	2950-0006		3	Nut: hex 1/4-32 x 3/8 in.	73734	9000
	2950-0001		3	Nut: hex 3/8-32 x 1/2 in.	73743	obd
	2950-0037		1	Nut: hex 1/2-16 x 11/16 in.	75915	obd
	2950-0038		1	Nut: hex 1/2-24 x 11/16 in.	75915	903-12
	0590-0039		4	Nut: speed 6-32	78553	C6800-632-1
	0590-0052		2	Nut: speed 6-32	78553	C8020-632-4
	00410-00211		1	Panel: front	-hp-	
	00410-00202		1	Panel: rear	-hp-	
	410C-41A		1	Plate: insulator (used with A1S1 and A2S2)	-hp-	
	1200-0043		1	Plate: insulator (used with Q1)	71785	294457
	1251-0209		1	Plug: telephone (p/o 11036A)	82389	2P-1297
	00410-42101		1	Probe: contact body (P/O 11036A)	-hp-	
	00410-42102		1	Probe head (P/O 11036A)	-hp-	
	410B-21F		1	Ring: retainer (p/o 11036A)	-hp-	
	2200-0006		2	Screw: machine 4-40 x 3/8 in. RH	80120	obd
	2200-0014		2	Screw: machine 4-40 x 9/16 in. RH	80120	obd
	2370-0001		20	Screw: machine 6-32 x 1/4 in. RH	80120	obd

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
	2390-0007		4	Screw: machine 6-32 x 5/16 in. BH w/lock	83385	obd
	2370-0002		8	Screw: machine 6-32 x 3/8 in. FH	80120	obd
	2370-0003		2	Screw: machine 6-32 x 1/2 in. FH	80120	obd
	410B-21E		1	Sleeve (p/o 11036A)	-hp-	
	1460-0006		1	Spring: diode contact (p/o 11036A)	91260	obd
	1490-0031		1	Stand: tilt	91260	obd
	410C-66A		2	Support: circuit board (used with A3)	-hp-	
	410C-21D		1	Test lead assembly: COM	-hp-	
	410C-21C		1	Test lead assembly: DCA - OHMS	-hp-	
	410C-21A		1	Test lead assembly: DCV (includes R1)	-hp-	
	5020-6852		1	Trim: meter	-hp-	
	11036-62101		1	Tube: socket and cable assembly (p/o 11036A)	-hp-	
	3050-0066		2	Washer: flat #6	73734	obd
	3050-0067		3	Washer: flat 3/8 in. ID	73734	obd
	0900-0016		1	Washer: fuse holder	76680	622710
	2190-0005		2	Washer: lock #4 external	80120	obd
	2190-0004		2	Washer: lock #4 internal	78189	SF1904
	2190-0003		2	Washer: lock #4 split	83385	obd
	2190-0047		30	Washer: lock #6 countersunk	78189	obd
	2190-0011		2	Washer: lock #10 internal	78189	1910
	2190-0028		2	Washer: lock #10 int/ext	78189	4010-18-00
	2190-0027		3	Washer: lock 1/4 in. internal	78189	1914
	2190-0022		4	Washer: lock 3/8 in. ID	78189	1920
	2190-0037		2	Washer: lock 1/2 in. internal	78189	1224-08
	1400-0090		1	Washer: Neoprene	75915	901-2

Figure 5-11, Amplifier Schematic:
Delete:



Page 5-1, Paragraph 5-11a:
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 5-34c:
Adjust A3R21 for zero meter deflection.

Page 5-8, Paragraph 5-34c:
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 8

Section VI, Table of Replaceable Parts:
Delete: A3C11; Capacitor: fxd, 100 μF, 25 vdcw -hp- Part No. 0180-0094.
Add: A3C11; Capacitor: fxd, 100 μF, 50 vdcw -hp- Part No. 0180-1819.

NOTE

Later Models 410C (Serial No's. 550-05301 and above use a 50 vdcw capacitor (-hp- 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 9

Section VI, Table of Replaceable Parts:
Delete: A3C1 -hp- Part No. 0160-2641.
A3C2 -hp- Part No. 0160-3116.
Add: A3C1 -hp- Part No. 0170-0030.
A3C2 -hp- Part No. 0170-0077.

CHANGE 10

Figure 5-9, Power Supply Schematic:
Add A7R7, 1100 Ω between anode of A7CR7 and base of Q1.
Change value of A7R8 to 1200 Ω.

Section VI, Table of Replaceable Parts:
Add A7R7 R: fxd met flm 1100 Ω ± 5% 1/2W -hp- Part No. 0758-0069.
Change A7R8 to 1200 Ω -hp- Part No. 0758-0070.

CHANGE 11

Section VI, Table of Replaceable Parts:
Change F1 to -hp- Part No. 2110-0018.
Change J3 to -hp- Part No. 1251-0148.
Change S1 to -hp- Part No. 3101-0100.
Change S2 to -hp- Part No. 3101-0033.
Change W1 to -hp- Part No. 8120-0078.

The following -hp- Part No's. concern color conversion and apply to earlier "blue" colored instruments. Part No's. for "brown" instruments are listed in Table 6-1.

Panel: Front	410C-2A
Panel: Rear	410C-2C
Cover: Side	5000-0703
Cover: Bottom	5060-0714
Trim: Meter	5020-5388

CHANGE 12

On instruments with Serial No's. 982-12404 and greater, rear panel markings were changed to conform to I.E.C. standards (No. 66), except on 410C-H60 instruments.

CHANGE 13

Section VI, Table of Replaceable Parts:
A3Q1 and Q2 were changed to silicon transistors -hp- Part No. 1853-0020. These parts should be used for all replacement. To modify earlier models, simply replace both Q1 and Q2 with the silicon part.

CHANGE 14

Section VI, Table of Replaceable Parts:
Series Regulator Tstr Q1 was changed to silicon -hp- Part No. 1853-0063. This part should be used for all replacement.

CHANGE 15

Section VI, Table of Replaceable Parts:
A7CR8 is changed to -hp- Part No. 5080-9050. This part no. is a hand selected component and should be used for all replacement.