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Errata

Title & Document Type: 4329A High Resistance Meter Operating and Service Manual

Manual Part Number: 04329-90012

Revision Date: November 1983

HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

About this Manual

We've added this manual to the Agilent website in an effort to help you support your product. This manual provides the best information we could find. It may be incomplete or contain dated information, and the scan quality may not be ideal. If we find a better copy in the future, we will add it to the Agilent website.

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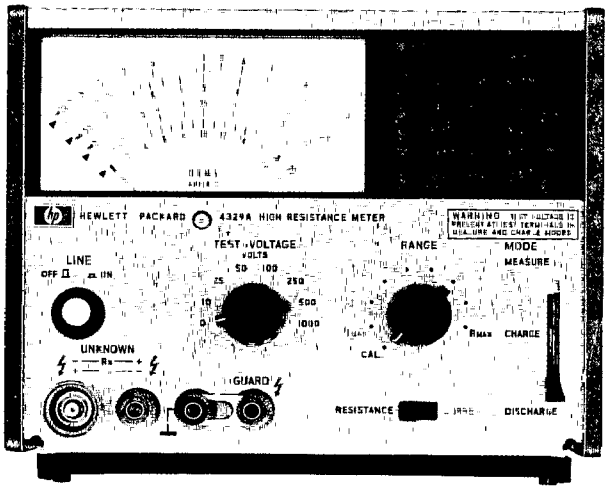
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Search for the model number of this product, and the resulting product page will guide you to any available information. Our service centers may be able to perform calibration if no repair parts are needed, but no other support from Agilent is available.

Agilent Technologies

OPERATING AND SERVICE MANUAL

METER
4329A



HEWLETT PACKARD

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 given 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.

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 the 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

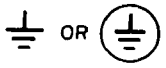
General Definitions of Safety Symbols Used On Equipment or In Manuals.



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.



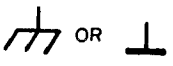
Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).



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 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.



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 A **WARNING** 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 A Note denotes important information. It calls attention to a procedure, practice, condition or the like, which is essential to highlight.

Herstellerbescheinigung

Hiermit wird bescheinigt, daß das Gerät HP 4329A high resistance meter in Übereinstimmung mit den Bestimmungen von Postverfügung 1046/84 funkentstört ist.

Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerätes angezeigt und die Berechtigung zur Überprüfung der Serie auf Einhaltung der Bestimmungen eingeräumt.

Anm: Werden Meß- und Testgeräte mit ungeschirmten Kabeln und/oder in offenen Meßaufbauten verwendet, so ist vom Betreiber sicherzustellen, daß die Funk-Entstörbestimmungen unter Betriebsbedingungen an seiner Grundstücksgrenze eingehalten werden.

GERÄUSCHEMISSION

Lpa < 70 dB
am Arbeitsplatz
normaler Betrieb
nach DIN 45635 T. 19

Manufacturer's Declaration

This is to certify that this product, the HP 4329A high resistance meter, meets the radio frequency interference requirements of directive 1046/84. The German Bundespost has been notified that this equipment was put into circulation and was granted the right to check the product type for compliance with these requirements.

Note: If test and measurement equipment is operated with unshielded cables and/or used for measurements on open set-ups, the user must insure that under these operating conditions, the radio frequency interference limits are met at the border of his premises.

ACOUSTIC NOISE EMISSION

Lpa < 70 dB
operator position
normal operation
per ISO 7779

HP 4329A
HIGH RESISTANCE METER

MANUAL IDENTIFICATION

Model Number: HP 4329A
Date Printed: November 1983
Part Number: 04329-90012

This supplement contains information for correcting manual errors and for adapting the manual to newer instruments that contains improvements or modifications not documented in the existing manual.

To use this supplement
1. Make all ERRATA corrections
2. Make all appropriate serial-number-related changes listed below

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES
All	1

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES

▸ New Item

▸ CHANGE 1

Page 6-9, Table 6-2, Reference Designation Index (Cont'd)

Add the following lists:

Reference Designation	Part No.	Description	Note
	5020-3713 5040-3311	TRANSPARENT SHIELD: MULTIPLIER INDICATOR BLACK BEZEL: MULTIPLIER INDICATOR	

NOTE

Manual change supplement are revised as often as necessary to keep manuals as current and accurate as possible. Hewlett-Packard recommends that you periodically request the latest edition of this supplement. Free copies are available from all HP offices. When requesting copies, quote the manual identification information from your supplement, or the model number and print date from the title page of the manual.

PRINTED IN JAPAN

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MANUAL CHANGES

HP 4329A

HIGH RESISTANCE METER

MANUAL IDENTIFICATION

Model Number: HP 4329A
Date Printed: NOV. 1983
Part Number: 04329-90012

This supplement contains information for correcting manual errors and for adapting the manual to newer instruments that contain improvements or modifications not documented in the existing manual.

To use this supplement
1. Make all ERRATA corrections
2. Make all appropriate serial-number-related changes listed below

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES
2510J06901 and above	1
2510J07714 and above	2
2510J08236 and above	3

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES

▶ New Item

ERRATA

Page 3-4, Paragraph 3-15,

Correct paragraph 3-15 as follows:

3-15. When measuring a capacitive component, the capacitor should be pre-charged for more than a few seconds (depending upon its capacitance). If the capacitor is not fully charged, . . .

NOTE

Manual change supplements are revised as often as necessary to keep manuals as current and accurate as possible. Hewlett-Packard recommends that you periodically request the latest edition of this supplement. Free copies are available from all HP offices. When requesting copies, quote the manual identification information from your supplement or the model number and print date from the title page of the manual.

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PRINTED IN JAPAN

Page 8-5, Figure 8-4, Test Voltage Switch Ass'y A4 and Range Switch Ass'y A7:

Correct the color code of the cable that connects A4S1AF-2 and A7S1BF-10 to WHT/BLK/ORG.

Correct the color code of the cable that connects A4S1AF-3 and A7S1AR-11 to WHT/BLK/RED. (Swap these color codes.)

Page 6-9, Table 6-2, Reference Designation Index:

Change the description of HP Part No. 04329-1044 to PANEL:REAR (OPT C10).

▶ Page 6-4, Table 6-2, Reference Designation Index:

See Table 1, Parts Information

CHANGE 1

Pages 6-7, 6-8, and 6-9, Table 6-2, Reference Designation Index:

See Table 1, Parts Information.

CHANGE 2

Page 6-5, Table 6-2, Reference Designation Index.

See Table 1, Parts Information.

▶ CHANGE 3

Page 6-5, Table 6-2, Reference Designation Index:

See table 1, Parts Information.

Page 8-7, Figure 8-5, Parametric Converter Ass'y A8 Diagram.

Change HP part numbers both of A8CR1 and A8CR2 from 0122-0104 to 0122-0178.

Table 1. Parts Information

CHANGE	PAGE	NOTE	REFERENCE DESIGNATION	HP PN	DESCRIPTION
ALL	6-4	► C	A4R5	0698-2323	R: FXD 2.5MΩ 1%
		► C	A4R6	0698-2324	R: FXD 5.0MΩ 1%
1	6-7	C	J1	9135-0035	FILTER
	6-8	A	MP1	5040-3340	COVER (FILTER)
	6-9	D		04329-10022	PANEL: REAR
		A		04329-00203	PANEL: REAR
		D		04329-1044	PANEL: REAR (OPT C10)
		A		04329-00213	PANEL: REAR (OPT C10)
2	6-5	C	A6R1	0757-0465	R:FXD COMP 100kΩ 1% 1/4W
3	6-5	► C	A8CR1	0122-0178	DIODE:VAR CAP.
	6-5	► C	A8CR2	0122-0178	DIODE.VAR CAP.

►: NEW ITEM
A: Added
D: Deleted
C: Change

OPERATING AND SERVICE MANUAL

MODEL 4329A
HIGH RESISTANCE METER

SERIAL PREFIXED : 2111J

See Section VII for Other Serial Prefixes.

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9-1, TAKAKURA-CHO, HACHIOJI-SHI, TOKYO, JAPAN

Manual Part No. 04329-90012
Microfiche Part No. 04329-90062

Printed: NOV. 1983

HEWLETT PACKARD

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SECTION I
GENERAL INFORMATION

1-1. GENERAL.

1-2. The HP Model 4329A High Resistance Meter is a solid-state measuring instrument intended for a majority of very-high-resistance test applications. The 4329A may be applied directly to the measurement of resistive elements such as high-valued resistors, capacitors and materials, or to the examination of volume and surface resistivities of solid or liquid materials using suitable resistivity cells. Covering a resistance range of 500 kilohms to 2 x 10^{16} ohms, the 4329A is provided with seven discrete Test Voltages for maximum flexibility over the resistance range. Automatic indication of meter and multiplier scales to be read is featured, providing rapid reading and straightforward operation.

1-3. The 4329A uses a unique measurement circuit known as a "self-oscillating parametric converter"; a variable-capacitance diode bridge circuit serves as the parametric element. This technique provides the needed conversion of minute dc currents to ac oscillations eliminating traditional problems of dc drift, noisy choppers and vacuum tubes.

1-4. The internal dc current measuring circuit which is the heart of the instrument is made available for current measurement. Use of the 4329A as a picoammeter is intended as a limited application, considering the necessity to calculate errors. This added current measurement feature, however, will be found a convenient complement to high-resistance testing.

1-5. The Model 4329A has a " recorder output " voltage proportional to meter deflection. This voltage varies from 0 to 100mV dc for meter deflection from ∞ to full-scale.

1-6. GROUND/GUARD DEFINITIONS.

1-7. Ground (⊥) is referred to as the power-line earth connection, and if properly connected, the instrument outer case and front panel ground connector are connected to this ground. Guard (⏚) is referred to in numerous ways in the 4329A. It is electrically a metallic enclosure around the low-current measurement circuits. This enclosure is also the circuit "common" or the traditional "chassis" relative to instrument circuitry. It is insulated from the instrument case. It is connected to the GUARD connector on the front panel, the UNKNOWN Rx (-) terminals on front and rear panels, and to the rear-

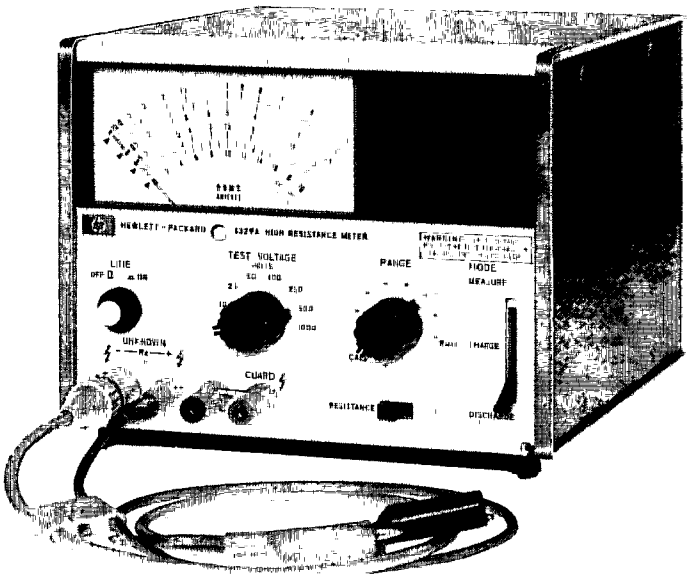


Figure 1-1. Model 4329A High Resistance Meter

panel RECORDER output connector low terminal. The GUARD and GROUND are interconnected at the front panel by a ground-strap for most measurements. When not so connected, the GUARD will be at Test Voltage potential relative to GROUND.

1-8. INSTRUMENT IDENTIFICATION

1-9. Hewlett-Packard uses a two-section ten-character (0000A00000) or eight-character (000-00000) serial number. The first three or four digits (serial prefix) identify a series of instrument; the last five digits identify a particular instrument in that series. A letter placed between the two sections identifies the country where the instrument was manufactured. The serial number appears on a plate located on the rear panel. All correspondence with Hewlett-Packard Sales/Service Offices with regard to an instrument should refer to the complete serial number.

1-10. MANUAL CHANGES.

1-11. This manual provides operating and service information for the HP Model 4329A High Resistance Meter. Information in this manual applies directly to instruments (as manufactured) with serial numbers prefixed by the four digits indicated on the title page. If the serial prefix of the instrument is different from that on the title page, a "Manual Change" sheet supplied will describe changes which will adapt this manual to provide correct coverage. Technical correction (if any) to this manual, due to known errors in print, are called Errata and are shown on the change sheet. For information on manual coverage of any HP instrument, contact the nearest HP Sales/Service Office (addresses are listed at the rear of this manual.)

Table 1-1. Specifications

Resistance Range: 500kΩ to 2×10^{16} Ω

Resistance Accuracy:
±10% of reading except on R MAX. range after initial ∞ and full-scale calibration. Accuracy depends on the deflection angle of the meter. At low resistance end of each scale, typical accuracy is about ±3%; near center scale about ±5%. Above effective upper limits (see table below), accuracy is not specified. On all voltage ranges, if multiplier is set to R MAX., add 3%.

Test Voltage	10V ±3%	25V ±3%	50V ±3%	100V ±3%	250V ±3%	500V ±3%	1000V ±3%
Available Resistance Readings	5×10^5Ω to 2×10^{14}Ω	1.25×10^6Ω to 5×10^{14}Ω	2.5×10^6Ω to 1×10^{15}Ω	5×10^6Ω to 2×10^{15}Ω	1.25×10^7Ω to 5×10^{15}Ω	2.5×10^7Ω to 1×10^{16}Ω	5×10^7Ω to 2×10^{16}Ω
Meter Scale	0.5 to 20	0.125 to 5	0.25 to 10	0.5 to 20	0.125 to 5	0.25 to 10	0.5 to 20
Effective Upper Limit	5	1.25	2.5	5	1.25	2.5	5

Current Range: 0.05pA to 20μA.

Current Accuracy:
±5% using ideal current source of infinite impedance; for finite source impedances, accuracy is determined by the range resistor which sets meter input impedance. These vary from 10^4 Ω to 10^{11} Ω, depending on the range selected. This additional error can be large, and should be calculated if the 4329A's current measurement capability is to be utilized.

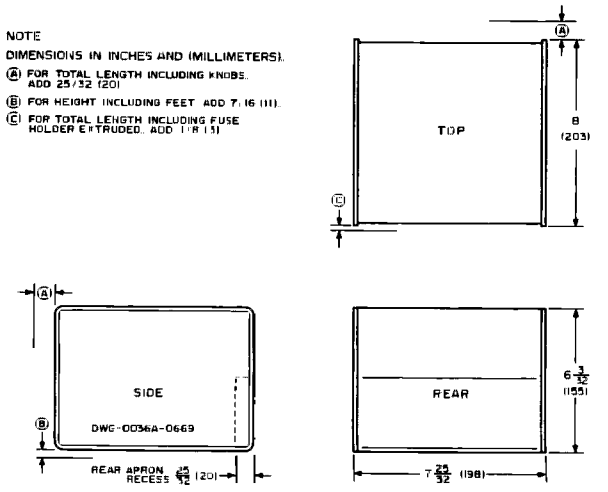
Recorder output: 0 to 100mVdc, proportional to meter deflection, output impedance 1kΩ.

Power: 115/230V, ±10%. 50 or 60Hz, 3W.

Weight: 7.7lbs. (3.5kg)

Accessories Furnished:
16117A Low Noise Test Leads, composed of insulated BNC to Alligator clip lead, and banana plug to Alligator clip lead. On BNC lead, outer conductor comprised guard shield. Guard isolated from low resistance alligator clip sleeve.

Dimensions:



SECTION II
INSTALLATION

2-1. INTRODUCTION

2-2. This section contains information for unpacking, inspection, repackaging, storage, and installation of the Model 4329A.

2-3. UNPACKING AND INSPECTION

2-4. If the shipping carton is damaged, ask that the carrier's agent be present when the instrument is unpacked. Inspect the instrument for damage (scratches, dents, broken knobs, etc.). If the instrument is damaged or fails to meet specifications, notify the carrier and the nearest Hewlett-Packard field office (see list at back of this manual). Retain the shipping carton and the padding material for the carrier's inspection. The field office will arrange for the repair or replacement of your instrument without waiting for the claim against the carrier to be settled.

2-5. STORAGE AND SHIPMENT.

2-6. PACKAGING. To protect valuable electronic equipment during storage or shipment always use the best packaging methods available. Your Hewlett-Packard field office can provide packing material such as that used for original factory packaging. Contract packaging companies in many cities can provide dependable custom packaging on short notice. Here are a few recommended packaging methods:

a. RUBBERIZED HAIR. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument securely in strong corrugated container (350 lb/sq in. bursting test) with 2-inch rubberized hair pads placed along all surfaces of the instrument. Insert fillers between pads and container to ensure a snug fit.

b. EXCELSIOR. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument in strong corrugated container (350 lb/sq in. bursting test) with a layer of excelsior about 6 inches thick packed firmly against all surfaces of the instrument.

2-7. ENVIRONMENT. Conditions during storage and shipment should normally be limited as follows:

a. Maximum altitude, 20,000 feet.

b. Minimum temperature, -40° F (-40°C).

c. Maximum temperature, 167° F (75°C)

2-8. INSTALLATION

2-9. The Model 4329A is a submodular unit, equipped with plastic feet and tilt stand for bench operation as shipped from the factory. However, when used in combination with other submodular units it can be bench and/or rack mounted. The HP combining case and adapter frame are designed for this purpose and are available through your Hewlett-Packard Sales and Service Office.

2-10. COMBINING CASE (HP Models 1051A or 1052A)

2-11. The combining case is a full-module unit which accepts various combinations of submodular units. Being a full-module unit, it can be bench or rack mounted and is analogous to any full-module instrument.

2-12. ADAPTER FRAME (HP Part No. 5060-0797)

2-13. The adapter frame is a rack frame that accepts any combination of submodular units. It can be rack mounted only.

2-14. POWER CONNECTION

2-15. LINE VOLTAGE The Model 4329A May be operated from either 115- or 230-volt ($\pm 10\%$) 50 or 60Hz power lines, which can supply approximately 3 watts. A slide switch on the rear panel permits quick conversion for operation from either voltage. Insert a narrow-blade screwdriver in the switch slot and slide the switch to the right for 230-volt operation ("230" marking exposed) or to the left for 115-volt operation ("115" marking exposed). The Model 4329A is supplied with a 0.1 ampere fuse for either 115-or 230-volt operation.

CAUTION

To avoid damage to the instrument, before connecting the power cable, set the 115/230 switch for the line voltage to be used.

2-16. POWER CABLE. To protect operating personnel, the National Electrical Manufactures' Association (NEMA) recommends that instrument panels and cabinets be grounded. Accordingly, the Model 4329A is equipped with a detachable three-conductor power cable which, when plugged into an appropriate receptacle, grounds panel and cabinet. The offset pin of the three-prong connector is the ground pin. Proceed as follows for power cable installation.

a. Connect flat plug (3-terminal connector) to LINE jack at rear of instrument.

b. Connect plug (2-blade with round grounding pin) to 3-wire (grounded) power outlet. Exposed portions of instrument are grounded through the round pin on the plug for safety; when only 2-blade outlet is available, use connector adapter (PN 1251-8196) then connect short wire from side of adapter to ground to preserve the protection feature.

CAUTION

In the design of the Model 4329A High Resistance Meter, many precautions have been taken to prevent the possibility of electrical shock. However, high voltage is necessary to make measurement at the desired levels and one should be aware of the dangers involved.

The current supplied by the 4329A under short-circuit conditions is less than approximately 0.5mA at any range. Painful shock may result upon contact. Note that any of UNKNOWN terminals, GUARD terminal, and RECORDER terminals may be at high voltage, depending on the position of the ground strap.

When capacitors are being tested, the possibility of dangerous charge level may exist. It is therefore recommended that all capacitors should be fully discharged. The following steps outlines the discharging procedure. The capacitor should always be shunted before connection, and the MODE switch should be set to DISCHARGE for a few seconds before disconnection.

SECTION III
OPERATION

3-1. INTRODUCTION

3-2. This section includes a complete description of the High Resistance Meter operating controls, its accessories, characteristics and techniques of use.

3-3. CONTROLS, INDICATORS AND CONNECTORS.

3-4. All controls and connectors of the 4329A are identified and described by Figures 3-2 and 3-3.

3-5. BASIC OPERATING PROCEDURE

3-6. TURN-ON

WARNING

IN VARIOUS MODES OF OPERATION DEPENDENT ON TEST-LEAD CONFIGURATION, GROUND-STRAP POSITION AND FRONT PANEL SWITCHES, THERE MAY BE UP TO 1000 VDC WITH RESPECT TO GROUND APPEARING ON THE "GUARD" AND "UNKNOWN" TERMINALS. ALTHOUGH MAXIMUM SHORT CIRCUIT CURRENT IS LIMITED TO SAFE LEVELS, THE POSSIBILITY OF HEAVY DISCHARGE CURRENT FROM CAPACITORS UNDER TEST IS PRESENT. GOOD MEASUREMENT PRACTICE REQUIRES THEREFORE THAT THE MODE "DISCHARGE" SWITCH BE USED AS MATTER OR ROUTINE, AND THAT THE TEST VOLTAGE BE REDUCED TO ZERO WHENEVER OPERATORS HANDLE LEADS OR SAMPLE UNDER TEST.

a. Set 115/230V slide-switch on rear panel to line voltage to be used.

b. Connect power line to power input jack, assuring that a power line ground is provided and that the LINE push-button is off.

c. Set TEST VOLTAGE to zero, and MODE to "DISCHARGE".

d. Set RESISTANCE/CURRENT to RESISTANCE.

e. Connect 16117A Low Noise Test Leads to UNKNOWN terminals, assuring that ground strap is connected from ground to guard.

f. Push line "ON".

g. Switch RANGE to "CAL". Check meter deflection. If meter reading does not indicate full-scale, adjust FULL-SCALE CAL on rear panel.

WARNING

WHEN YOU MAKE THIS ADJUSTMENT, GUARD TERMINAL SHOULD BE CONNECTED TO GND (GROUND) TERMINAL WITH THE SHORT STRAP.

h. Return RANGE switch to any other position. If pointer doesn't indicate infinity, adjust at rear panel ∞ ADJ using insulated screwdriver or tuning wand.

WARNING

WHEN YOU MAKE THIS ADJUSTMENT, GUARD TERMINAL SHOULD BE CONNECTED TO GND (GROUND) TERMINAL WITH THE SHORT STRAP.

3-7. 16117A LOW NOISE TEST LEADS

3-8. The 16117A Low Noise Test Leads are designed to provide maximum measurement convenience. The coaxial lead contains a graphite lubricant between conductors and dielectric to reduce errors generated by flexing the cable. The guard circuit is carried from the UNKNOWN connector out to the sample by the test lead outer coaxial conductor. The alligator clip's vinyl cover represents moderate insulation resistance; if the guard (outer conductor) and test voltage (inner conductor) were separated at the measurement point by only this material, poor guarding would result. For this reason the molded cylinder behind the clip encloses a special guard ring and lead separation design to reduce measurement error. Without the guard ring, if the low-resistance insulation on the positive (red) test lead were to contact the coaxial lead outer cover, this could represent a low resistance current path in parallel with Rx. Error currents could flow from the (+) conductor to the (-) center conductor through the (+) insulation, the surface resistance of the coaxial outer covering and the low resistance alligator-clip cover to the coaxial center conductor. The guard ring intercepts these possible error currents, returning them to the Test Voltage by way of the guard circuit, as a result they do not pass through the meter circuit, and potential error is eliminated. The molded grip on the connector provides convenience in handling when test voltage is present on the guard connector.

WARNING

HAZARDOUS VOLTAGE MAY EXIST AT GUARD RING WHEN GUARD IS NOT CONNECTED TO GROUND.

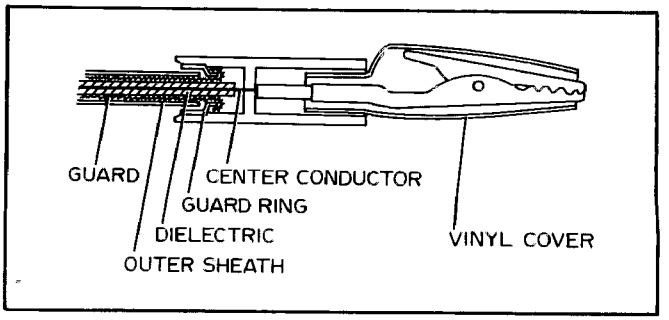
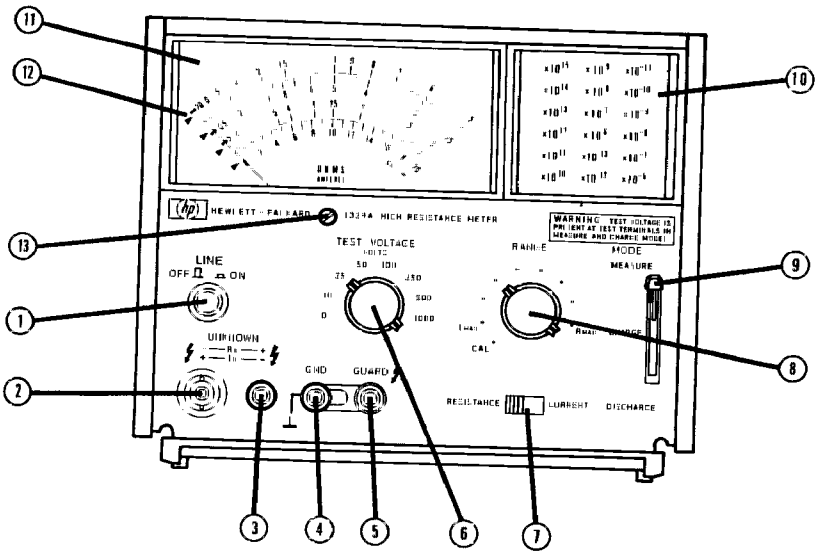


Figure 3-1. Low Noise Test Lead Guard Detail.



1. LINE: Applies power to instrument. Push ON/OFF. Illuminates in "ON" position.

2. UNKNOWN: High-impedance side of the UNKNOWN terminals. BNC jack outer conductor is internally connected to GUARD circuit. Outer plastic cover provides handling convenience when GUARD at is negative TEST VOLTAGE potential. In CURRENT mode 7, this is positive terminal of pico-ammeter.

3. UNKNOWN: Low-impedance side of the UNKNOWN terminals. In resistance measurement, TEST VOLTAGE is applied to sample. This is also negative terminal for current measurement.

4. GND: Power line ground. Ground strap is normally tied to GUARD.

5. GUARD: Circuit common for measurement circuitry internally insulated from ground. Common with 2 outer conductor. This terminal will be at negative test voltage potential relative to ground if the ground strap is tied to 3.

6. TEST VOLTAGE: Selects dc regulated voltage which is used to drive current through the sample. Zero position is grounded. Voltage is applied to sample through terminal 3. Determines meter scale and multiplying factor to be used in conjunction with 8.

7. RESISTANCE/CURRENT: Selects measurement of either Rx or Ix. Current position disconnects Test Voltage from measurement circuits and connects 5 to 3.

8. RANGE: Selects resistance or current meter-scale and multiplying factor dependent on test voltage being used. Meter-circuit shunts selected vary from 10^4 to 10^{11} ohms.

9. MODE: "DISCHARGE" disconnects test voltage internally, and connects 1 Megohm from 2 to 3 to provide discharge path for charge accumulated by sample. "CHARGE" disconnects meter circuits, and connects one side of sample to circuit common for rapid charging of sample effective capacity. "MEASURE" connects sample to meter circuit, and applies Test Voltage internally for resistance measurement.

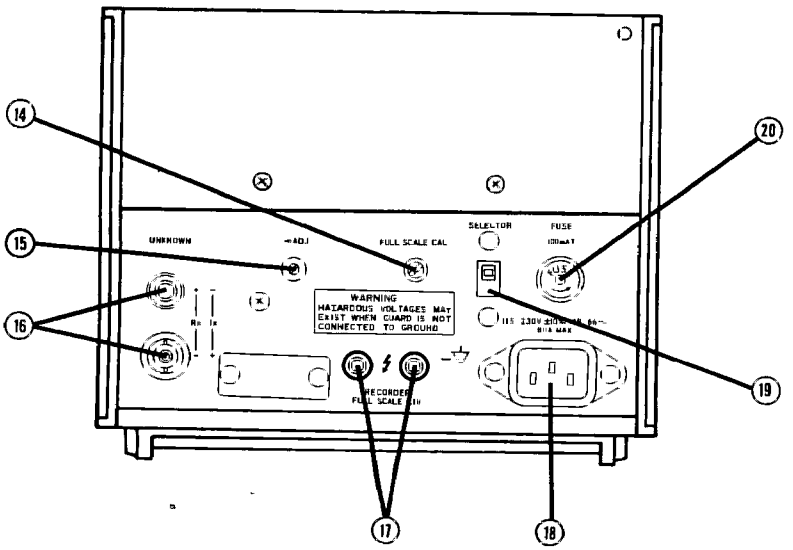
10. METER MULTIPLIER: Multiply by meter reading to obtain final reading. Controlled by 6 and 8. Illuminated readout of selected multiplier.

11. METER: Provides three resistance scales and one current scale. Meter Scale Indicators are provided to indicate meter scale to be read.

12. METER SCALE INDICATOR: Indicates meter scale to be read.

13. Mechanical zero-set.

Figure 3-2. Front Panel Controls and Indicators



14. FULL-SCALE CAL: Adjusts meter to "CAL" when 8 is full counter-clockwise (CAL position).

WARNING

WHEN YOU MAKE THIS ADJUSTMENT, GUARD TERMINAL SHOULD BE CONNECTED TO GND (GROUND) TERMINAL WITH THE SHORT STRAP.

15. ADJ: Sets electrical "zero" of meter.

WARNING

WHEN YOU MAKE THIS ADJUSTMENT, GUARD TERMINAL SHOULD BE CONNECTED TO GND (GROUND) TERMINAL WITH THE SHORT STRAP.

16. UNKNOWN: Terminals in parallel with front panel "UNKNOWN" terminals (Option C10 only).

17. RECORDER OUTPUT: 0 to 100mV analog output proportional to meter deflection. Output impedance is 1kΩ.

WARNING

HAZARDOUS VOLTAGES MAY EXIST WHEN GUARD IS NOT CONNECTED TO GROUND.

18. Power input jack. Make receptacle for 115/230V ac power. Center pin is ground.

19. 115/230V ac selector: Selects appropriate line voltage. Operate with power off.

20. Fuse: 0.1A slow-blow.

Figure 3-3. Rear Panel Controls

3-9. MEASUREMENT MODES

3-10. The 4329A High Resistance Meter can be applied in numerous ways: basic high resistance measurement of ungrounded resistances; measurement of grounded samples (such as grounded shield cables), current measurement; sheet in sulation surface and volume resistivity testing (using the 16008A Resistivity Cell Accessory); capacitor leakage tests, liquid resistivity testing (using a suitable cell), and combinations of these. This section outlines basic measurement considerations and specific operating techniques (Figure 3-5 to Figure 3-8).

3-11. APPLICATIONS

3-12. High resistance measurement and insulation testing find broad application in the design, production and use of insulating materials such as teflon, polyethylene, polystyrene, ceramics, plastics, fibres, synthetics, rubber, glass and phenolics. The insulating qualities of common materials used in switches, relays, stand-offs, printed-circuit boards, cables, insulating films, varnishes, tapes, oils, and papers can be readily measured.

3-13. Insulators, resistors, transformers and other devices finding application in high voltage circuitry (such as cathode-ray-tube power supplies) and high-power transmission are dependent on the stability and reliability of high level "teraohm" resistances. The flexibility of the 4329A Test Voltage supply and the wide measurement range provided (up to 2×10^{16} ohms) make the High Resistance Meter particularly useful for examination of the voltage coefficient of resistance of these components.

NOTE

Resistance values in the high megohm and teraohm regions are subject to wide variations in measured and operating values dependent on applied voltage. All high-valued insulating or resistor materials can be considered non-linear; this is particularly noticeable at increasingly high voltages

3-14. The directions taken in recent years by circuit designers have given rise to new requirements in high resistance measurement. Printed-circuit board materials and their resistance to environmental conditions such as humidity and elevated temperatures can be critical to high-impedance solid-state circuits. This is especially true for those employing FETs (Field Effect Transistors). Occasionally, materials applied in substrates and encapsulation of integrated circuits and transistors bring problems of insulation resistance and surface leakage to solid state circuit design. Testing of capacitors for dielectric qualities, particularly the "leakage" resistance of the dielectric material has long been a requirement for high-resistance measurement.

3-15. In measuring a capacitive sample, the capacitor should be pre-charged for more than few seconds capacitance of the sample). If the sample is not fully charged, when the MODE switch is set to "MEASURE" position, the meter will peg due to the charging current. Internal Test Voltage Supply current capacity is limited for safe measurement, since it takes relatively long time to charge to sample in measuring the capacitor having large capacitance greater than a several hundreds micro-farads. Essentially the 4329A is a high input resistance instrument (input resistance depends on RANGE used) so, when capacitor with high value and low leakage current is measure, it should be understood that very long measurement time may be required to get the final (correct) value.

WARNING

IN TESTING CAPACITORS, ALWAYS DISCHARGE THEM BEFORE AND AFTER MEASUREMENT; USE A SHORTING BAR OR CLIP LEAD AND USE THE INSTRUMENT "DISCHARGE" SWITCH FOR A FEW SECONDS TO ASSURE THAT DANCHARGE LEVELS ARE NOT ACCIDENTALLY HANDLED.

3-16. Resistivity (per-unit area or volume) measurement occupies a specialized place in the field of insulation testing. Surface and volume resistivity are readily measureable with the HP4329A, using the 16008A Resistivity cell. This technique applies the test voltage to the sample in such a way as to distribute the potential over both sides (volume) or one side (surface) of sheet samples of insulating material. Given the size of the electrodes and the dimensions of the sample, resistivity values are easily calculated. (see para. 3-25). Resistivity, conductivity, dielectric leakage, purity, and chemical content of liquids can be measured using suitable cells; again, cell construction essentially distributes and guards the test voltage potential for a given volume of liquid sample. Suitable cells can be constructed according to ASTM or user guidelines. Commercially, liquid resistivity cells are available from a number of manufacturers.

3-17. SAMPLE BREAKDOWN; SHORT CIRCUITS

3-18. If resistance samples should break down during test, or test leads should be inadvertently shorted, the meter pointer will "peg" up-scale. Although the measurement circuits are protected, prolonged short-circuit conditions are ill-advised. Reduce test voltage to zero as soon as possible, set MODE to DISCHARGE.

3-19. SHIELDING

3-20. Variation in total current seen by the measurement circuit can be caused by power-line pickup, adjacent fields of excessive strength, flexing the test leads beyond reasonable limits, or while changing the position of the leads relative to their surroundings Most noise problems of this type are transient, and contribute more inconvenience than error. If on sensitive ranges, shielding of the sample is required, any suitable enclosure will suffice to reduce unwanted pick-up. Connect the shield to guard (ground). If on sensitive ranges, lead movement or operator proximity affects stability of readings, stationary leads and

shielding are recommended.

3-21. CURRENT MEASUREMENT

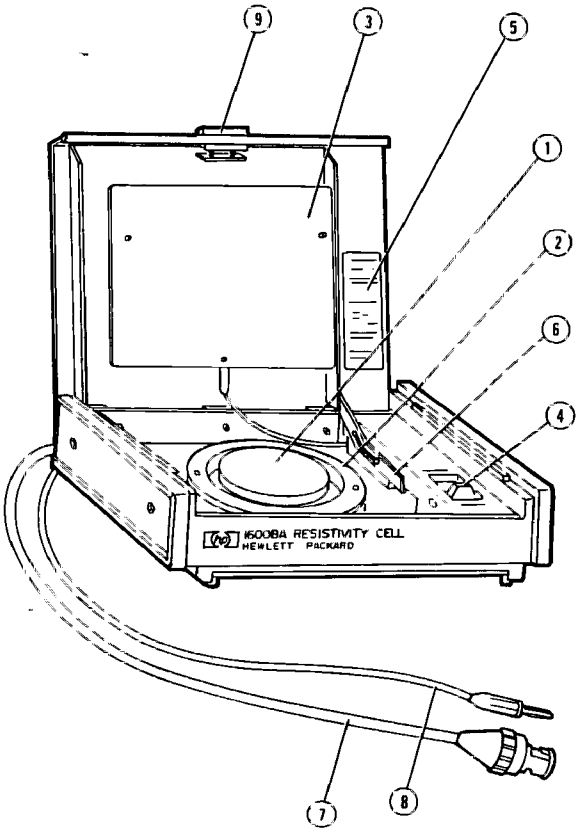
3-22. The High Resistance Meter's high-impedance measurement and metering circuits have been made available for current measurement. Basic measurement accuracy is 5% (8% on the most sensitive range) assuming an infinite source impedance. Additional errors due to finite values of source impedance on be calculated using the following expression:

$$\% \text{ ERROR} = \left(\frac{Rs}{Rr + Rs} - 1\right) \times 100\%$$

where Rs = output resistance of current source, and Rr = meter internal range resistor.

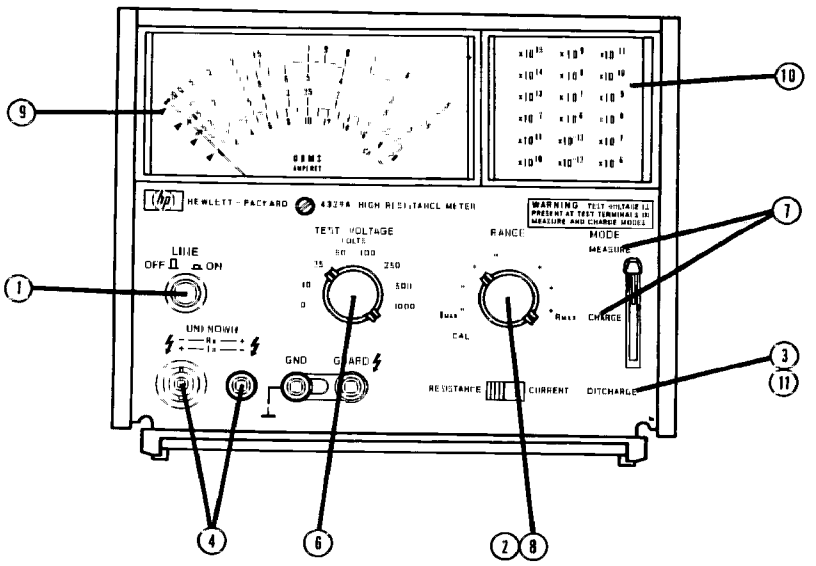
Applicable range resistors (Rr) are (for full-scale current ranges) indicated:

Rr (ohms)	Range (Amps)	Rr (ohms)	Range (Amps)
10^{11}	2×10^{-12}	10^{7}	2×10^{-8}
10^{10}	2×10^{-11}	10^{6}	2×10^{-7}
10^{9}	2×10^{-10}	10^{5}	2×10^{-6}
10^{8}	2×10^{-9}	10^{4}	2×10^{-5}



1. Center Electrode: covered with conducting plastic for uniform contact. Negative potential of Test Voltage is applied through Low Noise Test Lead.
2. Guard Ring: provides guarding for volume measurement. Positive potential of Test Voltage is applied for surface measurement.
3. Upper Electrode: provides guarding for surface measurement. Positive potential of Test Voltage is applied for volume measurement
4. VOLUME-SURFACE Switch: selects measurement mode of volume or surface resistivity.
5. Calculation formula: for both measurements are shown here for convenience.
6. Top Cover Arm: activates microswitch for application of Test Voltage. Test Voltage is not present when top cover is open.
7. Low Noise Test Lead: carries negative potential of Test Voltage to center electrode. Outer conductor of this cable is connected to guard circuit (to Guard Ring for volume measurement or upper electrode for surface measurement). Connect this to the Model 4329A UNKNOWN bnc connector.
8. Test Lead (Red): carries positive potential of Test Voltage to Guard Ring for surface measurement, or Upper Electrode for volume measurement.
9. Latch: locks top cover. Push to open.

Figure 3-4. Resistivity Cell Controls.

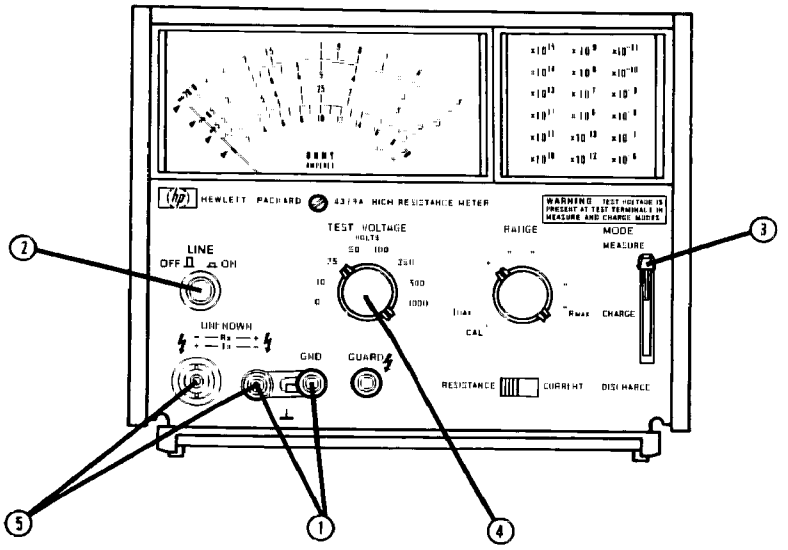


1. Read TURN-ON instructions. Turn on instrument according to para. 3-6.
2. Set RANGE to I MAX.
3. Set MODE to DISCHARGE.
4. Connect 16117A Low Noise Test leads to Rx (UNKNOWN) connectors.
5. Connect clips to sample. (If testing junction devices or capacitors, check polarity.)
6. Select a suitable Test Voltage.
7. Switch MODE to CHARGE. Switch MODE to MEASURE. (Sample test circuit charge time will depend on range, test voltage, sample type and sample magnitude).
8. Rotate RANGE switch until pointer indicates a convenient reading. (NOTE: Best accuracy is obtained on the low end of the Meter Scales).
9. Select scale to be read. (▷) lights at left end of scale indicate applicable scale.
10. Multiply reading from meter scale by factor illuminated. This is sample resistance in ohms.
11. Return MODE to DISCHARGE before disconnecting sample.

WARNING

Do not handle test lead clips during measurement without setting MODE switch to DISCHARGE, and TEST VOLTAGE switch to zero.

Figure 3-5. Ungrounded Sample Operation

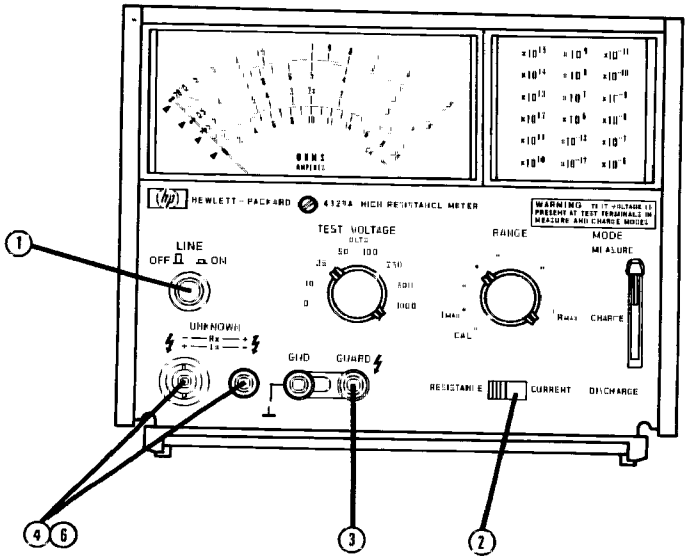


1. Shift ground-strap to interconnect ground and + of UNKNOWN.
2. Turn on instrument as in paragraph 3-6, leave ground-strap as in 1 above.
3. Set MODE to DISCHARGE.
4. Set TEST VOLTAGE to ZERO.
5. Connect 16117A Low-Noise Test Leads to UNKNOWN terminals.
6. Connect test lead clips to sample.
7. Continue as for Fig. 3-5, steps 6, through 11.

WARNING

In this mode, the GUARD terminal is at a potential equal to minus the test voltage. This applies to the Guard connection on the rear panel, and the outer conductor of the 16117A coaxial lead.

Figure 3-6. Grounded Sample Operation



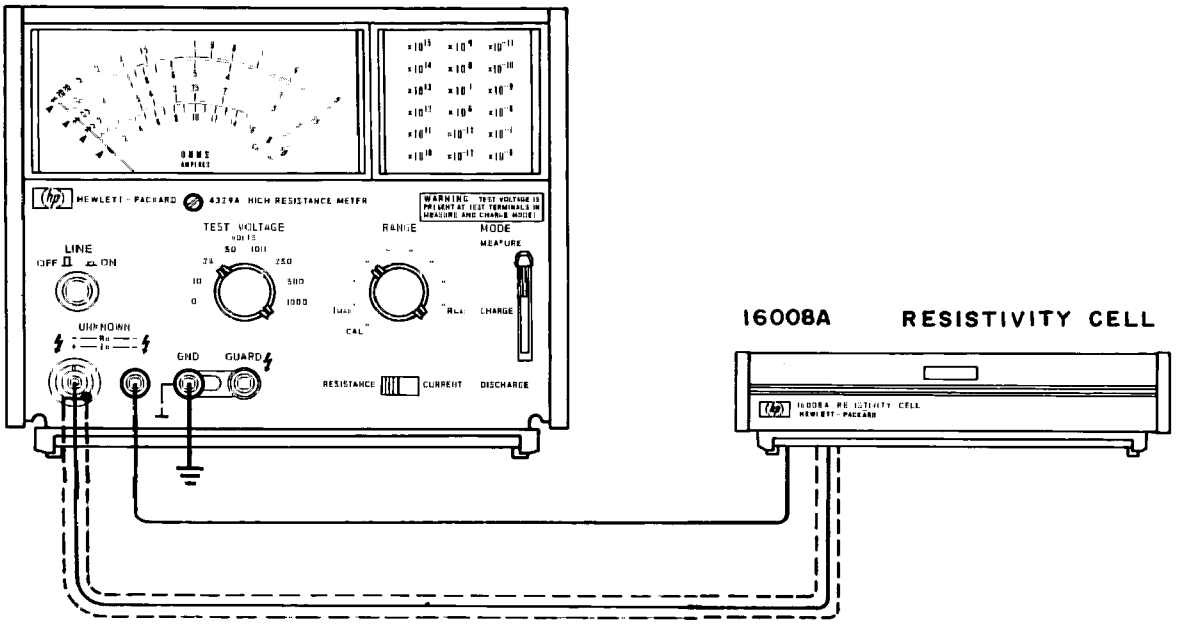
1. Turn on instrument according to instructions in para. 3-6.
2. Set RESISTANCE-CURRENT Slide-switch to CURRENT.
3. Ground the guard connector using the strap.
4. Connect test leads to instrument Ix terminals.
5. Note Ix polarity; connect test leads to appropriate points on current source to be measured.
6. Switch MODE to MEASURE.
7. Rotate RANGE until suitable reading is obtained. (See Figure 3-5, 8 to 10)
8. Do not set TEST VOLTAGE switch to other than zero, or slide switch to other than CURRENT during current measurement.

WARNING

The Test Voltage is disconnected from the UNKNOWN terminals by the RESISTANCE CURRENT slide switch when set to CURRENT. The TEST VOLTAGE should be set to zero position, and the MODE switch to DISCHARGE position.

9. See para. 3-20 on current measurement accuracy.

Figure 3-7. Current Measurement



1. Turn on 4329A as in para. 3-6.
2. Place sample in 16008A Resistivity Cell (or equivalent).
3. Select VOLUME or SURFACE (in using 16008A).
4. Close top cover of cell, snap catch firmly to lock.
5. Select suitable Test Voltage.
6. Switch MODE to CHARGE. Switch MODE to MEASURE.
7. Rotate RANGE to convenient reading.
8. Calculate resistivity using appropriate formula.

CAUTION

16008A Top cover (when closed) turns on the micro-switch which results in the application of Test Voltage to electrodes. Voltages are not present at the electrodes when top cover is open. Do not close resistivity cell top cover without a sample, or insulator present to separate electrodes. (See para. 3-28)

Figure 3-8. Resistivity Measurement

3-23. RECORDER OUTPUT

3-24. When monitoring slowly-varying resistance changes with humidity, voltage, temperature, etc. the recorder output in the instruments rear panel may be used. Note that the recorder output terminals common terminal is circuit guard and may be at the test potential relative to ground.

WARNING

HAZARDOUS VOLTAGES MAY EXIST WHEN GUARD IS NOT CONNECTED TO GROUND.

3-25. 16008A RESISTIVITY CELL

3-26. This accessory is used in conjunction with the HP 4329A High Resistance Meter for resistivity testing of insulation materials in "sheet" form. Samples are placed in the cell and clamped between electrods and guard "ring". Samples should be less than 7mm thick and greater than 10cm in width (or diameter) to be measured. (See Figure 3-4).

3-27. Surface Resistivity is defined as the ratio of potential grandient parallel to the current along a surface to the current per unit width of the surface. It follows that surface resistivity is equal to surface resistance if the electrodes on the measured surface form two sides of a square. Units of surface resistivity are ohms, and can be attributed to current flow through surface deposits, moisture, oxides and other semiconducting materials on insulator surfaces. 4329A Meter readings are converted to resistivity quantities using the following expression (derived from the dimensions of the 16008A electrodes):

$$\sigma = 18.8 \times Rs$$

where σ = surface resistivity in ohms,
and Rs = indicated surface resistance.

3-28. Volume resistivity is defined as the ratio of the potential gradient parallel to the current in the material to the current density. Thus, calculation of volume resistivity figures uses the following formura:

$$\rho = \frac{19.6}{t} Rv$$

where ρ = volume resistivity in ohm-cm.
t = sample thickness in cms.
Rv = indicated volume resistance in ohms.

3-29. The cell construction utilizes a conducting plastic electrode for uniform contace without the inconvenience of liquid mercury. The top cover interlocks with test voltage for safe handling, voltage is applied only when the cover is snapped shut. In surface operation, voltage is applied to one side of the sample only, through guard ring and center electrode. In volume, voltage is applied through both sides of the sample by way of the upper and center electrode. The ring provides normal guarding in volume measurement. (See Figure 3-4).

NOTE

The resistance accuracy of the 4329A is not guaranteed when measurement is performed with the 16008A.

SECTION IV
THEORY OF OPERATION

4-1. GENERAL INFORMATION

4-2. This section is provided to assist the instrument user in understanding the Model 4329A for purposes of maintenance and calibration. The best tool for maintaining and calibrating any electronic instrument is a clear, practical understanding of the principles applied in the operation of the instrument's circuitry.

4-3. HIGH RESISTANCE MEASUREMENT

4-4. The measurement of high resistance is essentially a problem of measuring extremely small currents. Until recently, the electrometer vacuum-tube, the vibrating reed capacitor, and the field-effect transistor have been the only devices available to provide the extremely high input impedances required. Further, it has been necessary to design dc to ac convertors to provide ac amplification of the outputs of tubes and transistors used in electrometers. These convertors (or "choppers") are required to eliminate the errors inherent in dc amplification of such low-level signals. (Errors due to "drift" or changes in values of components with time, temperature, etc.) The combined inherent instabilities, drift tendencies, leakage currents, grid currents, and convertor problems have led to the application of an entirely new principle in this type of measurement. As used in the HP 4329A, this principle is called the "self-oscillating parametric impedance convertor". This circuit provides both a high-input impedance and an ac output availabe for stable, drift-free amplification. Fig. 4-1 illustrates the basics of a high resistance measurement, showing how the HP circuit combines high impedance and dc to ac conversion in one functional circuit block.

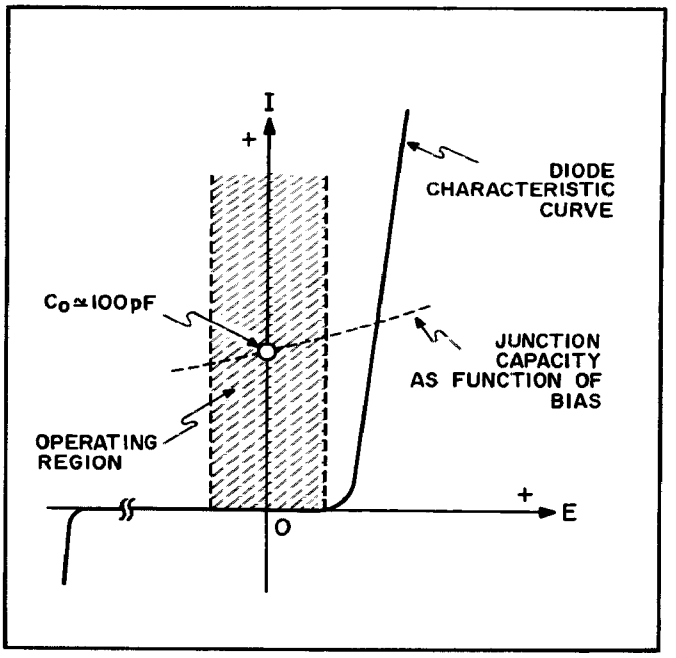


Figure 4-2. "Pico-diode" Characteristic

4-5. PRINCIPLE OF PARAMETRIC CONVERTOR

4-6. PICO-DIODES

4-7. The 4329A utilizes a unique pair of "pico-diodes". These diodes are essentially variable capacitance diodes designed to have a known junction-capacity characteristic, variable with applied diode voltage. Normally, this caracteristic is non-linear,

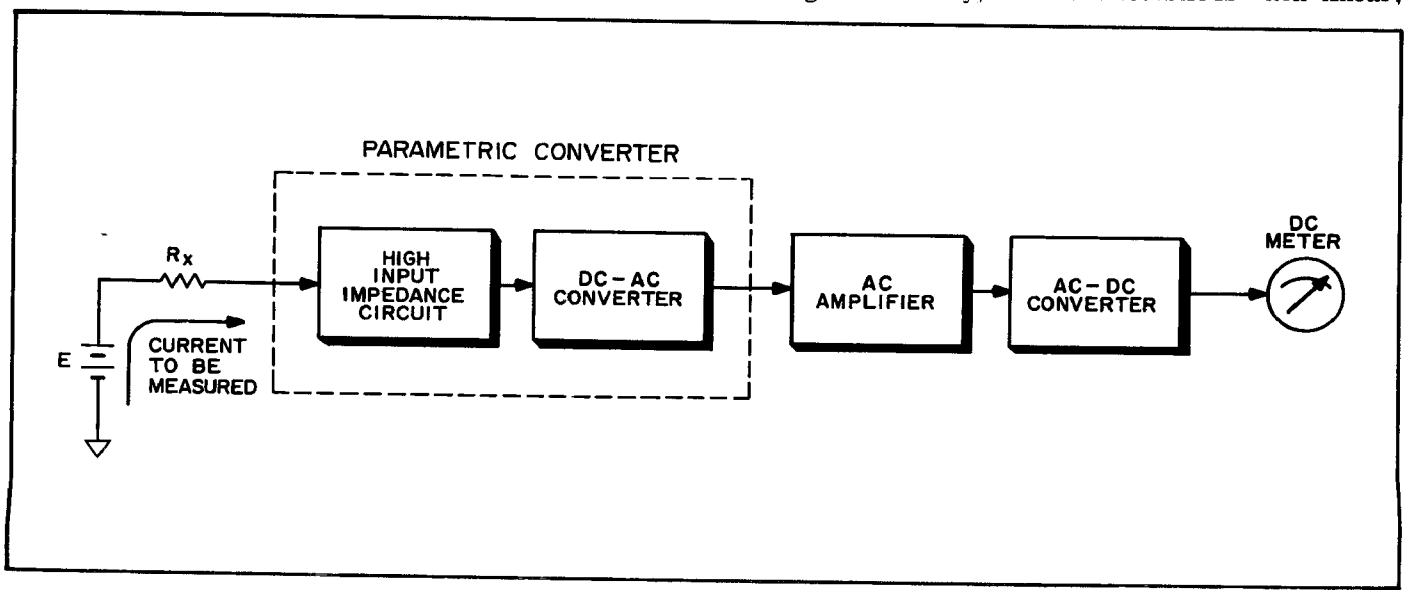


Figure 4-1. Basic High Resistance Measurement

and increases with increasing forward bias. The diodes used in the 4329A have been specially designed and produced to operate with less than 10^{-11} amps leakage current within the operating region used. As can be seen from Fig. 4-2, the pico-diodes are applied as variable-capacitors and not actually as diodes, as the forward bias does not extend into the conduction region of the diode.

4-8. BASIC PARAMETRIC CONVERTOR

4-9. The convertor circuit can be simplified for purposes of understanding its operation to a basic bridge circuit. (See Fig. 4-3). C1 and C2 are pico-diode "capacitors". The two resistance arms are equal. The bridge unbalance voltage is the input to an amplifier, the amplifier's output is the "supply" for the bridge. Assuming a simplified characteristic for C1, C2 as in Fig. 4-4, we can see that C1 does not equal C2 under the balanced, quiescent, ideal conditions shown in Fig. 4-3. That is, the 1 volt difference out of the amplifier does not divide equally over the two capacitors as it does over the two resistors, and the amplifier input could not be zero. The variable capacitor C_T set at 20pf then is added to C2, setting both C1 and C2 to 110pf effectively bringing our imaginary bridge into balance. To understand the parametric convertor, we have only to consider the result of making a very small change in the value of C_T. if for example, C_T is varied upwards (towards a higher value), the net C in the lower arm now is greater than that of C1. Thus the voltage across the lower arm will tend to decrease to a value less than that across C1. Point 1 tends to become more negative. This represents a bridge unbalance, and the amplifier sees this as a net negative-going signal at its input. This signal is inverted and amplified (amplifier has 180° phase shift) and the bridge "supply voltage" changes. This change in the net voltage between points 3 and 4 is seen by C1 as an increase in forward bias, and by C2 as a decrease in forward bias. C1, therefore tends to increase its capacitance, and C2 tends to decrease its capacitance. Thus the effect of the fed-back voltage is to cancel the initial unbalance due to the change in C_T. However, the circuit constants (R, L, C) determine the speed at which the response can catch up with the initial unbalance, and by the time the bridge is rebalanced and "quiescent", the total C value of the upper arm is greater than that of the lower and the cycle repeats with all polarities reversed. This action continues as a normal oscillator, at a frequency and amplitude determined by the initial change in C_T and by other component values.

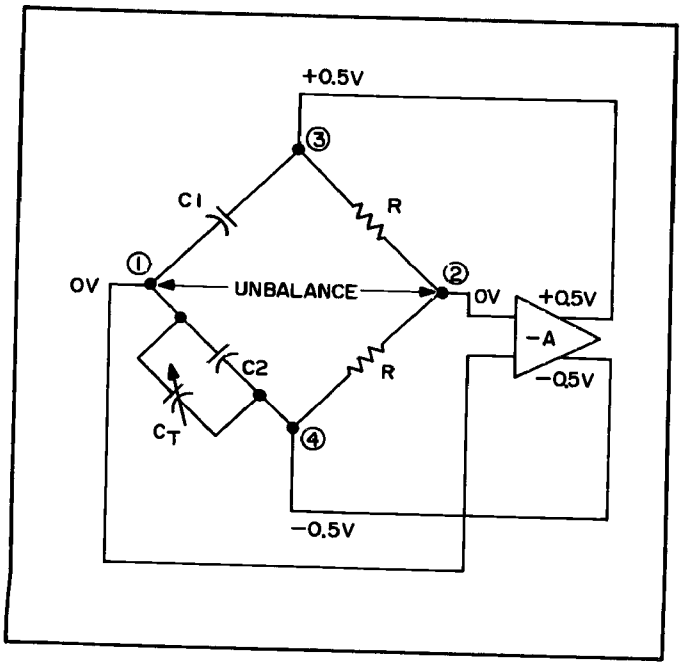


Figure 4-3. Basic Parametric Convertor Bridge Circuit

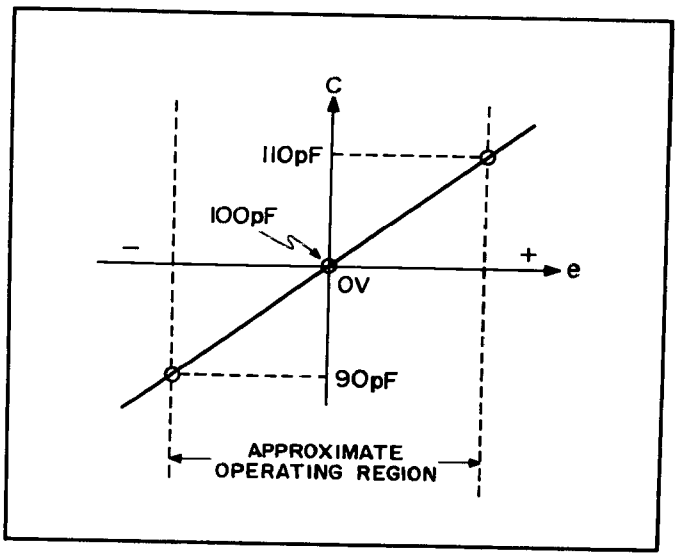


Figure 4-4. Simplified Pico-diode Characteristic

4-10. This type of oscillation is called a parametric oscillation, in that the modulation of the reactance parameter ("C") determines the behaviour of the oscillator. In applying this concept to a practical high-resistance measuring circuit, only a few simple changes are necessary. Point 1, the junction between C1 and C2 can be considered the "input" point, where a current to be measured is injected into the circuit. Any change in current at this point will be seen as a further unbalance in the bridge. This additional unbalance will be seen as an increase in signal to the amplifier and a resultant increase in the amplitude of oscillations. It remains only to develop a dc voltage proportional to the increase in oscillation amplitude, suitable for driving a meter circuit. The high impedance input is developed by the non-conducting pico-diode "capacitors", aided in a practical circuit by suitable isolating capacitors, high resistance circuit mountings, and augmented by negative feed-back. (See para. 4-18) The stable gain characteristic of the 4329A is provided by the standard ac feedback-controlled amplifier approach, made possible by the conversion of the dc input current to a change in the amplitude of convertor oscillations.

4-11. ACTUAL CIRCUIT SIMPLIFIED

4-12. The actual circuit used in the HP4329A operates in a similar fashion to the analogous circuit described in para. 4-9. The following relates the

more complicated actual circuit to that of para. 4-9.

4-13. PARAMETRIC CONVERTOR ASSEMBLY, A8

4-14. The convertor is comprised of a transformer bridge, pico-diodes CR1 and CR2 being two arms, and the two halves of center-tapped T1 primary winding being the remaining two arms. C6 and C7 isolate dc from the transformer windings. C_T is the variable capacitor providing a slight unbalance to the bridge and is used to set the "no-input" oscillation amplitude. (∞ adjust)

4-15. Bridge unbalance is taken from the junction of C_T and Co to oscillator/amplifier A9Q1/Q2 through series resonant circuit Co/Lo, which sets the oscillation frequency at approximately 100KHz. The amplifier's output is fed back to the bridge by transformer action (from M3 to M2, M1).

4-16. Oscillations are also transferred by transformer action to the input of meter amplifier A10Q1/Q2, rectified, and the resultant direct current drives the meter M. R9 sets the meter circuit current such that 200mV at the convertor input gives full-scale deflection.

4-17. The dc negative feedback through the R-C network to the pair of 2 Meg resistors is provided to stabilize the circuit against variations in circuit parameters, particularly the pico-diode characteristics.

4-18. The dc feedback to the input point adds to the total effective insulation resistance of the insulator which isolates the convertor input lead from the leakage resistance of the printed circuit board. This feedback is equal in size and polarity to the input voltage itself, and is applied to the conducting surface around the periphery of the insulating cylinder containing the input junction point. Since the voltage at the inner surface of the cylinder is therefore equal to that at the outer surface, no leakage occurs through the teflon cylinder and its insulating qualities are enhanced. (See Fig. 4-6) The input conductor connects to the central "tie-point" within the teflon cylinder, the feedback connects to the printed-circuit conductor surrounding the teflon.

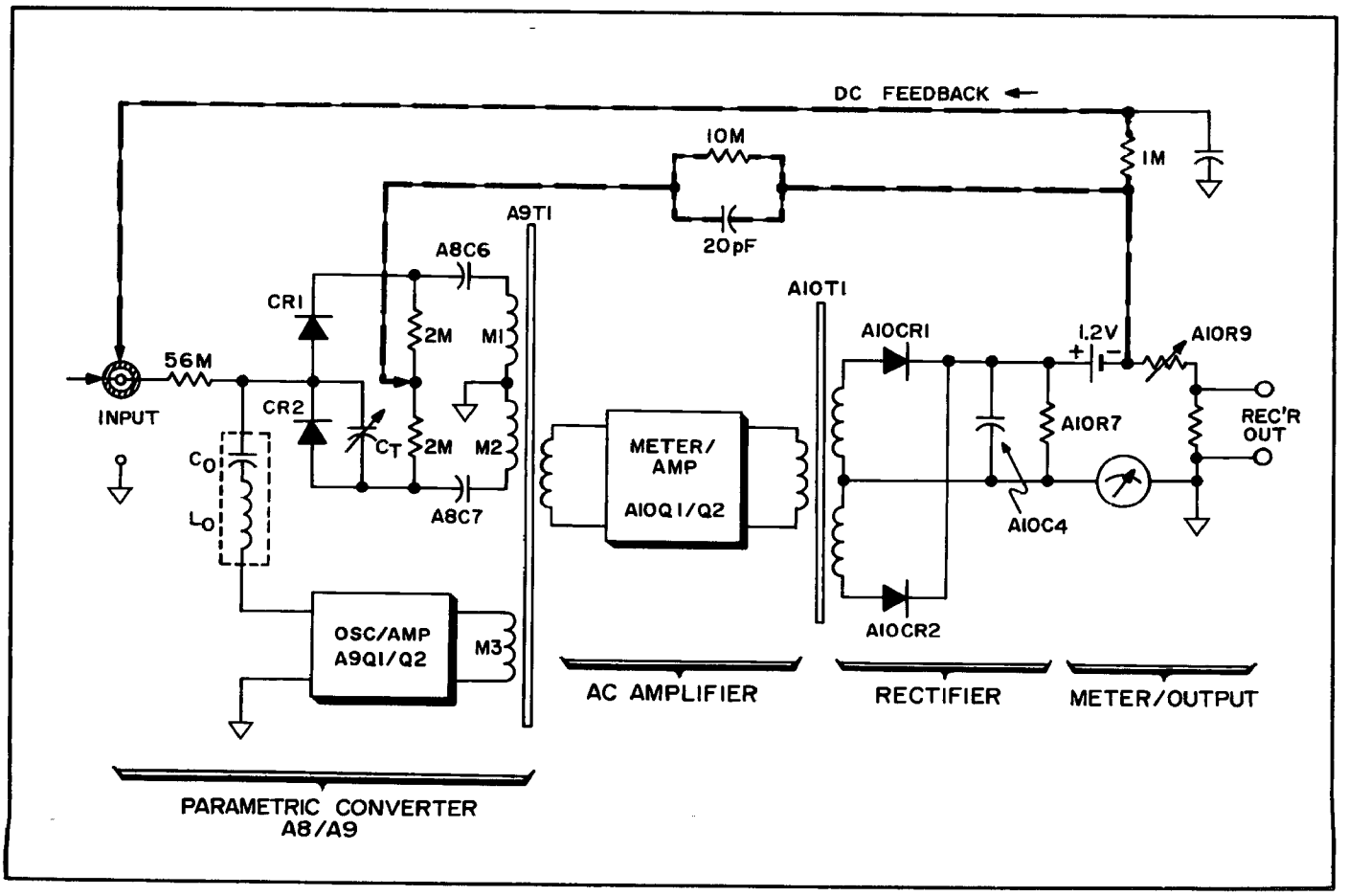


Figure 4-5. Simplified Circuit

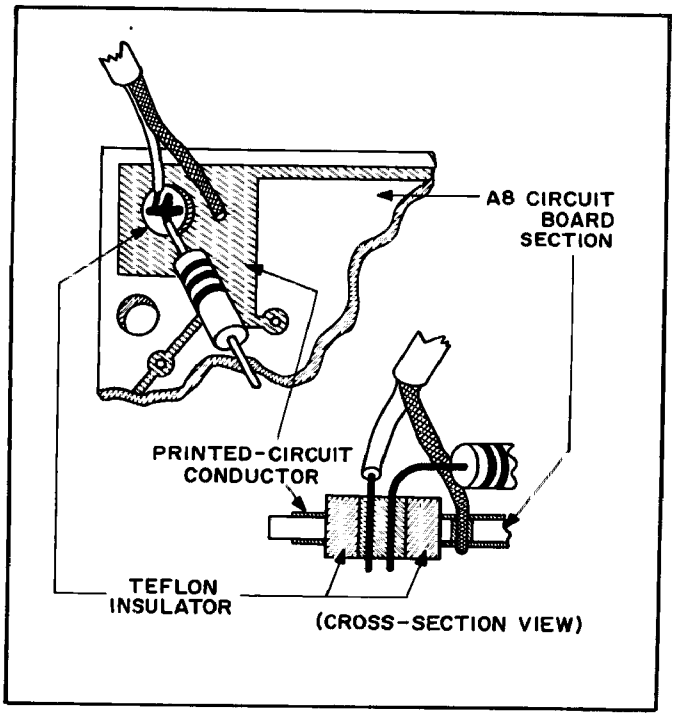


Figure 4-6. Input Insulator Detail

4-19. COMPLETE INSTRUMENT SIMPLIFIED

4-20. The complete high-resistance meter can be represented as shown in Fig. 4-7.

4-21. Test voltages from 10 to 1000VDC are generated to $\pm 3\%$ accuracies by the test voltage power supply A3. The front panel control "Test Voltage" selects the desired voltage by changing the total value of control resistance in the sensor amplifier input in the supply itself. Part of the same switch assembly (A4) selects the appropriate meter scale indicator to be lit. These are: Upper scale 1000V, 100V, 10V; middle scale 25V, 250V; lower scale 50V, 500V. The full-scale adjust sets the meter pointer to the "CAL" position, when the RANGE switch is set to CAL. When the range switch is in CAL, 10VDC is taken from the test voltage switch, divided down to 200mV, and applied to the input of the convertor.

4-22. The voltage selected is passed to the MODE switch assembly A5, where three possibilities are present, depending on the position of the front panel switch. In MEASURE the test voltage is passed directly to the plus side of the front and rear panel measuring terminals. The negative side of the measuring terminals is connected to the measuring circuits via the range switch assembly. In CHARGE, the test voltage is connected as in MEASURE, but the negative side is returned to circuit common. This provides rapid charging of the resistance under test. In DISCHARGE, the test voltage is disconnected from the sample, and the sample charge is allowed to discharge through a 1 Megohm resistor.

4-23. Current in the sample due to application of the test voltage flows through selected RANGE resistor as determined by the setting of the front panel RANGE switch. The selected resistor shunts the input to the parametric convertor assembly determining therefore, the total current used to cause meter deflection. (These resistors have values up to 10^{11} ohms).

4-24. Selection of the desired range resistor, giving the most convenient scale will also select the correct multiplier (10^6 to 10^{15}) by which to multiply the reading. The following shows which multipliers are used with each test voltage:

10V	: $x10^6$ to 10^{13}
25V, 50V, 100V	: $x10^7$ to 10^{14}
250V, 500V, 1000V	: $x10^8$ to 10^{15}

4-25. ADDITIONAL CIRCUIT DETAILS.

4-26. Examination of the circuit diagrams in section VIII, and study of paragraphs 4-1 through 4-24 will provide an overall understanding of the 4329A circuit operation. Paras. 4-27 through 4-40 contain further detail. Reference to section V, covering maintenance, will further clarify the operation of circuits containing adjustable components.

4-27. PARAMETRIC CONVERTOR ASSEMBLY A8

4-28. C8 and R7, in the dc feedback path from the meter circuit provide appropriate phase and amplitude stability to the overall loop gain of the measuring circuit. C2, the infinity adjust, sets the "no-input" level of oscillation which is balanced by the ±1.2Vdc bias in the meter circuit, resulting in zero deflection at the meter.

4-29. OSCILLATOR/AMPLIFIER ASSEMBLY A9

4-30. Input is via the tuned series resonant circuit C1, L1 to the base of Q1, and signal levels of 20 to 30μV are amplified to levels of 20 to 30mV at the Q2 collector. The output of Q2 is fed back to the bridge circuit diodes by way of T1. Part of the signal is coupled across T1 into the meter amplifier assembly, A10. Diodes CR2 and CR3 are added as protection against excessively large signals, which could damage the bridge assembly pico-diodes. Excessive signal levels result if the input current is high due to inadvertent shorts at the front panel UNKNOWN terminals, with test voltage applied. CR1 derives a 6.5Vdc level from the 12.5V supply for Q1 and Q2 biasing.

4-31. AMPLIFIER, METER CIRCUIT ASS'Y A10

4-32. Amplifier Q1 and Q2 combined have a gain of about 100. The 20-30mV signal at Q1 base is amplified to about 2-3V (peak to peak) at Q2 collector. This signal is coupled to the rectifier (CR1 and CR2) by T1. The dc output of filter R7, C4 flows, through meter M1, deflecting the pointer in proportion to the resistance under test. The overall gain from the connector input to the filter output is equal to unity. The meter is calibrated to deflect full-scale if 200mV appears at

the negative terminal of the 1.2V supply with respect to common. Applying a dc signal of 200mV (with respect to circuit common) to the convertor input, then will cause full-scale deflection. Note that feedback to the bridge circuit is through the 1.2Vdc power supply. R8 is the RECORDER output resistance, setting the output impedance therefore, to 1K. The dc amplifier adjust, R9, sets the total meter current for full-scale deflection at a 200mVdc convertor input. This sets the circuit gain to unity.

4-33. TEST VOLTAGE POWER SUPPLY ASS'Y A3

4-34. Essentially a 1000V supply, the remaining test voltages are derived from voltage divider A4R1-A4R6. Oscillator Q1 oscillates at about 25KHz, its output is stepped up by T1 from 26Vpp to 1100Vpp and rectified by diodes CR1/CR2. C2/R1/C3 provide filtering. Part of the dc output is fed back to amplifier Q8 across control resistor A1R1. This signal is passed to Q7 base, where it is compared to the reference voltage established at Q6 base by CR3. The difference, represented by the signal at Q1 collector, is passed to the complementary amplifier, Q4/Q3, where it is amplified and impedance-matched into the Q1 base circuit. This signal therefore controls Q1 gain, and the resultant amplitude of oscillation in the T1 primary circuit. Thus, the power supply tends to resist changes in output voltage due to load and supply variations. Adjusting A1R1 sets the exact dc level at Q8 base, thus calibrating the power supply. Power supply calibration is checked and adjusted by switching to "Cal" and adjusting Full Scale Cal for full scale deflection.

4-35. LOW VOLTAGE POWER SUPPLY ASS'Y A2.

4-36. The low voltage power supply A2 is composed of 2 identical supplies, providing regulated ±12.5 Vdc voltages, and an unregulated 1.2Vdc supply. The ±12.5V circuits supply the working voltages for all the instrument functions including the high-voltage supply; the 1.2V circuit acts merely as a bias in the meter circuit, to offset the meter current due to the "no-input" oscillations produced by the parametric convertor at quiescence. The ±12.5V circuits are feedback-controlled. Approximately 6V derived from the 12.5V outputs is compared to the 5.9V Zener outputs at CR5 and CR10. Any changes in the ±12.5V outputs will be seen as increases or decreases in col-

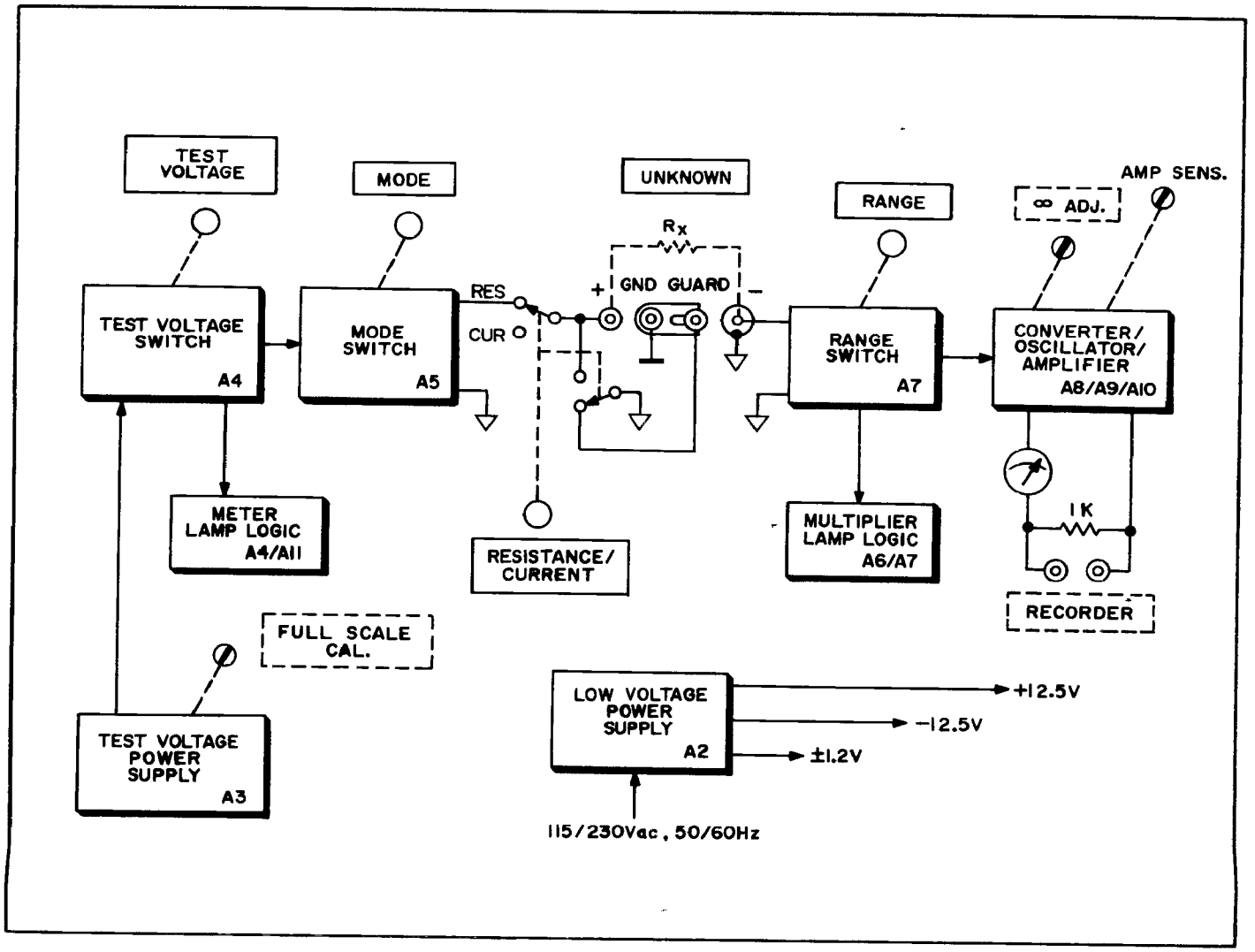


Figure 4-7. Simplified Block Diagram

lector current in Q1 or Q4. These current changes will increase or decrease the effective resistance of series regulators Q2 and Q5, thus compensating for the change in the supply output voltages. Q1 and Q4 are provided to impedance-match the current signal into the regulator base circuits.

4-37. RANGE SWITCH ASSEMBLY, A7

4-38. Resistors R1 to R9 are the current-dividers ("range" resistors) selected to set the appropriate full-scale meter current. Effectively, these resistors shunt the complete convertor and meter/amplifier circuit. Thus, for increasing current inputs (decreasing resistance under test) the maximum current into the meter remains equivalent to full-scale deflection.

4-39. INDICATOR (LAMP) ASSEMBLIES

4-40. All lamps are illuminated by the ac line voltage. Part of test voltage switch (A4S1), and parts of Range Switch (A7S1) are used to interconnect the ac line and the ac common to illuminate the appropriate lamp. (Reference to the schematic diagram, paras. 4-21 and paras. 4-24 will aid in understanding switching logic).

SECTION V
MAINTENANCE

5-1. INTRODUCTION

5-2. This section outlines routine maintenance, performance checks, adjustments, calibration and troubleshooting for the 4329A High Resistance Meter. Performance checks may be used on incoming inspection to verify instrument specifications. The performance checks should also be used after any adjustments have been made.

5-3. CAUTION

If cleaning is necessary, it is recommended that contamination be removed from the circuit by swabbing lightly with alcohol. Any other method may cause adverse effects to the high resistance circuitry; however, since the high resistance meter runs at low levels and all critical circuits are shielded, it is unlikely that circuitry contamination will be a problem, except that which is caused from fingers or solder flux. The internal glass encapsulated resistor may be cleaned with the use of dry, soft cloth.

5-4. PERFORMANCE CHECKS

5-5. The performance checks are intended to determine whether the instrument is operating within its specifications. Should adjustments be required, refer to paragraph 5-16 to paragraph 5-18.

5-6. Recommended test equipment for use during checks and adjustments is listed in Table 5-1.

5-7. CHECK 1: FRONT PANEL INDICATORS

a. Turn instrument on according to Turn-on procedure in Section 3.

b. Set Mode to DISCHARGE

c. Set TEST VOLTAGE to 10V

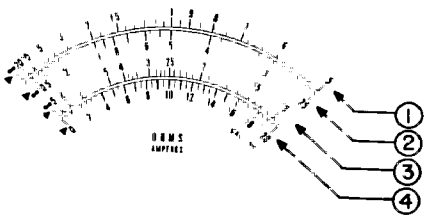
d. Set RANGE to I_{MAX}.

e. Set RESISTANCE-CURRENT to RESISTANCE.

Table 5-1. Recommended Test Equipment

Instrument	Specifications	Used for:	Recommended Model
Voltmeter	20mVdc - 1000Vdc, ±1% accuracy	Checks, adjustments, and troubleshooting	HP 410C
Oscilloscope	DC - 200kHz, 1mV/cm sensitivity	Troubleshooting	HP 1740A
High Resistance Standard	$10^6\Omega$ - $10^{11}\Omega$, variable in decade steps, ±1% accuracy	Checks and adjustments	HP 16340A with furnished accessories
BNC Connector (male) 2 ea.		Checks and adjustments	HP P/N: 1250-1233

Table 5-2. Multiplier & Range Indicator Logic

RANGE SWITCH POSITION	RESISTANCE FUNCTION TEST VOLTAGES (V)							CURRENT FUNCTION
	10	25	50	100	250	500	1000	
I max	10^6	10^7	10^7	10^7	10^8	10^8	10^8	10^{-6}
UP 1	10^7	10^8	10^8	10^8	10^9	10^9	10^9	10^{-7}
UP2	10^8	10^9	10^9	10^9	10^{10}	10^{10}	10^{10}	10^{-8}
UP3	10^9	10^{10}	10^{10}	10^{10}	10^{11}	10^{11}	10^{11}	10^{-9}
UP4	10^{10}	10^{11}	10^{11}	10^{11}	10^{12}	10^{12}	10^{12}	10^{-10}
UP5	10^{11}	10^{12}	10^{12}	10^{12}	10^{13}	10^{13}	10^{13}	10^{-11}
UP6	10^{12}	10^{13}	10^{13}	10^{13}	10^{14}	10^{14}	10^{14}	10^{-12}
R max	10^{13}	10^{14}	10^{14}	10^{14}	10^{15}	10^{15}	10^{15}	10^{-13}
	①	③	②	①	③	②	①	④
METER SCALE								

f. Rotate RANGE through all positions from $I_{MAX.}$ to $R_{MAX.}$ noting that scale and multiplier indicators are illuminated in the order shown in Table 5-2. Repeat for all test voltages from 10V to 1000V.

g. Set RESISTANCE - CURRENT to CURRENT.

h. Repeat (f) noting that CURRENT multiplier and scale indicators are illuminated correctly as given in Table 5-2.

5-8. CHECK 2: TEST VOLTAGES

5-9. Test Voltages are equal to values given on the front panel ±3%. These values are measured by connecting a high input-impedance voltmeter between the UNKNOWN Rx + and GUARD terminals.

a. Set RESISTANCE-CURRENT to RESISTANCE.

b. Set TEST VOLTAGE to 0V.

c. Connect the voltmeter leads to the UNKNOWN Rx + and GUARD terminals, noting correct polarities.

d. Set MODE to CHARGE or MEASURE.

e. Rotate TEST VOLTAGE switch through all Test Voltages; monitor values on the voltmeter for ±3% accuracy check.

5-10. CHECK 3 METER DEFLECTION

a. Set RANGE Switch to CAL.

b. Check that the pointer indicates "CAL" mark on meter-face.

c. Set RANGE to $I_{MAX.}$; check that the pointer indicates ∞.

5-11. CHECK 4 ACCURACY

5-12. Using the $10^6\Omega$ through $10^{11}\Omega$ ranges of the HP 16340A RC Box, check the accuracy of the 4329A's internal range resistors at 10V. Meter readings should be ±10% of indicated range value on the 10^6 through 10^{11} ranges. The procedure is as follows:

a. Connect the triaxial male-to-BNC female adapter to the 16340A's 10^{10}--10^2 triaxial terminal.

b. Connect one BNC male connector to the triaxial-to-BNC adapter and the other BNC male connector to the corresponding BNC female connector on the 16340A.

c. Connect the 4329A to the brass pins on the BNC connectors.

d. Set RESISTANCE-CURRENT to RESISTANCE.

e. Set TEST VOLTAGE to 10V, MODE to MEASURE, and RANGE to $I_{MAX.}$

f. Set the 16340A to the 10^6 range and verify that the meter reading is 1MΩ±10%.

g. Check the 10^7 through 10^{11} ranges in the same manner.

5-13. CHECK 5: RECORDER OUTPUT

5-14. Connect a voltmeter to the 4329A's recorder output terminals and set RANGE to CAL. The reading on the voltmeter should be 100mV±5%.

5-15. ADJUSTMENTS

5-16. Should performance checks reveal that adjustment is required, the following procedure should be

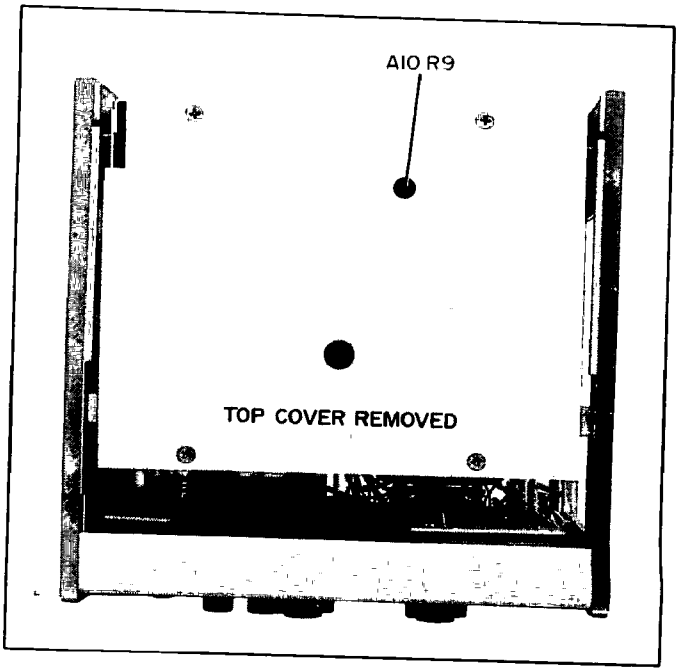


Figure 5-1. 4329A Adjustment Locations

used. 1. Set TEST VOLTAGE power supply, 2. full-scale CAL., ADJ., and AMPLIFIER SENSITIVITY ADJ., all of which are interdependent. Following this sequence, CHECK 2, CHECK 3, and CHECK 4 will verify correct adjustment.

a. Set TEST VOLTAGE to 0V and adjust A3R21 until the base of A3Q2 is -8.5V±.3V.

b. Connect a voltmeter to the Rx + and GUARD terminals of the 4329A. Set TEST VOLTAGE to 10V. The voltmeter should read 10V±3%. If it doesn't, adjust the rear panel FULL-SCALE CAL. ADJ until the voltage is correct. Repeat this procedure on the other TEST VOLTAGE ranges.

Note

If the correct test voltages cannot be obtained, adjust A3R21 again.

c. Set MODE to "MEASURE" and RANGE to IMAX., and apply 200mV dc to the UNKNOWN Rx(-) BNC connector (center conductor is positive and outer conductor is negative) using suitable regulated power supply and attenuator combination. Note the deflection and set it to full-scale using AMP, SENS, ADJ. A10R9 (Remove top cover for access to adjustment through hole in circuit shield. See Figure 5-1). Disconnect 200mV.

d. Set RANGE to CAL. If the pointer doesn't indicate full-scale, set it to full-scale by adjusting A1R2.

e. Set RANGE to IMAX. and note deflection. Set it to infinity using rear panel ∞ ADJ. The ∞ ADJ. is a capacitor; use a plastic adjustment tool or other suitable tool for adjustment.

f. Should performance checks indicate that one or more ranges are outside accuracy specification limits this excess error may be due to slight changes in range resistor values. It is possible to adjust the gain of the meter amplifiers (A10R9) to bring the net error within the accuracy limits. This will shift accuracies on all other ranges, so recalibration will be necessary. This will shift the deflection of full-scale "CAL." also, so readjustment of A1R2 is necessary.

(ie) 1. Set RANGE to out-of-tolerance setting.

2. Using working standard resistor as UNKNOWN, adjust A10R9 to bring reading into specified accuracy.

3. Recheck accuracies on all other ranges.

4. Repeat for any range not giving specified accuracy.

5. Set RANGE to CAL.

6. Adjust A1R2 for full-scale "CAL". meter deflection.

f. Figure 5-2 illustrates the relationship between the adjustments mentioned above and is a pictorial reference for the adjustment procedure.

5-17. CALIBRATION

5-18. The 4329A calibration procedure is complete if the performance checks can be made satisfactorily for the instrument as described in paras. 5-7 thru 5-13. Should the instrument not perform as indicated, proceed to the adjustment in para. 5-15. Further difficulties will indicate that troubleshooting is required. Proceed to para. 5-20 for troubleshooting techniques.

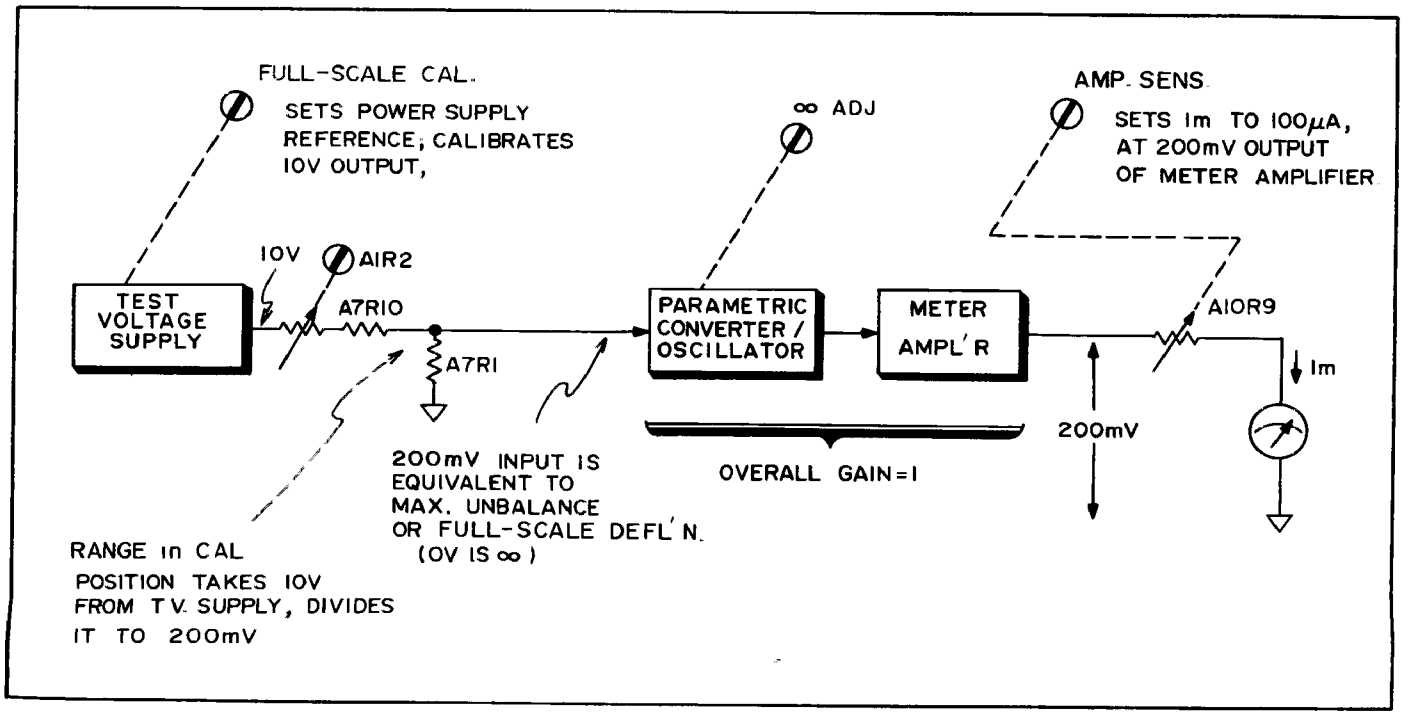


Figure 5-2. 4329A Adjustments

Figure 5-3A

ASSEMBLY LOCATION (TOP AND BOTTOM VIEW)

SEE INSIDE

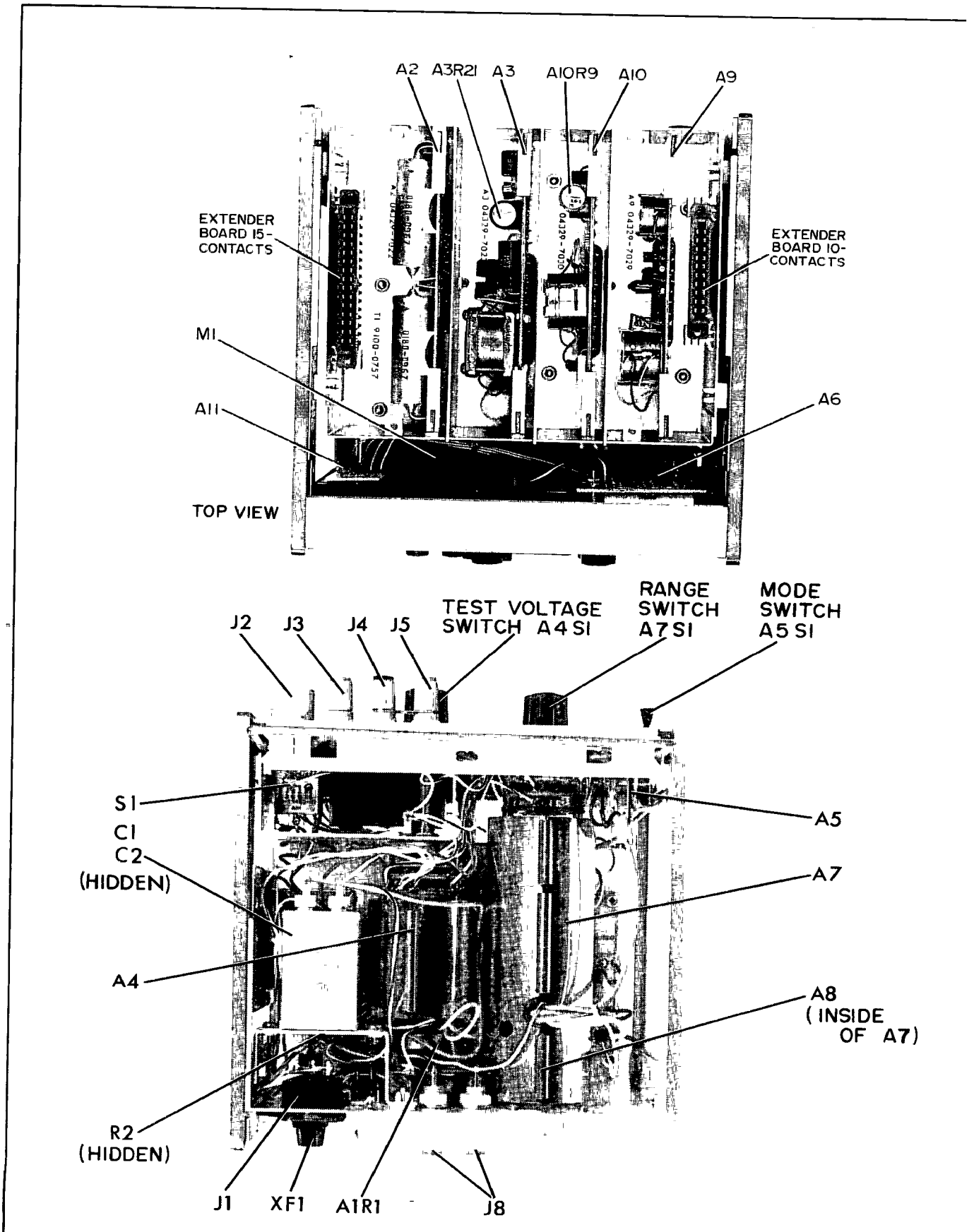


Figure 5-3A. Assembly Location (Top and Bottom View)

5-19. TROUBLESHOOTING

5-20. The information added here is to aid in locating malfunctions in the 4329A circuitry. For technicians troubleshooting this instrument, the following are the required tools in order of importance·

a. Familiarity with the principles of operation of the instrument circuits.

b. Ability to apply test equipment and this manual to instrument maintenace.

c. A logical troubleshooting approach.

The logical troubleshooting approach referred to above is specifically that described by D. Schuster in his book Logical Electronic Troubleshooting (McGraw-Hill). No amount of diagnostic guidelines to fault-finding contained in this manual could duplicate the value of a logical troubleshooting approach by an experienced technician.

5-21. The 4329A is essentially composed of one very-high-resistance circuit and a number of conventional amplifiers, power supplies and dc circuits. Problems in troubleshooting will inevitably reduce to "Is the malfunction inside or outside the high-resistance-circuit?" (The high-resistance-circuit referred to is the parametric convertor assembly A8). If the malfunction can be determined to be outside the A8 assembly, then further diagnosis and parts replacement will be quite straightforward. However, if all indications and checks show that the A8 assembly itself is faulty, then it is recommended that the assembly be replaced as a complete unit (printed circuit assembly, HP Part No. 04329-7028), however it is highly un-

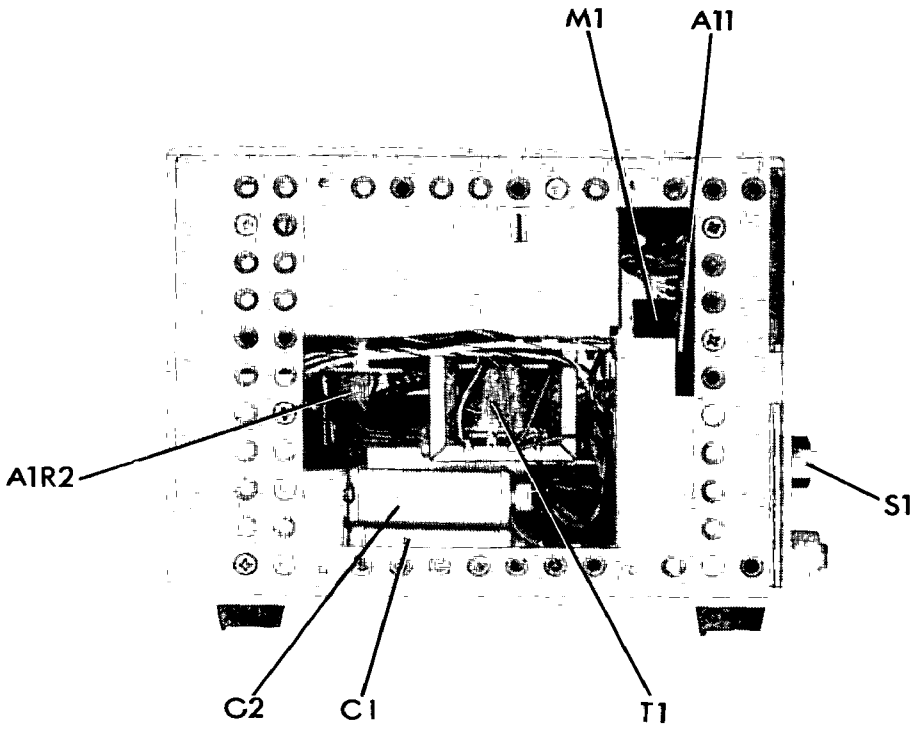


Figure 5-3B. Component Location (Left Side View)

likely that the A8 assembly will malfunction, because it contains no active components, is protected against overload, is completely enclosed, and operates at very low levels. If symptoms indicate A8 faults-doublecheck! Specifically, check connections and signal flow into and out of the convertor. The A8 assembly cannot be checked by conventional "low-impedance test-equipment. Attempts to "troubleshoot" or "repair" this board will prove extremely uneconomical. Complete replacement is recommended.

5-22. It is assumed that the technician troubleshooting the 4329A understands the essentials of operating the instrument, and will have no difficulty in determining whether or not apparent faults lie inside the High Resistance Meter, rather than being due to incorrect use of the controls, connectors or indicators by the operator.

5-23. "IN-CABINET" CHECKS

5-24. These tests are designed to aid the technician in determining whether faults lie in the test voltage supplies or within the measurement circuits.

a. Set RANGE to CAL.; if meter deflects, the power supplies, and the meter circuits are operating.

b. Measure Test Voltage (any setting) between UNKNOWN Rx + and GUARD terminals. If equal to value set, then ±12.5 Vdc and Test Voltage power supplies are O. K. (This does not check the 1.2V supply).

c. If faults are suspected in the meter itself, measure the recorder output. Note that this output voltage across 1kΩ is in series with the meter. For ∞ readings, recorder output is 0V, for full-scale deflection, recorder output is 100m Vdc.

d. Correct operation of all circuits other than the Test Voltage supply can be verified by making a current measurement. A simple current measurement can be made using a dc power supply and a 10 megohm resistor. Set the supply to 1 Volt and connect its output, the 10MΩ, and the 4329A UNKNOWN terminals in series (note correct polarities). Meter should indicate I=1A, multiplier should indicate 10^{-7}. (Range set to first position clockwise from IMAX.)

5-25. CIRCUIT CHECKS

5-26. If the operating tests made in para 5-24 indicate that a fault does exist in the instrument circuitry, proceed to troubleshoot either the low voltage and Test Voltage supplies or the measurement circuits. See Figure 5-4.

5-27. ASSEMBLY AND COMPONENT LOCATION

5-28. Each schematic diagram in Section VIII includes a photograph and component location grid of the assembly shown in the schematic. Figures 5-3 illustrate assembly locations.

5-29. POWER SUPPLY TROUBLESHOOTING

a. Suspected problems in the ±12.5Vdc supplies are rapidly confirmed by measuring the supply output values. Power supply faults can be further categorized into AC or DC circuit problems by checking the 16V AC level at the rectifier inputs. If this AC is not present, check transformers and connections between line input and low voltage rectifiers. If the 16V ac is present, proceed to troubleshoot the transistor regulator, transistor amplifier, and the full-wave rectifier portions of the supply. See Figure 5-5 and 5-6.

b. Regulator/Amplifier Problems: If the low voltage power supply voltage output value is high, it

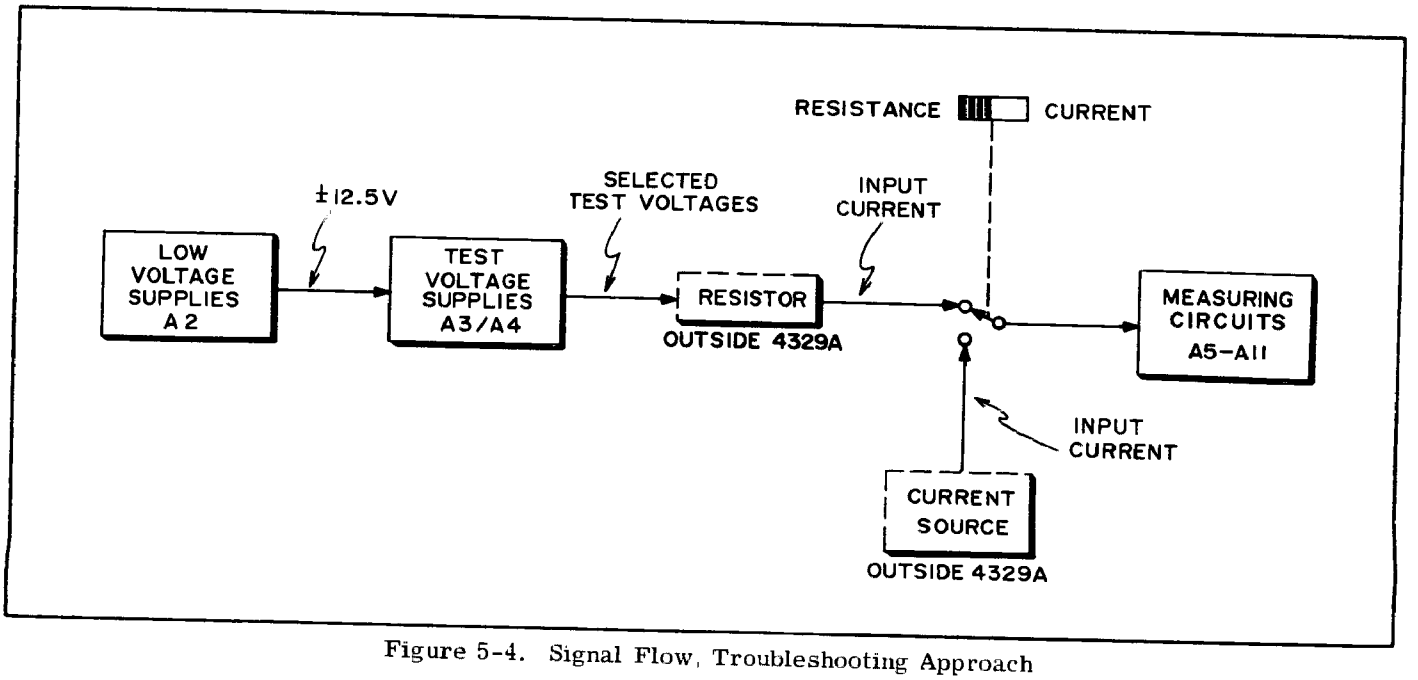


Figure 5-4. Signal Flow, Troubleshooting Approach

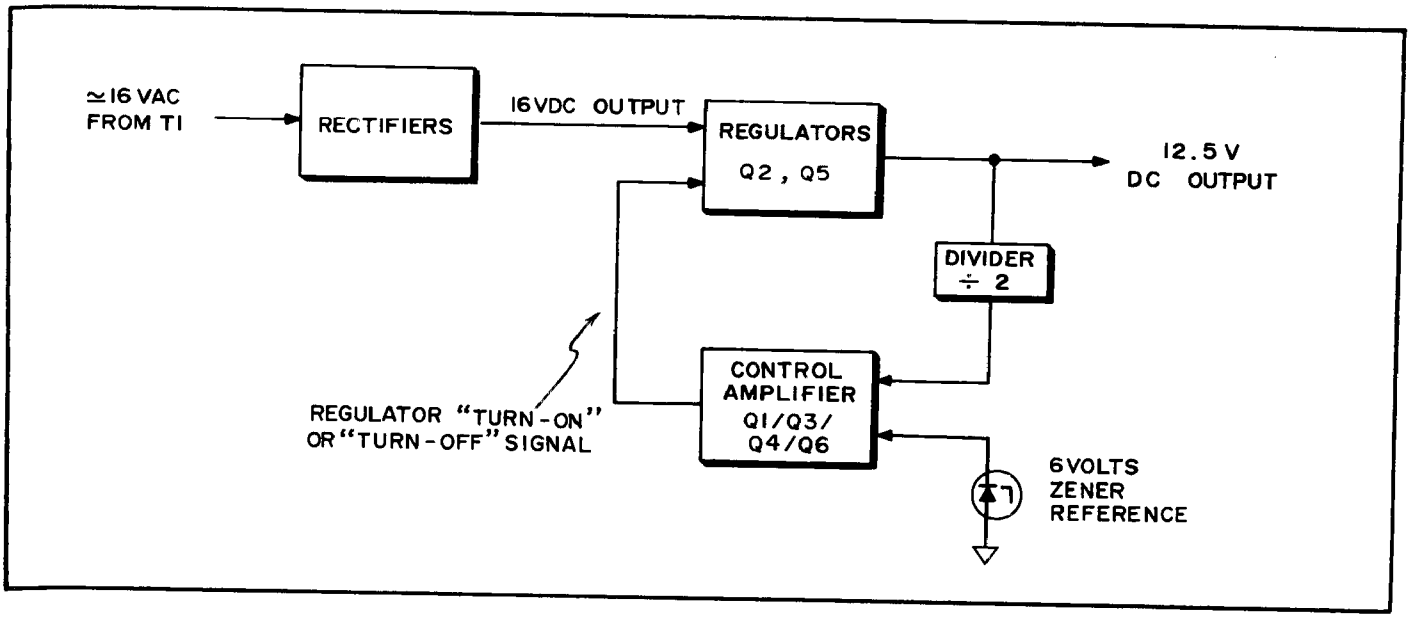


Figure 5-5. Low Voltage Power Supply

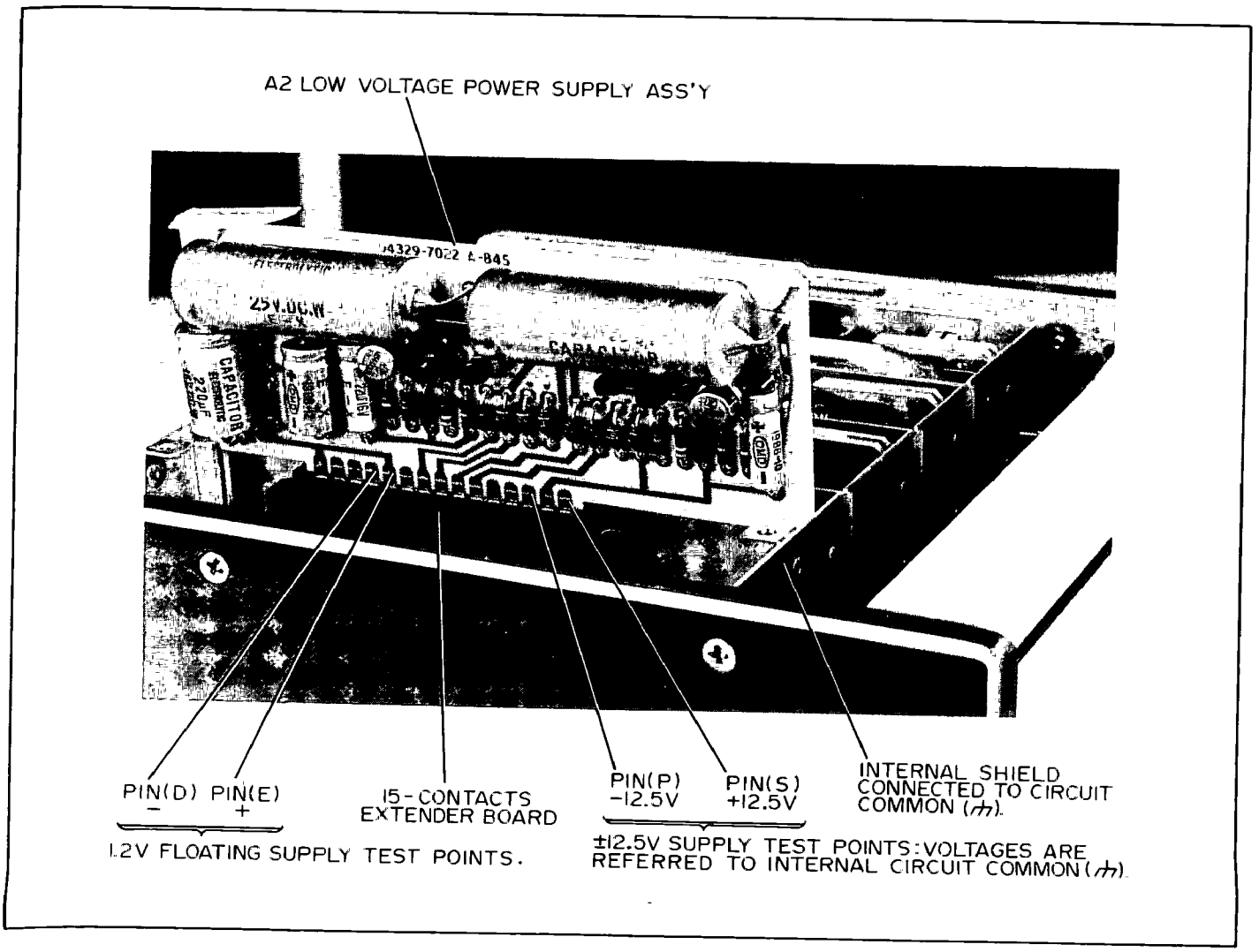


Figure 5-6. Low Voltage Power Supply Test Points

is likely that either the regulator transistor (Q2, or Q5) is shorted, or that "control amplifier" transistors (Q1/Q3 or Q4/Q6) are faulty. Shorted transistors can be verified by measuring 0 volts from collector to emitter. If, however the regulator transistor is conducting heavily, but not shorted, the control amplifier is at fault. This can be verified by monitoring the supply output and momentarily shorting emitter to base of the Q2 or Q5 regulator. If the supply dips to a lower value the regulator is O. K. -- troubleshoot the reference and amplifier section. For a "too-high" output the amplifier transistors Q6 or Q3 should give a very low voltage drop from collector to emitter, and more than 0.6V from base to emitter (Base more positive). Driver transistors Q4 and Q1 should be "off" or show a large voltage drop from collector to emitter if operating correctly under "too-high" output conditions. Their base to emitter voltages should be less than 0.6V.

Note

Do not replace transistors unless it can be verified that the transistor is actually faulty. Monitoring collector voltage values while determining if the base-emitter bias is forward or back-bias will indicate correct or incorrect operation. Silicon transistors require about 0.6V forward bias to "turn on" the transistor. If less, the device is not conducting. For germanium devices, 0.2V is required. This simple approach can be a powerful tool in dealing with dc, low-frequency, and digital transistor circuits. Note that any transistor can be made to "turn off" by shorting its base lead to its emitter lead. For correctly operating devices, this will cause collector voltage to rise towards maximum. A transistor can be "turned-on" by driving more current into its base. This can be done easily by shunting the base-bias resistor with a similarly valued resistor. Correctly-operating devices should show a drop in value of collector voltage towards minimum, under these conditions. Remember, replacing 10 transistors is an uneconomical way of locating the one that failed.

c. In the absence of Low Voltage Supply (positive) output, the regulator Q2 may be either open or not conducting. If subsequent checks reveal no faulty regulator, the control circuit and associated amplifiers should then be checked. The same condition applies to the negative supply.

Note

The input to control amplifiers Q3 and Q6 is the junction of R3/R4 and R7/R8 respectively. For normal operation, the dc value of this input should be about 0.6V more than the zener reference value.

5-30. TEST VOLTAGE SUPPLY

5-31. Figure 5-7 illustrates the essential elements

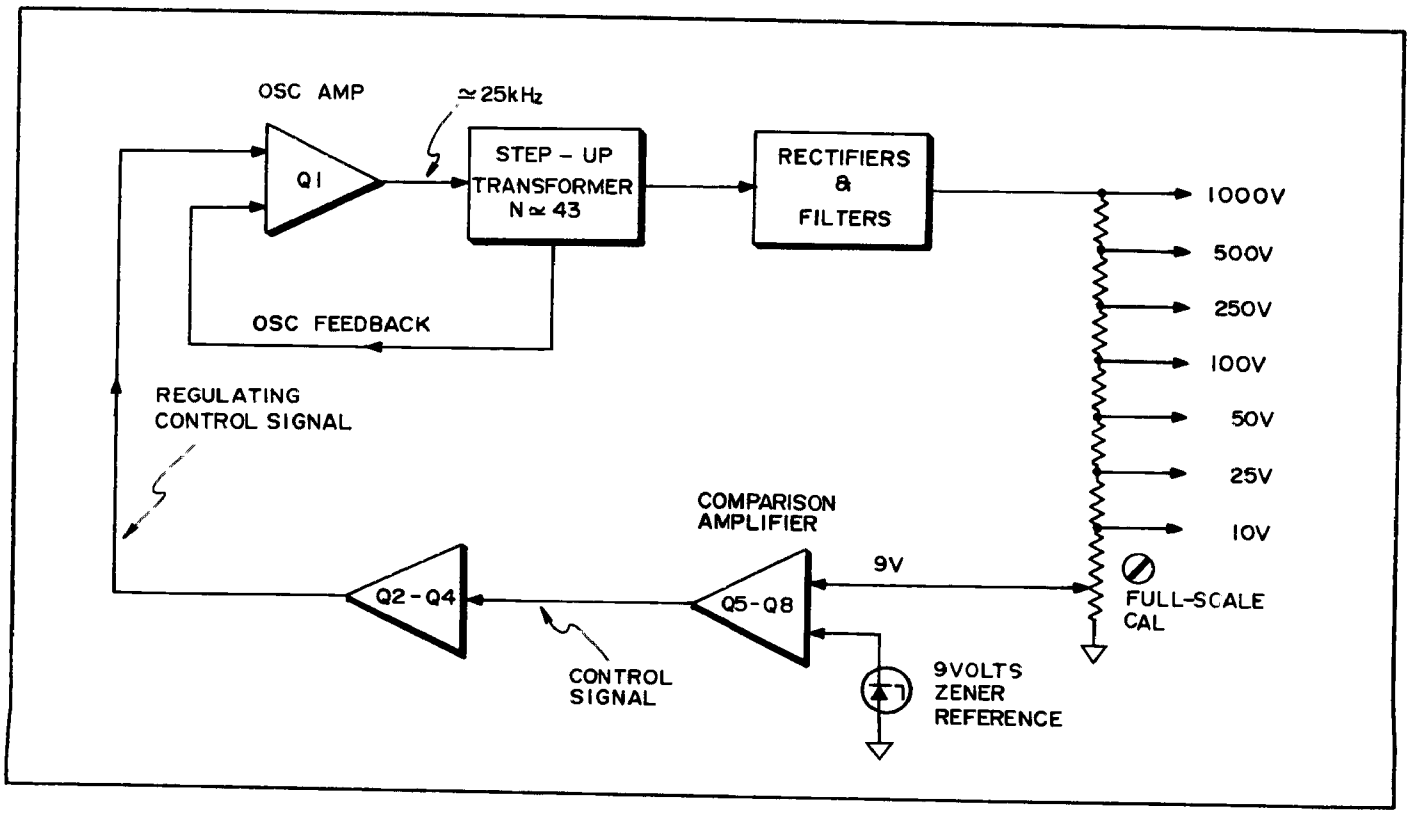


Figure 5-7. Test Voltage Supply

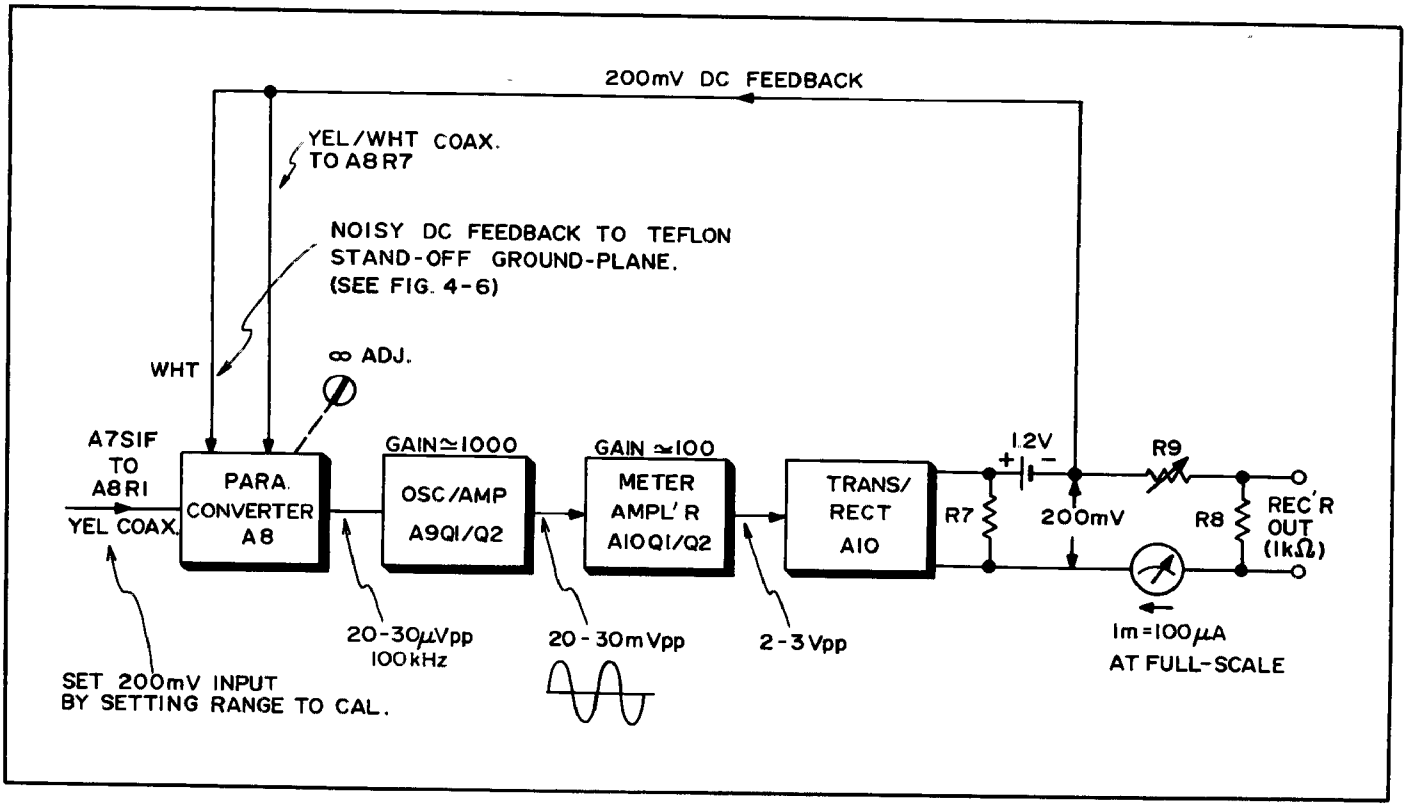


Figure 5-8. Troubleshooting Approach for Measurement Circuits.

of the test voltage circuit. Troubleshooting reduces to determining if the fault lies in the comparison amplifier or control circuit to generate the correct level of control signal to the base of Q1. Or, whether or not the Q1 oscillator the transformer and the rectifier circuit are at fault. Therefore the first check is to monitor the Q1 base while varying the FULL-SCALE CAL control, R1. Q1 should track R1; if it does, the amplifiers are O.K., and the problem is very likely in the oscillator or rectifiers circuits.

5-32. TROUBLESHOOTING THE MEASUREMENT CIRCUITS

5-33. If power supplies are free of faults, check the following. The "measurement circuits" are shown in Figure 5-8.

5-34. Use the diagram in Figure 5-8 as a guide to troubleshooting the measurement circuits. Set a known input to the A8 ass'y by setting RANGE to CAL. Verify that it is 200mV. Check now for a known output at R9 equal to 200mV. Depending on the exact nature of the fault, the R9 voltage will be indicative of what to do next. For example:

a. Zero volts: Possible problem in 1.2V power supply: Could also be problem in A8. Doublecheck connections. Proceed to verify correct operation of A9 and A10 before considering A8 replacement.

b. 2-3V (at about 100kHz): Rectifier problem. If A10 rectifiers O.K. but high frequency signal persists, A8 could be bad.

c. Approximately 200mV. A10R9 or A8C2 are slightly out of adjustment.

d. Very low or negative voltage: Check out rectifiers and A9, A10 gain values.

e. 1-2 volts rms at 60 cycles: Indicates problem in 1.2V power supply.

5-35. After verifying that the 1.2V power supply is not at fault and that the meter is O.K. proceed to check the amplifier chain from A9Q1 base to A10R9. Inject a 100kHz signal at very low level (20μVp-p) using a suitable signal generator or oscillator, voltmeter, attenuator combination. Trace this signal through to R9, where it should be 200mV. This should locate any amplifier, transformer, or rectifier problems.

5-36. If the amplifiers, etc. are not faulty, then follow the 100kHz signal from A9T1 back to the blk, wht coax input to A8. The A3 TEST VOLTAGE Ass'y should be removed while performing this check.

5-37. The foregoing should verify whether or not the possibility of replacing the A8 ass'y should be considered, or that you have discovered a fault elsewhere. Should replacement of A8 be decided upon, however,

the following lists the steps to remove and replace the board.

a. Remove all instrument side-covers.

b. Remove rear panel retaining screws.

c. Remove screw holding rear panel to A7 range switch assembly.

d. Unsolder rear-panel UNKNOWN coax cable.

e. Tilt back panel out.

f. Carefully remove cylindrical shield on A7 ass'y by prying rubber grommet out, and sliding off two retaining clips.

g. Remove the two screws which secure the A8 board under the shield section at rear of A7 switch ass'y.

h. Record color and locations of all connections to A8 board, unsolder and remove.

i. Install new board; reassemble carefully using same procedure in reverse. Do not handle or contaminate parts or the printed circuit itself while installing.

5-38. None of the previous paragraphs included possible faults between test voltage and measurement circuits. The switch assemblies and indicator lamp assemblies may tend to confuse the above analysis if they are faulty. However, a fault in one of these assemblies should be reasonably easy to detect and locate.

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION

6-2. This section contains information for ordering replacement parts. Table 6-2 lists parts in alpha-numerical order of their reference designators and indicates the description (see Table 6-1 for abbreviations used) and HP Part number of each part, together with any applicable notes.

6-3. Miscellaneous parts associated with each assembly are listed at the end of each assembly listing. Others are listed at the end of Table 6-2.

6-4. ORDERING INFORMATION

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

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.

Table 6-1. List of Reference Designators and Abbreviations

REFERENCE DESIGNATORS

A	assembly	E	misc electronic part	P	plug	V	vacuum, tube, neon bulb, photocell, etc.
B	motor	F	fuse	Q	transistor		
BT	battery	FL	filter	R	resistor	VR	voltage regulator
C	capacitor	J	jack	RT	thermistor	W	cable
CP	coupler	K	relay	S	switch	X	socket
CR	diode	L	inductor	T	transformer	Y	crystal
DL	delay line	M	meter	TB	terminal board		
DS	device signaling (lamp)	MP	mechanical part	TP	test point		

ABBREVIATIONS

A	amperes	H	henries	NPN	negative-positive-negative	RMS	root-mean square
A. F. C.	automatic frequency control	HEX	hexagonal	NRFR	not recommended for field replacement	RWV	reverse working voltage
AMPL	amplifier	HG	mercury	NSR	not separately replaceable	S-B	slow-blow
B. F. O.	beat frequency oscillator	HR	hour(s)			SCR	screw
BE CU	beryllium copper	IF	intermediate freq			SE	selenium
BH	binder head	IMPG	impregnated			SECT	section(s)
BP	bandpass	INCD	incandescent			SEMICON	semiconductor
BRS	brass	INCL	include(s)	OBD	order by description	SI	silicon
BWO	backward wave oscillator	INS	insulation(ed)	OH	oval head	SIL	silver
		INT	internal	OX	oxide	SL	slide
CCW	counter-clockwise	K	kilo = 1000			SPG	spring
CER	ceramic					SPL	special
CMO	cabinet mount only	LH	left hand	P	peak	SST	stainless steel
COEF	coefficient	LIN	linear taper	PC	printed circuit	SR	split ring
COM	common	LK WASH	lock washer	PF	picofarads = 10 farads	STL	steel
COMP	composition	LOG	logarithmic taper				
COMPL	complete	LPF	low pass filter	PH BRZ	phosphor bronze	TA	tantalum
CONN	connector			PHL	Phillips	TD	time delay
CP	cadmium plate	M	milli = 10^{-3}	PIV	peak inverse voltage	TGL	toggle
CRT	cathode-ray tube	MEG	meg = 10^{6}	PNP	positive-negative-positive	THD	thread
CW	clockwise	MET FLM	metal film	P/O	part of	TI	titanium
		MET OX	metallic oxide	POLY	polystyrene	TOL	tolerance
DEPC	deposited carbon	MFR	manufacturer	PORC	porcelain	TRIM	trimmer
DR	drive	MINAT	miniature	POS	position(s)	TWT	traveling wave tube
		MOM	momentary	POT	potentiometer		
ELECT	electrolytic	MTG	mounting	PP	peak-to-peak	U	micro = 10^{-6}
ENCAP	encapsulated	MY	"mylar"	PT	point	VAR	variable
EXT	external			PWV	peak working voltage	VDCW	dc working volts
F	farads	N	nano (10^{-9})			W/	with
FH	flat head	N/C	normally closed			W	watts
FIL H	fillister head	NE	neon	RECT	rectifier	WIV	working inverse voltage
FXD	fixed	NI PL	nickel plate	RF	radio frequency		
		N/O	normally open	RH	round head or right hand	WW	wirewound
GE	germanium	NPO	negative positive zero (zero temperature coefficient)			W/O	without
GL	glass			RMO	rack mount only		
GRD	ground(ed)						

Table 6-2, Reference Designation Index

Reference Designation	Part No.	Description	Note
A1	04329-7021	MOTHER BOARD ASS'Y	
	04329-8701	BOARD: BLANK P.C.	
A1R1	2100-1181	R: VAR W.W. 10kΩ 1% RA-30	
A1R2	2100-0942	R:VAR 50kΩ 3/4W	
A1XA1	1251-1633	CONNECTOR: PRINTED CIRCUIT 15 CONTACTS	
A1XA2	1251-1631	CONNECTOR: PRINTED CIRCUIT 10 CONTACTS	
A1XA3	1251-1631	CONNECTOR: PRINTED CIRCUIT 10 CONTACTS	
A1XA4	1251-1631	CONNECTOR: PRINTED CIRCUIT 10 CONTACTS	
		MISCELLANEOUS	
	5040-4529	EXTRACTOR: GRAY 2REQ'D	
A2	04329-7022	LOW VOLTAGE POWER SUPPLY ASS'Y	
	04329-8702	BOARD. BLANK P.C.	
A2C1	0180-0967	C: FXD ALUM ELECT 470μF 25VDCW	
A2C2	0180-0756	C: FXD ALUM ELECT 22μF 16VDCW	
A2C3	0180-0967	C: FXD ALUM ELECT 470μF 25VDCW	
A2C4	0180-0756	C: FXD ALUM ELECT 22μF 16VDCW	
A2C5	0180-0947	C: FXD ALUM ELECT 220μF 16VDCW	
A2C6	0180-0936	C: FXD ALUM ELECT 220μF 6.3VDCW	
A2CR1	1901-0230	DIODE: SILICON TOSHIBA 1S1888	
A2CR2	1901-0230	DIODE: SILICON TOSHIBA 1S1888	
A2CR3	1901-0230	DIODE: SILICON TOSHIBA 1S1888	
A2CR4	1901-0230	DIODE: SILICON TOSHIBA 1S1888	
A2CR5	1902-3110	DIODE: SILICON BREAKDOWN 5.9V	
A2CR6	1901-0230	DIODE: SILICON TOSHIBA 1S1888	
A2CR7	1901-0230	DIODE: SILICON TOSHIBA 1S1888	
A2CR8	1901-0230	DIODE: SILICON TOSHIBA 1S1888	
A2CR9	1901-0230	DIODE: SILICON TOSHIBA 1S1888	
A2CR10	1902-3110	DIODE: SILICON BREAKDOWN 5.9V	
A2CR11	1901-0040	DIODE: SILICON	
A2Q1	1854-0071	TRANSISTOR: SILICON 2N3391	
A2Q2	1854-0003	TRANSISTOR: SILICON	
A2Q3	1854-0071	TRANSISTOR: SILICON 2N3391	
A2Q4	1854-0071	TRANSISTOR: SILICON 2N3391	
A2Q5	1854-0003	TRANSISTOR: SILICON	
A2Q6	1854-0071	TRANSISTOR: SILICON 2N3391	
A2R1	0683-1245	R: FXD COMP 120kΩ 5% 1/4W	
A2R2	0683-3925	R: FXD COMP 3.9kΩ 5% 1/4W	
A2R3	0683-5635	R: FXD COMP 56kΩ 5% 1/4W	
A2R4	0683-5635	R: FXD COMP 56kΩ 5% 1/4W	
A2R5	0683-1245	R: FXD COMP 120kΩ 5% 1/4W	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index

Reference Designation	Part No.	Description	Note
A2R6	0683-3925	R: FXD COMP 3.9kΩ 5% 1/4W	
A2R7	0683-5635	R: FXD COMP 56kΩ 5% 1/4W	
A2R8	0683-5635	R: FXD COMP 56kΩ 5% 1/4W	
A2R9	0683-4715	R: FXD COMP 470Ω 5% 1/4W	
A2R10	0683-1315	R: FXD COMP 130Ω 5% 1/4W	
		MISCELLANEOUS	
	5040-3304	HOLDER: CAPACITOR C1 AND C3	
	5040-4529	EXTRACTOR: GRAY	
A3	04329-7023	HIGH VOLTAGE POWER SUPPLY ASS'Y	
	04329-8703	BOARD: BLANK P.C.	
A3C1	0150-0012	C: FXD CER 0.01μF 1kVDCW	
A3C2	0150-0012	C: FXD CER 0.01μF 1kVDCW	
A3C3	0150-0012	C: FXD CER 0.01μF 1kVDCW	
A3C4	0160-1333	C: FXD MYLAR 0.1μF 100VDCW	
A3C5	0180-0376	C: FXD TANT ELECT 0.47μF 35VDCW	
A3C6	0180-1025	C: FXD TANT ELECT 22μF 6VDCW	
A3C7	0180-0210	C: FXD TANT ELECT 3.3μF 15VDCW	
A3C8	0160-0128	C: FXD CER 2.2μF 20% 25VDCW	
A3CR1	1901-0231	DIODE: SILICON SANKEN SF-1	
A3CR2	1901-0231	DIODE: SILICON SANKEN SF-1	
A3CR3	1902-0785	DIODE: SILICON BREAKDOWN 9V 1N936	
A3CR4	1902-0057	DIODE: SILICON BREAKDOWN 6.49V	
A3Q1	1854-0022	TRANSISTOR: SILICON	
A3Q2	1854-0071	TRANSISTOR: SILICON 2N3391	
A3Q3	1854-0071	TRANSISTOR: SILICON 2N3391	
A3Q4	1853-0010	TRANSISTOR: SILICON	
A3Q5	1854-0071	TRANSISTOR: SILICON 2N3391	
A3Q6	1854-0071	TRANSISTOR: SILICON 2N3391	
A3Q7	1854-0071	TRANSISTOR: SILICON 2N3391	
A3Q8	1854-0071	TRANSISTOR: SILICON 2N3391	
A3R1	0683-1045	R: FXD COMP 100kΩ 5% 1/4W	
A3R2	0683-4705	R: FXD COMP 47Ω 5% 1/4W	
A3R3	0683-5125	R: FXD COMP 5.1kΩ 5% 1/4W	
A3R4	0683-5605	R: FXD COMP 56Ω 5% 1/4W	
A3R5	0683-3035	R: FXD COMP 30kΩ 5% 1/4W	
A3R6	0683-1035	R: FXD COMP 10kΩ 5% 1/4W	
A3R7	0683-2245	R: FXD COMP 220kΩ 5% 1/4W	
A3R8	0683-3025	R: FXD COMP 3kΩ 5% 1/4W	
A3R9	0683-1635	R: FXD COMP 16kΩ 5% 1/4W	
A3R10	0683-1225	R: FXD COMP 1.2kΩ 5% 1/4W	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description	Note
A3R11	0683-9135	R: FXD COMP 91kΩ 5% 1/4W	
A3R12	0683-7535	R: FXD COMP 75kΩ 5% 1/4W	
A3R13	0683-1055	R: FXD COMP 1MΩ 5% 1/4W	
A3R14	0683-1835	R: FXD COMP 18kΩ 5% 1/4W	
A3R15	0683-1835	R: FXD COMP 18kΩ 5% 1/4W	
A3R16	0683-2045	R: FXD COMP 200kΩ 5% 1/4W	
A3R17	0683-7535	R: FXD COMP 75kΩ 5% 1/4W	
A3R18	0683-1055	R: FXD COMP 1MΩ 5% 1/4W	
A3R19	0698-1477	R: FXD MET. FILM 10kΩ 1% 1/4W	
A3R20	0698-1478	R: FXD MET. FILM 105kΩ 1% 1/4W	
A3R21	2100-0942	R: VAR MET. FILM 50kΩ 20% 1W	
A3T1	04329-8604	TRANSFORMER: OSCILLATOR	
		MISCELLANEOUS	
	5040-4529	EXTRACTOR: GRAY	
	1205-0033	HEAT SINK FOR A3Q1	
A4	04329-7024	TEST VOLTAGE SWITCH ASS'Y	
A4C1	0150-0012	C: FXD CER 0.01μF 1KVDCW	
A4R1	0698-1479	R: FXD MET. FILM 150kΩ 1% 1/2W	
A4R2	0698-1480	R: FXD MET. FILM 250kΩ 1% 1/2W	
A4R3	0698-1482	R: FXD MET. FILM 500kΩ 1% 1/2W	
A4R4	0698-1483	R: FXD MET. FILM 1.5MΩ 1% 1/2W	
A4R5	0698-1484	R: FXD MET. FILM 2.5MΩ 1% 1/2W	
A4R6	0698-1485	R: FXD MET. FILM 5MΩ 1% 1W	
A4R7	0683-6245	R: FXD COMP 620kΩ 5% 1/4W	
A4S1	3100-1177	SWITCH : ROTARY	
		MISCELLANEOUS	
	04329-1030	SHIELD: ROTARY SWITCH	
	04204-3021	KEY: SHIELD	
A5	04329-7025	MODE SWITCH ASS'Y	
A5R1	0683-1055	R: FXD COMP 1MΩ 5% 1/4W	
A5R2	0683-5145	R:FXD COMP 510kΩ 5% 1/4W	
A5S1	3101-0252	SWITCH: LEVER	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd).

Reference Designation	Part No.	Description	Note
A6	04329-7026	MULTIPLIER INDICATOR ASS'Y	
	04239-8706	BOARD:BLANK P.C.	
A6DS1-A6DS18	2140-0535	LAMP:GLOW NE-2	
A6R1	0683-1045	R:FXD COMP 100kΩ 5% 1/4W	
A7	04329-7027	RANGE SWITCH ASS'Y	
A7R1	0757-0839	R:FXD MET. FILM 10kΩ 1% 1/2W	
A7R2	0757-0839	R:FXD MET. FILM 10kΩ 1% 1/2W	
A7R3	0757-0367	R:FXD MET. FILM 100kΩ 1% 1/2W	
A7R4	0757-0059	R:FXD MET. FILM 1MΩ 1% 1/2W	
A7R5	0698-2289	R:FXD METAL GLAZE 10MΩ 1% 100mW	
A7R6	0698-2290	R:FXD METAL GLAZE 100MΩ 1% 10mW	
A7R7	0698-2291	R:FXD METAL GLAZE 1000MΩ 1% 1mW	
A7R8	0698-2292	R:FXD METAL GLAZE 10,000MΩ 1% 100μW	
A7R9	0698-2293	R:FXD METAL GLAZE 100,000MΩ 1% 10μW	
A7R10	0698-3260	R:FXD MET. FILM 464kΩ 1% 1/8W	
A7S1	3100-1180	SWITCH:ROTARY	
		MISCELLANEOUS	
	04329-1031	SHIELD:ROTARY SWITCH CR	
	04204-3021	KEY:SHIELD LONG	
	04329-3021	KEY:SHIELD SHORT 2 REQ'D	
	04329-1033	SHIELD:ROTARY SWITCH CR	
	04329-1038	BRACKET:ROTARY SWITCH UR	
A8	04329-7028	PARAMETRIC CONVERTER ASS'Y LOCATED IN A7	
	04329-8708	BOARD:BLANK P.C. RANGE SWITCH ASS'Y	
A8C1*	0160-1584	C:FXD STYCON 100pF 125VDCW	
A8C2	0121-0493	C:VAR AIR 1.7-11.8pF	
A8C3	0160-1584	C:FXD STYCON 100pF 10% 125VDCW	
A8C4	0160-1583	C:FXD STYCON 20pF 10% 125VDCW	
A8C5	0160-1584	C:FXD STYCON 100pF 10% 125VDCW	
A8C6	0160-1165	C:FXD STYCON 1000pF 10% 125VDCW	
A8C7	0160-1165	C:FXD STYCON 1000pF 10% 125VDCW	
A8C8	0160-1583	C:FXD STYCON 20pF 10% 125VDCW	
A8C9	0212-0528	C:VAR AIR 1.6pF-9pF	
A8C10	0150-0059	C:FXD DER 3.3pF ± 0.25pF	
A8CR1 - A8CR2	0122-0104	DIODE:VAR CAP. SELECTED PAIR	

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description	Note
A8R1	0687-5661	R: FXD COMP 56MΩ 10% 1/2W	
A8R2	0683-3955	R: FXD COMP 3.9MΩ 5% 1/4W	
A8R3	0683-1065	R: FXD COMP 10MΩ 5% 1/4W	
A8R4	0683-1065	R: FXD COMP 10MΩ 5% 1/4W	
A8R5	0683-2055	R: FXD COMP 2MΩ 5% 1/4W	
A8R6	0683-2055	R: FXD COMP 2MΩ 5% 1/4W	
A8R7	0683-1065	R: FXD COMP 10MΩ 5% 1/4W	
A8R8	0683-1065	R:FXD COMP 10MΩ 5% 1/4W	
		MISCELLANEOUS	
	0340-0060	INSULATOR: TEFLON CLOVER LEAF TEN REQ'D	
A9	04329-7029	OSCILLATOR/AMPLIFIER ASS'Y	
	04329-8709	BOARD: BLANK P.C.	
A9C1*	0160-0362	C: FXD DIPPED MICA 510pF 5% 300VDCW	
A9C2*	0140-0192	C: FXD DIPPED MICA 68pF 5% 300VDCW	
A9C3	0180-1029	C: FXD TANT ELECT 1μF 15VDCW	
A9C4	0160-0346	C: FXD DIPPED MICA 5100pF 5% 300VDCW	
A9CR1	1902-0057	DIODE: SILICON BREAKDOWN 6.49V	
A9CR2	1901-0040	DIODE: SILICON	
A9CR3	1901-0040	DIODE: SILICON	
A9L1	04329-8601	COIL: 16mH	
A9Q1	1854-0114	TRANSISTOR: SILICON TOSHIBA 2SC752 RED	
A9Q2	1854-0014	TRANSISTOR: SILICON TOSHIBA 2SC752 RED	
A9R1	0683-2435	R: FXD COMP 24kΩ 5% 1/4W	
A9R2	0683-1035	R: FXD COMP 10kΩ 5% 1/4W	
A9R3	0683-5115	R: FXD COMP 510Ω 5% 1/4W	
A9R4	0683-5135	R: FXD COMP 51kΩ 5% 1/4W	
A9R5	0683-1525	R: FXD COMP 1.5kΩ 5% 1/4W	
A9R6	0683-2025	R: FXD COMP 2kΩ 5% 1/4W	
A9R7	0683-1525	R: FXD COMP 1.5kΩ 5% 1/4W	
A9T1	04329-8602	TRANSFORMER: OSCILLATOR/AMPLIFIER	
		MISCELLANEOUS	
	5040-4529	EXTRACTOR: GRAY	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description	Note
A10	04329-7030	AMPLIFIER, METER CIRCUIT ASS'Y	
	04329-8710	BOARD: BLANK P.C.	
A10C1	0160-1548	C: FXD MYLAR 0.22μF 10% 200VDCW	
A10C2	0160-1548	C: FXD MYLAR 0.22μF 10% 200VDCW	
A10C3*	0160-1544	C FXD MYLAR 4700pF 10% 100VDCW	
A10C4	0160-1333	C: FXD MYLAR 0.1μF 10% 100VDCW	
A10C5	0160-1548	C FXD MYLAR 0.22μF 10% 200VDCW	
A10CR1	1910-0016	DIODE: GERMANIUM	
A10CR2	1910-0016	DIODE: GERMANIUM	
A10Q1	1854-0114	TRANSISTOR: SILICON TOSHIBA 2SC752 RED	
A10Q2	1854-0114	TRANSISTOR: SILICON TOSHIBA 2SC752 RED	
A10R1	0683-1035	R: FXD COMP 10kΩ 5% 1/4W	
A10R2	0683-5605	R: FXD COMP 56Ω 5% 1/4W	
A10R3	0683-1035	R: FXD COMP 10kΩ 5% 1/4W	
A10R4	0683-2435	R: FXD COMP 24kΩ 5% 1/4W	
A10R5	0683-3015	R: FXD COMP 300Ω 5% 1/4W	
A10R6	0683-1035	R: FXD COMP 10kΩ 5% 1/4W	
A10R7	0683-3925	R: FXD COMP 3.9kΩ 5% 1/4W	
A10R8	0757-0280	R: FXD MET. FILM 1kΩ 1% 1/8W	
A10R9	2100-1759	R: VAR W.W. LIN 2kΩ 10% 1W	
A10R10	0683-1055	R: FXD COMP 1MΩ 5% 1/4W	
A10T1	04329-8603	TRANSFORMER OUTPUT	
		MISCELLANEOUS	
	0340-0060	EXTRACTOR GRAY	
A11	04329-7031	METER SCALE INDICATOR ASS'Y	
	04329-8711	BOARD: BLANK P.C.	
A11DS1-A11DS4	2140-0123	LAMP: GLOW	
A11R1	0683-4335	R: FXD COMP 43kΩ 5% 1/4W	
		MISCELLANEOUS	
	5040-3313	HOLDER: LAMP	
C1	0160-1646	C: FXD PAPER 0.5μF 1000VDCW	
C2	0160-1647	C FXD PAPER 0.3μF 1500VDCW	
F1	2110-0234	FUSE: SLOW BLOW 100mAT	
J1	1251-8695	CONN-AC POWER MALE	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description	Note
J2	1250-0118	CONNECTOR:BNC FEMALE FOR "UNKNOWN"	
	5040-0345	INSULATOR	
	04329-5125	INSULATOR:COVER	
J3	1510-0091	CONNECTOR:BINDING POST RED FOR "UNKNOWN"	
	3050-0067	INSULATOR	
J4	1510-0107	CONNECTOR:BINDING POST BLACK FOR "GND"	
	3050-0067	INSULATOR	
	5000-4206	SHORTING LINK	
J5	1510-0091	CONNECTOR:BINDING POST BLACK FOR "GUARD"	
	3050-0067	INSULATOR	
J6 (OPT C10)	1250-0118	CONNECTOR:BNC FEMALE FOR "UNKNOWN", REAR	
	5040-0345	INSULATOR	
	04329-5125	INSULATOR COVER	
	04329-5126	CAP:BNC MALE INSULATED	
J7 (OPT C10)	1510-0091	CONNECTOR:BINDING POST RED FOR "UNKNOWN", REAR	
	3050-0067	INSULATOR	
J8	1510-0091	CONNECTOR FOR RECORDER	
	3050-0067	INSULATOR	
M1	1120-0760	METER 100 μA SPEC	
R1	0757-0465	R:FXD COMP 100kΩ 5% 1/4W	
S1	3101-2139	SWITCH:LINE PUSH ON-OFF	
S2	3101-1235	SWITCH:SLIDE DPDT 115/230V	
S3	04329-7032	SWITCH:SLIDE 8PDT	
T1	9100-0757	TRANSFORMER:POWER	
W1	8120-1378	CABLE ASS'Y:POWER CORD	
	1251-0048	ADAPTER:THREE PRONG TO TWO PRONG	
XF1	2110-0564	HOLDER, FUSE	
	2110-0565	CAP	
	2110-0569	NUT	

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description	Note
		MISCELLANEOUS	
	16117A	TEST LEAD: LOW NOISE	
	04329-00202	PANEL: FRONT (HP)	
	04329-00201	PANEL: FRONT (YHP)	
	04329-1049	PLATE: POWER TRANS	
	04329-10022	PANEL: REAR	
	04329-1044	PANEL: REQR (OPT C10)	
	04329-5024	SEPARATOR: MULTIPLIER INDICATOR	
	04329-8521	FILM: MULTIPLIER INDICATOR	
	04329-5022	KNOB: LEVER FOR MODE SWITCH	
	0370-0287	KNOB: WING WHITE LINE BLK	
	0370-0288	CAP: KNOB	
	5040-4555	GUIDE: BOARD ASS'YGRAY 8REQ'D	
	6960-0001	PLUG HOLE FOR ∞ ADJ AND FULL SCALE ADJ	

See list of abbreviations in introduction to this section

SECTION VII
MANUAL CHANGES AND OPTIONS

7-1. OPTIONS

7-2. Options are standard modifications performed on HP instruments at the factory. No options for the Model 4329A are offered at the present time.

7-3. SPECIAL INSTRUMENTS

7-4. "Specials" are standard HP instruments that are modified according to customer specifications. A separate insert sheet is included with the manual for special instruments having electrical changes. Make the changes specified in addition to any other changes that are necessary.

7-5. MANUAL CHANGES

7-6. This manual applies directly to the Model 4329A with serials prefixed 2111. The following paragraphs explain how to adapt this manual to apply to later instruments with higher serial prefix, or earlier instruments with lower serial prefix or number. Technical corrections to this manual (if any) are called errata and are listed on a separate "Manual Changes" sheet supplied with this manual.

7-7. LATER INSTRUMENTS: If the serial prefix of your Model 4329A is above 2111, refer to a separate "Manual Changes" sheet supplied with this manual. Locate the serial prefix of your instrument and make the indicated changes.

7-8. EARLIER INSTRUMENTS (Backdating Changes): If the serial prefix of your Model 4329A is below 2111, refer to Table 7-1 for the changes necessary to adapt this manual to your particular instrument. Locate the serial prefix of number of your instrument in the table and make the indicated changes. Note that instrument-component values that differ from those in this manual, yet are not listed in this backdating changes, should be replaced using the part number given in this manual.

Table 7-1. Backdating Changes.

Instrument Serial Prefix or Number	Make Changes
831/832-00195 and below	1 thru 22
831/832-00230 and below	2 thru 22
831/832-00350 and below	3 thru 22
941/942- and below	4 thru 22
947/948-00470 and below	5 thru 22
947/948-00550 and below	6 thru 22
947/948-00710 and below	7 thru 22
1051/1052-00980 and below	8 thru 22
1207/1208- and below	9 thru 22
1230 and below	10 thru 22
1304 and below	11 thru 22
1311 and below	12 thru 22
1325 and below	13 thru 22
1512 and below	14 thru 22
1521J00291 and below	15 thru 22
1521J02230 and below	16 thru 22
1804J and below	17 thru 22
1804J03700 and below	18 thru 22
1830J03770 and below	19 thru 22
1836J04881 and below	20 thru 22
2111J05080 and below	21 and 22
2111J05420 and below	22 only

CHANGE 1

Page 6-4, Table 6-2

Change A3R3 to HP Part No. 0683-1535; R:FXD COMP 15kΩ 5% 1/4W.

Page 6-6, Table 6-2

Change A7R10 to HP Part No. 0698-1481; R:FXD MET FILM 490kΩ 1% 1/8W.

Page 6-8, Table 6-2

Change A11DS1 through A11DS4 to HP Part No. 2140-0018; LAMP:GLOW NE-2.

Change A11R1 to HP Part No. 0683-3335, R:FXD COMP 33kΩ 5% 1/4W.

Page 6-9, Table 6-2

Delete R2.

CHANGE 1 (Cont'd)

Page 5-2, Paragraphs 5-15 and 5-16, ADJUSTMENT

Delete Steps (c) to (g).

Add Steps (c) to (e) as following:

c. Set RANGE to CAL.; if the pointer does not indicate full-scale, set it to full-scale using the AMP. SENS. ADJ. A10R9(Remove top cover for access to adjustment through hole in circuit shield. See Figure 5-1).

d. Set RANGE to I MAX., note deflection. Set it to infinity, using rear panel ∞ ADJ. The ∞ ADJ. is a capacitor. Use a plastic tuning wand or other suitable tool for adjustment.

e. Figure 5-2 illustrates the relationship between the three adjustments and is a pictorial reference for the adjustment procedure.

Page 5-3, Figure 5-2

Delete R2.

CHANGE 2

Page 6-7, Table 6-2

Delete asterisk (*) from A9C1.

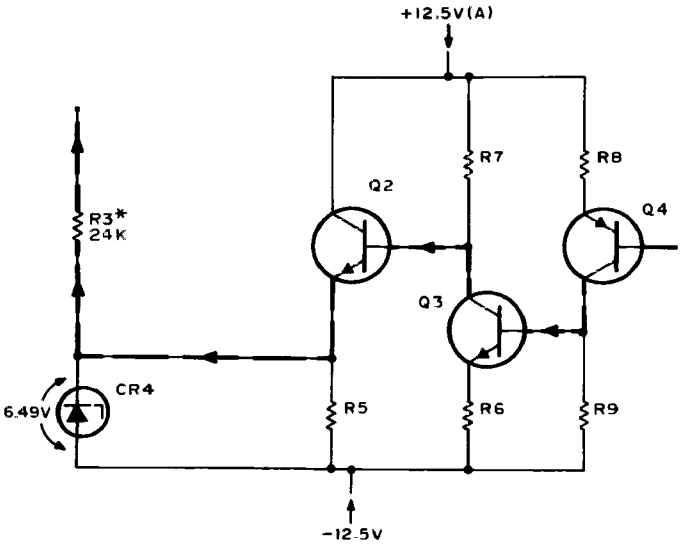
Page 8-7, Figure 8-5, Oscillator/Amplifier Ass'y A9

Delete asterisk (*) from A9C1.

CHANGE 3

Page 8-9, Figure 8-6, High Voltage Power Supply Ass'y A3

Change the circuit as shown in partial schematic below.



CHANGE 4

Page 6-8, Table 6-2

Delete C2.

Page 8-5, Figure 8-4

Delete C2 from circuit.

CHANGE 5

Page 6-8, Table 6-2

Change A10C3 to HP Part No. 0160-1568; C:FXD MYLAR 6800pF 10% 100VDCW and delete asterisk (*) from A10C3.

Page 8-7, Figure 8-5, Amplifier/Meter Circuit Ass'y A10

Change values of A10C3 to 6800pF, and delete asterisk (*) from A10C3.

CHANGE 6

Page 6-4, Table 6-2

Change A3R3 to HP Part No. 0683-2435; R:FXD COMP 24kΩ 5% 1/4W and add asterisk (*) to A3R3.

Page 6-5, Table 6-2

Delete A3R21.

Page 6-8, Table 6-2

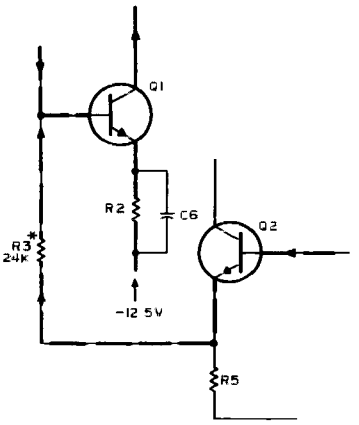
Change C2 to HP Part No. 0160-1318; C:FXD PAPER 0.5μF 1000VDCW.

Page 8-9, Figure 8-6, Test Voltage Power Supply Ass'y A3

Change the circuit as shown in partial schematic below.

Page 8-5, Figure 8-4

Change value of C2 to 0.5μF.



Page 5-2, Paragraphs 5-15 and 5-16, ADJUSTMENT

Delete Step (a).

CHANGE 7

Page 6-8, Table 6-2

Change HP Part No. of F1 to 2110-0110.

Change HP Part No. of J1 to 1251-0148.

Page 6-9, Table 6-2

Change HP Part No. of S1 to 3101-0100.

Change HP Part No. of S2 to 3101-0033.

Change HP Part No. of W1 to 8120-0078.

Page 6-10, Table 6-2

Change HP Part No. of PANEL:FRONT (HP) to 04329-1021.

Change HP Part No. of PANEL:REAR to 04329-1022.

CHANGE 8

Page 6-9, Table 6-2

Change HP Part No. of INSULATOR for J2 and J6 to 5040-0702.

Change HP Part No. of COVER for J2 and J6 to 04329-5025.

Change HP Part No. of CAP for J6 to 04329-5026.

Change HP Part No. of W1 to 8120-1348.

Page 6-10, Table 6-2

Change HP Part No. of PANEL:FRONT to 04329-1041.

CHANGE 9

Page 6-8, Table 6-2

Change C1 to HP Part No. 0160-1318; C-F Paper 0.5μF 1000VDCW.

Change C2 to HP Part No. 0160-1604; C-F Paper 0.3μF 1500VDCW.

CHANGE 10

Page 6-4, Table 6-2

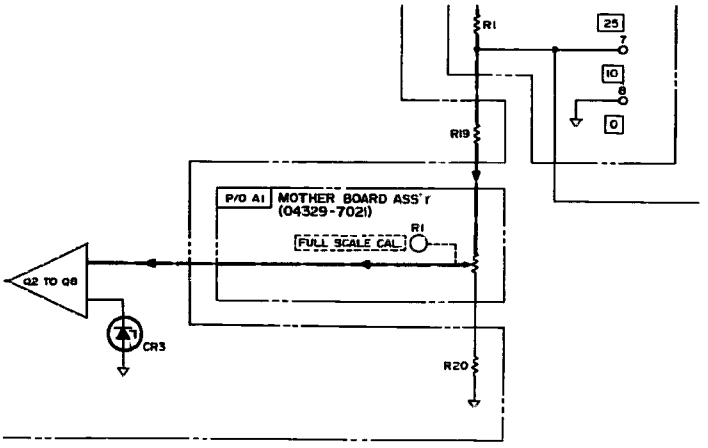
Delete A3C8 0160-0128, C:FXD CER 2.2μF 20% 25VDCW.

Page 6-3, Table 6-2

Delete A1R2 2100-0942; R:VAR 50kΩ 3/4W.

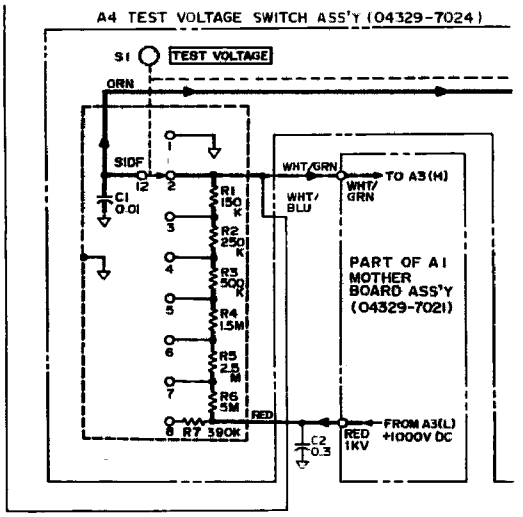
Page 8-3, Figure 8-3

Change the circuit as shown in partial schematic below.



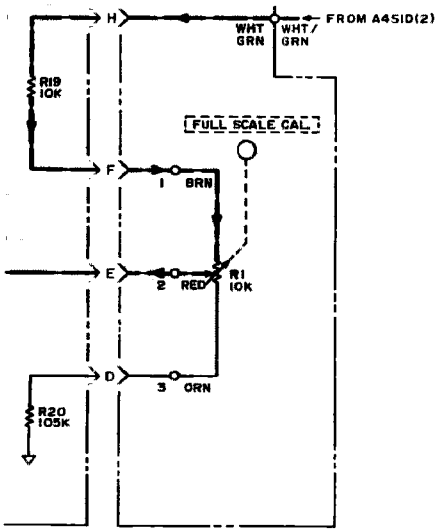
Page 8-5, Figure 8-4

Change the circuit as shown in partial schematic below.



Page 8-9, Figure 8-6

Change the circuit as shown in partial schematic below.



Page 6-6, Table 6-2

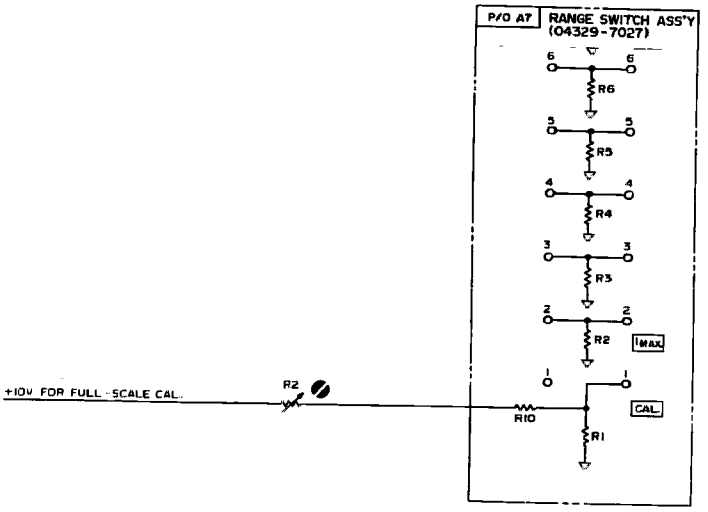
Change HP Part No. of BRACKET:ROTARY SWITCH to 04329-1032.

Page 6-9, Table 6-2

Delete J8 04260-5028; CONNECTOR FOR RECORDER.
Add J8 1510-0008; CONNECTOR BINDING POST RED.
0340-0221; INSULATOR.
04260-5022; INSULATOR.
Add J9 1510-0009; CONNECTOR BINDING POST BLACK.
0340-0221; INSULATOR.
04260-5022; INSULATOR.
Add R2 2100-1084; R:VAR C-FILM 50kΩ TYPE B.

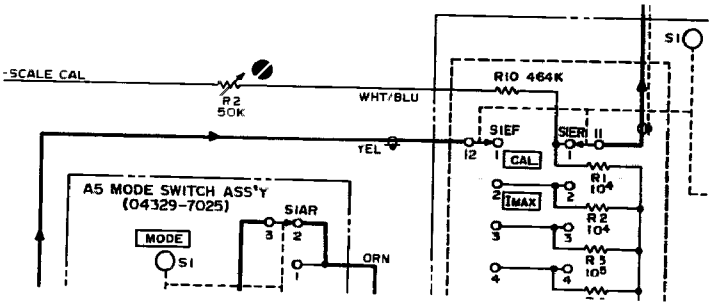
Page 8-3, Figure 8-3

Change the circuit as shown in partial schematic below.



Page 8-5, Figure 8-4

Change the circuit as shown in partial schematic below.



Page 6-10, Table 6-2

Change HP Part No. of PANEL:REAR to 04329-1042.

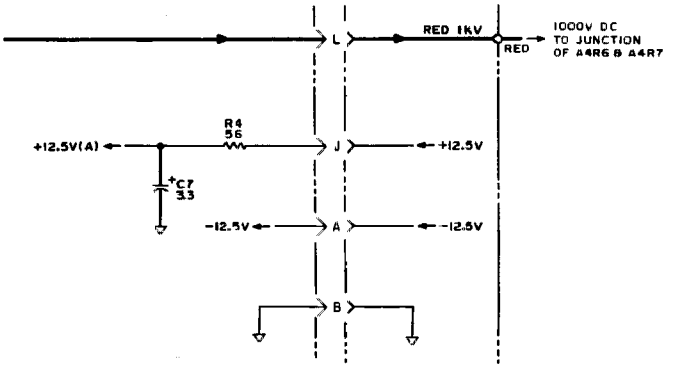
CHANGE 11

Page 6-10, Table 6-2

Change HP Part No. of PANEL:REAR to 04329-1042.
Delete HP Part No. of CONNECTOR:FOR RECORDER 04260-5028.

Page 8-9, Figure 8-6

Change the circuit as shown in partial schematic below.



CHANGE 12

Page 6-6, Table 6-2

Change HP Part No. of A4S1 to 3100-1140.
Change HP Part No. of A7S1 to 3100-1139.
Change HP Part No. of A8C1 to 0160-1582; C:FXD STYCON 100pF 125VDCW.
Delete A8C9 0121-0060; C:VAR CER 2-8pF.

Page 6-7, Table 6-2

Delete A8R8 0683-1065; R:FXD COMP 10MΩ 5% 1/4W.

Page 6-8, Table 6-2

Change HP Part No. of C1 to 0160-1617.
Change HP Part No. of C2 to 0160-1618.
Change HP Part No. of A1XA1 to 1251-1558.
Change HP Part No. of A1XA1 THRU A1XA4 to 1251-1557.

Page 6-10, Table 6-2

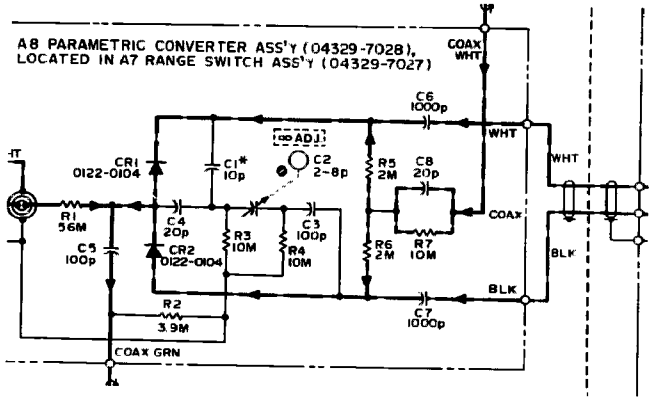
Change HP Part No. of REAR PANEL to 04329-1039.

Page 8-7, Figure 8-5

Change value of A8C1 to 10pF.

Page 8-7, Figure 8-5

Change the circuit as shown in partial schematic below.



CHANGE 13

Page 5-4, Figure 5-3A, Figure 5-3B, page 6-7, Table 6-2, page 8-2, Figure 8-2A, Figure 8-2B, page 8-3, Figure 8-3, and page 8-5, Figure 8-4

Add C1 0160-1646 ; C : FXD PAPER 0.5μF 1000VDCW.

Page 6-8, Table 6-2

Delete HP Part No. 04329-1049 ; PLATE: POWER TRANS.

Page 6-6, Table 6-2 and page 8-5, Figure 8-4

Change A4R7 to HP Part No. 0683-3945 ; R : FXD COMP 390kΩ 5% 1/4W.

CHANGE 14

Page 6-4, Table 6-2, page 8-3, Figure 8-3 and page 8-5, Figure 8-4

Delete A5R2.

Page 6-8, Table 6-2

Change HP Part No. of J3 to 1510-0008, and of INSULATOR to 0340-0221.
Change HP Part No. of J4 to 04329-7033, and of INSULATOR to 0340-0221.
Change HP Part No. of J5 to 1510-0009, and of INSULATOR to 0340-0221.
Add INSULATOR HP Part No. 04260-5022 to J3.
Change HP Part No. of J7 to 1510-0008, and of INSULATOR to 0340-0221.
Change HP Part No. of J8 to 04260-5028, and
Delete 3050-0067 INSULATOR.

Page 6-9, Table 6-2

Change HP Part No. of PANEL FRONT to 04329-1141.
Change HP Part No. of PANEL REAR to 04329-1044.

CHANGE 15

Page 6-5, Table 6-2, page 8-3, Figure 8-3 and page 8-7, Figure 8-5

Delete A8C10.
Change A8C2 to HP Part No. 0121-0059 ; C : VAR CER 2-8pF.
Change A8C9 to HP Part No. 0121-0060 ; C : VAR CER 2-8pF.

CHANGE 16

Page 6-9, Table 6-2

Change the P/N for KNOB : WING WHITE LINE BLK to 0370-0227.
Change the P/N for CAP : KNOB to 0370-0228.

CHANGE 17

Page 5-4, Figure 5-3A, Figure 5-3B, page 6-7, Table 6-2, page 8-2, Figure 8-2A, Figure 8-2B, page 8-3, Figre 8-3, and page 8-5, Figure 8-4 : Delete C1 0160-1646 ; C: FXD PAPER 0.5μF 1000VDCW.

Page 3-2, Figure 3-2, page 3-6, Figure 3-5, page 3-7, Figure 3-6, page 3-8, Figure 3-7 and page 3-9, figure 3-8 : Delete WARNING SILK.

CHANGE 18

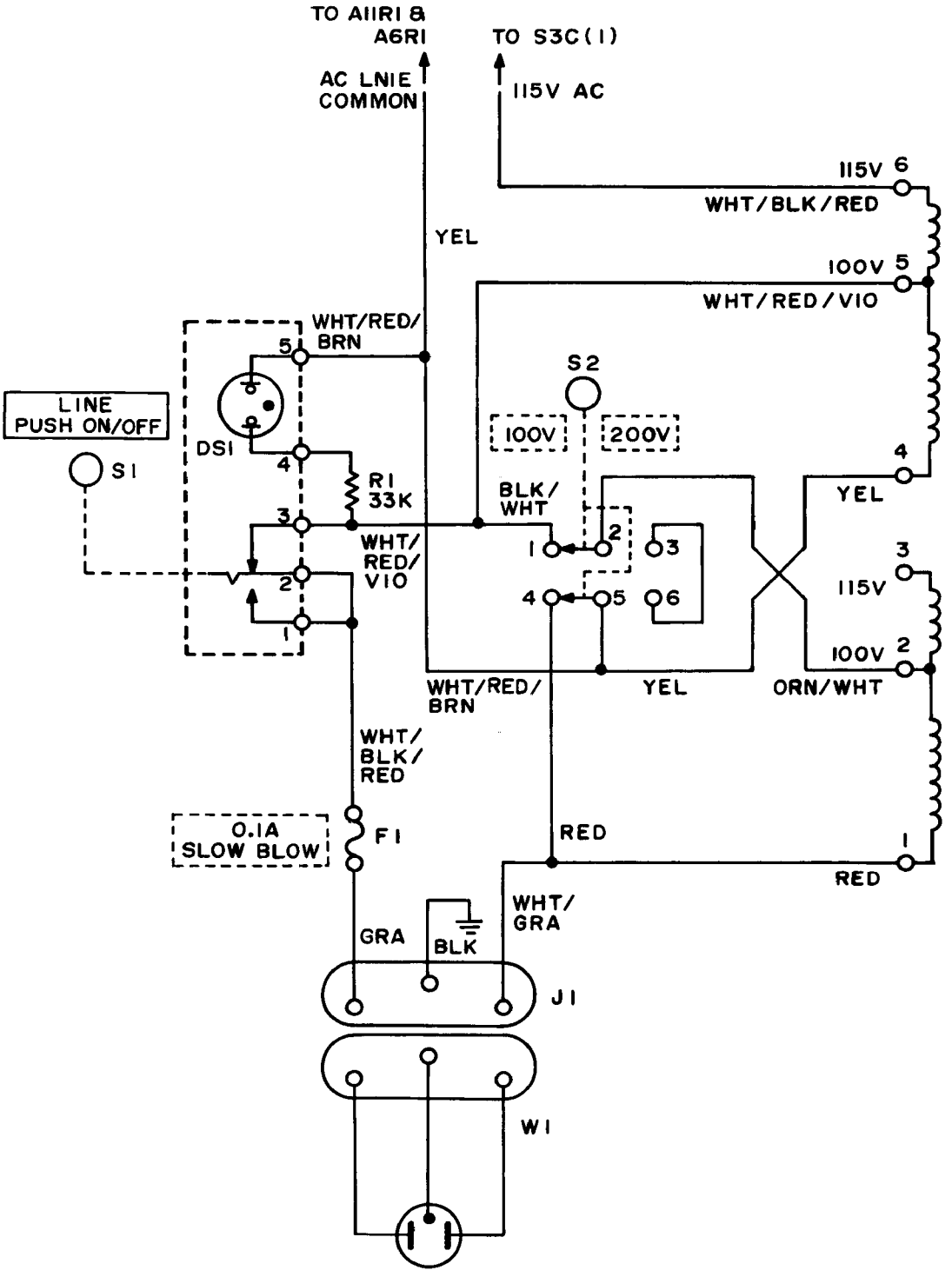
Page 6-8, Table 6-2

Change R1 to HP Part No. 0683-3335 ; R : FXD COMP 33kΩ 5% 1/4W
Change S1 to HP Part No. 3101-1248 ;SWITCH: LINE PUSH ON-OFF

Page 6-9, Table 6-2

Change PANEL FRONT (HP) to HP Part No. 04329-10021
Change PANEL FRONT (YHP) to HP Part No. 04329-10020

Page 8-9, Figure 8-6
Change the Circuit as shown in partial schematic below.



CHANGE 19

Page 6-9, Table 6-2
Add HP Part No. 5060-3998:EXTENDER:BOARD 10PINS
Add HP Part No. 5060-3999;EXTENDER:BOARD 15PINS

CHANGE 20

Page 6-7, Table 6-2, Page 8-7, Figure 8-5

Change A10R2 to HP Part No. 0683-1015 R : FXD 100Ω 5% 1/4W

CHANGE 21

Page 6-5, Table 6-2, Page 8-5 Figure 8-4

Change A6R1 to HP Part No. 0683-3335 R : FXD 33kΩ 5% 1/4W

CHANGE 22

Page 6-5, Table 6-2, Reference Designation Index:

Change the part numbers and descriptions for A8C9 and A8C10 to read:

A8C9	0121-0235	C: VAR AIR 1.3 7.2pF
A8C10	0160-2240	C: FXD CER 2pF 2.5% 500VDCW

Page 8-7, Figure 8-5:

Change the indicated values of A8C9 and A8C10 to 1.3 ∿ 7.2pF and 2pF, respectively.

SECTION VIII
CIRCUIT DIAGRAMS

8-1. INTRODUCTION

8-2. This section includes the following:

a. General Notes for schematic diagrams.

b. Functional Overall Block Diagram (Figure 8-3).

c. Schematic Diagrams and Parts Location Illustrations. Waveforms and voltages at indicated test points are also included.

8-3. GENERAL NOTES.

a. Unless otherwise indicated, resistance is in ohms, capacitance is in microfarads, and inductance is in microhenries.

b. Components assigned and asterisk (*) are factory selected, average values shown.

c. The components mounted on chassis or mainframe parts are not assigned an assembly designation (ie. R1, Q1 etc.).

d. Reference designations (R1, Q1, etc.) within assembly (A1, A2, ... etc.) use assembly designation as prefix to form complete designation (ie. R1 in A1 assembly is A1R1).

e. WHT/YEL/VIO indicates wire color. First color identifies ground color, second color identifies wide stripe, and third color identifies narrow stripe.

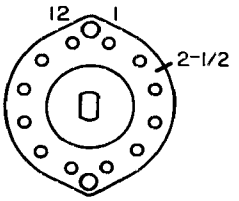
8-4. Additional notes are shown in Figure 8-1.

SYMBOLS

- FRONT PANEL
- REAR PANEL
- KNOB CONTROL
- SCREWDRIVER ADJUST
- MAIN SIGNAL PATH
- FEEDBACK PATH
- CONDUCTING ELEMENT
- CW — WIPER MOVES TOWARD "CW" WHEN CONTROL IS ROTATED CLOCKWISE
- POWER LINE GROUND
- CIRCUIT COMMON GROUND
- 8 — TEST POINT
- A — "AND" GATE
- I — INHIBIT GATE
- O — "OR" GATE

WAVEFORMS SHOWN ARE TYPICAL

SWITCH DESIGNATIONS



A3S1BR(2-1/2)

A3S1	SWITCH S1 WITHIN ASSEMBLY A3
B	2ND WAFER FROM FRONT (A=1ST, ETC)
R	REAR OF WAFER (F=FRONT)
(2-1/2)	TERMINAL LOCATION ($2\frac{1}{2}$) (VIEWED FROM FRONT)

REFERENCE DESIGNATIONS

REFERENCE DESIGNATIONS WITHIN ASSEMBLIES ARE ABBREVIATED
ADD ASSEMBLY NUMBER TO ABBREVIATION FOR COMPLETE DESCRIPTION

ASSEMBLY	ABBREVIATION	COMPLETE DESCRIPTION
A25	C1	A25C1
A25A1	CR1	A25A1CR1
NO PREFIX	J3	J3

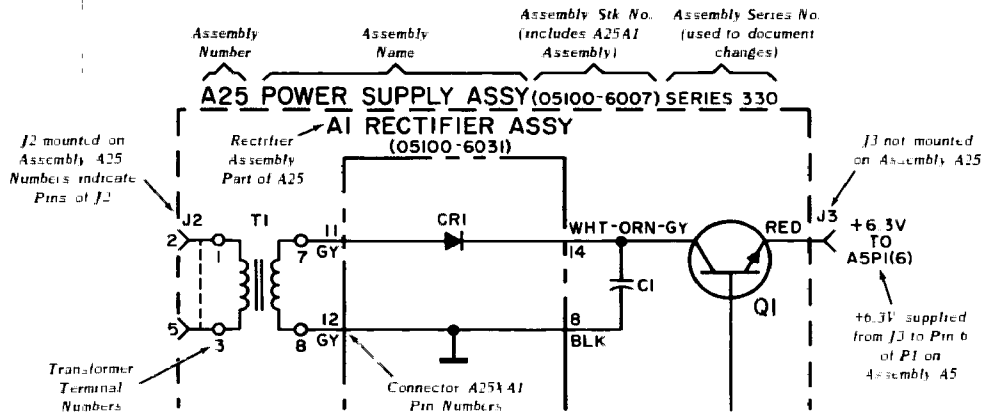
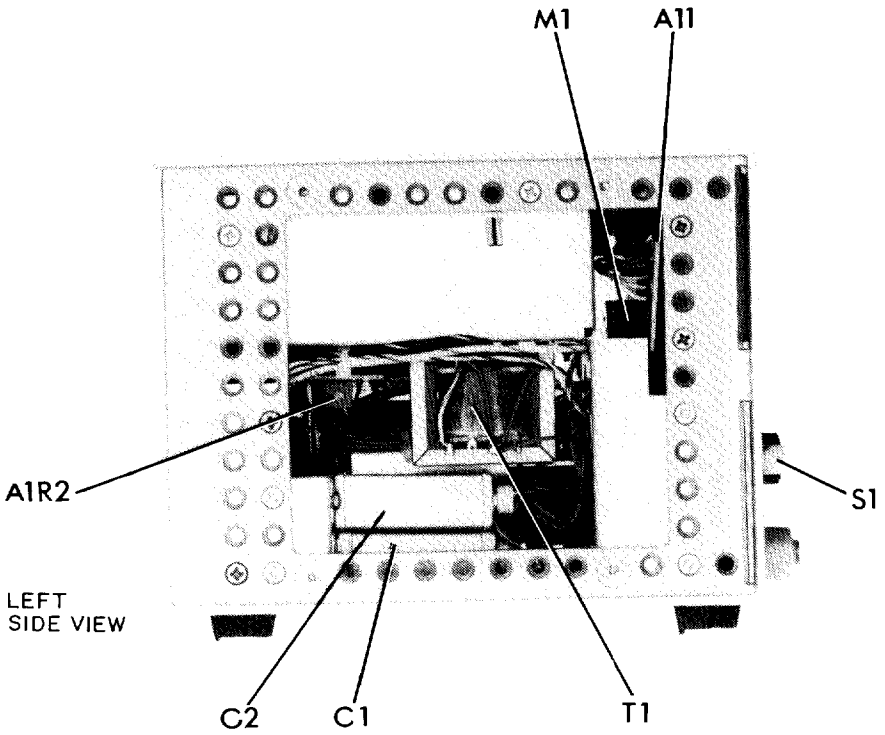


Figure 8-1. Schematic Diagram Notes



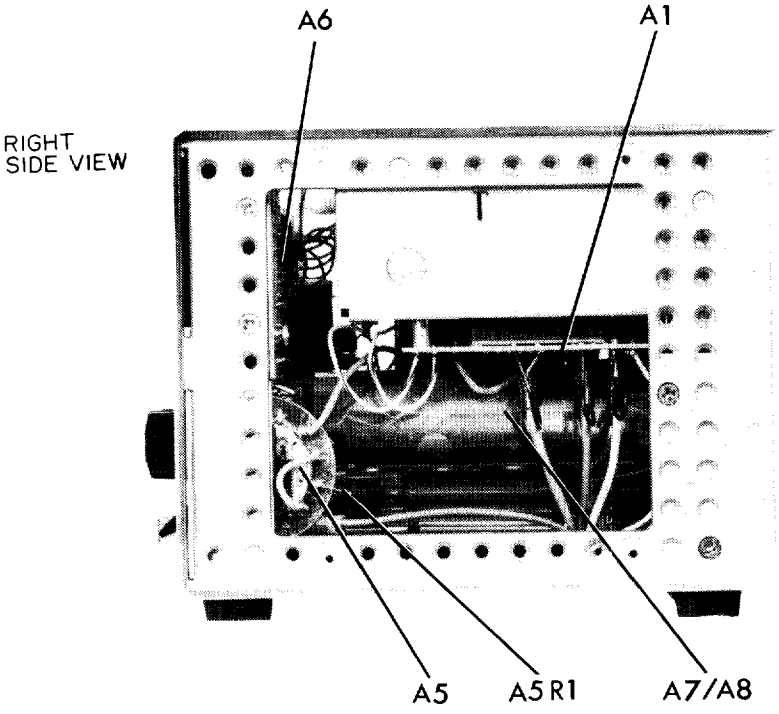


Figure 8-2A. Assembly and Component Location (Side View)



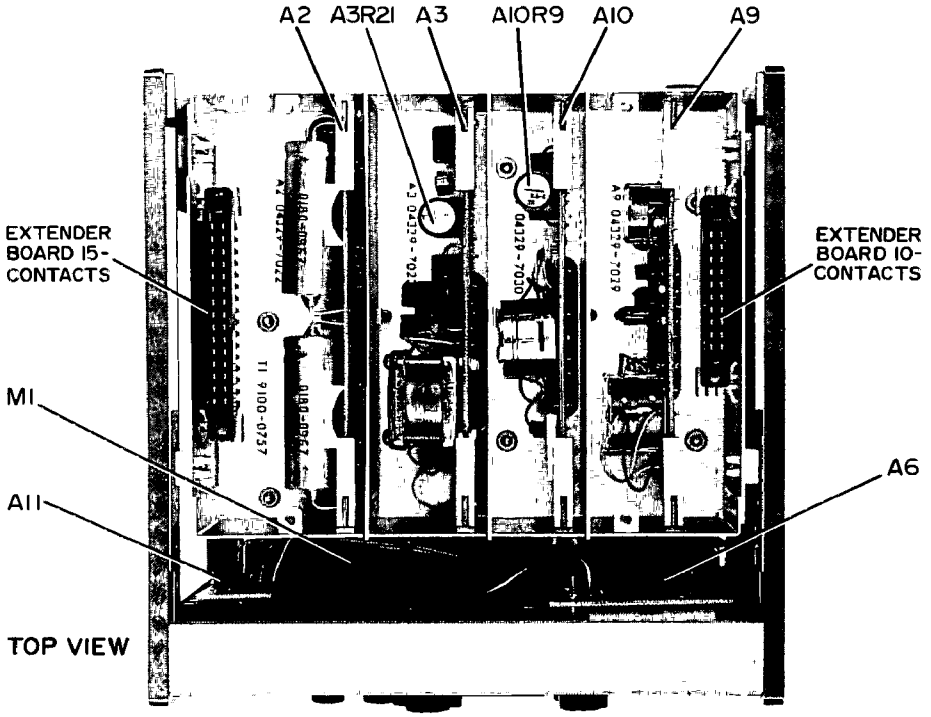
SEE INSIDE

Section VIII

CIRCUIT DIAGRAMS

Figure 8-1

SCHEMATIC DIAGRAM NOTES



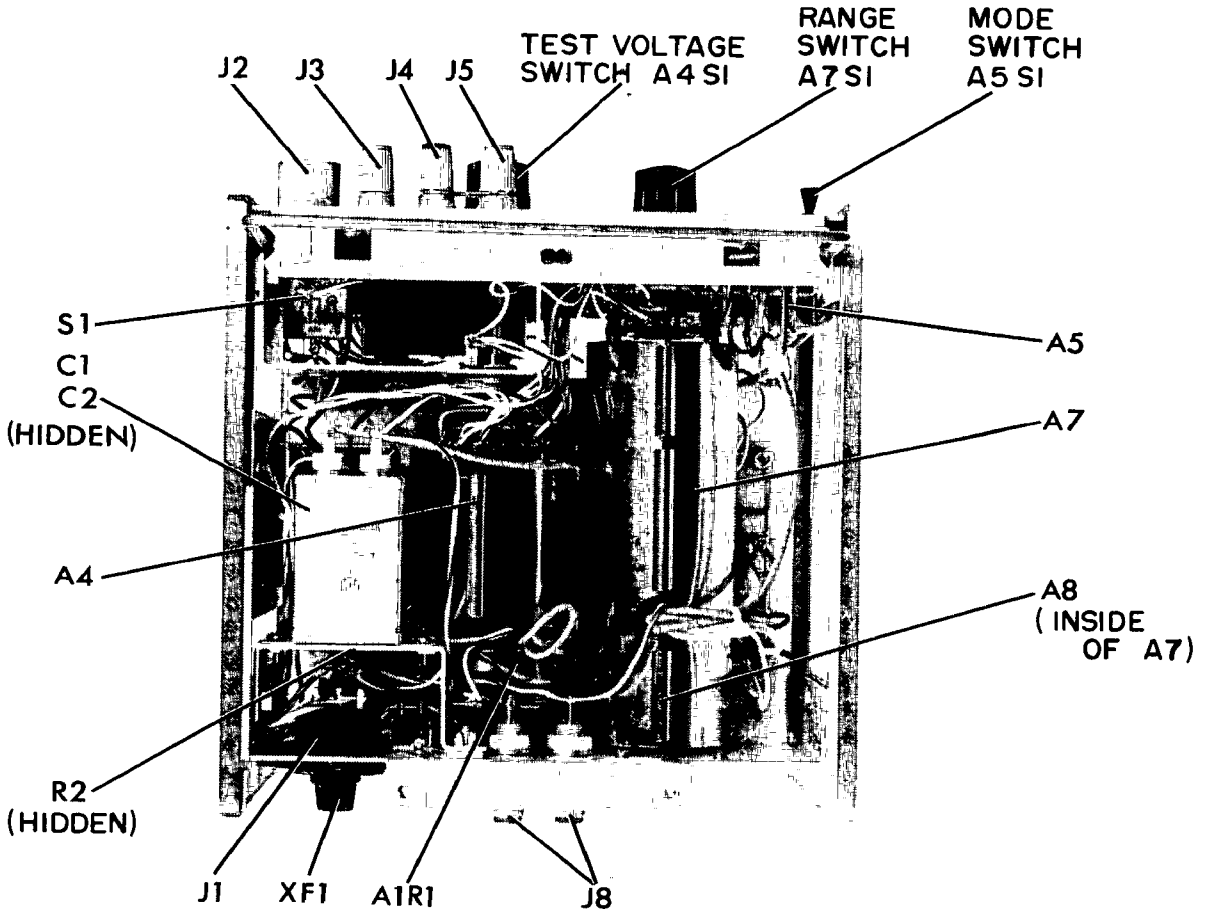
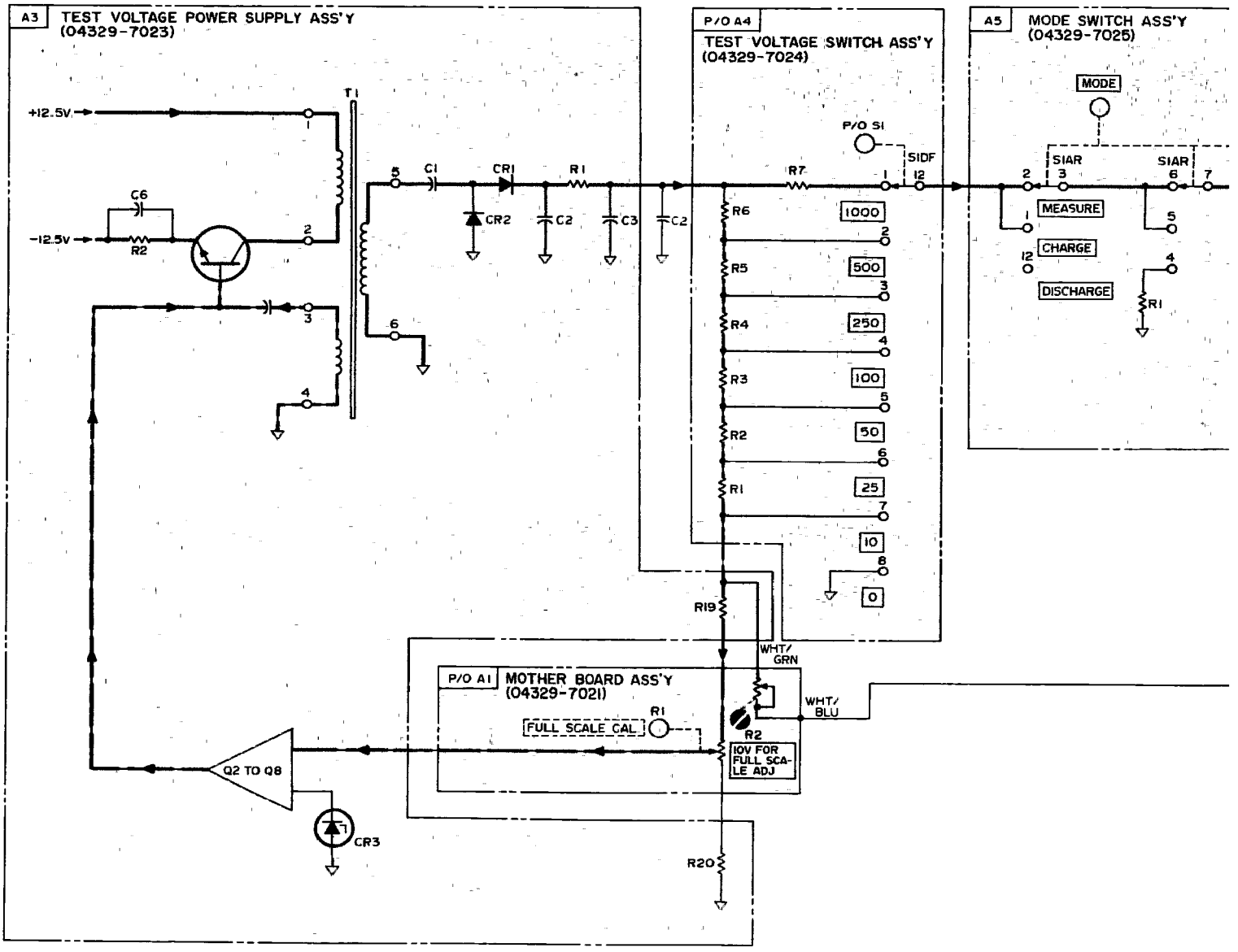
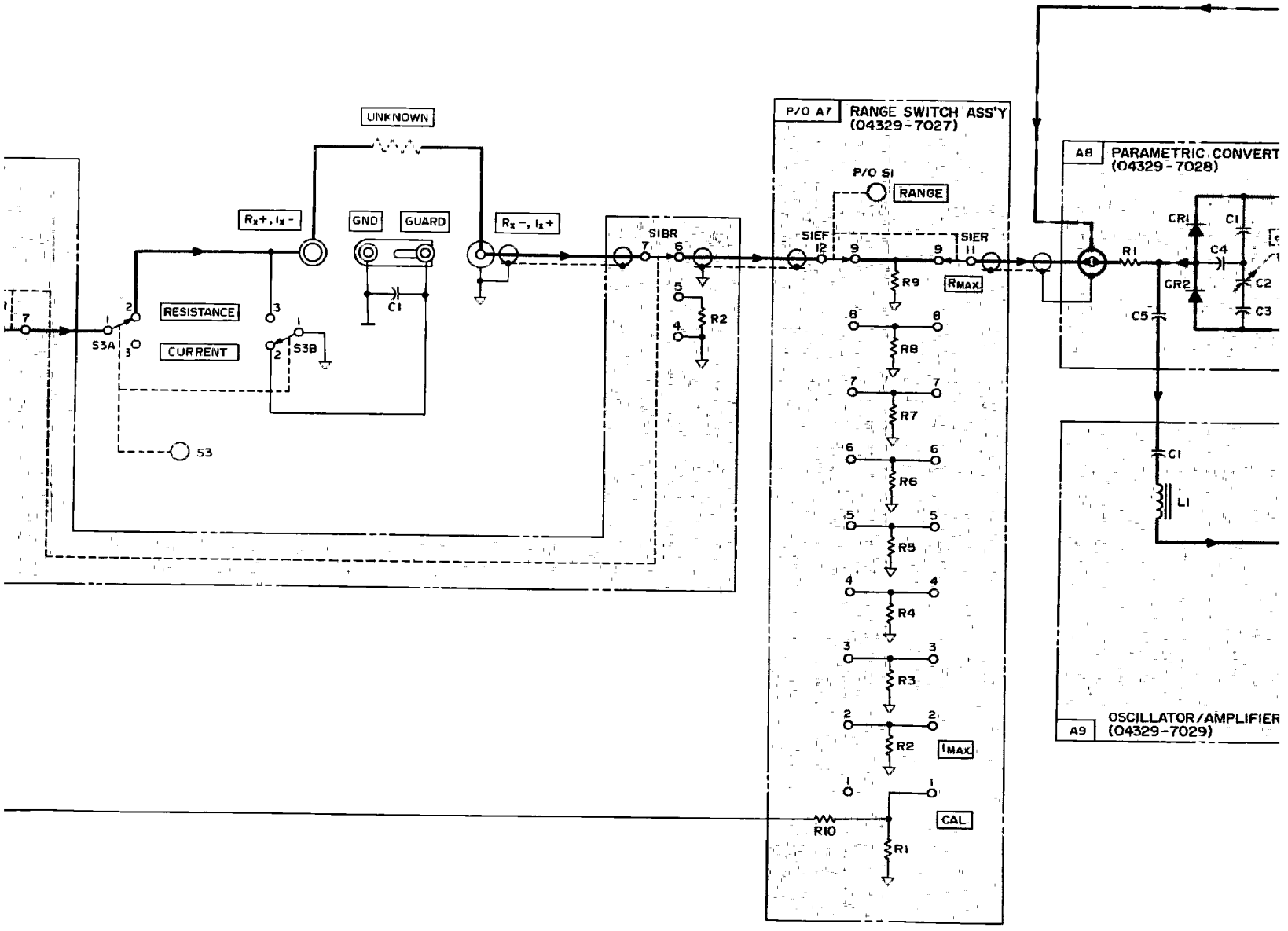
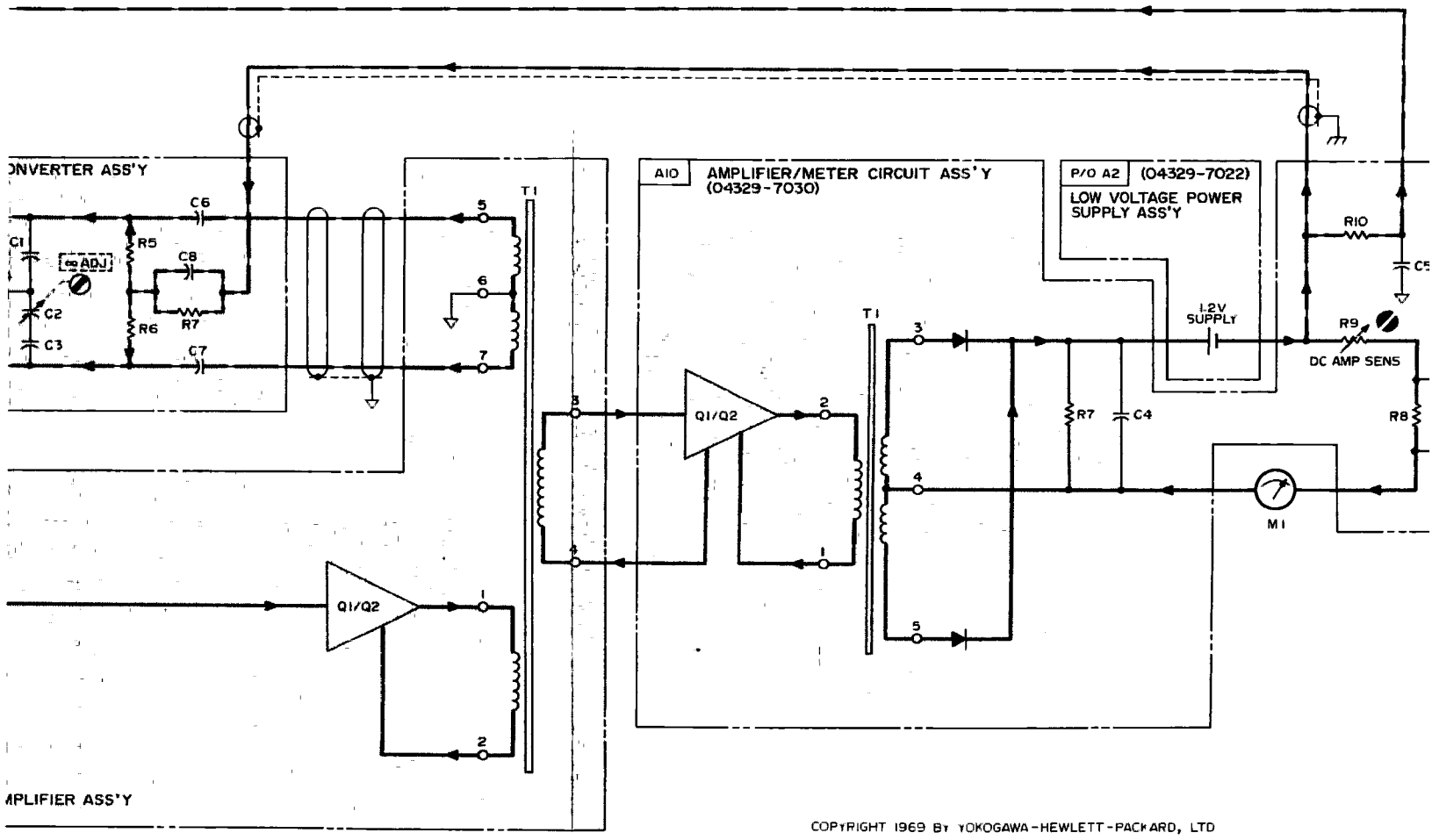


Figure 8-2B. Assembly and Component Location (Top and Bottom View)

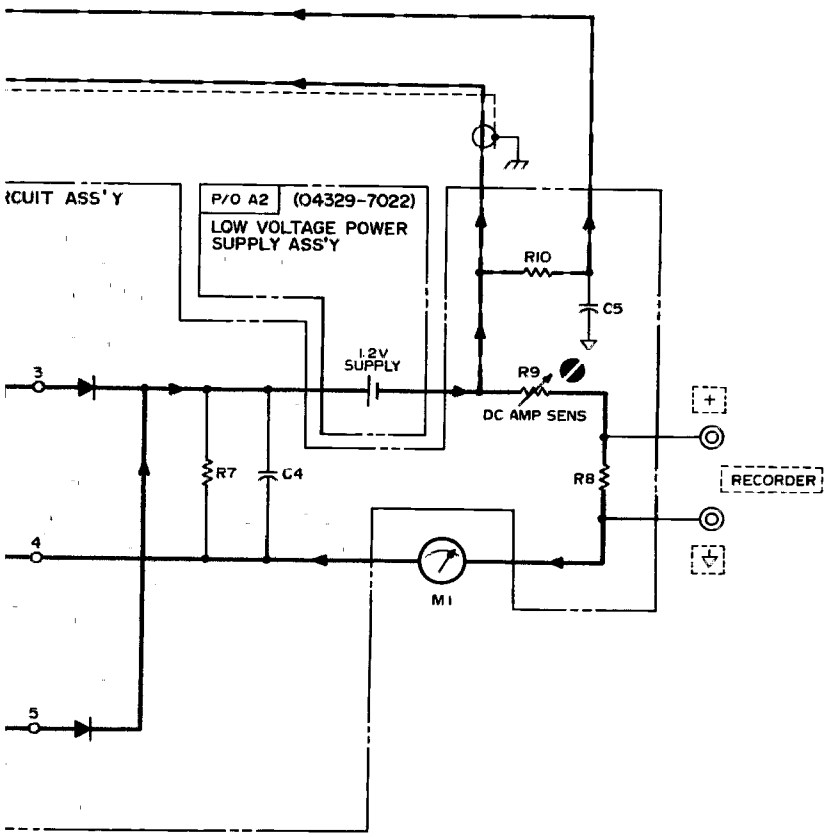

A3 TEST VOLTAGE POWER SUPPLY ASS'Y
(04329-7023)
P/O A4
TEST VOLTAGE SWITCH ASS'Y
(04329-7024)
A5 MODE SWITCH ASS'Y
(04329-7025)
+12.5V
-12.5V
T1
C6
R2
C1
CR1
R1
CR2
C2
C3
C2
P/O S1
S1DF
R7
R6
R5
R4
R3
R2
R1
1000
500
250
100
50
25
10
0
R19
MODE
S1AR
S1AR
MEASURE
CHARGE
DISCHARGE
R1
WHT/
GRN
WHT/
BLU
P/O A1 MOTHER BOARD ASS'Y
(04329-7021)
R1
FULL SCALE CAL
R2
10V FOR
FULL SCA-
LE ADJ
Q2 TO Q8
CR3
R20


UNKNOWN
R_x+, I_x-
GND
GUARD
R_x-, I_x+
RESISTANCE
CURRENT
S3A
S3B
S3
C1
SIBR
P/O A7
RANGE SWITCH ASS'Y
(04329-7027)
P/O S1
RANGE
SIEF
SIER
R9
RMAX
R8
R7
R6
R5
R4
R3
R2
IMAX
R10
R1
CAL
R2
A8
PARAMETRIC CONVERT
(04329-7028)
CR1
CR2
C1
C4
C2
C3
C5
R1
L1
A9
OSCILLATOR/AMPLIFIER
(04329-7029)



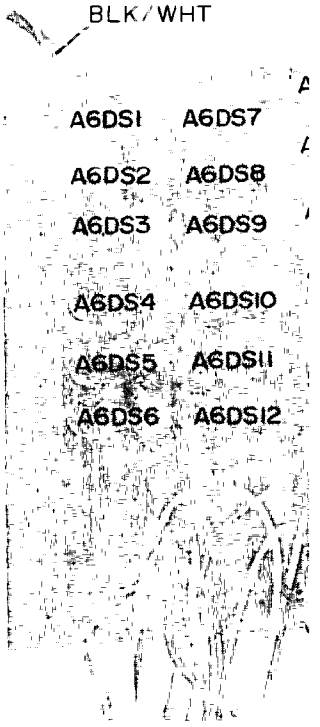
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Figure 8-3. Functional Overall Bloc



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Figure 8-3. Functional Overall Block Diagram



A6 MULTIPLIER INDICATOR ASS'Y COMPONENT LOCATION

WHT/
BLK/
BRN

A11 METER SCALE INDICATOR ASS'Y COMPONENT LOCATION

A11R1

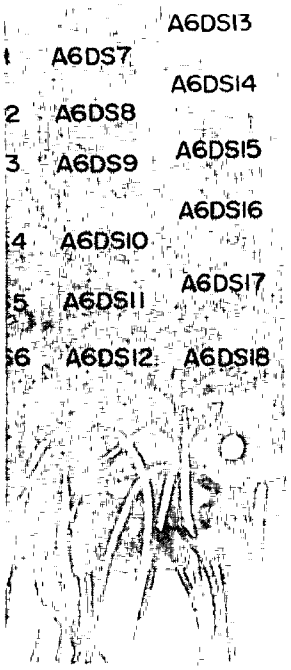
A11DS4

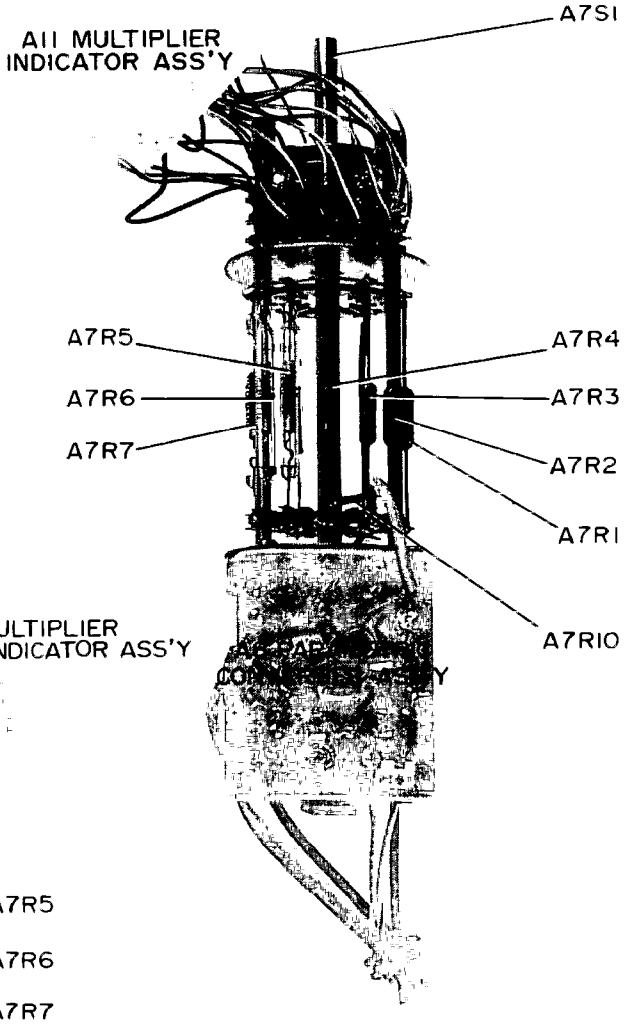
A11DS3

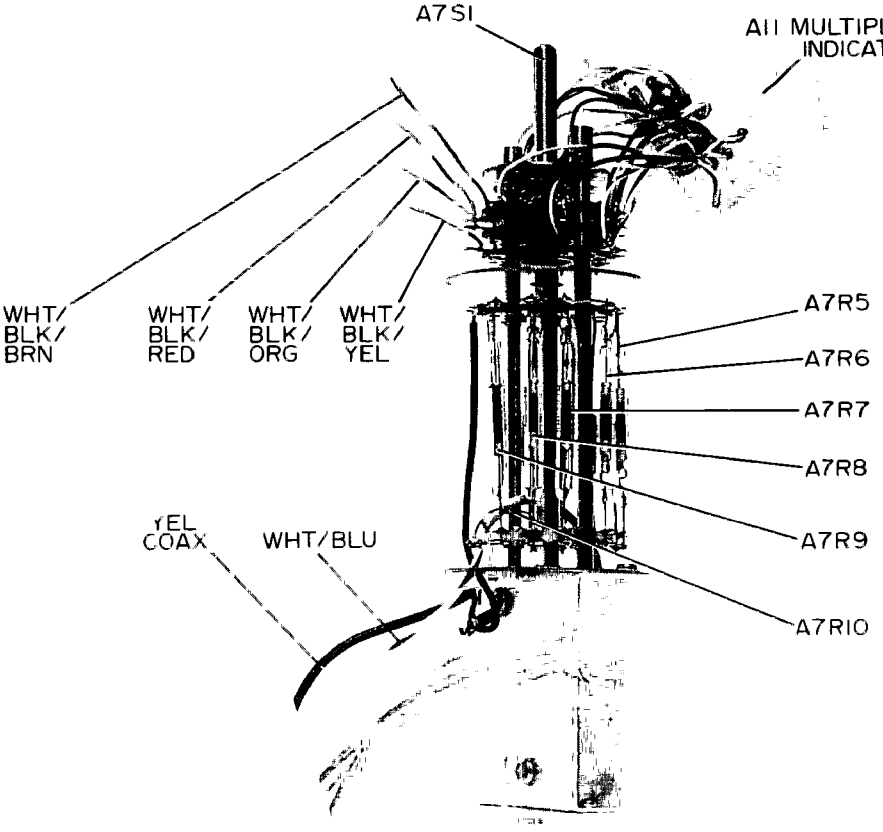
A11DS2

A11DS1

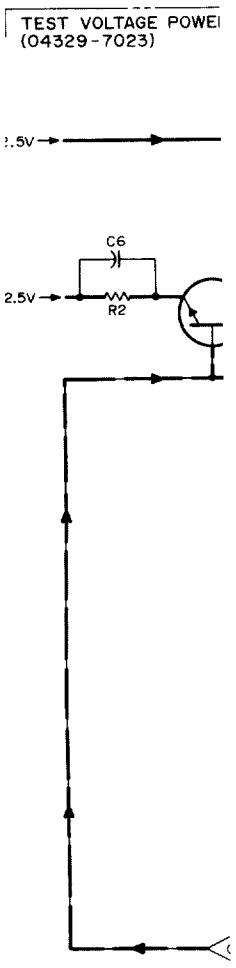
/WHT







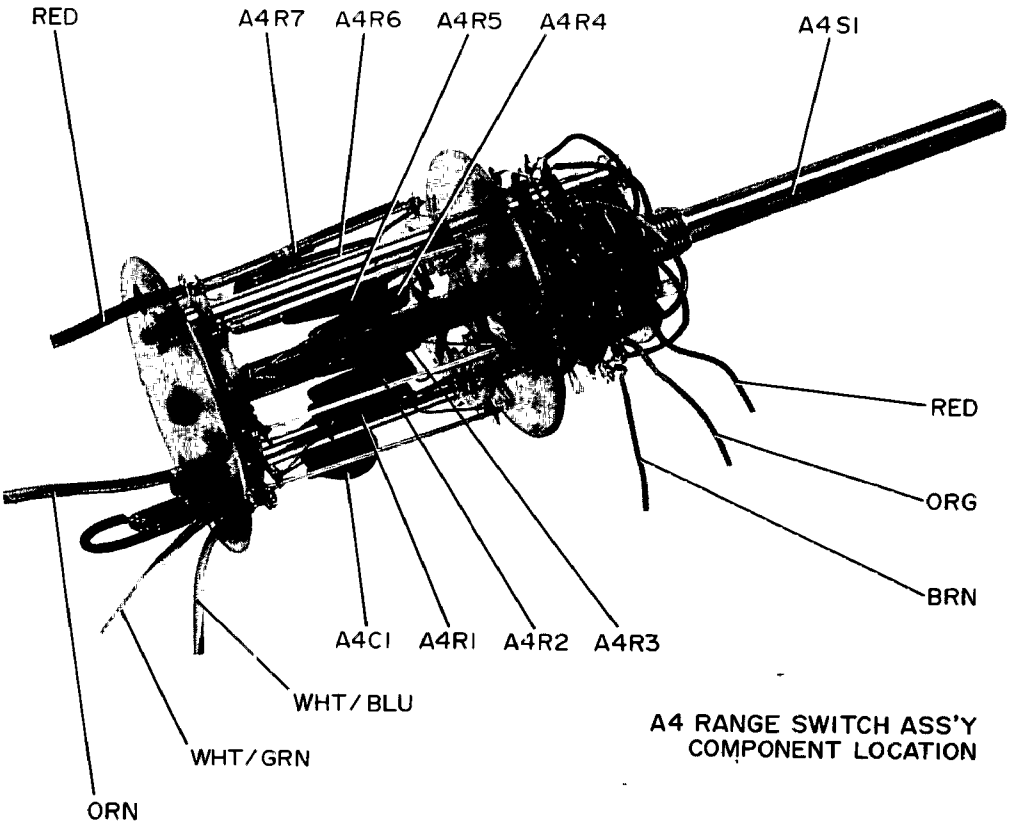
A7 RANGE SWITCH ASS'Y
COMPONENT LOCATION



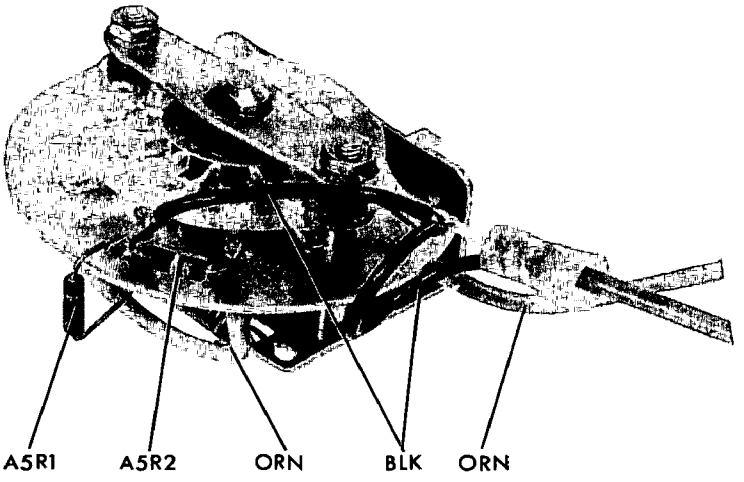
SEE INSIDE

Figure 8-3

FUNCTIONAL OVERALL BLOCK DIAGRAM



A4 RANGE SWITCH ASS'Y
COMPONENT LOCATION



A5 MODE SWITCH ASS'Y
COMPONENT LOCATION

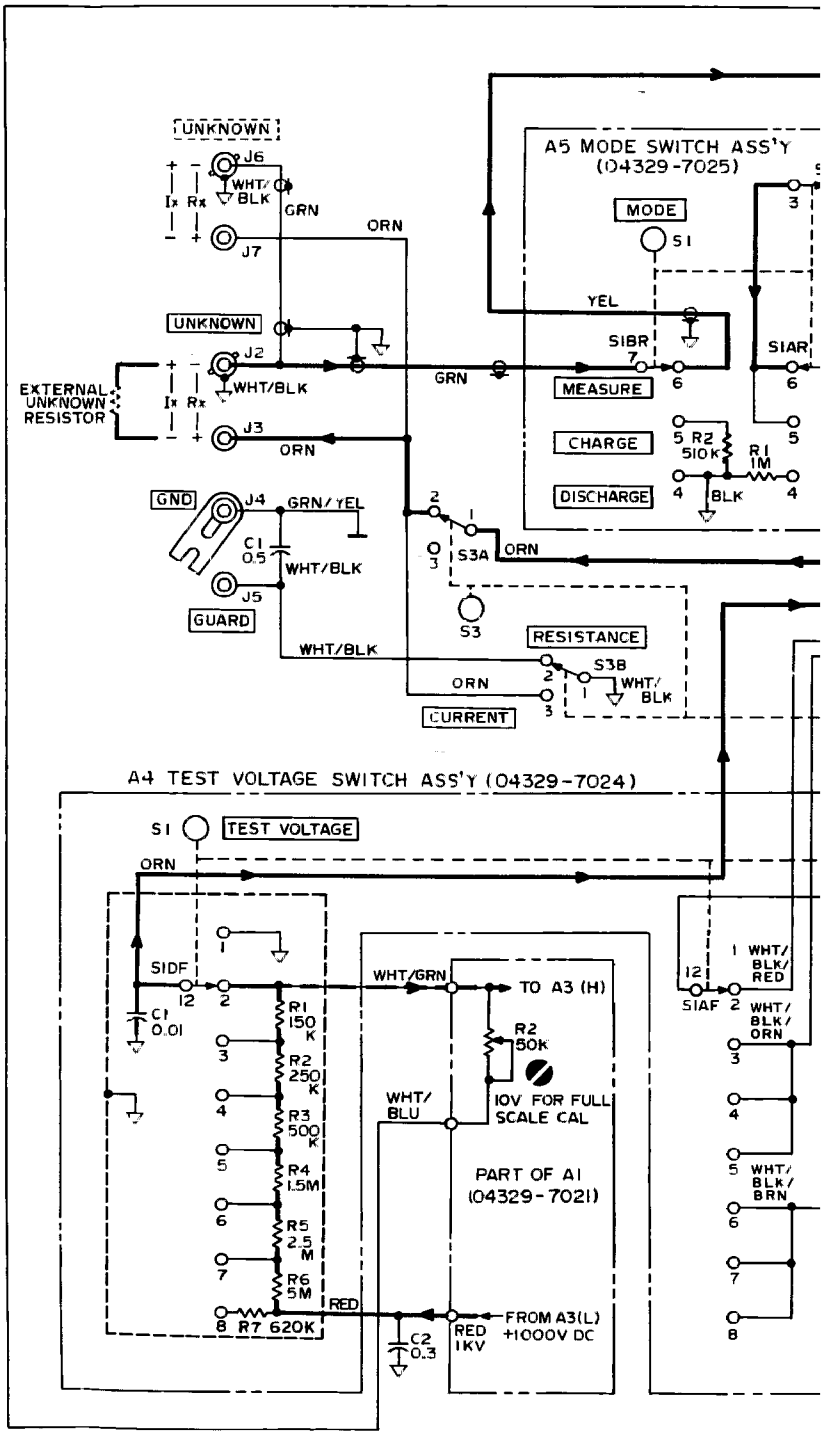
REFERENCE DESIGNATIONS

NO PREFIX	A1 ASS'Y	A4 ASS'Y	A5 ASS'Y
J2 - J7 R2 S3	R2	C1 R1 - R7 S1	R1 - R2 S1

DELETED;

A6 ASS'Y	A7 ASS'Y	A11 ASS'Y
DS1 - DS18 R1	R1 - R10 S1	DS1 - DS4 R1

DELETED;



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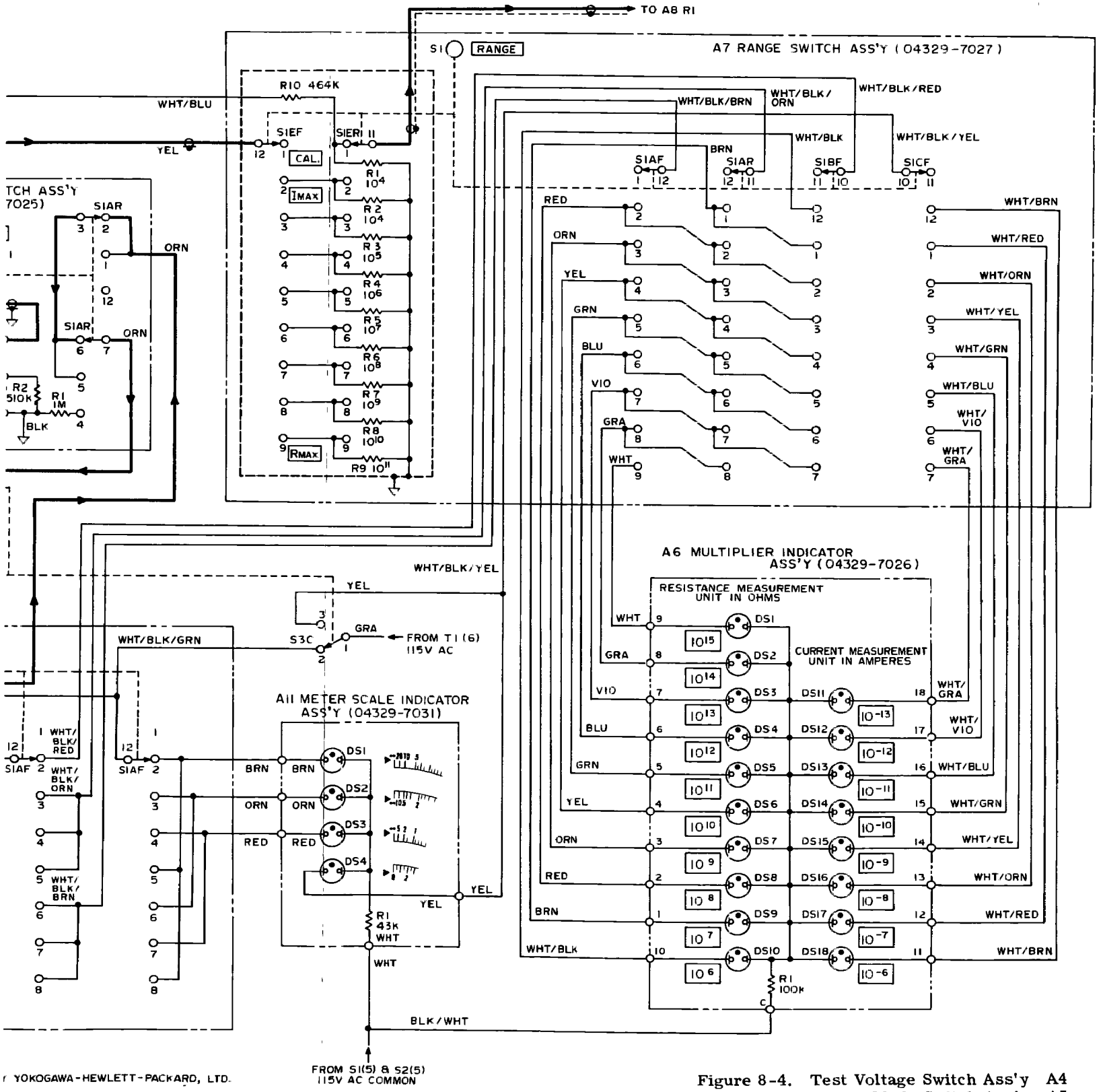
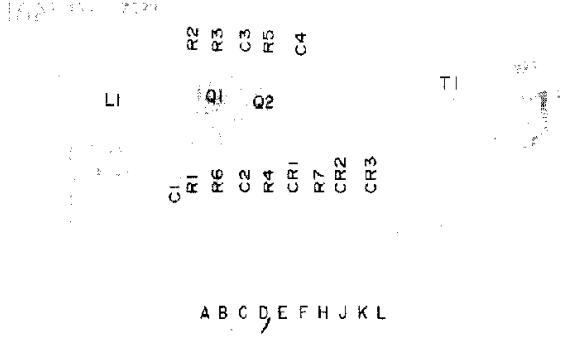
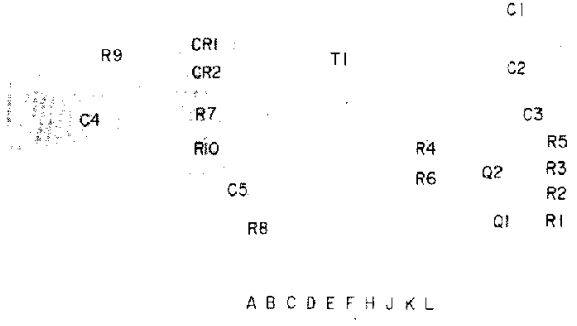


Figure 8-4. Test Voltage Switch Ass'y A4
Mode Switch Ass'y A5
Multiplier Indicator Ass'y A6
Range Switch Ass'y A7
Meter Scale Indicator Ass'y A11



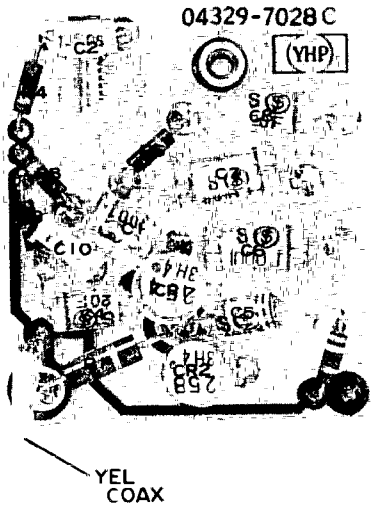
A9 OSCILLATOR/
AMPLIFIER ASS'Y
COMPONENT LOCATION

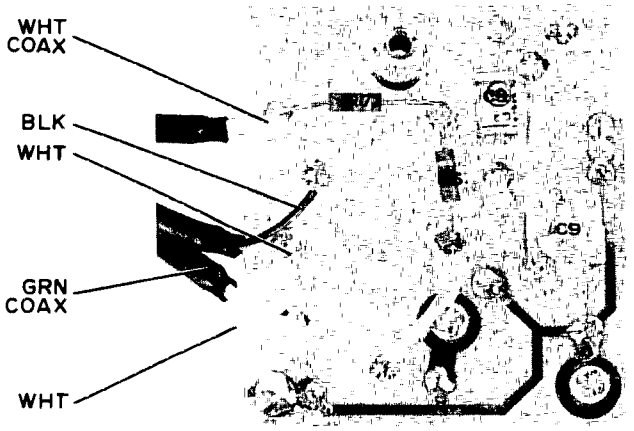


A 0 AMPLIFIER/
METER CIRCUIT ASS'Y
COMPONENT LOCATION

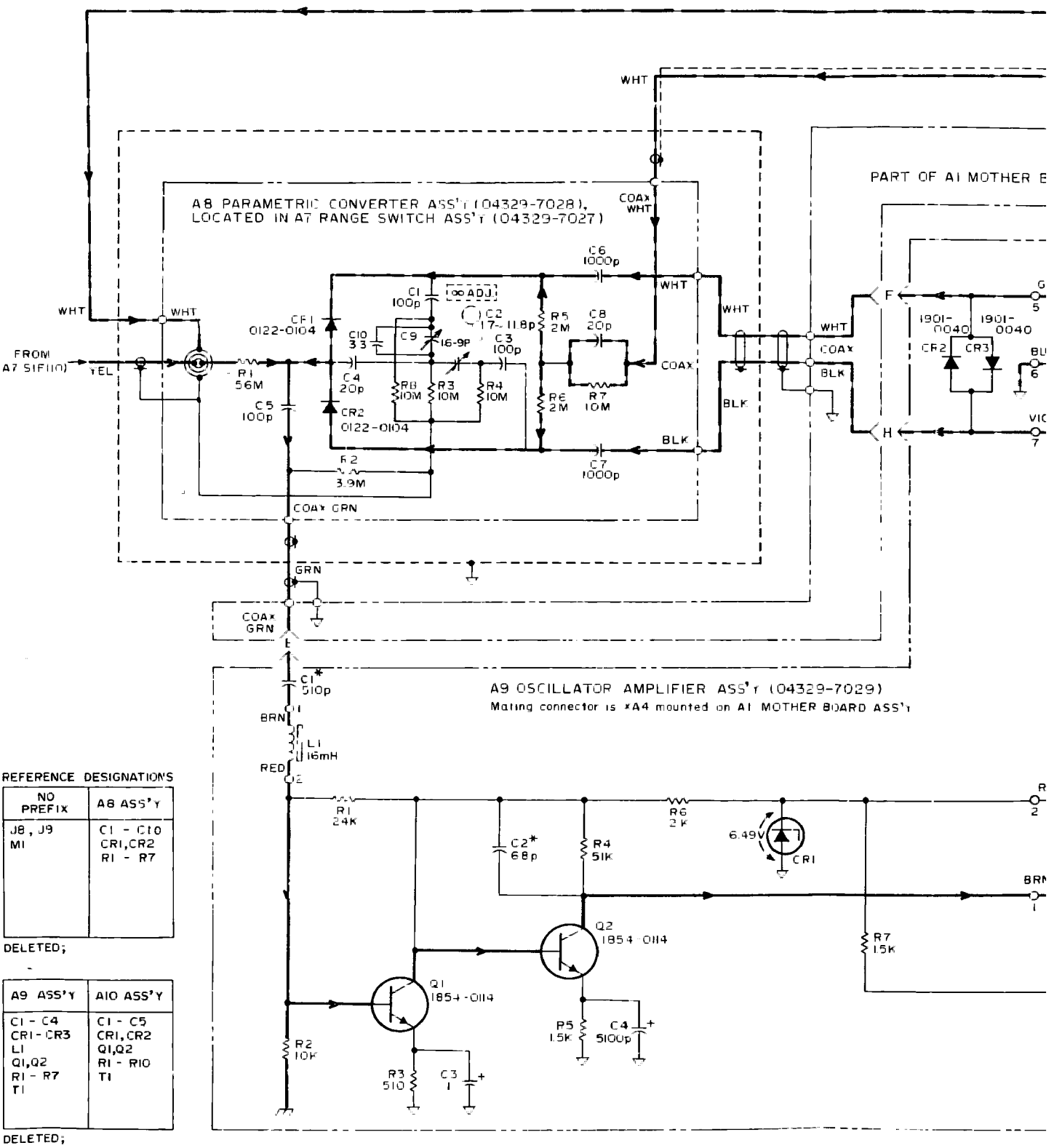
SEE INSIDE

Figure 8-4
TEST VOLTAGE SWITCH ASS'Y A4
MODE SWITCH ASS'Y A5
MULTIPLIER SWITCH ASS'Y A6
RANGE SWITCH ASS'Y A7
METER SCALE INDICATOR ASS'Y A11





A8 PARAMETRIC
CONVERTER ASS'Y
COMPONENT LOCATION



REFERENCE DESIGNATIONS

NO PREFIX	A8 ASS'Y
J8, J9 M1	C1 - C10 CR1,CR2 R1 - R7

DELETED;

A9 ASS'Y	A10 ASS'Y
C1 - C4 CR1 - CR3 L1 Q1,Q2 R1 - R7 T1	C1 - C5 CR1,CR2 Q1,Q2 R1 - R10 T1

DELETED;

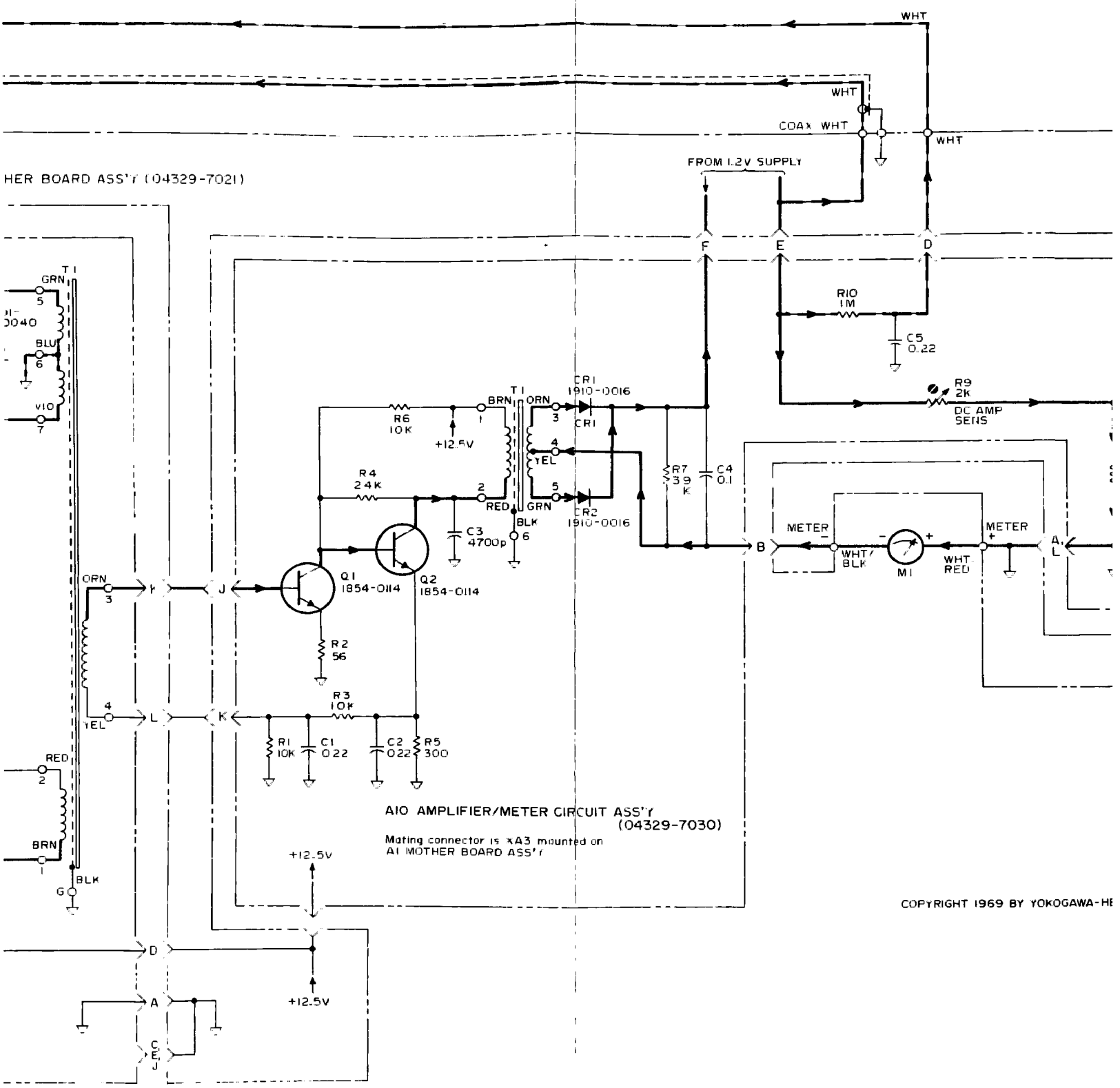
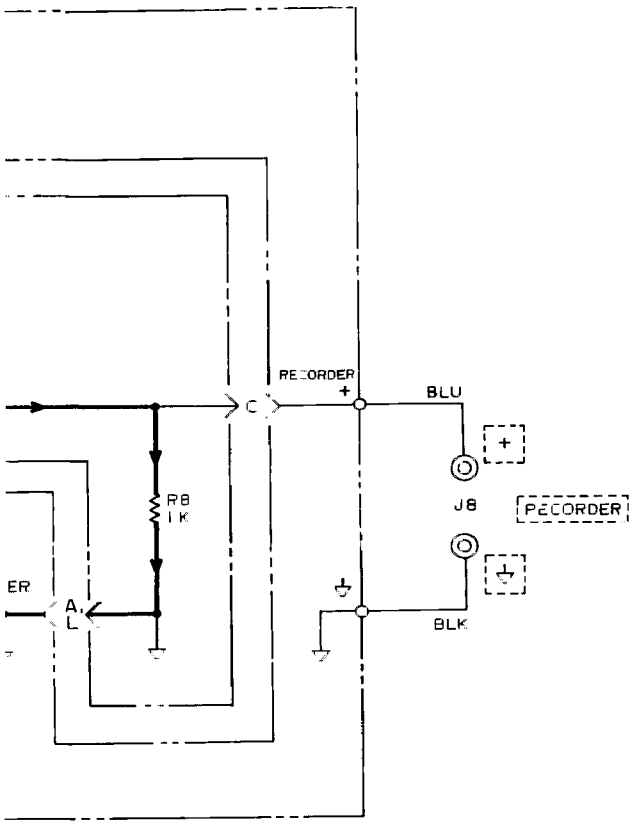
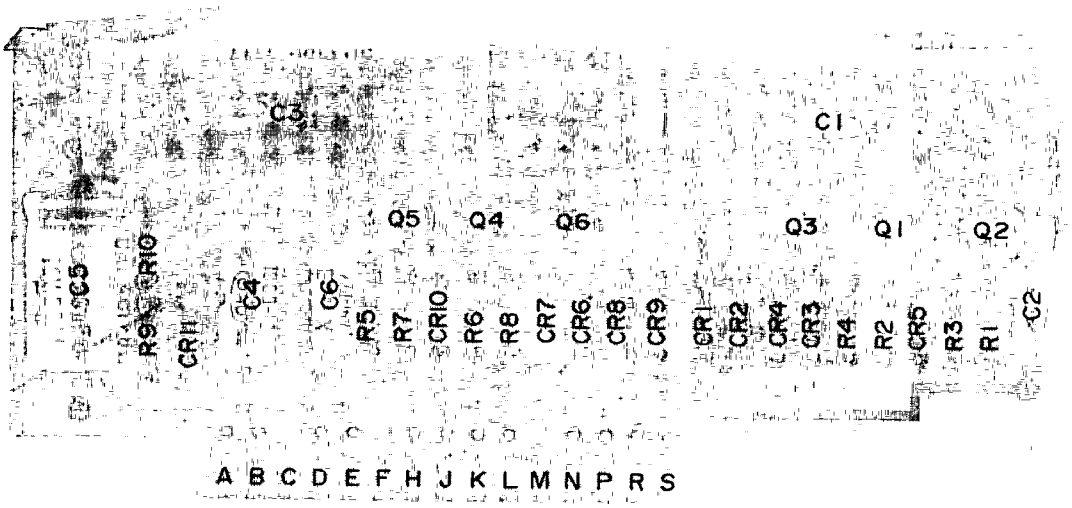

WHT
WHT
COAX WHT
WHT
FROM 1.2V SUPPLY
HER BOARD ASS'Y (04329-7021)
F
E
D
T1
GRN
5
BLU
6
VIO
7
R10
1M
C5
0.22
R9
2K
DC AMP
SENS
CR1
1910-0016
CR1
R6
10K
+12.5V
BRN
1
ORN
3
4
YEL
5
GRN
R4
24K
2
RED
BLK
6
CR2
1910-0016
R7
39
K
C4
0.1
C3
4700p
METER
METER
WHT/
BLK
WHT
RED
M1
B
A
L
ORN
3
H
J
Q1
1854-0114
Q2
1854-0114
R2
56
4
YEL
L
K
R3
10K
R1
10K
C1
0.22
C2
.022
R5
300
RED
2
BRN
1
BLK
G
AIO AMPLIFIER/METER CIRCUIT ASS'Y
(04329-7030)
Mating connector is *A3 mounted on
A1 MOTHER BOARD ASS'Y
+12.5V
D
A
C
E
J
+12.5V
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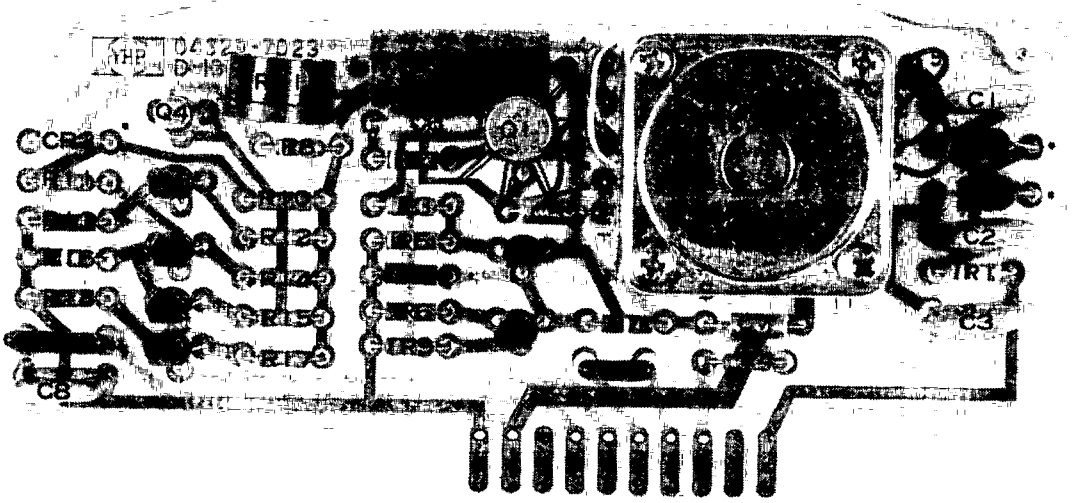
Figure 8-5.

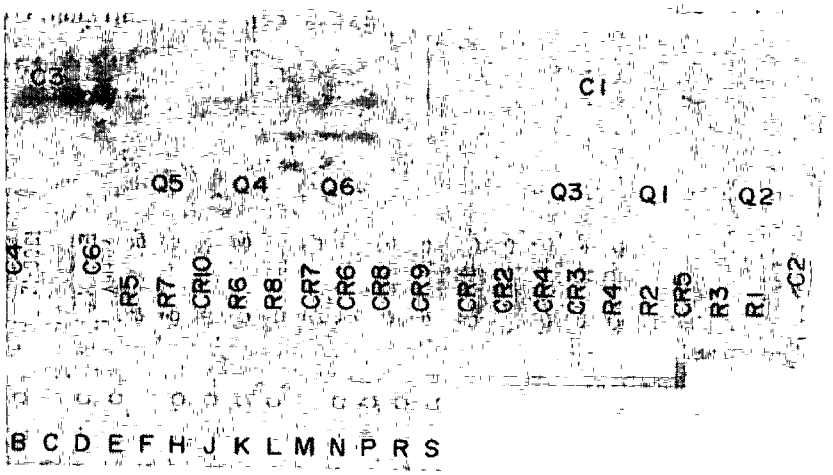


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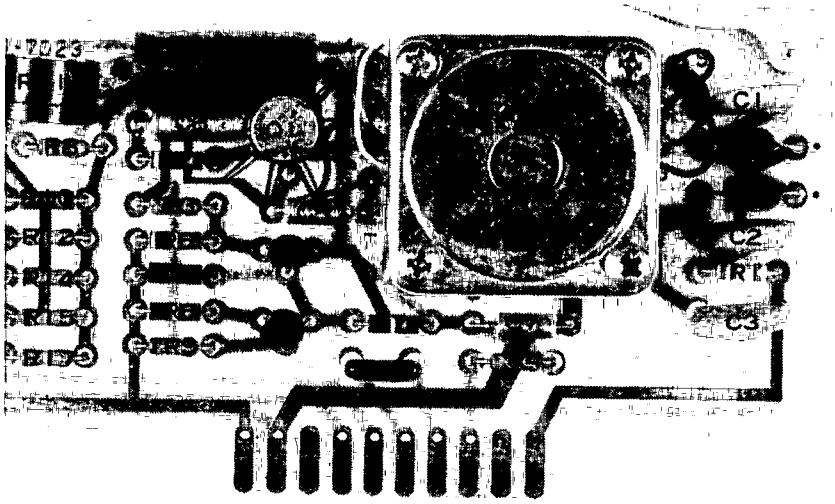
Figure 8-5. Parametric Converter Ass'y A8
Oscilator/Amplifier Ass'y A9
Amplifier/Meter Circuit Ass'y A10


C3
C1
Q5
Q4
Q6
Q3
Q1
Q2
C5
CR10
R9
CR11
C4
C6
R5
R7
CR10
R6
R8
CR7
CR6
CR8
CR9
CR1
CR2
CR4
CR3
R4
R2
CR5
R3
R1
C2
A B C D E F H J K L M N P R S


HP
Q4
C1
C2
C3
C8



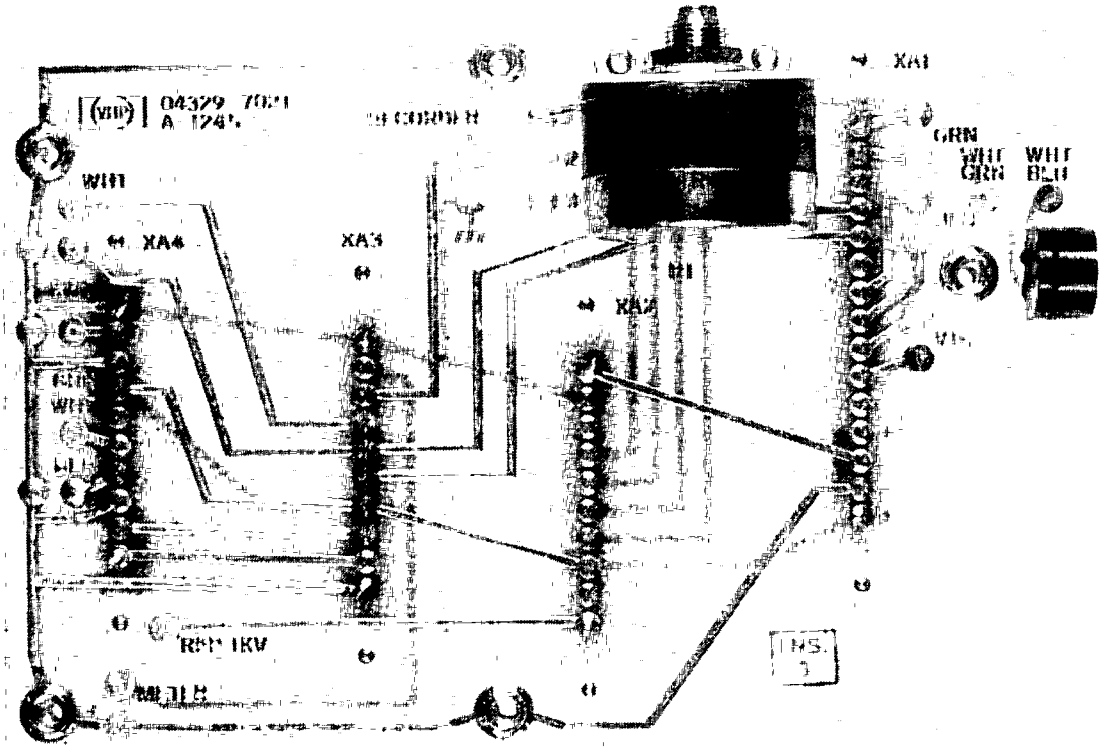
A2 LOW VOLTAGE
POWER SUPPLY ASS'Y
COMPONENT LOCATION



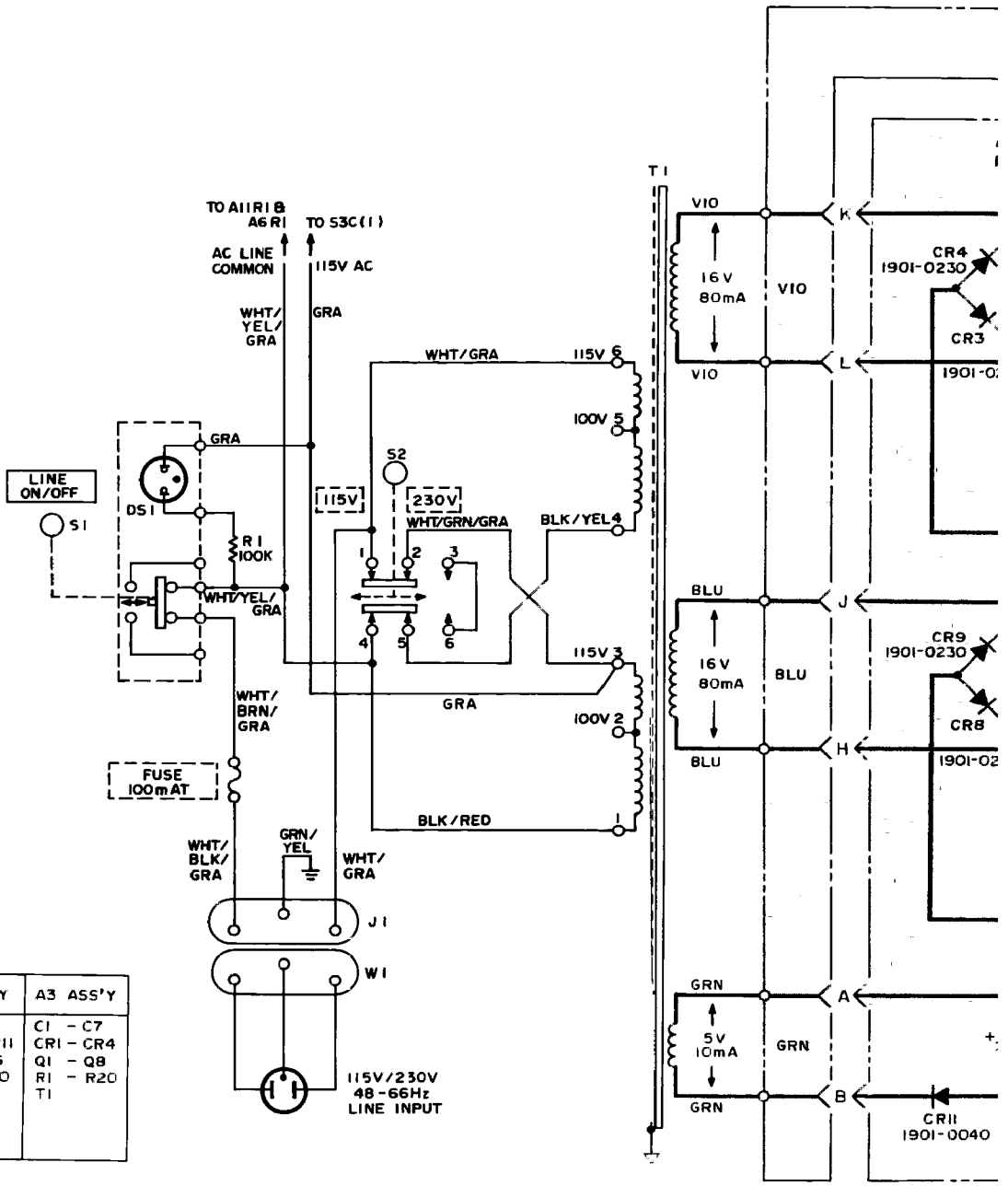
A3 HIGH VOLTAGE
POWER SUPPLY ASS'Y
COMPONENT LOCATION

SEE INSIDE

Figure 8-5
PARAMETRIC CONVERTER ASS'Y A8
OSCILLATOR/AMPLIFIER ASS'Y A9
AMPLIFIER/METER CIRCUIT ASS'Y A10



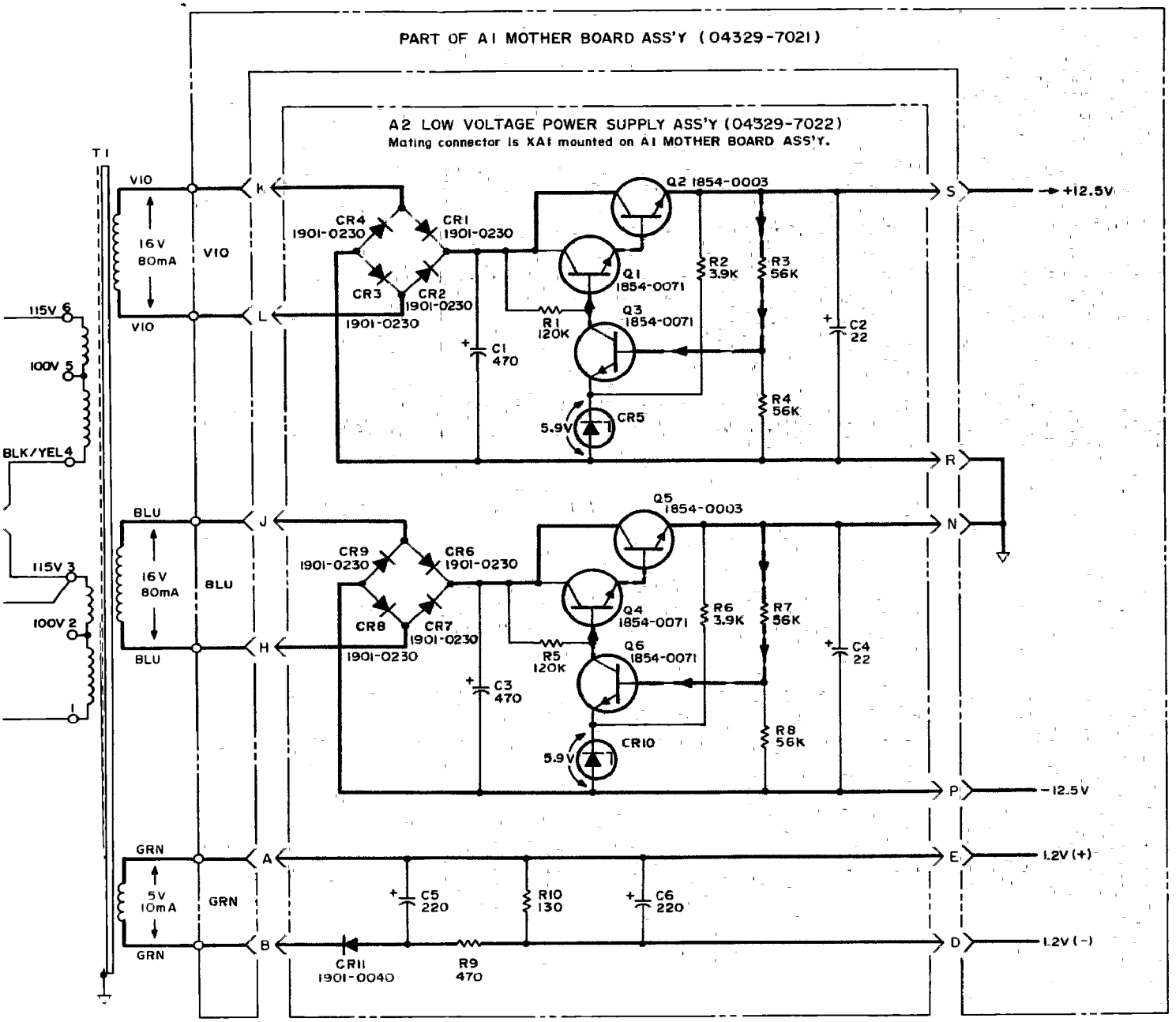
A1 MOTHER BOARD ASS'Y
COMPONENT LOCATION



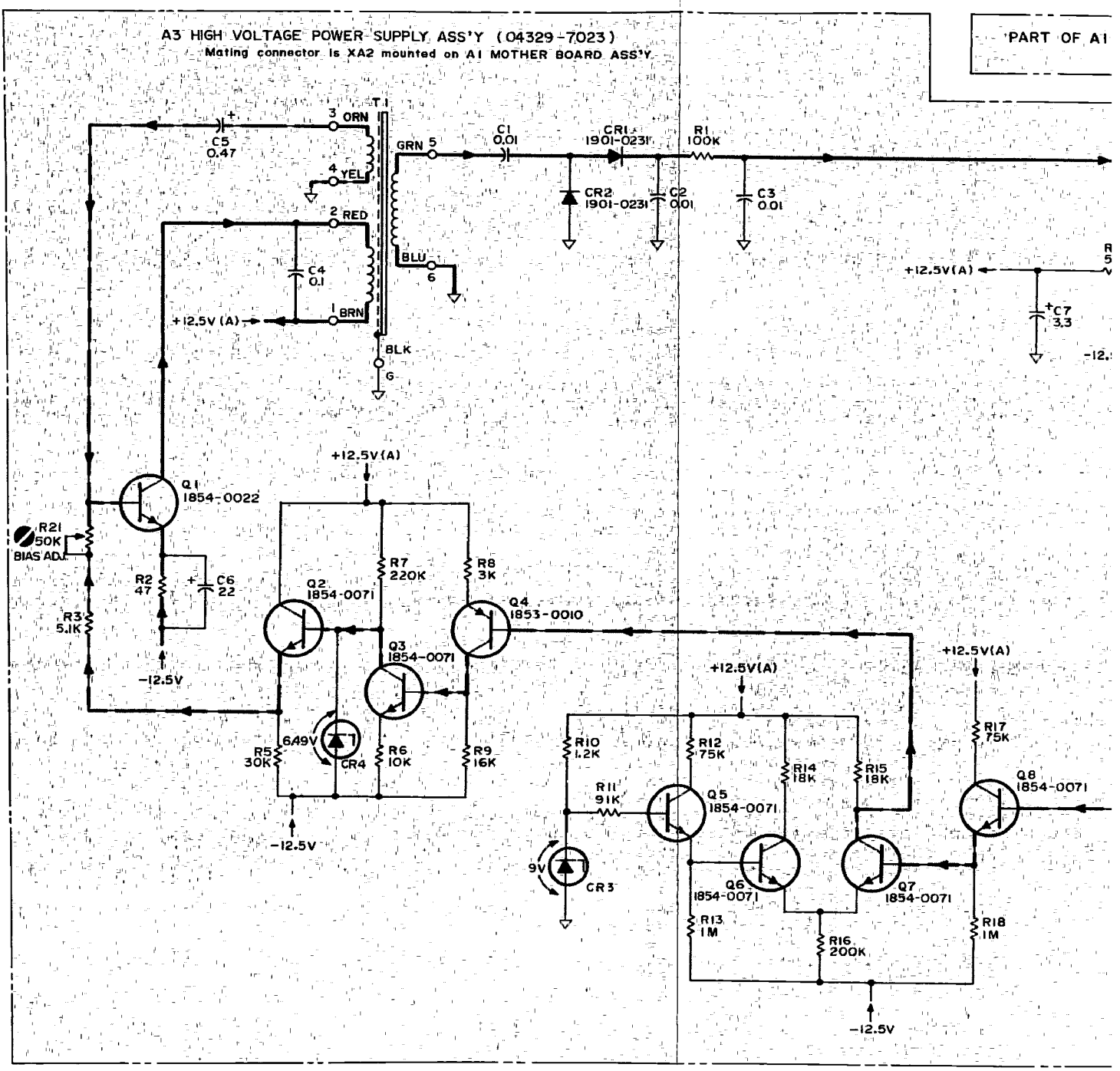
REFERENCE DESIGNATIONS

NO PREFIX	A1 ASS'Y	A2 ASS'Y	A3 ASS'Y
DS1	R1	C1 - C6	C1 - C7
J1	R2	CR1 - CR11	CR1 - CR4
R1		Q1 - Q6	Q1 - Q8
S1, S2		R1 - R10	R1 - R20
T1			T1
W1			

DELETED



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A3 HIGH VOLTAGE POWER SUPPLY ASS'Y (04329-7023)
Mating connector is XA2 mounted on A1 MOTHER BOARD ASS'Y
PART OF A1
3 ORN
4 YEL
2 RED
1 BRN
GRN 5
BLU 6
BLK G
C5 0.47
C4 0.1
C1 0.01
CR1 1901-0231
CR2 1901-0231
C2 0.01
C3 0.01
R1 100K
+12.5V(A)
C7 3.3
-12.5
Q1 1854-0022
R21 50K BIAS ADJ.
R2 47
C6 22
R3 5.1K
-12.5V
R7 220K
R8 3K
Q2 1854-0071
Q3 1854-0071
Q4 1853-0010
6.49V
CR4
R5 30K
R6 10K
R9 16K
R10 1.2K
R11 91K
R12 75K
R14 18K
R15 18K
Q5 1854-0071
9V
CR3
Q6 1854-0071
Q7 1854-0071
R13 1M
R16 200K
R17 75K
Q8 1854-0071
R18 1M

Figur

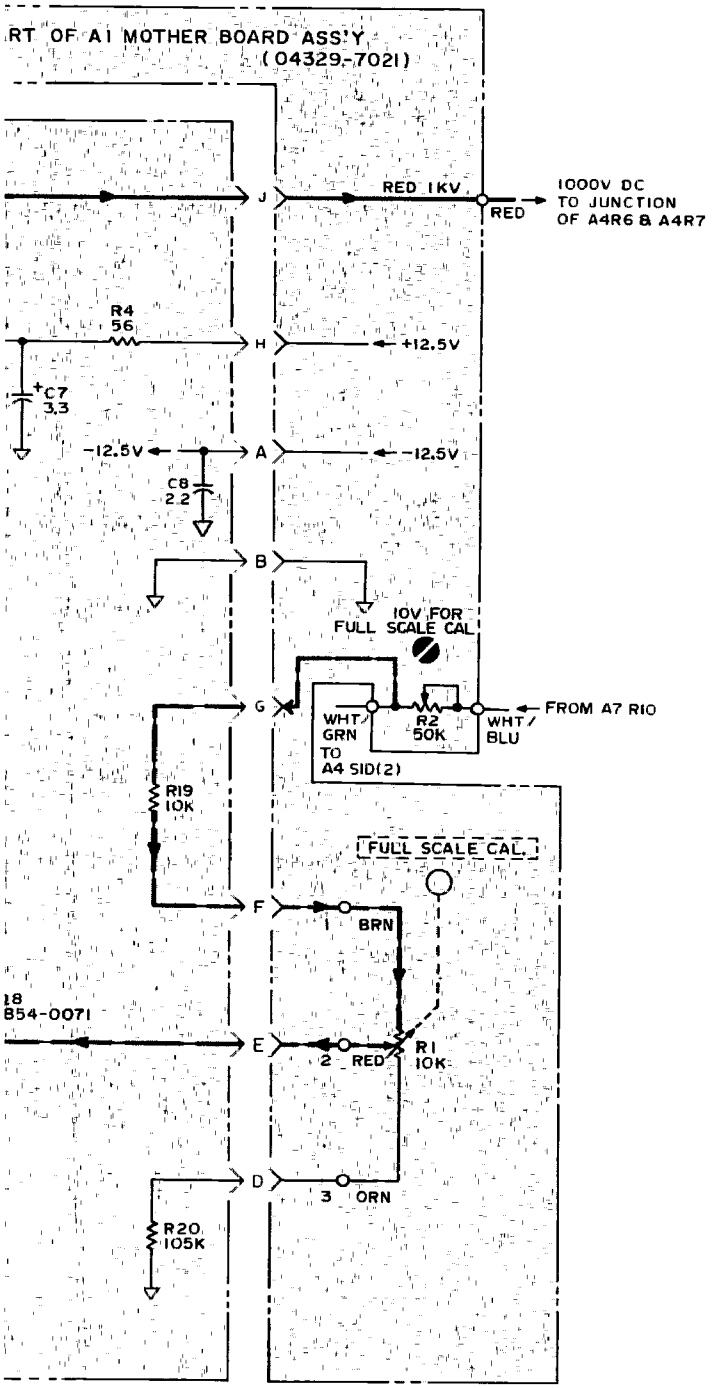


Figure 8-6. Mother Board Ass'y A1
Low Voltage Power Supply Ass'y A2
Test Voltage Power Supply Ass'y A3

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