419A
DC NULL
VOLTMETER

OPERATING AND SERVICE MANUAL

HEWLETT hp PACKARD

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CERTIFICATION

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

WARRANTY AND ASSISTANCE

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

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

OPERATING AND SERVICE MANUAL

(HP PART NO. 00419-90002)

MODEL 419A
DC NULL VOLTMETER

SERIALS PREFIXED: 707-

Appendix C, Manual Backdating Changes,
adapts this manual to Serials Prefixed:
514-, 532-, 646-

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

01779-2

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Table 1-1. Model 419A Specifications

VOLTMETER

Ranges: ±3 μV to ±1000 volts dc end scale in 18 zero center ranges.

Accuracy: ±(2% of end scale +0.1 μV).

Limits of Zero Control: ±15 μV.

Input Resistance:

3 μV to 3 mV ranges: 100 kΩ (infinite when nulled).

10 mV to 30 mV ranges: 1 MΩ (infinite when nulled).

100 mV to 300 mV ranges: 10 MΩ (infinite when nulled).

1 volt to 1000 volt ranges: 100 MΩ

Internal Bucking Voltage: ±120% end scale, 3 μV through 300 mV range.

Response Time: 95% of final reading within 3 sec on the 3 μV range. 95% of final reading within 1 sec on the 10 μV to 1000 V ranges.

Superimposed AC Rejection: Ac voltages 60 Hz and above: 80 db greater than end scale--affects reading less than 2%. Peak ac voltage not to exceed max overload voltage.

Drift: < 0.5 μV/day after 30 minutes warmup. T.C. < 0.05 μV/^{o}C from 0^{o} to +50^{o}C.

Noise*: < 0.3 μV peak-to-peak.

* Peak-to-peak noise is less than 0.3 μV 95% of the time since the noise amplitude approximates a Gaussian distribution where the standard deviation (which is also the rms value) = 0.075 μV.

AMPLIFIER

Gain: 110 db maximum at recorder output terminals. Gain depends on range.

Output: 0 to ±1 volt at 1 mA max for end scale reading. Output level is adjustable for convenience when used with recorders.

Output Impedance: Depends on setting of output level control. < 35 ohms when output level is set to maximum.

Noise: 0.01 Hz to 5 Hz: Same as voltmeter (referred to input). > 5 Hz: rms noise < 10 mV (referred to output).

DC AMMETER

Current Ranges: ±30 pA, ±100 pA, ±300 pA, ±1 nA, ±3 nA, ±10 nA and ±30 nA.

Accuracy: ±(3% of end scale +1 pA).

GENERAL

Overload Voltages: 50 Vdc max, 3 μV to 3 mV ranges; 500 Vdc max, 10 mV to 300 mV ranges; 1200 Vdc max on 1 volt range and above.

Overload Recovery Time: Meter indicates within 3 seconds for a 10^6 overload.

Input Terminals: Positive and negative terminals are solid copper, gold flashed.

Input Isolation: > 10^{10} ohms shunted by 250 pF. May be operated up to 500 Vdc or 350 Vac (rms) above ground.

Operating Temperature: 0^{o} to +50^{o}C.

Storage Temperature: -40^{o}C to +60^{o}C.

Power Source: 4 internal rechargeable batteries (furnished). Thirty hour operation per recharge. The 419A may be operated during recharge from ac line. 115 or 230 V ±10%, 50 to 1000 Hz, approximately 3 watts.

Dimensions: Standard -hp- 1/2 module; 6" high, 7-3/4" wide, 8" deep (152 x 197 x 203 mm).

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This section contains general information about the Model 419A DC Null Voltmeter (Figure 1-1). Included are Specifications, Description and Purpose, Instrument Identification, Accessory Equipment Supplied, and Accessory Equipment Available.

1-3. SPECIFICATIONS.

1-4. Table 1-1 contains the specifications for the Model 419A.

1-5. DESCRIPTION AND PURPOSE.

1-6. The Model 419A is housed in a standard -hp- 1/2 module case. A rechargeable battery power supply allows operation independent of ac line. Range and function switching is accomplished by front panel controls.

1-7. The Model 419A provides 18 end scale dc voltage ranges in a 1, 3, 10 sequence from 3 microvolts to 1000 volts. The Model 419A also provides 7 end scale dc current ranges from 30 picoamps to 30 nanoamps. An internal bucking supply allows voltages up to 300 millivolts to be measured with infinite input impedance. The input impedance for the higher ranges is 100 MΩ.

1-8. Recorder output terminals are provided on the rear panel. The voltage available is proportional to the meter deflection and is adjustable from 0 to 1 volt at full scale.

1-9. INSTRUMENT/MANUAL IDENTIFICATION.

1-10. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 419A described in this manual

1-11. ACCESSORY EQUIPMENT SUPPLIED.

1-12. The accessory equipment supplied with each Model 419A is listed and described in Table 1-2.

Table 1-2. Accessory Equipment Supplied

IDENTIFICATION NUMBER	QUANTITY	DESCRIPTION
8120-0078	1	Power Cord
00419-90002	1	Operating and Service Manual

1-13. ACCESSORY EQUIPMENT AVAILABLE.

1-14. The accessory equipment available is listed in Table 1-3. For further information, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

Table 1-3. Accessory Equipment Available

IDENTIFICATION NUMBER	DESCRIPTION
5060-0630	22-Pin Printed Circuit Board Extender
11000A	Dual Banana Plugs to Dual Banana Plugs (44")
11002A	Dual Banana Plugs to Alligator Clips (60")
11003A	Dual Banana Plugs to Probe and Alligator Clip (60")

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary for the installation and shipping of the Model 419A DC Null Voltmeter. Included are initial inspection procedures, power and grounding requirements, installation information, and instructions for repackaging for shipment.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be physically free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also check for supplied accessories, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-5. If there is damage or deficiency, see the warranty on the inside front cover of this manual.

2-5. POWER REQUIREMENTS.

2-6. The Battery Power Supply in the Model 419A can be charged from any source of 115 or 230 volts (±10%), at 50 to 1000 Hz. With the instrument disconnected from the ac power source, move the slide switch (located on the rear panel) until the desired line voltage appears. Power Dissipation is approximately 3 watts.

2-7. GROUNDING REQUIREMENTS.

2-8. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground wire.

2-9. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

2-10. INSTALLATION.

2-11. The Model 419A is fully transistorized; therefore, no special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 50°C (122°F).

2-12. BENCH MOUNTING.

2-13. The Model 419A is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument.

2-14. RACK MOUNTING.

2-15. The Model 419A may be rack mounted by using an Adapter Frame (-hp- Part No. 5060-0797). The adapter frame is a rack frame that accepts any combination of submodular units. It can be rack mounted only. For additional information, address inquiries to your -hp- Sales and Service Office. (See Appendix B for office locations.)

2-16. COMBINATION MOUNTING.

2-17. The Model 419A may be mounted in combination with other submodular units by using a Combining Case (-hp- Models 1051A and 1052A). 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.

2-18. REPACKAGING FOR SHIPMENT.

2-19. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-20 if the original container is to be used; 2-21 if it is not. If you have any questions, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

NOTE

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

2-20. If original container is to be used, proceed as follows:

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

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

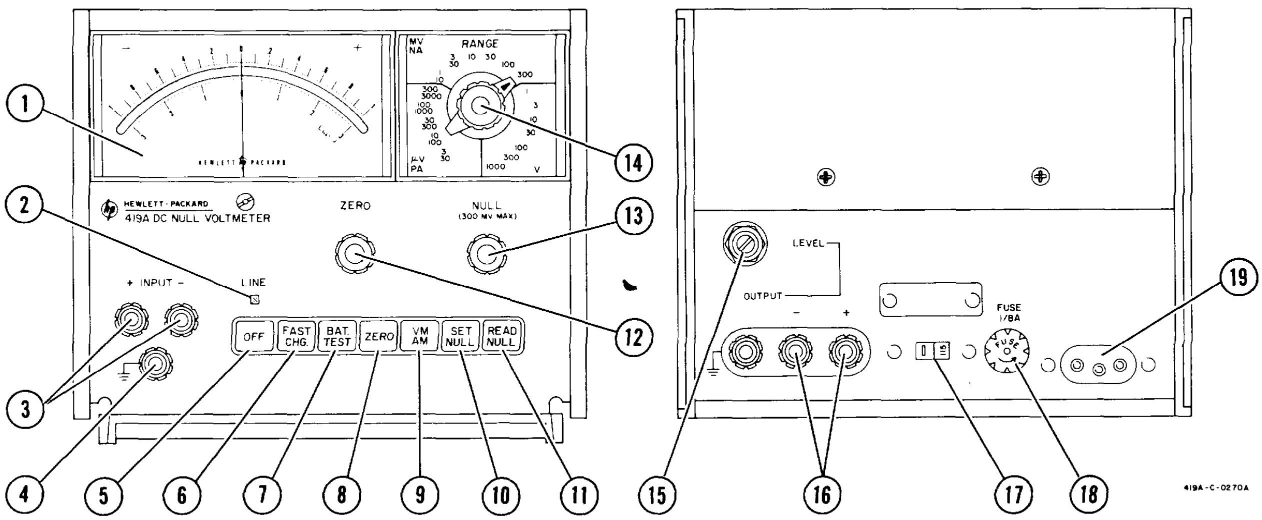
2-21. If original container is not to be used, proceed as follows:

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

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

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

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



INDEX NO.	NAME	FUNCTION
1	Meter	Indicates value of applied voltage or current in conjunction with RANGE switch and function pushbuttons.
2	LINE Indicator	Lights to indicate application of ac line voltage to power supply circuits.
3	+ and - INPUT terminals	Accepts leads for application of dc voltage or current input.
4	Ground (⏚) terminal	Accepts lead for grounding of instrument case.
5	OFF	When depressed all functions are turned off.
6	FAST CHG.	When depressed enables batteries to charge at a fast rate.
7	BAT. TEST	When depressed enables meter to indicate battery voltage.
8	ZERO	When depressed internally disconnects voltmeter from + terminal and shorts to - terminal.
9	VM/AM	When depressed enables meter to indicate value of input voltage or current.
10	SET NULL	When depressed places null supply in series opposition to input voltage.
11	READ NULL	When depressed enables meter to indicate value of null supply.
12	ZERO control	Provides continuously variable control of zero offset to $\pm 15\ \mu V$.
13	NULL control	Provides continuously variable control for nulling of input voltages below 300 mV when SET NULL pushbutton is depressed.
14	RANGE switch	Selects one of full scale voltage or current ranges.
15	LEVEL control	Provides variable control (0 to ± 1 V full scale) of + and - recorder OUTPUT.
16	+ and - OUTPUT terminals	Provide for connection of external recorder.
17	Line Voltage Switch	Enables selection of either 115 or 230 Vac line voltage.
18	FUSE 1/8 A	Accepts fuse for protection of primary power circuits.
19	AC Power Connector	Accepts 3 pin power cord.

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

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. The Model 419A functions as a dc voltmeter with full (end) scale ranges from 3 μV to 1000 V. An internal bucking supply allows essentially infinite input impedance to be achieved on the 3 μV to 300 mV ranges. The Model 419A can also measure low level dc currents with full (end) scale ranges from 30 pA to 30 nA. This section describes the operating procedures and presents some applications for the Model 419A.

3-3. CONTROLS, INDICATORS AND CONNECTORS.

3-4. Each operating control, indicator and connector located on the Model 419A is identified in Figure 3-1. The description of each component is keyed to the illustration of that component which is included within the figure.

3-5. OPERATING INSTRUCTIONS.

3-6. The Model 419A may be operated on its internal battery power supply or from an ac line. The instrument operates on its internal batteries whenever the ac power cable is removed from the ac power connector. Line operation occurs automatically whenever the power cable is connected to the power connector.

NOTE

Best isolation characteristics and freedom from ground loop problems results when the 419A is operated on its internal battery supply.

3-7. TURN-ON PROCEDURE (BATTERY OPERATION).

NOTE

Disconnect the power cable from the power receptacle for battery operation.

a. Depress BAT. TEST pushbutton; if meter does not indicate within BAT limits, perform battery charging procedure (Paragraph 3-13).

NOTE

When the 419A is received or after a period of storage (especially at high temperatures), the batteries may require changing. Erratic and inaccurate operation may result if the instrument is operated on weak batteries.

b. Set RANGE switch to 1 V.

c. Depress ZERO pushbutton. If meter does not indicate zero, perform the meter zero adjustments (Paragraphs 5-31 thru 5-36).

d. Zero meter on 3 μV range with ZERO control. Periodically recheck setting of ZERO control on the 3 μV range.

3-8. TURN-ON PROCEDURE (AC LINE OPERATION).

a. Set line voltage two-position slide switch (rear panel) to correct position for available line voltage.

CAUTION

DAMAGE TO INSTRUMENT MAY RESULT IF LINE VOLTAGE SWITCH IS SET INCORRECTLY.

b. Connect ac power connector to the line using the ac power cable supplied.

c. Set RANGE switch to 1 V.

d. Depress ZERO pushbutton. If meter does not indicate zero, perform meter zero adjustments (Paragraphs 5-31 thru 5-36).

e. Zero meter on 3 μV range with ZERO control. Periodically recheck setting of zero control on the 3 μV range.

3-9. DC VOLTAGE MEASUREMENTS.

a. Turn on the Model 419A and zero it according to the steps in Paragraph 3-7 (battery operation) or Paragraph 3-8 (AC Line Operation). Allow at least ten minutes warmup time if low voltages (below 1 mV) are to be measured.

b. Connect test leads to + and - INPUT terminals. (See Table 1-3 for a list of test leads available.)

c. Set RANGE switch to range nearest above input voltage. If in doubt, start on the 1000 V range and downrange as necessary.

CAUTION

TO PREVENT DAMAGE TO THE MODEL 419A, DO NOT EXCEED THE FOLLOWING OVERLOAD LIMITS.

RANGE	MAXIMUM INPUT VOLTAGE
3 μV to 3 mV	50 Vdc
10 mV to 300 mV	500 Vdc
1 V to 1000 V	1200 Vdc

d. Connect test leads to voltage to be measured.

CAUTION

DO NOT FLOAT MODEL 419A -INPUT TERMINAL MORE THAN ± 500 VDC FROM GROUND (⏚).

e. Depress VM/AM pushbutton. Read value of input voltage on meter scale.

NOTE

If input voltage is 300 mV or less, infinite input impedance may be obtained by proceeding with steps f thru h.

f. Depress SET NULL pushbutton.

g. Rotate NULL control until meter indicates exactly zero.

NOTE

NULL control gives both coarse and fine adjustment. Rotate control until pointer is slightly down scale from zero; then reverse direction to obtain fine adjustment.

h. Depress READ NULL pushbutton. Read value of input voltage on meter.

3-10. DC CURRENT MEASUREMENTS.

a. Turn on and zero the Model 419A according to the steps in Paragraph 3-7 (Battery Operation) or 3-8 (AC Line Operation). Allow at least ten minutes warmup time if low value currents (below 10 nA) are to be measured.

b. Connect test leads to + and - INPUT terminals.

c. Set RANGE to range nearest above current to be measured. If in doubt, start on 300 nA position and reduce as necessary.

d. Connect test leads in series with current to be measured.

e. Depress VM/AM pushbutton. Read value of input current on meter scale.

3-11. Amplifier Output.

3-12. The rear panel OUTPUT terminals provide a dc voltage which is proportional to meter deflection. The LEVEL control adjusts the maximum value of output voltage. With the LEVEL control turned fully cw, the voltage varies from 0 to ±1 Vdc into a 1 kΩ load. Polarity of the voltage depends upon polarity of the meter deflection.

3-13. Battery Charging Procedure.

3-14. The batteries are automatically trickle charged whenever the Model 419A is connected to an ac powerline and the ZERO, VM/AM, SET NULL or READ NULL pushbutton is depressed. The instrument may be used while trickle charging occurs except when the batteries have been almost completely discharged. Under this condition the Model 419A may not operate properly and the batteries should be at least partially recharged before using the instrument. Generally, 72 hours of trickle charging will restore the batteries to their fully charged state; however, the batteries may be trickle charged indefinitely without damage.

3-15. The batteries may be fast charged by connecting the Model 419A to an ac powerline and depressing the FAST CHG. pushbutton. The instrument cannot be used to make measurements while fast charging the batteries. The batteries should reach full charge in approximately 15 hours.

3-16. To obtain maximum battery life, the following points should be observed.

a. Do not allow the batteries to discharge below the BAT limits on the meter scale.

b. Use fast charge only when necessary.

c. Charge the batteries in moderate temperatures ($80^{o}F \pm 10^{o}F$, $27^{o}C \pm 5.6^{o}C$) whenever possible.

d. Do not store the instrument at temperatures above $122^{o}F$ ($50^{o}C$) or below $-40^{o}F$ ($-20^{o}C$).

3-17. APPLICATIONS.

3-18. In addition to straightforward dc voltage and current measurements, the Model 419A has a number of applications. Several of these are presented in the following paragraphs.

3-19. Measuring Leakage.

3-20. By using the Model 419A as a sensitive dc ammeter, very high resistance leakage paths in insulating materials can be detected and measured. Leakage is observed by connecting the output of a dc power supply across the insulating material and placing the Model 419A in series with one of the power supply leads. By noting the current flow on the Model 419A, the leakage resistance can be calculated from the formula:

$$R_{(leakage)} = \frac{E_{(power\ supply)}}{I_{(419A)}}$$

Example:

Assume the leakage between 2 points (A and B) in a standards laboratory oil bath is to be measured. A 100 V power supply and the 419A are connected as shown in Figure 3-2.

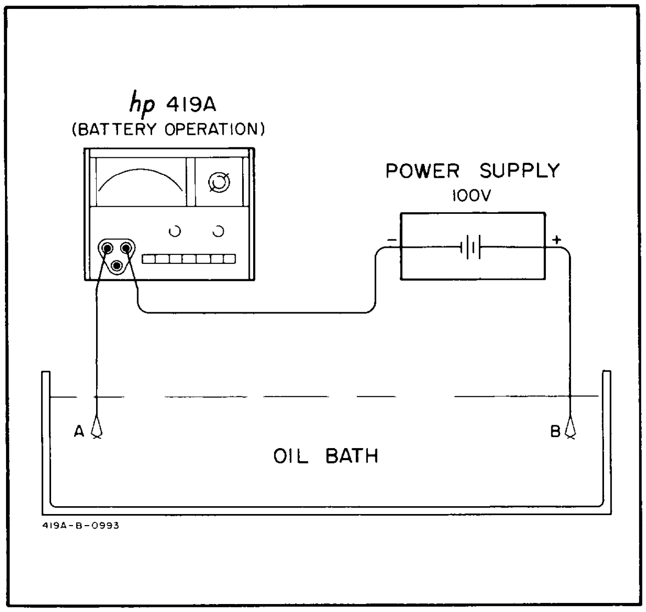


Figure 3-2. Leakage Measurement

Assume the 419A indicates 10 pA. The leakage of the oil can then be calculated.

$$R_{(leakage)} = \frac{E_{(power\ supply)}}{I_{(419A)}}$$

$$R_{(leakage)} = \frac{100\ V}{10\ pA}$$

$$R_{(leakage)} = 10^{13}\ \Omega$$

$$R_{(leakage)} = 10^{7}\ M\Omega$$

3-21. Calibrating A Voltage Source.

3-22. The Model 419A can serve as a very sensitive and accurate null detector. These features can be especially useful when matching the output of an adjustable voltage source to a reference standard. The adjustable voltage source and the reference standard are connected in series opposition with the Model 419A in series with one of the leads. The adjustable voltage source is then adjusted for a null indication on the Model 419A.

Example:

Assume the output of a dc standard (-hp- Model 741B) is to be matched to the output of a 1 V transfer standard (-hp- Model 735A). These instruments and the Model 419A are connected as shown in Figure 3-3.

The reference standard and the adjustable voltage source are both set for a 1 V output. The Model 419A indicates any deviations between the two outputs. By making internal adjustments affecting the output of the voltage source until null is reached on the Model 419A's 3 μV range, the output of the adjustable voltage source **is** very accurately matched to the reference standard.

3-23. Measuring and Recording Drift.

3-24. The rear panel OUTPUT terminals provide a dc voltage (0 to $\pm$1 V) proportional to meter deflection. This output can be used to record the drift of a dc voltage source when that source is compared to a very stable reference voltage.

Example:

Assume that the drift of a 10 V power supply is to be observed and recorded. The power supply, Model 419A, stable voltage source (-hp- Model 740B) and a strip chart recorder (-hp- Sanborn Model 7701A) are connected as shown in Figure 3-4.

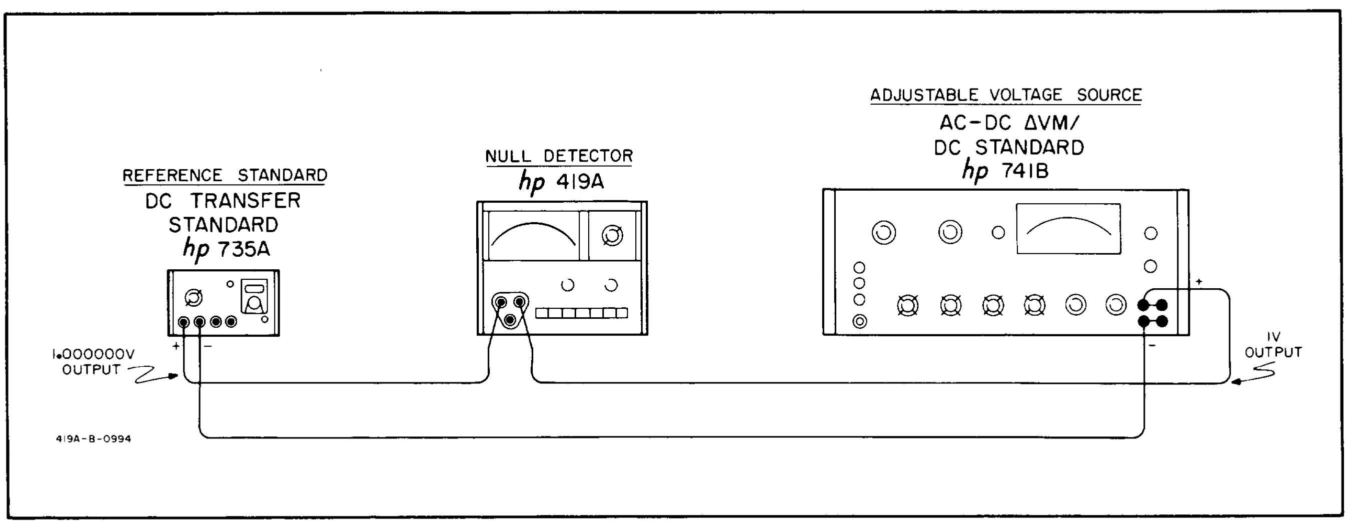


Figure 3-3. Calibrating A DC Standard

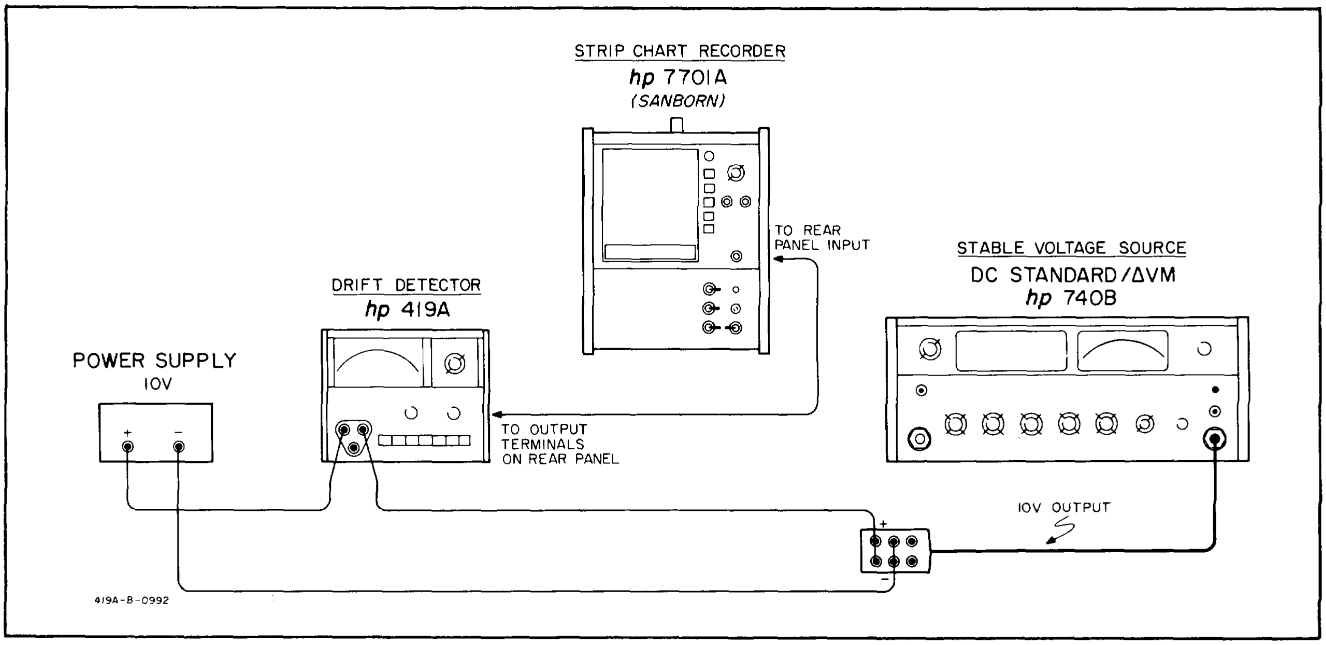


Figure 3-4. Measuring Power Supply Drift

The output of the stable voltage source or the power supply is adjusted until the Model 419A indicates null. The voltage range used on the Model 419A depends on how much drift is anticipated from the power supply. If the power supply output drifts 8 mV over a period of time, the Model 419A will indicate this variation (on the 10 mV range) and supply the strip chart recorder with a voltage that changes from 0 to 0.8 V over the same period. In this case, the drift is amplified by a factor of 100. Gains as high as 333,000 (on the 3 μV range) are available when the Model 419A is used on the lower ranges.

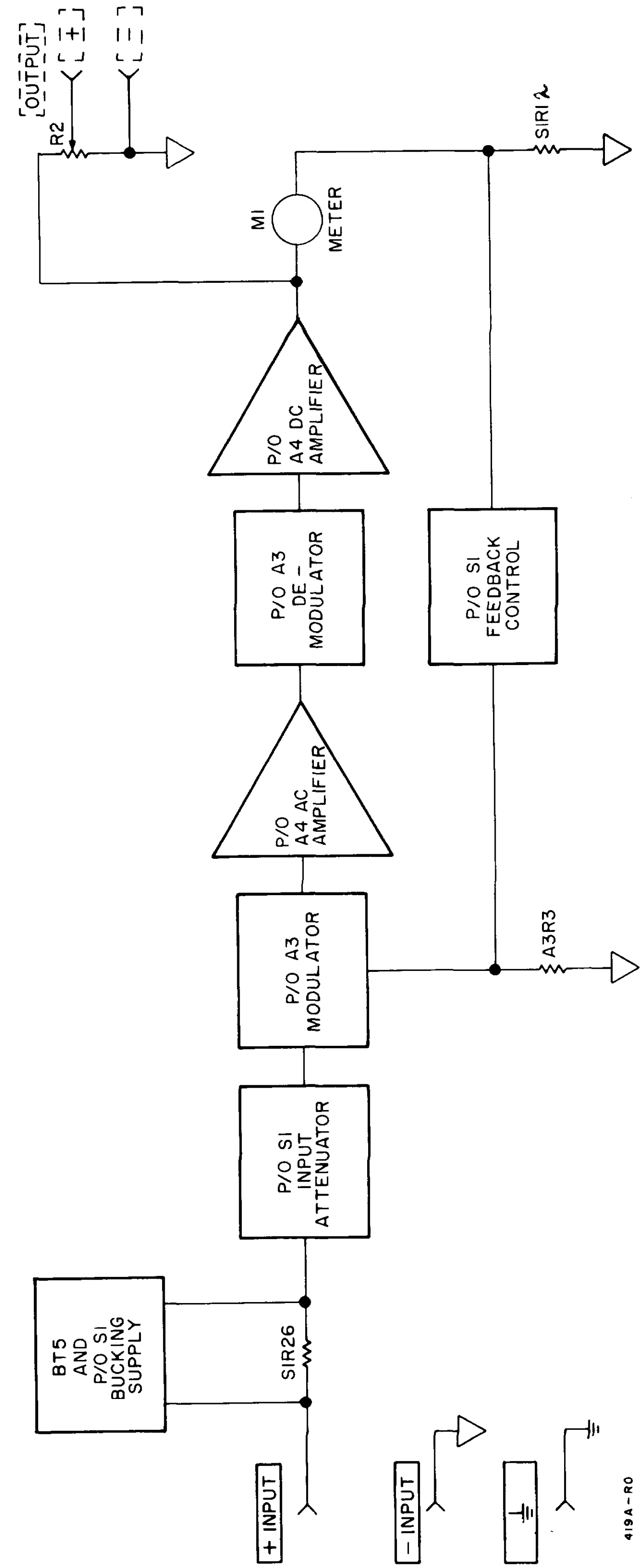


Figure 4-1. Model 419A Block Di

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. This section contains the theory of operation of the Model 419A DC Null Voltmeter.

4-3. GENERAL DESCRIPTION.

4-4. The Model 419A functions as a dc voltmeter, a dc null voltmeter and a dc ammeter. When used as a dc voltmeter, the Model 419A provides end scale ranges from 3 μV to 1000 V with an input resistance of 100 kΩ to 100 MΩ, depending on the range selected. When used as a dc null voltmeter, end scale ranges from 3 μV to 300 mV are provided with infinite input resistance. End scale ranges from 30 pA to 30 nA are provided in the ammeter function with a constant 100 kΩ input resistance.

4-5. When used as an ammeter, circuit operation is identical to the voltmeter mode of operation. Current values are derived from the voltage drop across the constant 100 kΩ input resistance on the 30 pA (3 μV) to 30 nA (3 mV) ranges.

4-6. A dc voltage being measured with the Model 419A is applied to the Input Attenuator through the + and - INPUT terminals, located on the front panel. In the dc voltmeter and ammeter modes, the input is applied to the input attenuator through S1R26. In the dc null voltmeter mode, the output of the Bucking Supply is applied to S1R26 in series opposition to the input dc voltage. The difference between the Bucking Supply output and the input dc voltage is applied to the Input Attenuator. Table 4-1 lists the attenuation factors provided by the Input Attenuator for all ranges.

4-7. The dc output of the Input Attenuator is modulated by the Modulator. The Modulator is comprised of two photocells which are alternately illuminated by two neon lamps. The output of the modulator is a square wave whose amplitude is proportional to the difference between the amplitudes of the input dc voltage and the feedback.

4-8. The square wave output of the modulator is amplified by the AC Amplifier. The AC Amplifier is a six-stage, high gain amplifier. Its output is applied to the Demodulator. The Demodulator output is a dc level whose amplitude is proportional to the amplitude of the square wave. The Demodulator output is applied to the DC Amplifier, a three-stage voltage and power amplifier.

4-9. The forward gain provided by the AC and DC Amplifiers for each range is listed in Table 4-1. The output of the DC Amplifier (approximately 1 Vdc for end scale meter deflection) is applied to M1 and is also available at the OUTPUT + and - terminals.

4-10. The Feedback Control circuit is ganged to the Input Attenuator by the RANGE switch S1. The feedback provided by the Feedback Control circuit is listed in Table 4-1. Algebraic addition of attenuation factor, forward gain and feedback gives the closed loop gain. The closed loop gain provides 18 end scale ranges in 10 dB steps.

4-11. DETAILED DESCRIPTION.

4-12. <u>BUCKING SUPPLY (See Figure 6-3).</u>

4-13. Dc input voltages up to 200 mV may be measured in either the dc voltmeter mode or the null voltmeter

Table 4-1. Model 419A Attenuation and Gain Characteristics

RANGE	ATTENUATION FACTOR	FORWARD GAIN	FEEDBACK	CLOSED LOOP GAIN
3 μV/ 30 pA	0 dB	+150 dB	-40 dB	+110 dB
10 μV/ 100 pA	0 dB	+150 dB	-50 dB	+100 dB
30 μV/ 300 pA	0 dB	+150 dB	-60 dB	+ 90 dB
100 μV/1000 pA	0 dB	+150 dB	-70 dB	+ 80 dB
300 μV/3000 pA	0 dB	+130 dB	-60 dB	+ 70 dB
1 mV/ 10 nA	0 dB	+130 dB	-70 dB	+ 60 dB
3 mV/ 30 nA	0 dB	+120 dB	-70 dB	+ 50 dB
10 mV	- 20 dB	+120 dB	-60 dB	+ 40 dB
30 mV	- 20 dB	+120 dB	-70 dB	+ 30 dB
100 mV	- 40 dB	+120 dB	-60 dB	+ 20 dB
300 mV	- 40 dB	+120 dB	-70 dB	+ 10 dB
1 V	- 60 dB	+120 dB	-60 dB	0 dB
3 V	- 60 dB	+120 dB	-70 dB	- 10 dB
10 V	- 80 dB	+120 dB	-60 dB	- 20 dB
30 V	- 80 dB	+120 dB	-70 dB	- 30 dB
100 V	-100 dB	+120 dB	-60 dB	- 40 dB
300 V	-100 dB	+120 dB	-70 dB	- 50 dB
1000 V	-120 dB	+120 dB	-60 dB	- 60 dB

mode. In the dc voltmeter mode, the input voltage is applied to the Input Attenuator through the + and - INPUT terminals and through S1R26. In the null voltmeter mode, the input is applied in the same manner, but is opposed by the bucking voltage applied to S1R26.

4-14. When the SET NULL Pushbutton is depressed, the BT5 voltage is applied through R4 and R5 and the voltage divider network (S1R1 thru S1R11) to S1R26. The difference between the input voltage and the bucking voltage is indicated on the Meter M1. The bucking voltage is then adjusted through the use of course and fine NULL controls (R4 and R5) until a null is indicated on the Meter. When the READ NULL Pushbutton is depressed, the input voltage is disconnected and the polarity of the bucking voltage is reversed. The value of the bucking voltage (equal to input voltage) is indicated on the Meter M1.

4-15. INPUT ATTENUATOR.

4-16. All voltages and currents to be measured are applied to the input attenuator, which is a resistive divider consisting of S1R20 to S1R25 and R3. The attenuation factor depends upon the position of the RANGE switch. The attenuator is divided into two separate networks to provide the proper impedance levels for filter capacitors A3C2 and A3C3. (Table 4-1 lists the attenuation factors for all ranges.)

4-17. INPUT FILTER.

4-18. L1 and L2, and A3C2 and A3C3 filter superimposed ac noise from the input signal.

4-19. MODULATOR/DEMODULATOR.

4-20. The modulator/demodulator is a photo-conductive chopper. It consists of a neon oscillator with two neon bulbs and four photocells mounted in one assembly. The photocells have an extremely high resistance when not illuminated, and a very low resistance when illuminated.

4-21. Assume that A3V1 is illuminated and A3V2 is not. The resistance of A3V2 will be many times greater than the resistance of A3V1. The voltage across A3V2 (input voltage) will be applied through A3C4 to the base of Q1. The oscillator will then switch off the bulb illuminating A3V1, and switch on a bulb which illuminates A3V2. A3V1 now has the greatest resistance, and A3V2 is a virtual short to the feedback which is coupled to Q1. The modulator provides a square wave output proportional to the difference between the dc input and dc feedback signals. The square wave frequency will depend upon the switching frequency of the neon oscillator.

4-22. The demodulator is operated by the neon oscillator in the same manner. It provides a dc output proportional to the amplitude of the square wave input.

4-23. AC AMPLIFIER.

4-24. Amplification of the square wave output from the modulator is provided by a six stage direct-coupled amplifier. Dc feedback from the base of Q4 to the base of Q1 provides bias stabilization. Ac feedback from the emitter of Q3 to the emitter of Q1 is used to vary the gain of Q1 thru Q3. This is accomplished by varying the amount of feedback to Q1, due to the position of the RANGE Switch. In the 3 μV to 1 mV range, resistor R7 is shorted out, decreasing the negative feedback applied to Q1.

4-25. Feedback from the emitters of Q6 and Q7 is also controlled to vary the gain of Q4 thru Q7. In the 3 μV to 100 μV range resistor R16 is shorted out, decreasing the negative feedback applied to Q4. Capacitors A3C4 and A4C9 couple the ac input and output and block the dc bias voltages.

4-26. DC AMPLIFIER.

4-27. The output of the demodulator is applied to a four stage voltage and power amplifier. Q9 provides temperature compensation for the circuit. When Q8 and Q9 increase conduction due to a rise in temperature, the emitter to base voltage of Q4 decreases, which decreases the Q8 forward bias. This maintains Q8 conduction at a constant level.

4-28. The final stage of amplification is a complimentary symmetry amplifier consisting of Q12, Q13, CR13 and CR14. The diodes bias the transistors at a constant idling state, with no input signal applied. When an input is applied, the transistor responds immediately with an output. The input does not have to reach a certain amplitude to cause conduction in the transistors, since they are already at an idling condition.

4-29. The output of the dc amplifier will be 1 V for end scale input on all ranges. An output is also applied to the + and - OUTPUT terminals J5 and J6. Adjustable resistor R2 provides control of the recorder output from 0 to $\pm$1 volt end scale. Diode network CR5 to CR12 protects the amplifier circuit from an overload.

4-30. METER CIRCUIT.

4-31. The meter is a current driven device which utilizes a taut band movement. A 1 volt output of the dc amplifier provides end scale needle deflection on all ranges. During FAST CHARGE and off (positions 1 and 2 of Function Switch S2), the meter is protected from transient voltages by a short across it. During the BATTERY TEST mode (position 3 of Function Switch S2), resistor S2R1 provides the amplifier load, because the meter is disconnected from the amplifier circuit.

4-32. Resistors R41 to R44 provide for calibration of the meter. The resistors are connected in parallel with the meter as a function of the RANGE switch setting.

4-33. FEEDBACK CONTROL.

4-34. Control of feedback is accomplished through a deck of the RANGE switch. The amount of feedback depends upon the position of the RANGE switch. The closed loop gain of the amplifier may be determined by subtracting the feedback from the forward gain. The feedback provided for each range is listed in Table 4-1.

4-35. POWER SUPPLY AND NEON DRIVER (Figure 6-4).

4-36. The power source for the 419A is four rechargeable batteries, which supply a +13 V and a -13 V output. The 419A may also be operated from line voltage, which will trickle-charge the batteries during operation.

4-37. The line input may be either 115 V or 230 V from 50 to 1000 Hz. The input is rectified by CR1 thru CR4 and applied to series regulator Q1.

4-38. Zener diode CR5 supplies a constant reference to the base of Q1. The emitter of Q1 is referenced to the voltage across R2 or R3. If the output current increases, Q1 will conduct less, due to less emitter to base bias. This will decrease the output current. If either output decreases, Q1 will conduct harder, increasing the output current.

4-39. The neon driver consists of a series regulator circuit, a blocking oscillator, and a neon circuit. Transistor Q5 and zener diode CR9 provide a constant reference to series regulator Q4. The frequency of the blocking oscillator is controlled by varying the voltage across C3. This is accomplished through adjustable resistor R9, which controls the bias on the base of Q4.

4-40. Due to inherent characteristics, either Q2 or Q3 will conduct harder when power is applied. Assume that Q2 conducts more than Q3. As Q2 conducts, a negative going signal is coupled through T2 to the base of Q3. This causes Q3 to cut off completely. At the same time, a positive going signal is coupled to the base of Q2, causing it to conduct more. While Q2 is conducting, a negative output will be coupled to the neon circuit.

4-41. When T2 becomes saturated, the positive signal is removed from the base of Q2, and it cuts off. At the same time, the negative signal is removed from the base of Q3, allowing it to start conducting. As Q3 conducts, a negative going signal is applied to the base of Q2, holding it cut off, and a positive going signal is applied to the base of Q3. Q3 continues to conduct, causing a positive output to be coupled to the neon circuit. This will continue until T2 becomes saturated, and starts the cycle over again.

4-42. The output of the oscillator is coupled through T2 to the neon circuit. When an input is applied to the circuit, due to inherent resistance characteristics, either DS1 or DS2 will light, depending upon which has the least resistance.

4-43. Assume that DS1 lights when the input is applied to T2. Capacitor C1 charges until the oscillator switches the input, and DS1 goes off. When the oscillator switches again, the charge on C1 insures that DS2 fires, and DS1 stays off. This cycle continues with DS1 and the DS2 firing, as long as there is an output from the oscillator. CR1 and CR2 prevent the capacitor from discharging through R1 and R2.

Table 5-1. Test Equipment Required

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	RECOMMENDED MODEL
Voltmeter Calibrator	DC Voltage Range: 0.3 mV to 300 V Accuracy: ±0.2%	-hp- Model 738BR Voltmeter Calibrator
Strip Chart Recorder	Voltage Range: 1 Vdc Speed: 50 mm/sec Frequency Response: 5 Hz	Sanborn Model 7701A Strip Chart Recorder
Oscillator	Output Freq: 60 Hz Output Voltage: 0.5 V rms	-hp- Model 208A Oscillator
Oscilloscope	Horizontal Sensitivity: 2 ms/cm Vertical Sensitivity: 50 mV/cm Frequency Response: 100 kHz	-hp- Model 130C Oscilloscope
Electronic Counter	Counting Range: 300 to 400 pps Accuracy: ±1 count	-hp- Model 5211A Electronic Counter
DC Voltmeter	Voltage Range: 30 Vdc Accuracy: ±2%	-hp- Model 427A Voltmeter
Capacitor	0.1 μF ±20% 10 Vac	-hp- Part No. 0170-0085
Resistors	100 Ω ±0.1% 1/8 W ww 600 Ω ±1% 1/8 W comp 10 kΩ ±0.25% 1/8 W met flm 100 kΩ ±0.25% 1/8 W met flm 900 kΩ ±0.5% 1/2 W met flm 1 MΩ ±0.1% 1/8 W ww 9 MΩ ±0.5% 1/2 W met flm	-hp- Part No. 0811-0398 -hp- Part No. 0684-1031 -hp- Part No. 0698-3193 -hp- Part No. 0698-4057 -hp- Part No. 0698-5488 -hp- Part No. 0811-0473 -hp- Part No. 0698-5443

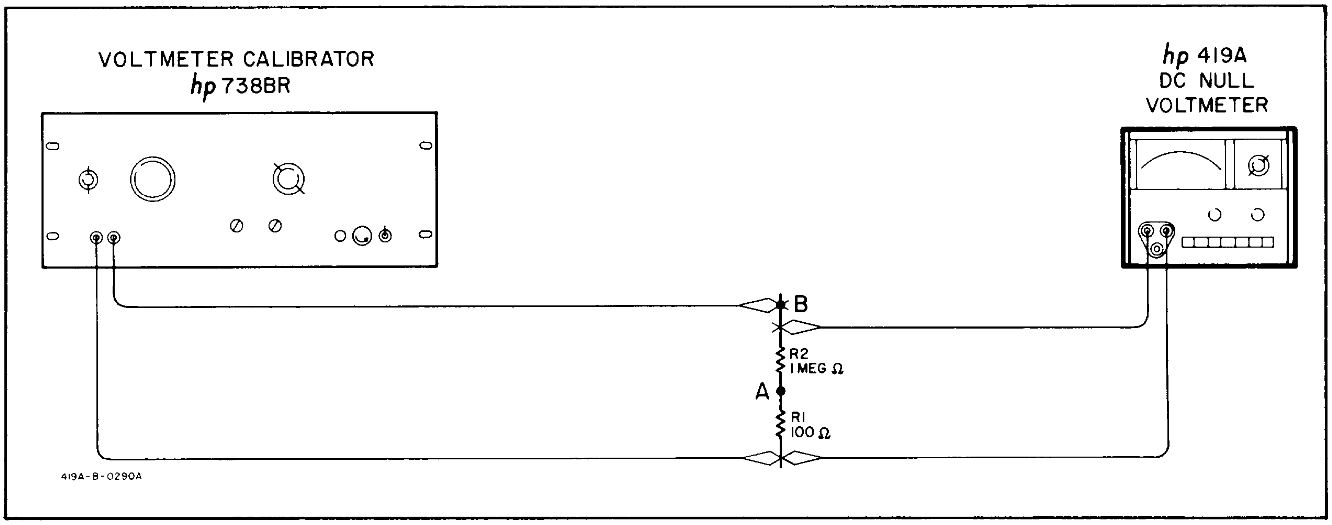


Figure 5-1. Voltmeter Accuracy Performance Test Setup

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains the information necessary for maintenance of the Model 419A DC Null Voltmeter. Included are performance tests, repair procedures, adjustment and calibration procedures, and trouble-shooting procedures.

5-3. TEST EQUIPMENT.

5-4. The test equipment required for maintenance of the Model 419A is listed in Table 5-1. Equipment having similar characteristics may be substituted for the equipment listed.

5-5. PERFORMANCE TESTS.

5-6. The performance tests presented in this section are front-panel procedures designed to compare the Model 419A with its published specifications (Table 1-1). These tests may be incorporated in periodic maintenance, post repair, and incoming quality control inspection. These tests should be conducted before any attempt is made at instrument calibration.

5-7. VOLTMETER ACCURACY TEST.

5-8. The voltmeter accuracy performance test setup is illustrated in Figure 5-1. A voltmeter calibrator (-hp- Model 738BR), a 100 Ω resistor (-hp- Part No. 0811-0398), and a 1 MΩ resistor (-hp- Part No. 0811-0473) are required for this test.

a. Connect test setup illustrated in Figure 5-1.

b. Make control settings indicated in step 1 of Table 5-2; if Model 419A reading is not within tolerances listed, perform Full Scale Calibration procedure (Paragraph 5-37).

c. Repeat step b for remaining steps in Table 5-2.

5-9. BUCKING VOLTAGE TEST.

5-10. No external test equipment is required for the bucking voltage performance test.

a. Depress 419A READ NULL pushbutton; set RANGE to 300 mV.

b. Rotate NULL control fully clockwise and then fully counterclockwise; if 419A meter does not peg in negative and positive direction, respectively, replace BT5.

Table 5-2. Accuracy Performance Test, Supplemental Data

STEP	VOLTMETER CALIBRATOR DC OUTPUT	POINT OF MEASUREMENT FIGURE 5-1	419A RANGE	419A READING
1	30 mV	A	3 μV	2.84 to 3.16
2	100 mV	A	10 μV	9.7 to 10.3
3	300 mV	A	30 μV	29.3 to 30.7
4	1.0 V	A	100 μV	97.9 to 102.1
5	0.3 mV	B	300 μV	293.9 to 306.1
6	1 mV	B	1 mV	0.98 to 1.02
7	3 mV	B	3 mV	2.94 to 3.06
8	10 mV	B	10 mV	9.8 to 10.2
9	30 mV	B	30 mV	29.4 to 30.6
10	100 mV	B	100 mV	98 to 102
11	300 mV	B Remove Attenuator	300 mV	294 to 306
12	1 V	B	1 V	0.98 to 1.02
13	3 V	B	3 V	2.94 to 3.06
14	10 V	B	10 V	9.8 to 10.2
15	30 V	B	30 V	29.4 to 30.6
16	100 V	B	100 V	98 to 102
17	300 V	B	300 V	294 to 306
18	300 V	B	1000 V	280 to 320

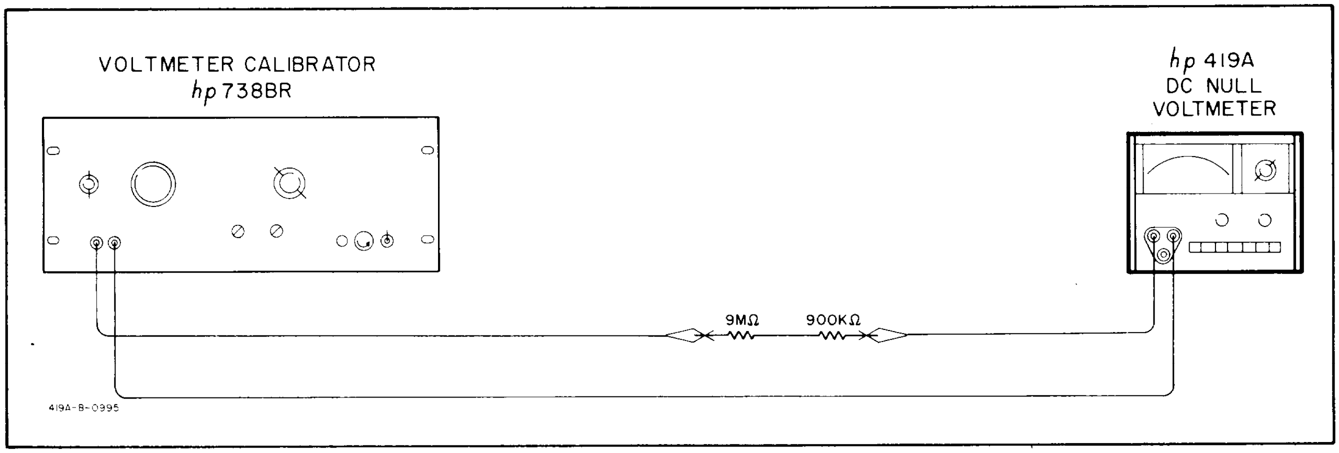


Figure 5-2. Ammeter Accuracy Test Setup

5-11. AMMETER ACCURACY TEST.

5-12. The ammeter accuracy performance test is illustrated in Figure 5-2. A voltmeter calibrator (-hp- Model 738BR), a 9 MΩ resistor (-hp- Part No. 0698-5443) and a 900 kΩ resistor (-hp- Part No. 0698-5488) are required for this test.

a. Connect test setup illustrated in Figure 5-2.

b. Set Model 419A and voltmeter calibrator controls as indicated in step 1 of Table 5-3. If Model 419A reading is not within the listed tolerances, troubleshoot the input attenuator (Paragraph 5-49).

Table 5-3. Ammeter Accuracy Test

STEP	VOLTMETER CALIBRATOR DC OUTPUT	419A RANGE	419A READING
1	.3 mV	30 pA	28.1 to 31.9
2	.001 V	100 pA	96 to 104
3	.003 V	300 pA	290 to 310
4	.01 V	1000 pA	970 to 1030
5	.03 V	3000 pA	2910 to 3090
6	.1 V	10 nA	9.7 to 10.3
7	.3 V	30 nA	29.1 to 30.9

5-13. RESPONSE TIME TEST.

5-14. A strip chart recorder (Sanborn Model 7701A), a voltmeter calibrator (-hp- Model 738BR), a 100 Ω resistor (-hp- Part No. 0811-0398), and a 1 MΩ resistor (-hp- Part No. 0811-0473) are required for this test.

a. Connect strip chart recorder to 419A + and - OUTPUT terminals.

b. Construct test setup illustrated in Figure 5-1; turn voltmeter calibrator dc output off and set for 30 mV output; connect 419A + INPUT terminal to Point A.

c. Set 419A RANGE switch to 3 μV position; depress VM/AM pushbutton.

d. Start strip chart recorder and turn voltmeter calibrator dc output on; if strip chart recorder does not show OUTPUT at 95% between 2 and 3 seconds, perform Chopper Adjustment (Paragraph 5-33).

e. Turn voltmeter calibrator dc output off and set for 100 mV output; set 419A RANGE switch to 10 μV position.

f. Start strip chart recorder and turn voltmeter calibrator dc output on; if strip chart recorder does not show OUTPUT at 95% within 1 second, perform Chopper Adjustment (Paragraph 5-33).

5-15. SUPERIMPOSED AC REJECTION TEST.

5-16. The superimposed ac rejection test setup is illustrated in Figure 5-3. An oscillator (-hp- Model 208A), a 600 Ω resistor (-hp- Part No. 0727-0081), a 10 kΩ resistor (-hp- Part No. 0684-1031), and a 0.1 μF capacitor (-hp- Part No. 0170-0085) are required for this test.

a. Connect test setup illustrated in Figure 5-3; do not connect oscillator.

b. Depress 419A SET NULL pushbutton; set NULL control for +9 μV on 10 μV range.

c. Connect oscillator and set its output frequency for 60 Hz; output voltage for 0.5 volts rms. Model 419A reading should not vary more than ±0.2 μV after the initial transient.

5-17. NOISE TEST.

5-18. No external test equipment is required for the noise test.

a. Short 419A + and - INPUT terminals.

b. Zero 419A in VM function on 3 μV RANGE.

c. If noise displayed on 419A meter exceeds 0.3 μV p-p, perform Chopper Adjustment (Paragraph 5-33).

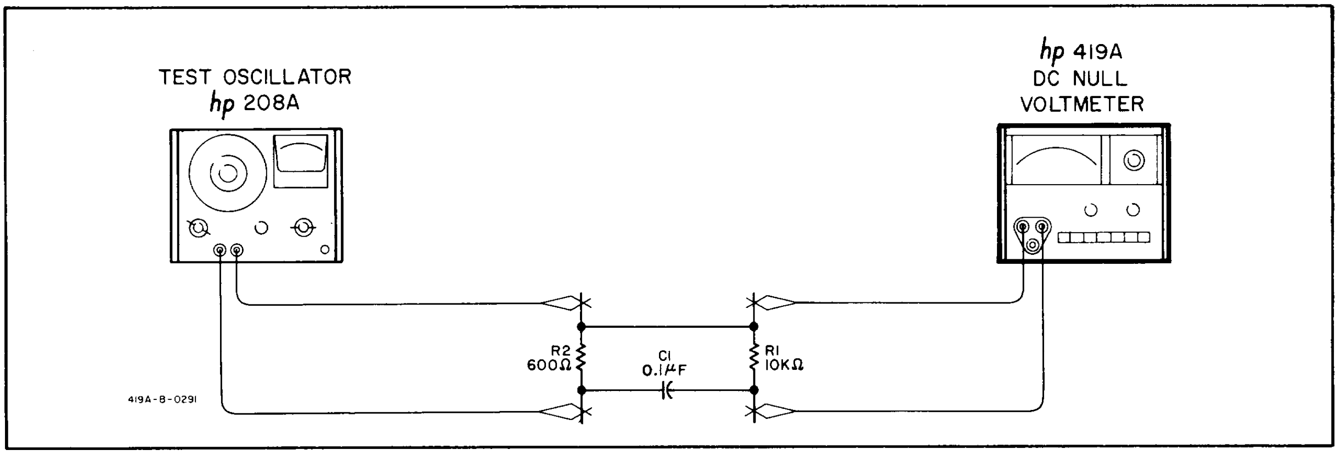


Figure 5-3. Superimposed AC Rejection Performance Test Setup

5-19. INPUT RESISTANCE TEST.

5-20. A Voltmeter Calibrator (-hp- Model 738BR), a 10 kΩ resistor (-hp- Part No. 0698-3193), a 100 kΩ resistor (-hp- Part No. 0698-4057), a 1 MΩ resistor (-hp- Part No. 0757-1054) and a 10 MΩ resistor (-hp- Part No. 0698-4128) are required for this test.

a. Connect a 10 kΩ resistor to Model 419A + INPUT terminal.

b. Connect voltmeter calibrator dc output terminals to 10 kΩ resistor and -INPUT terminal on the Model 419A.

c. Set Model 419A RANGE to 3 mV; set voltmeter calibrator output to 3 mV (.003 V).

d. The Model 419A should indicate 2.73 mV which verifies an input resistance of 100 kΩ on the 3 mV range, as given by the following formula:

$$R_{in} = \frac{R_s \times E_m}{E_o - E_m}$$

where R_{in} is the 419A input resistance, R_s is the series resistance, E_m is the voltage indicated on the Model 419A meter and E_o is the voltmeter calibrator output voltage.

NOTE

The input resistance may vary slightly and a tolerance of ±3% should be allowed.

e. Replace the 10 kΩ resistor with a 100 kΩ resistor.

f. Set Model 419A RANGE to 10 mV; set voltmeter calibrator output to 10 mV (.01 V).

g. Model 419A should read 9.09 mV which verifies an input resistance of 1 MΩ on the 10 mV range.

h. Replace the 100 kΩ resistor with a 1 MΩ resistor.

i. Set Model 419A RANGE to 100 mV; set voltmeter calibrator output to 100 mV (.1 V).

j. Model 419A should read 90.9 mV which verifies an input resistance of 10 MΩ on the 100 mV range.

k. Replace the 1 MΩ resistor with a 10 MΩ resistor.

l. Set Model 419A RANGE to 1 V; set voltmeter calibrator output to 1 V.

m. Model 419A should read 0.909 V which verifies an input resistance of 100 MΩ on the 1 V range.

5-21. REPAIR PROCEDURES.

5-22. COVER REMOVAL.

5-23. When it is necessary to repair or adjust the Model 419A, one or more covers will have to be removed. Refer to the following steps for cover removal procedure.

a. TOP COVER. Remove top cover screws; slide cover to rear and lift to remove.

b. SIDE COVERS. Remove four screws from side cover; lift to remove.

c. BOTTOM COVER. Remove bottom cover screws at rear of cover. Slide cover to rear and remove.

5-24. SERVICING PRINTED CIRCUIT BOARDS.

5-25. The Model 419A has two etched circuit boards. Use caution when removing to avoid damaging mounted components. The assembly and -hp- part number are etched on the interior of the circuit board to identify them. Refer to Section VII for parts replacement and -hp- part number information.

5-26. The etched circuit boards are a plated-through type. The electrical connection between sides of the board is made by a layer of metal plated through the component holes. When working on these boards, observe the following general rules.

a. To avoid contamination, wear clean lint-free cotton or rubber gloves.

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

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

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

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

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

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

5-27. INSTALLATION OF REPLACEMENT NEON SUBASSEMBLY (-hp- Part No. 1990-0214).

5-28. Physical alignment and neon selection are critical. When trouble is isolated to the neon subassembly, the complete subassembly should be changed rather than replacing the defective neons.

a. Remove the top and side cover on the meter side of the instrument.

b. Disconnect the neon subassembly leads from pins on A2 board. (Note location for reconnecting the new leads). Maneuver subassembly cable through the grommet on the inner shield.

c. Remove the two photochopper assembly mounting screws and remove neon subassembly.

d. Install new neon subassembly. Note that the rubber grommet on the subassembly is offset toward the top of the instrument.

e. Route the neon subassembly cable through the inner shield and reconnect the cable to the A2 board.

f. Replace the side cover and recalibrate the Model 419A as outlined in Paragraph 5-29.

5-29. ADJUSTMENT AND CALIBRATION.

5-30. The following is a complete adjustment and calibration procedure for the Model 419A. These procedures should be conducted only if it has been previously established by Performance Tests (Paragraphs 5-5 to 5-20) that the Model 419A is out of adjustment.

5-31. MECHANICAL ZERO ADJUSTMENT.

5-32. The mechanical zero adjustment is located on the instrument front panel. If the meter pointer does not indicate zero when the instrument power has been off for at least one minute, mechanically zero the meter following the procedure outlined below.

a. Turn instrument power off; disconnect input signal; remove output cable; and allow one minute for meter pointer to stabilize.

b. Rotate zero adjustment CW until pointer is to left of zero, moving upscale. Continue until pointer is at zero. If pointer overshoots zero, repeat operation.

c. When the pointer is exactly at zero, rotate zero adjustment slightly CCW to free it. If the meter pointer moves to the left during this step, repeat steps b and c.

5-33. CHOPPER ADJUSTMENT.

5-34. An Oscilloscope (-hp- Model 130C) and an Electronic Counter (-hp- Model 5211A) are required for the chopper adjustment.

NOTE

If Serial Prefix of instrument is 514-, refer to Appendix C for chopper adjustment information.

a. Remove 419A top cover and shield.

b. Connect Oscilloscope and Electronic Counter to A2TP2.

c. Set Oscilloscope for 2 ms/cm horizontal sensitivity and 50 mV/cm vertical sensitivity.

d. Adjust A2R9 (FREQ.) for Electronic Counter indication of 320 to 340. (This corresponds to chopper rate of 160-170 pps as Electronic Counter also counts smaller pulses.) Adjust A2R5 (NEON CURRENT) for waveform amplitude of 140 to 160 mV. Figure 5-4 shows the chopper waveform.

NOTE

If the Neon Waveform is unstable, an intermittent neon bulb is indicated. See Paragraph 5-27 for replacement information.

e. If correct waveform is obtained and response time is still not within limits of Paragraph 5-13, A4R26 will have to be reselected. If response on 3 μV range is longer than 3 seconds, the value of A4R26 should be decreased. If response on 3 μV range is less than 2 seconds, A4R26 should be increased. A4R26 should be between 6.8 kΩ and 15 kΩ with a typical value of 10 kΩ. A4R26 is an Allen-Bradley, composition, 1/4 watt ±10%, resistor.

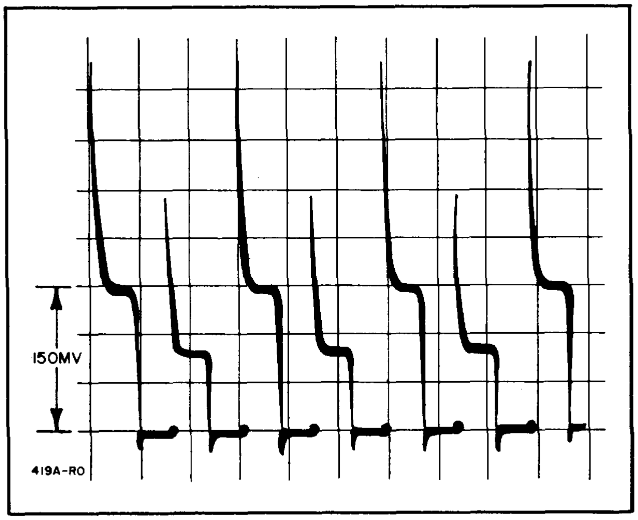


Figure 5-4. Neon Drive Waveform (A2TP2)

5-35. ELECTRICAL ZERO ADJUSTMENT.

5-36. The electrical zero adjustment should be performed when the meter pointer does not indicate zero on the 1 volt range when instrument power has been on for at least one minute. No external equipment is required for this adjustment.

a. Set 419A controls as follows:
RANGE . . . . 1 V
ZERO pushbutton . . . . Depressed

b. Remove top cover; adjust A4R14 (1 V ZERO for zero deflection on 419A meter.

5-37. FULL SCALE CALIBRATION.

5-38. The full scale calibration consists of performing the 3 μV, 10 μV, 1 mV, and 1 V adjustments. A Voltmeter Calibrator (-hp- Model 738BR), a 100 Ω Resistor (-hp- Part No. 0811-0398) and a 1 MΩ Resistor (-hp- Part No. 0811-0473) are required for this test.

a. Connect test setup illustrated in Figure 5-1.

b. Remove 419A top cover; depress VM/AM pushbutton.

c. Set Voltmeter Calibrator for 30 mV output; connect 419A to Point A; adjust A4R41 (3 μV) for full scale deflection on 3 μV range.

d. Set Voltmeter Calibrator for 100 mV output; connect 419A to Point A; adjust A4R42 (10 μV) for full scale deflection on 10 μV range.

NOTE

Remove resistive attenuator before performing steps e and f.

e. Set Voltmeter Calibrator for 1 mV output; connect 419A to Point B; adjust A4R43 (1 MV) for full scale deflection on 1 mV range.

f. Set Voltmeter Calibrator for 1 V output; connect 419A to Point B; adjust A4R44 (1 V) for full scale deflection on 1 V range.

5-39. BATTERY TEST CALIBRATION.

5-40. A DC Voltmeter (-hp- Model 427A) is required for the battery test calibration.

NOTE

Batteries must be fully charged before performing this procedure. (See Paragraph 3-13).

a. Remove 419A top cover and shield.

b. Connect DC Voltmeter across BT1 thru BT4. If DC Voltmeter indicates less than 26 V, recharge battery power supply in accordance with Paragraph 3-13. If DC Voltmeter indicates at least 26 V, proceed to step c.

c. Depress Model 419A BAT TEST Pushbutton; adjust A4R25 (BAT TEST CAL) for Model 419A Meter reading (0-3 scale) equal to DC Voltmeter reading in step b.

5-41. TROUBLESHOOTING.

5-42. This section contains information designed to assist in the isolation of malfunctions. These checks should be undertaken only after it has been established that the trouble cannot be eliminated by the Adjustment and Calibration Procedures, Paragraph 5-29.

NOTE

The 419A operates erratically when the charge on the batteries is marginal. Since the exact capacity of the Nickel Cadmium batteries cannot be determined by voltage measurements, it is advisable to charge the batteries before troubleshooting.

5-43. NO RESPONSE TO INPUT.

5-44. If the meter does not respond to input (usually accompanied by a constant offset near full scale after meter has been on for one or two minutes), proceed as follows:

a. If one neon is bad, all the pulses at A2TP2 will be the same amplitude. If the blocking oscillator is bad, there will be no pulses at A2TP2.

b. Check for approximately 8 volts dc at the emitter of Q4 to isolate between the blocking oscillator and its voltage regulator.

c. If the neon waveform at A2TP2 is correct, the trouble is in the amplifier.

5-45. POSITIVE OR NEGATIVE FOLDOVER.

5-46. Foldover is when the meter needle pegs and then returns on scale when the input is overloaded.

a. If positive foldover occurs, check A4Q12 for low gain.

b. If negative foldover occurs, check for low gain in A4Q13 and for a leaky A4C8 or C12.

5-47. EXCESSIVE NOISE.

5-48. If the 419A meter noise is in excess of 0.3 μV peak-to-peak, proceed as follows:

a. Check the batteries for low charge.

b. Check the chopper frequency in accordance with Paragraph 5-33. Misadjustment of chopper frequency or drive or a misfiring neon bulb will cause noise.

c. Clean the pin connectors on the A4 board with a fiberglass brush or typewriter eraser and ensure they are making good connections.

d. Check the transistors in the AC Amplifier for noise (A4Q1 or Q2 most probable).

5-49. TROUBLESHOOTING THE INPUT ATTENUATOR.

5-50. If trouble is suspected in the input attenuator or feedback divider, proceed as follows:

a. Rotate the range switch through all positions several times to clean the switch contacts.

b. Check the 90 MΩ resistor (S1R3) for dust accumulation; clean if necessary.

c. If trouble persists, carefully check the input attenuator and feedback divider resistors.

NOTE

Parallel paths exist for several of the resistors. Before replacing a suspected resistor, unsolder one lead and check the resistor again.

5-51. REPLACEMENT OF FACTORY SELECTED COMPONENTS.

5-52. Certain components within the Model 419A are individually selected in order to compensate for slightly varying circuit parameters. These components are identified by an asterisk (*) on the schematic diagrams and a typical value is shown. The following paragraphs describe the function of the factory selected components and give replacement instructions.

5-53. A4R26*.

5-54. A4R26* is factory selected to provide proper amplifier response time. Response time can be evaluated by performing the Response Time Test (Paragraph 5-13). A4R26* should be replaced only if response time cannot be corrected by performing the chopper adjustment procedure (Paragraphs 5-33). Paragraph 5-34 step e gives specific replacement instructions.

5-55. A4R47*.

5-56. A4R47* is factory selected to provide approximately 1.1 Vdc at the rear panel OUTPUT terminals into a 1 kΩ load with the LEVEL control turned fully cw and a full scale input applied to the INPUT terminals. Once A4R47* has been selected at the factory, there should be no reason to change its value unless one of the output transistors A4Q12 and A4Q13 or one of the diodes A4CR13 and A4CR14 is replaced. Factory values of A4R47* range from 16 kΩ to 20 kΩ with a typical value of 18 kΩ. A4R47* is an Allen-Bradley composition ±5% 1/2 watt resistor. If the value of A4R47* must be changed, proceed as follows:

a. Apply a 1 Vdc input to the Model 419A, INPUT terminals (1 V range).

b. Connect a 1 kΩ load across the rear panel OUTPUT terminals.

c. Turn LEVEL control fully cw.

d. Measure the voltage across the load. If the voltage is less than 1.0 Vdc, increase the value of A4R47*; if the voltage is greater than 1.15 Vdc, reduce the value of A4R47*.

e. After replacing A4R47*, perform the Full Scale Calibration procedure (Paragraph 5-37).

SECTION VI
CIRCUIT DIAGRAMS

6-1. INTRODUCTION.

6-2. This section contains the circuit diagrams necessary for the operation and maintenance of the Model 419A DC Null Voltmeter. Included are schematic and component location diagrams.

6-3. SCHEMATIC DIAGRAMS.

6-4. The electrical configuration of the 419A is shown on the schematic diagrams. Individual schematics are provided for the metering circuit and the power supply circuit.

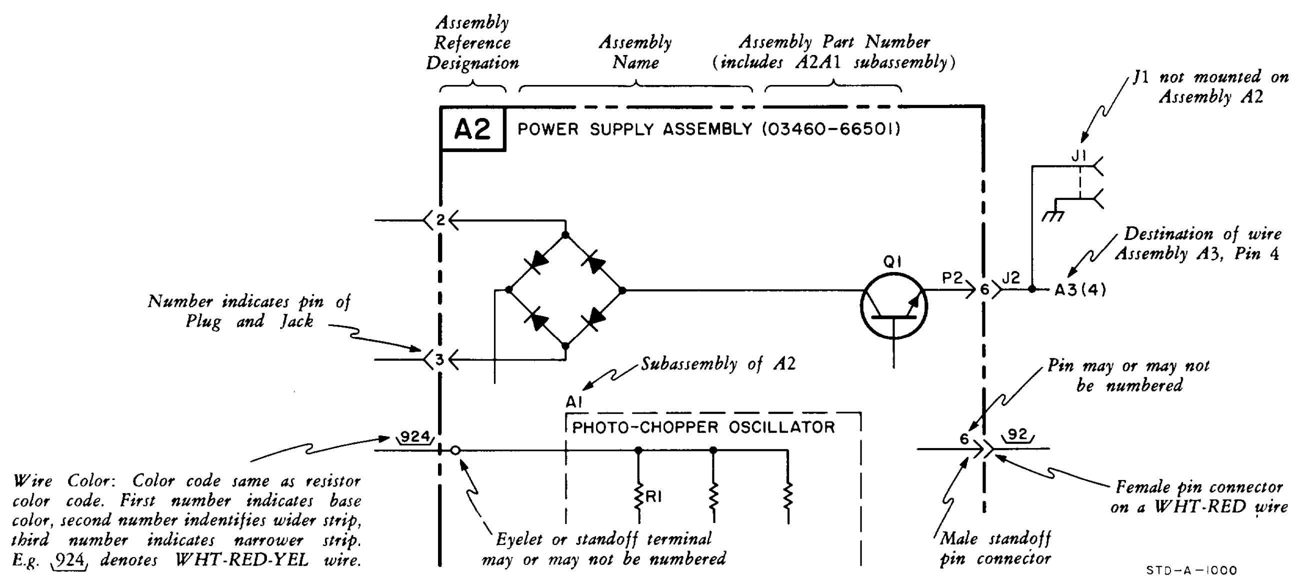
6-5. COMPONENT LOCATION DIAGRAMS.

6-6. The physical configuration of the 419A is shown on the component location diagrams. Each component is identified by reference designation.

REFERENCE DESIGNATIONS

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

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



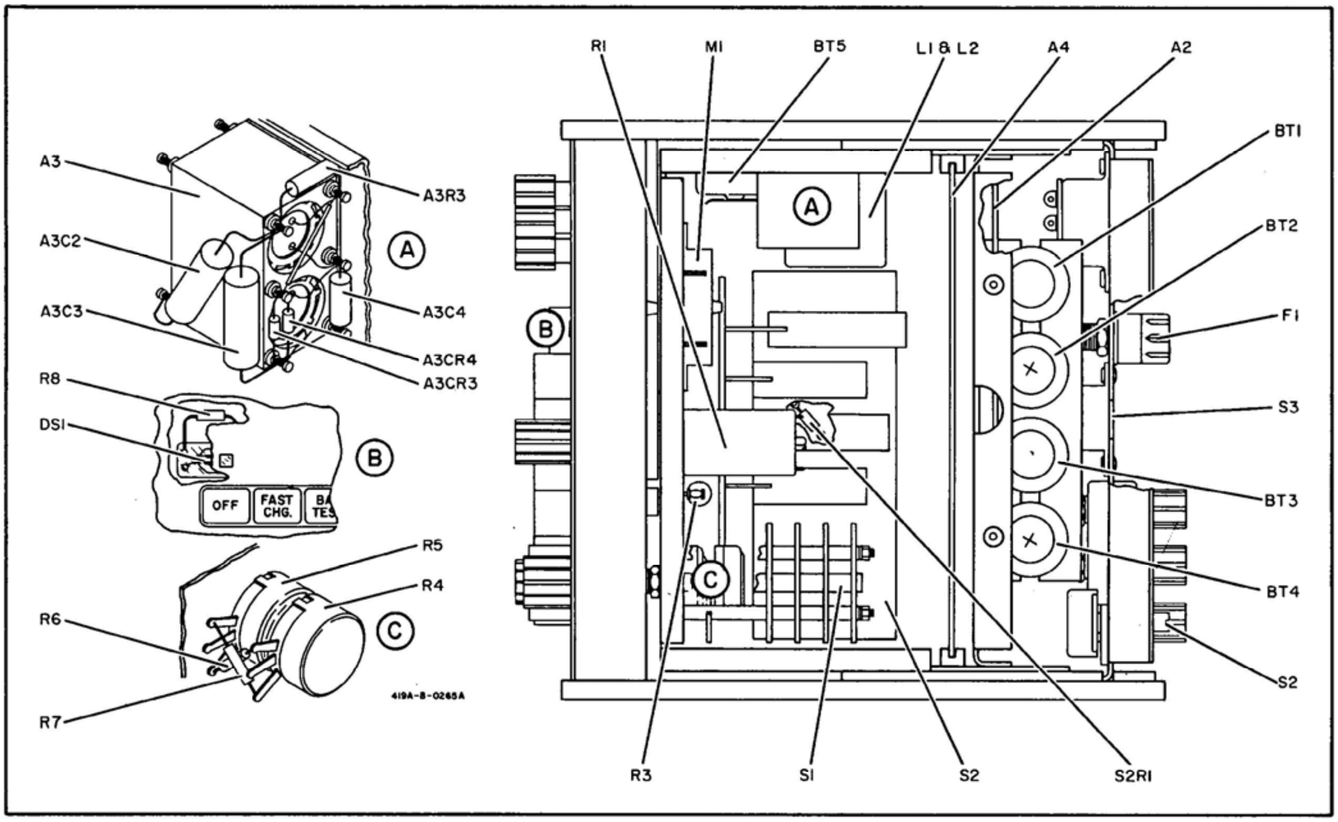


Figure 6-1. Model 419A, Component Location Diagram

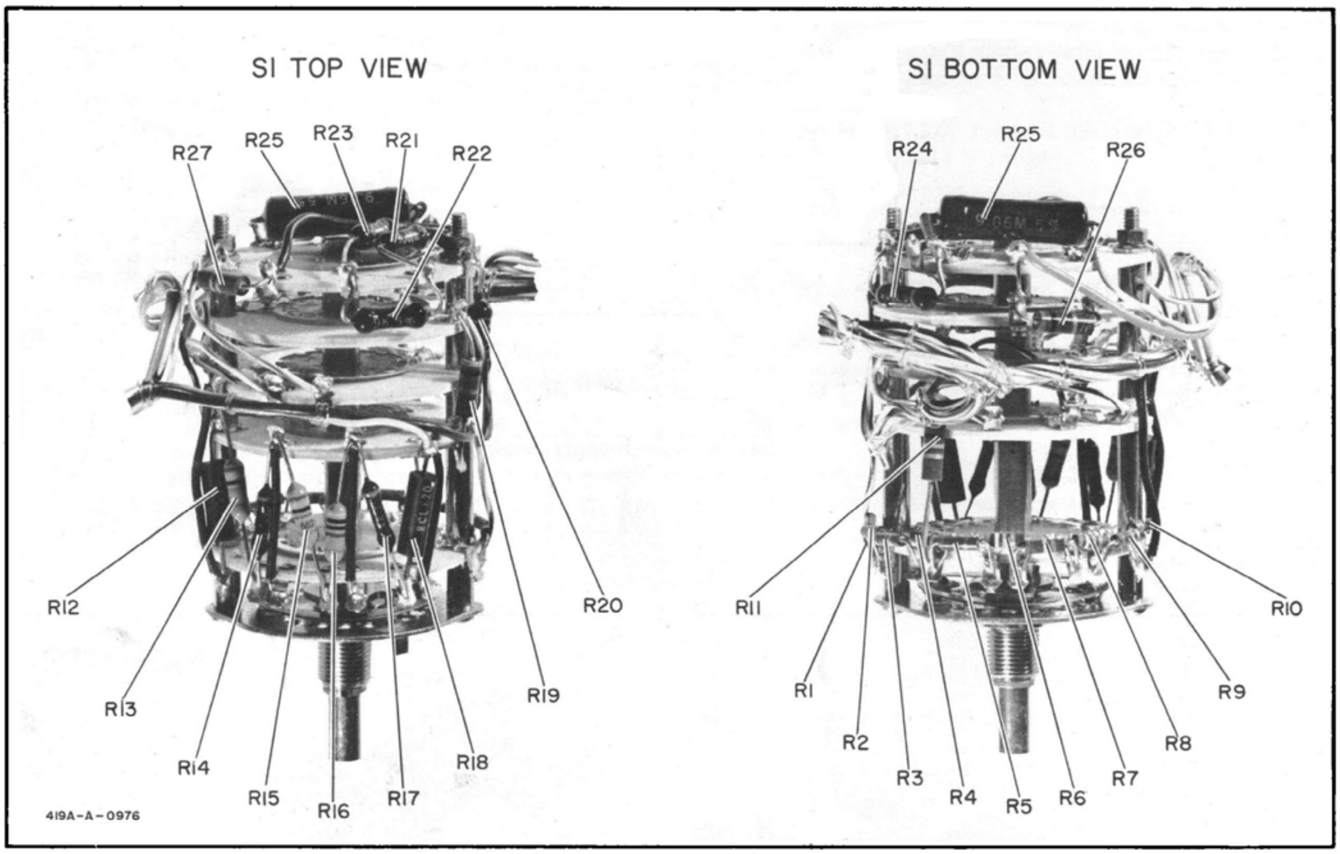
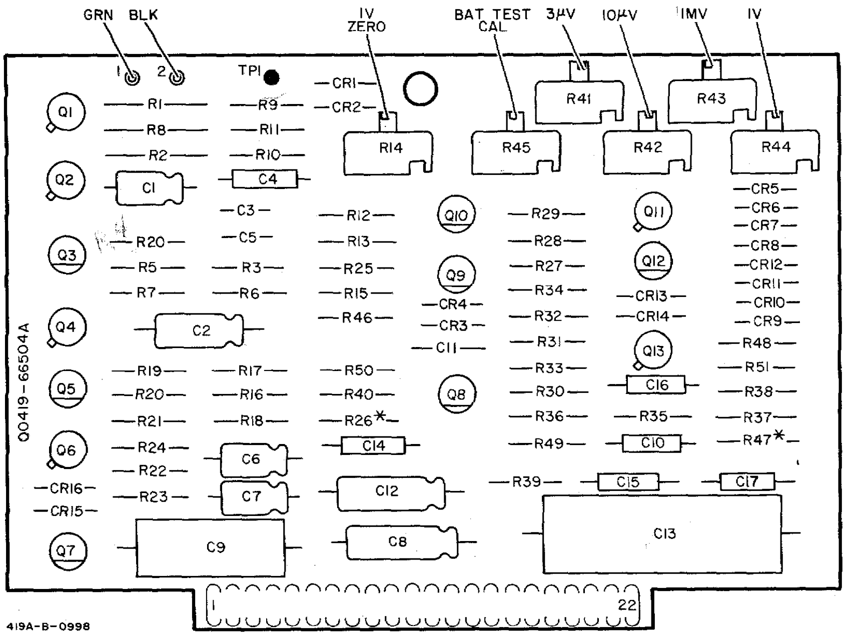
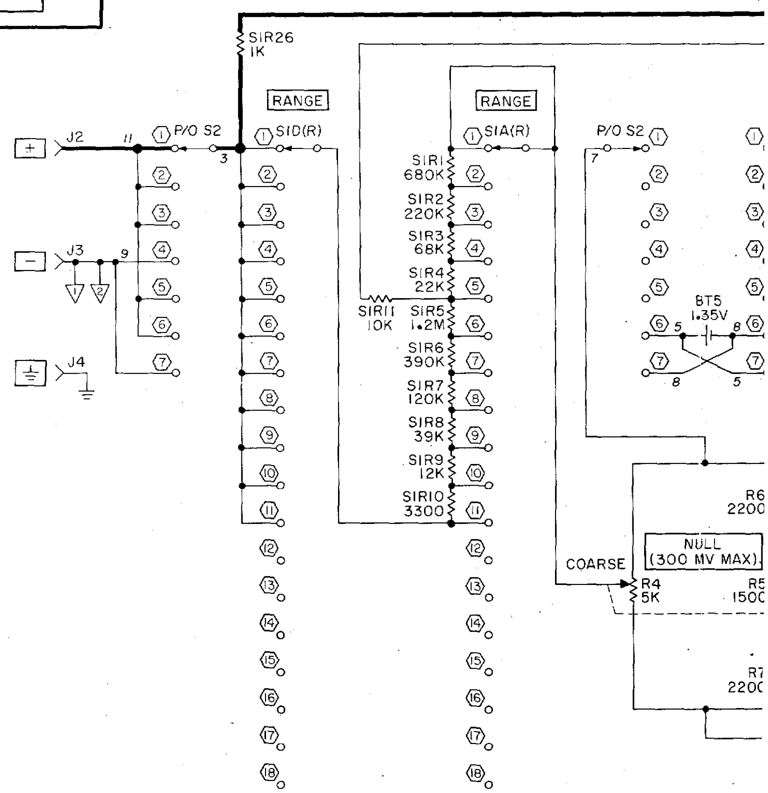


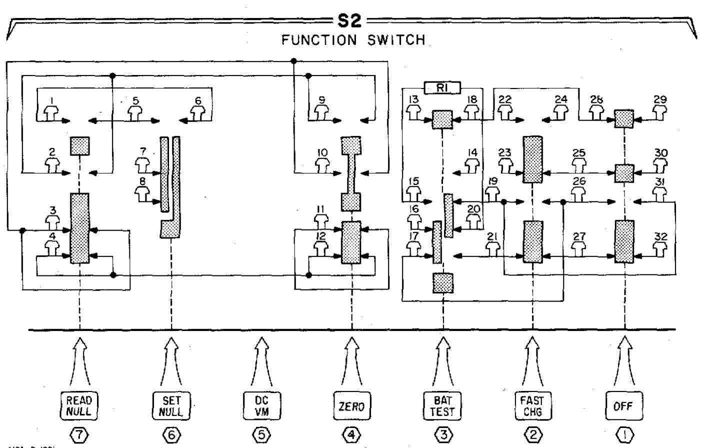
Figure 6-2. Range Switch S1, Component Location Diagram



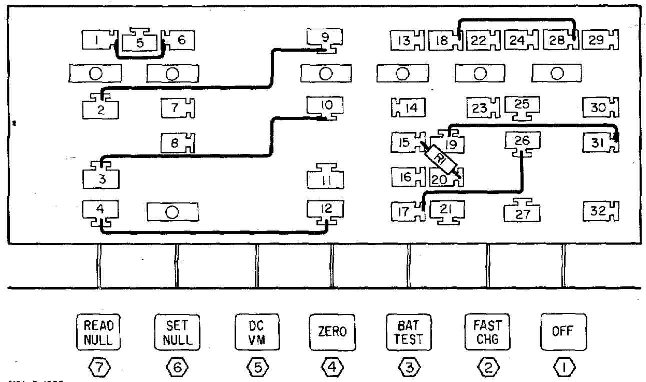
A4
(*hp* Part No. 00419 66504)

1. PARTIAL REFERENCE
WITH ASSEMBLY OR S
FOR COMPLETE DESI
2. COMPONENT VALUES
WISE NOTED.
RESISTANCE IN C
CAPACITANCE IN
3. DENOTES POWER
DENOTES POWER
DENOTES SIGNAL
4.
5. DENOTES FRO
DENOTES RE
6. DENOTES SCR

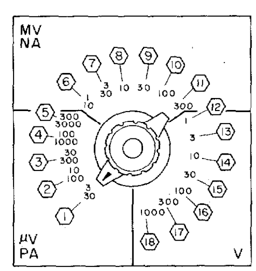


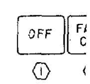


BOTTOM VIEW



S1
RANGE SWITCH





NOTES

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

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

   RESISTANCE IN OHMS

   CAPACITANCE IN MICROFARADS

3. ⏚ DENOTES POWER LINE (CHASSIS) GROUND.

   ▽ DENOTES POWER SUPPLY COMMON.

   ▽ DENOTES SIGNAL COMMON.

4. ———— — — ———— DENOTES ASSEMBLY.

   ━━━━━━━━ DENOTES MAIN SIGNAL PATH.

   —— —— —— —— DENOTES DC FEEDBACK PATH.

   —●—●—●— DENOTES AC FEEDBACK PATH.

5. [ ] DENOTES FRONT PANEL MARKING.

   [- - -] DENOTES REAR PANEL MARKING.

6. DENOTES SCREWDRIVER ADJUST.

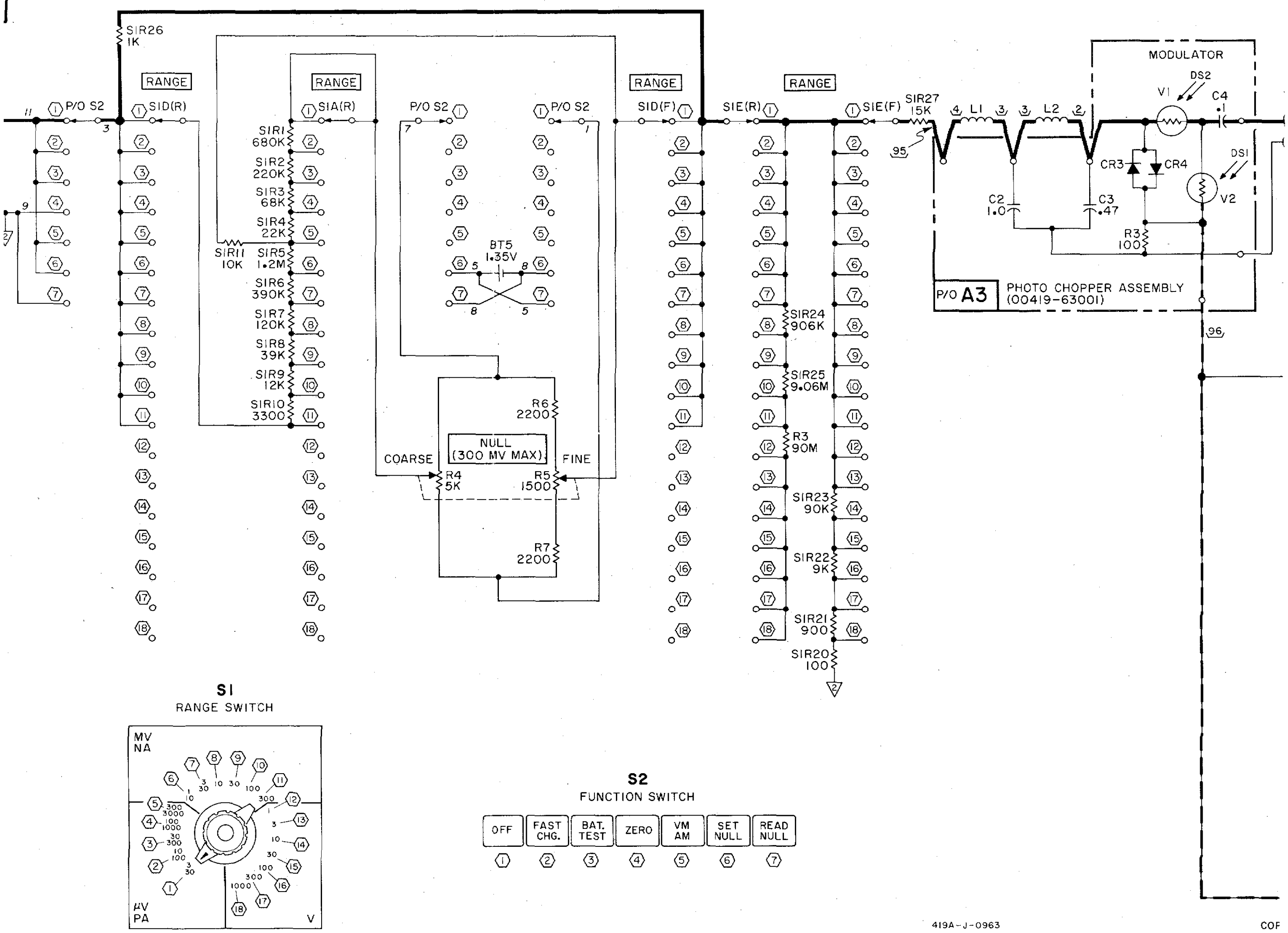
7. 924 DENOTES WIRE COLOR: COLOR CODE SAME AS RESISTOR COLOR CODE. FIRST NUMBER IDENTIFIES BASE COLOR, SECOND NUMBER IDENTIFIES WIDER STRIP, THIRD NUMBER IDENTIFIES NARROWER STRIP. (e.g. 924 =WHITE, RED, YELLOW.)

WIRE COLOR	
0	BLK
1	BRN
2	RED
3	ORN
4	YEL
5	GRN
6	BLU
7	VIO
8	GY
9	WHT

8. ✱ AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY. SEE PARAGRAPH 5-51 FOR REPLACEMENT INSTRUCTIONS.

9. DENOTES TWISTED PAIR.

10. VOLTAGES INDICATED IN RED ARE MEASURED WITH VM PUSHBUTTON DEPRESSED, 1 V RANGE, INPUT SHORTED. ALL VOLTAGES ARE ±10%.



— NOTES —

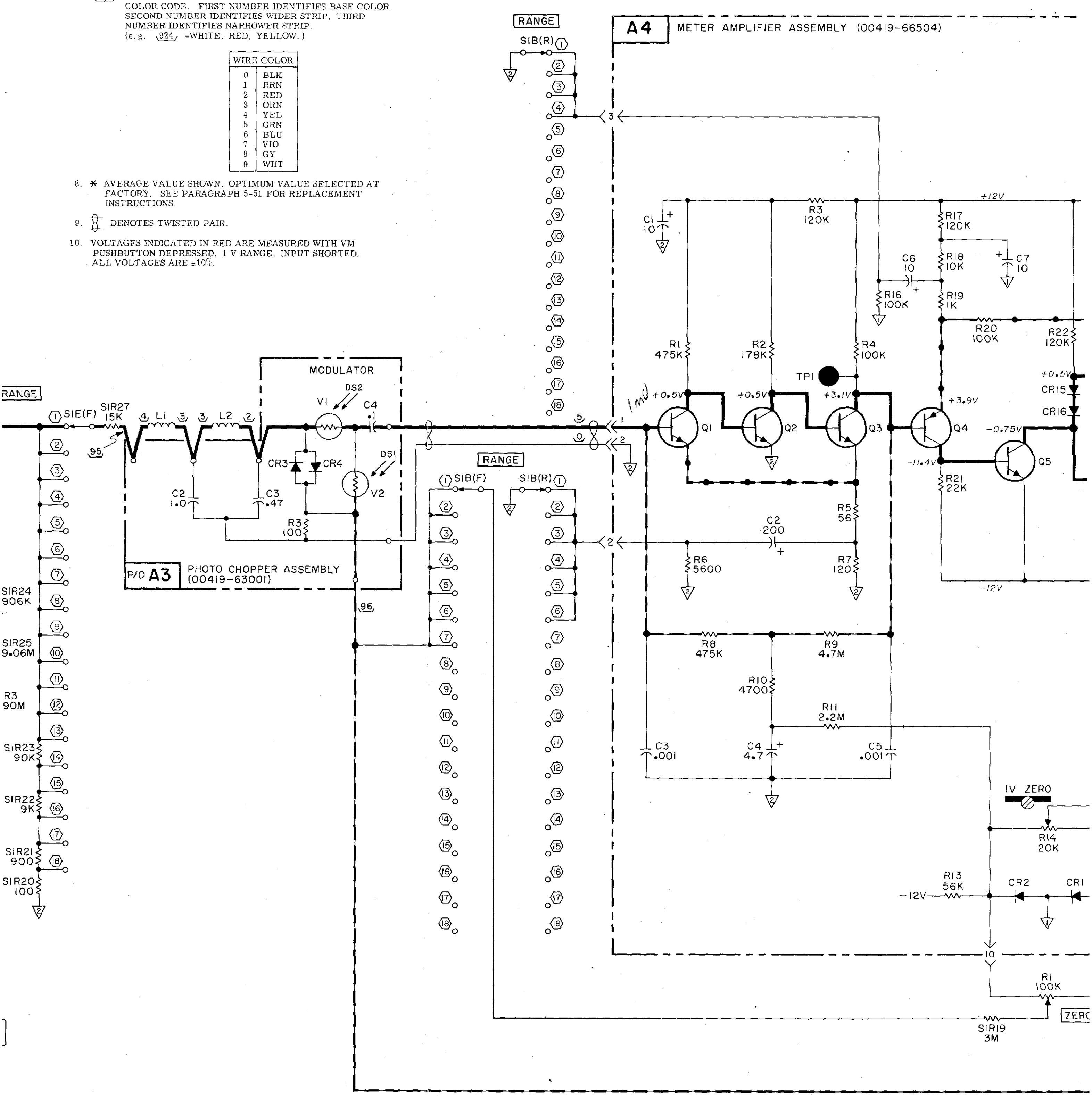
7. 924 DENOTES WIRE COLOR: COLOR CODE SAME AS RESISTOR COLOR CODE. FIRST NUMBER IDENTIFIES BASE COLOR, SECOND NUMBER IDENTIFIES WIDER STRIP, THIRD NUMBER IDENTIFIES NARROWER STRIP. (e.g. 924 =WHITE, RED, YELLOW.)

WIRE COLOR	
0	BLK
1	BRN
2	RED
3	ORN
4	YEL
5	GRN
6	BLU
7	VIO
8	GY
9	WHT

8. * AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY. SEE PARAGRAPH 5-51 FOR REPLACEMENT INSTRUCTIONS.

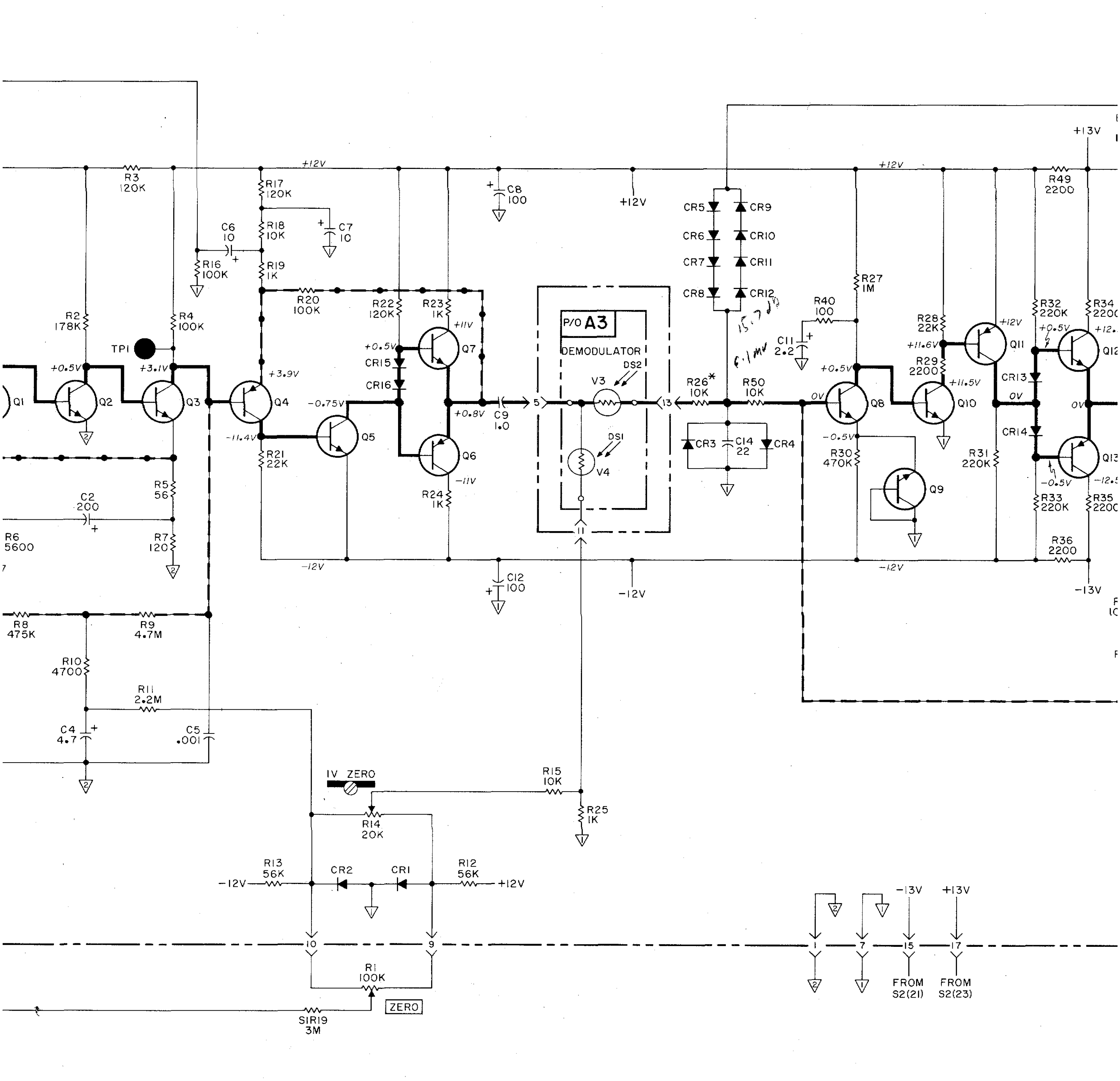
9. DENOTES TWISTED PAIR.

10. VOLTAGES INDICATED IN RED ARE MEASURED WITH VM PUSHBUTTON DEPRESSED, 1 V RANGE, INPUT SHORTED. ALL VOLTAGES ARE ±10%.



419A-J-0963

TER AMPLIFIER ASSEMBLY (00419-66504)



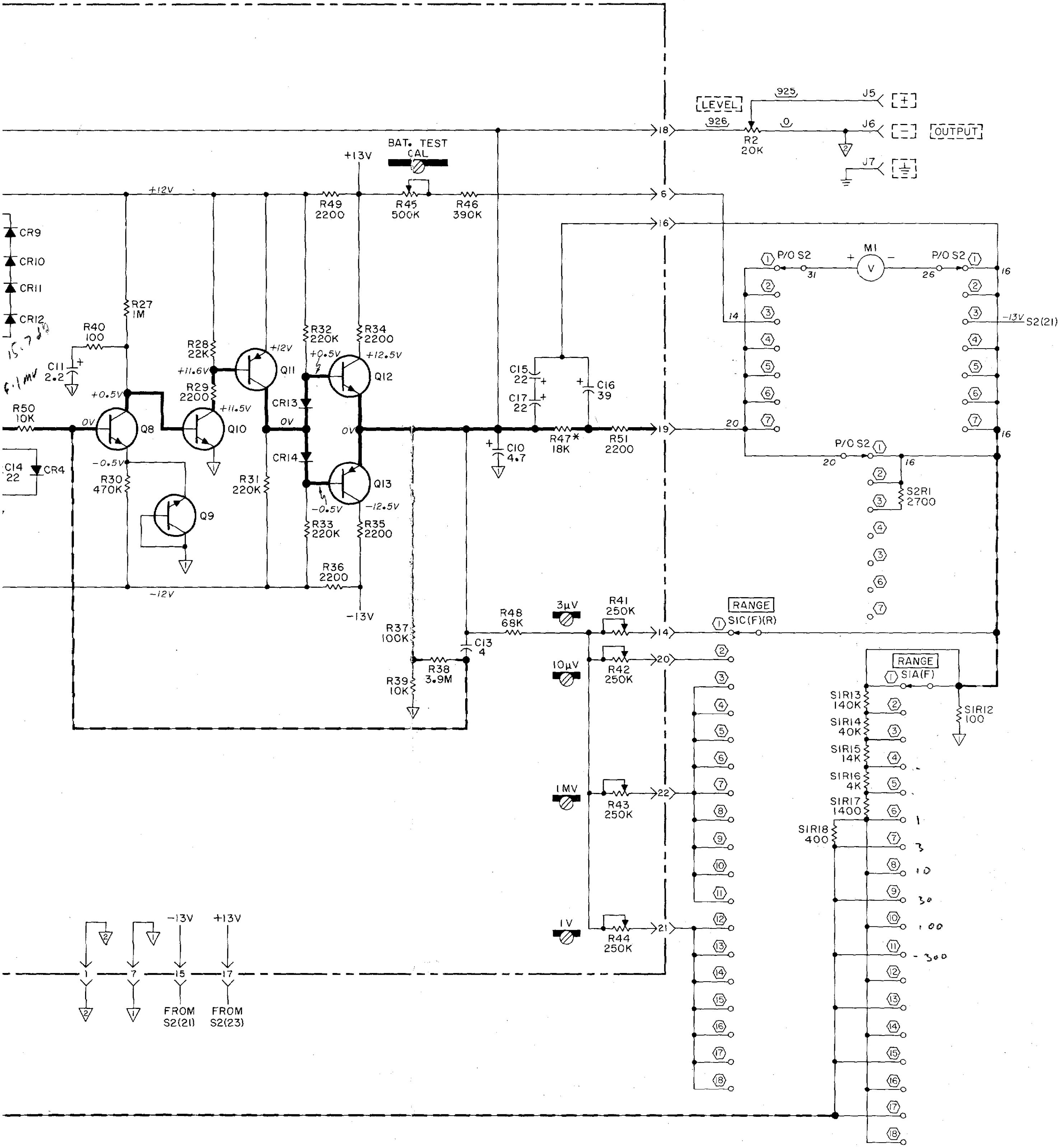
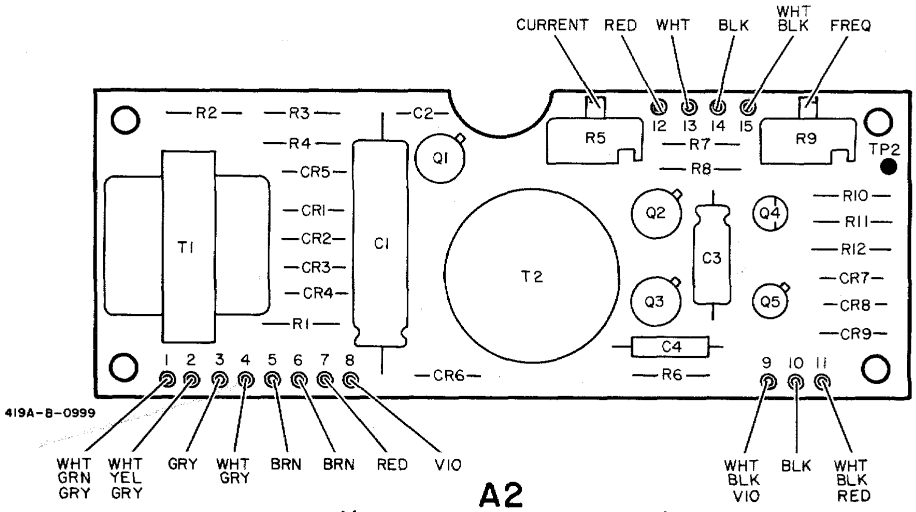


Figure 6-3. Amplifier and Amplifier Switching Schematic and Component Location Diagrams



A2
(*hp* Part No. 00419-66502)

—— NOTES ——

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

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

   RESISTANCE IN OHMS

   CAPACITANCE IN MICROFARADS

3. ⏚ DENOTES POWER LINE (CHASSIS) GROUND.

   ▽ DENOTES POWER SUPPLY COMMON.

4. ———— — — ———— DENOTES ASSEMBLY.

   — — — — — — — DENOTES SUBASSEMBLY.

   DENOTES COMPONENTS NOT MOUNTED ON ASSEMBLY.

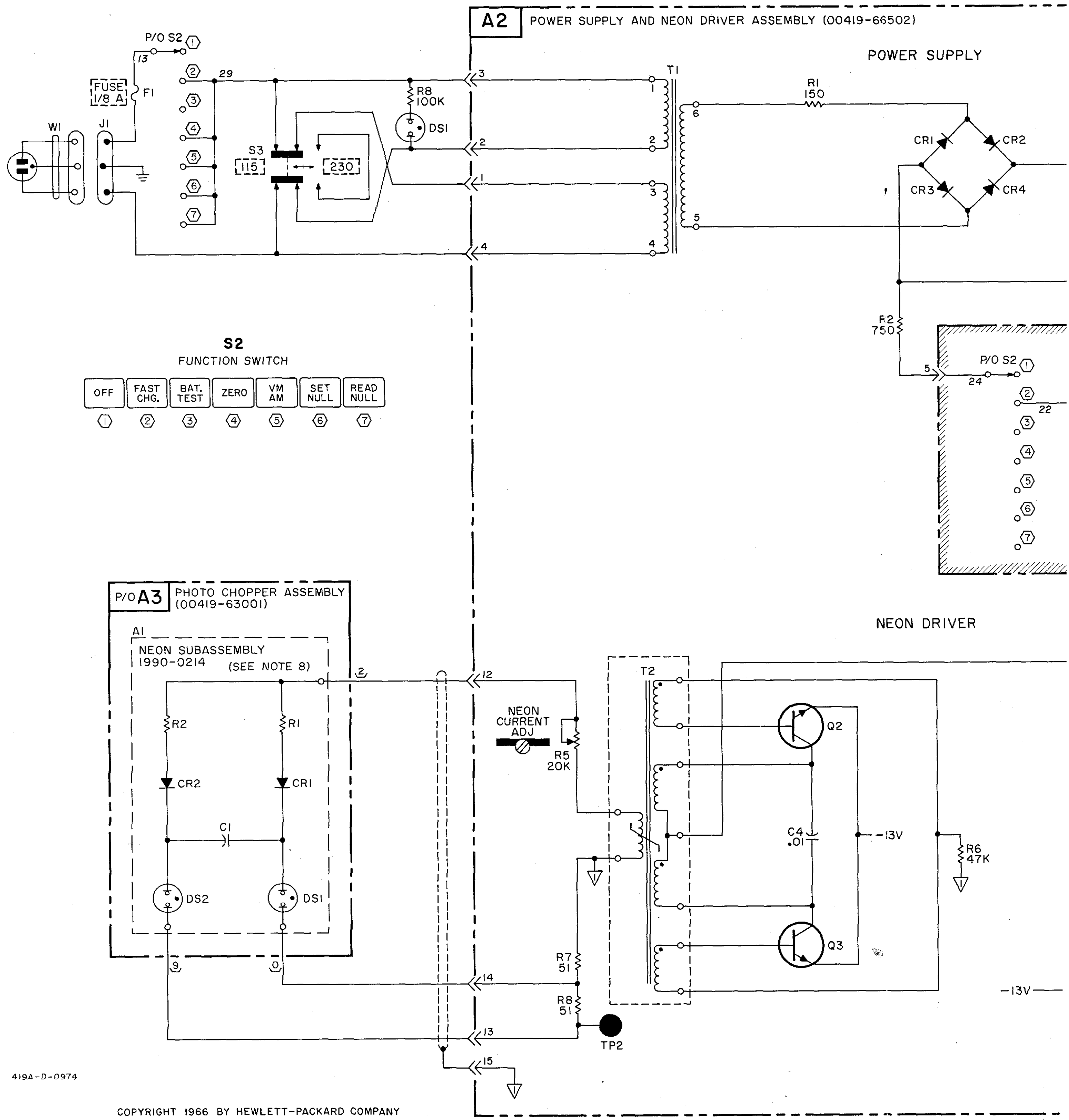
5. [- - - -] DENOTES REAR PANEL MARKING.

6. DENOTES SCREWDRIVER ADJUST.

7. 924 DENOTES WIRE COLOR: COLOR CODE SAME AS RESISTOR COLOR CODE. FIRST NUMBER IDENTIFIES BASE COLOR, SECOND NUMBER IDENTIFIES WIDER STRIP, THIRD NUMBER IDENTIFIES NARROWER STRIP. (e.g. 924 = WHITE, RED, YELLOW.)

WIRE	COLOR
0	BLK
1	BRN
2	RED
3	ORN
4	YEL
5	GRN
6	BLU
7	VIO
8	GY
9	WHT

8. INDIVIDUAL COMPONENTS ON A3A1 ARE NOT SEPARATELY REPLACEABLE. SEE PARAGRAPH 5-27.


A2
POWER SUPPLY AND NEON DRIVER ASSEMBLY (00419-66502)
POWER SUPPLY
P/O S2
FUSE 1/8 A
F1
W1
J1
S3
115
230
R8 100K
DS1
T1
R1 150
CR1
CR2
CR3
CR4
R2 750
S2
FUNCTION SWITCH
OFF
FAST CHG.
BAT. TEST
ZERO
VM AM
SET NULL
READ NULL
P/O A3
PHOTO CHOPPER ASSEMBLY (00419-63001)
A1
NEON SUBASSEMBLY 1990-0214
(SEE NOTE 8)
R2
R1
CR2
CR1
C1
DS2
DS1
NEON DRIVER
NEON CURRENT ADJ
R5 20K
T2
Q2
Q3
C4 .01
-13V
R6 47K
R7 51
R8 51
TP2
-13V

419A-D-0974

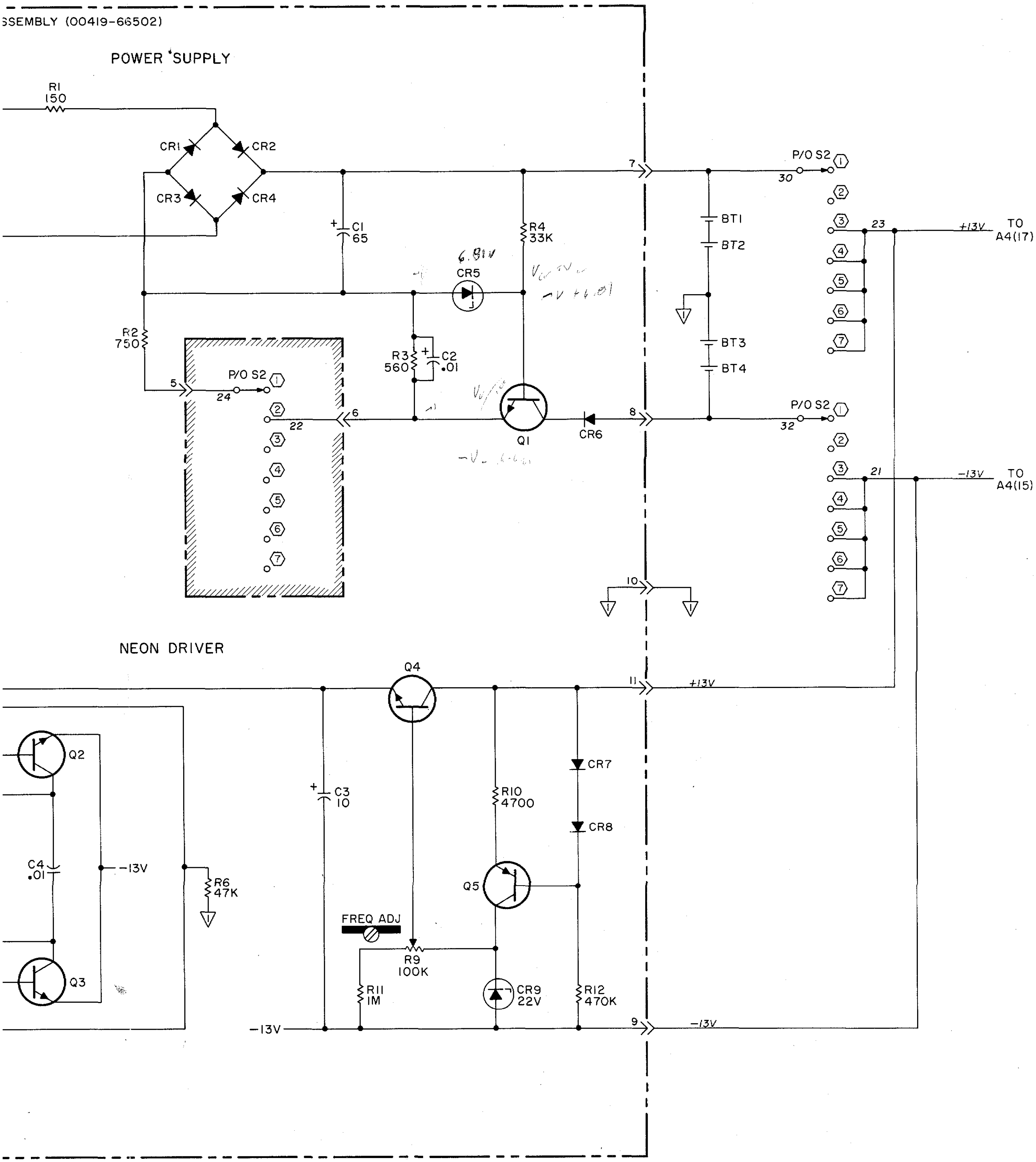


Figure 6-4. Power Supply and Neon Driver, Schematic and Component Location Diagrams

SECTION VII
REPLACEABLE PARTS

7-1. INTRODUCTION.

7-2. This section contains information for ordering replacement parts. Table 7-1 lists parts in alphameric order of their reference designators and indicates the description, -hp- part number of each part, together with any applicable notes, and provides the following:

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

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

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

d. Manufacturer's part number.

7-3. Miscellaneous parts are listed at the end of Table 7-1.

7-4. ORDERING INFORMATION.

7-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office. (See Appendix B for list of office locations.) Identify parts by their Hewlett-Packard part numbers. Include instrument model and serial numbers.

7-6. NON-LISTED PARTS.

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

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

DESIGNATORS

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

ABBREVIATIONS

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

® Dupont de Nemours

REV F

Table 7-1. Replaceable Parts

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1				Not Assigned		
A2	00419-66502		1	Assembly: Power Supply		
A2C1	0180-0149		1	C: fxd Al elect 65 μF +100% -10% 60 vdcw	56289	Type 30D obd
A2C2	0150-0093		1	C: fxd 0.01 μF +80% -20% 100 vdcw	91418	TA obd
A2C3	0180-0059		1	C: fxd elect 10 μF +100% -10% 25 vdcw	56289	30D106G025 BB4
A2C4	0160-0161		1	C: fxd 0.01 μF ±10%	56289	192P10392
A2CR1 thru A2CR4	1901-0025		2	Diode: Si 100 mA at +1 V 100 piV 12 pF	93332	D3072
A2CR5	1902-0048		1	Diode: breakdown 6.81 V ± 5%	07910	CD35658
A2CR6 thru A2CR8	1901-0025			Diode: Si 100 mA at +1 V 100 piV 12 pF	93332	D3072
A2CR9	1902-0563		1	Diode: breakdown 100 μA 22.1 V ±2%	04713	SZ11327
A2Q1 thru A2Q3	1854-0039		3	Transistor: NPN Si 2N3053	86684	2N3053
A2Q4	1854-0033		9	Transistor: NPN Si 2N3391	24446	2N3391
A2Q5	1853-0010		4	Transistor: PNP Si**	04713	SM4713
A2R1	0687-1511		1	R: fxd comp 150 Ω ±10% 1/2 W	01121	EB1511
A2R2	0686-7515		1	R: fxd comp 750 Ω ± 5% 1/2 W	01121	EB7515
A2R3	0687-5611		1	R: fxd comp 560 Ω ±10% 1/2 W	01121	EB5611
A2R4	0687-3331		1	R: fxd comp 33 kΩ ±10% 1/2 W	01121	EB3331
A2R5	2100-1410		5	R: var lin 20 kΩ ±30% 1/8 W	71450	XQS-200 obd
A2R6	0687-4731		1	R: fxd comp 47 kΩ ±10% 1/2 W	01121	EB4731
A2R7, A2R8	0686-5105		1	R: fxd comp 51 Ω ± 5% 1/2 W	01121	EB5105
A2R9	2100-0362		1	R: var lin 100 kΩ ±30% 1/8 W	71450	XQS-200 obd
A2R10	0687-4721		2	R: fxd comp 4700 Ω ±10% 1/2 W	01121	EB4721
A2R11	0687-1051		1	R: fxd comp 1 MΩ ±10% 1/2 W	01121	EB1051
A2R12	0687-4741		1	R: fxd comp 470 kΩ ±10% 1/2 W	01121	EB4741
A2T1	9100-0172		1	Transformer: power	28480	9100-0172
A2T2	9100-1319		1	Transformer: neon driver	28480	9100-1319
A3	00419-63001		1	Assembly: Photochopper	28480	00419-63001
A3A1	1990-0214		1	Subassembly: Neon Driver	28480	1990-0214
A3C1				Not Assigned		
A3C2	0160-0859		2	C: fxd my die 1.0 μF ±10% 50 vdcw	56289	148P obd
A3C3	0170-0064		1	C: fxd my die 0.47 μF ±10% 100 vdcw	56289	148P4791
A3C4	0160-2446		1	C: fxd poly die 0.1 μF ±20% 200 vdcw	84411	863 UW
A3CR1, A3CR2				Not Assigned		
A3CR3, A3CR4	1901-0156		2	Diode: Si 50 mA at 1 Vdc 20 piV	01281	PS5553
A3R1, A3R2				Not Assigned		
A3R3	0811-1505		2	R: fxd prec ww 100 Ω ±0.1% 1/2 W	01686	E-20 obd
A3V1 thru A3V4	00419-63001			Photocells: part of A3 (not separately replaceable)	28480	00419-63001
A4	00419-66504		1	Assembly: amplifier	28480	00419-66504
A4C1	0180-0224		3	C: fxd Al elect 10 μF +75% -10% 15 vdcw	56289	30D106G015 BA4
A4C2	0180-0060		1	C: fxd elect 200 μF +100% -10% 3 vdcw	56289	30D207G003 DC4
A4C3	0150-0069		2	C: fxd cer die 0.001 μF +100% -20% 500 vdcw	72982	#801-010X5G 0102Z
A4C4	0180-0100		1	C: fxd Ta die 4.7 μF ±10% 35 vdcw	56289	150D475X903 5B2
A4C5	0150-0069			C: fxd cer die 0.001 μF +100% -20% 500 vdcw	72982	#801-010X5G 0102Z

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A4C6, A4C7	0180-0224			C: fxd Al elect 10 µF +75% -10% 15 vdcw	56289	30D106G015 BA4	
A4C8	0180-0061		2	C: fxd elect 100 µF +100% -10% 15 vdcw	56289	30D107G015 DD4	
A4C9	0160-0859			C: fxd my die 1.0 µF ±10% 50 vdcw	56289	148P	obd
A4C10	0180-0100		1	C: fxd Ta die 4.7 µF ±10% 35 vdcw	56289	150D475X9035 B2	
A4C11	0180-0155		1	C: fxd Ta elect 2.2 µF ±20% 20 vdcw	56289	150D225X0020 AZ	
A4C12	0180-0061			C: fxd elect 100 µF +100% -10% 15 vdcw	56289	30D107G015 DD4	
A4C13	0160-0932		1	C: fxd my die 4 µF ±20% 30 vdcw	56289	Type 148P	
A4C14, A4C15	0180-0228		2	C: fxd Ta elect 22 µF ±10% 15 vdcw	56289	150D226X9015 B2-DYS	
A4C16	0180-0393		1	C: fxd Ta elect 39 µF ±10% 10 vdcw	56289	150D396X9010 B2-DYS	
A4C17	0180-0228			C: fxd Ta elect 22 µF ±10% 15 vdcw	56289	150D226X9015 B2-DYS	
A4CR1 thru A4CR16	1901-0025			Diode: Si 100 mA at +1 V 100 piV 12 pF	93332	D3072	
A4Q1, A4Q2	1854-0226		2	Transistor: NPN Si	56289	TN-56	
A4Q3	1854-0033			Transistor: NPN Si 2N3391	24446	2N3391	
A4Q4	1853-0010			Transistor: PNP Si**	04713	SM4713	
A4Q5	1854-0033			Transistor: NPN Si 2N3391	24446	2N3391	
A4Q6	1853-0010			Transistor: PNP Si**	04713	SM4713	
A4Q7 thru A4Q10	1854-0033			Transistor: NPN Si 2N3391	24446	2N3391	
A4Q11	1853-0010			Transistor: PNP Si**	04713	SM4713	
A4Q12	1854-0033			Transistor: NPN Si 2N3391	24446	2N3391	
A4Q13	1853-0010			Transistor: PNP Si**	04713	SM4713	
A4R1	0757-0374		2	R: fxd prec met flm 475 kΩ ±1% 1/2 W	19701	MF7C T-O	obd
A4R2	0757-0129		1	R: fxd prec met flm 178 kΩ ±1% 1/2 W	19701	MF7C T-O	obd
A4R3	0687-1241		3	R: fxd comp 120 kΩ ±10% 1/2 W	01121	EB1241	
A4R4	0687-1041		5	R: fxd comp 100 kΩ ±10% 1/2 W	01121	EB1041	
A4R5	0687-5601		1	R: fxd comp 56 Ω ±10% 1/2 W	01121	EB5601	
A4R6	0687-5621		1	R: fxd comp 5600 Ω ±10% 1/2 W	01121	EB5621	
A4R7	0687-1211		1	R: fxd comp 120 Ω ±10% 1/2 W	01121	EB1211	
A4R8	0757-0374			R: fxd prec met flm 475 kΩ ±1% 1/2 W	19701	MF7C T-O	obd
A4R9	0687-4751		1	R: fxd comp 4.7 MΩ ±10% 1/2 W	01121	EB4751	
A4R10	0687-4721			R: fxd comp 4700 Ω ±10% 1/2 W	01121	EB4721	
A4R11	0687-2251		1	R: fxd comp 2.2 MΩ ±10% 1/2 W	01121	EB2251	
A4R12, A4R13	0687-5631		2	R: fxd comp 56 kΩ ±10% 1/2 W	01121	EB5631	
A4R14	2100-1410			R: var lin 20 kΩ ±30% 1/8 W	71450	XQS-200	obd
A4R15	0687-1031		4	R: fxd comp 10 kΩ ±10% 1/2 W	01121	EB1031	
A4R16	0687-1041			R: fxd comp 100 kΩ ±10% 1/2 W	01121	EB1041	
A4R17	0687-1241			R: fxd comp 120 kΩ ±10% 1/2 W	01121	EB1241	
A4R18	0687-1031			R: fxd comp 10 kΩ ±10% 1/2 W	01121	EB1031	
A4R19	0687-1021		4	R: fxd comp 1000 Ω ±10% 1/2 W	01121	EB1021	
A4R20	0687-1041			R: fxd comp 100 kΩ ±10% 1/2 W	01121	EB1041	
A4R21	0687-2231		3	R: fxd comp 22 kΩ ±10% 1/2 W	01121	EB2231	
A4R22	0687-1241			R: fxd comp 120 kΩ ±10% 1/2 W	01121	EB1241	
A4R23 thru A4R25	0687-1021			R: fxd comp 1000 Ω ±10% 1/2 W	01121	EB1021	
A4R26*				See Paragraph 5-53			
A4R27	0687-1051			R: fxd comp 1 MΩ ±10% 1/2 W	01121	EB1051	
A4R28	0687-2231			R: fxd comp 22 kΩ ±10% 1/2 W	01121	EB2231	

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A4R29	0687-2221		7	R: fxd comp 2200 Ω ±10% 1/2 W	01121	EB2221
A4R30	0687-4741			R: fxd comp 470 kΩ ±10% 1/2 W	01121	EB4741
A4R31 thru A4R33	0687-2241		3	R: fxd comp 220 kΩ ±10% 1/2 W	01121	EB2241
A4R34 thru A4R36	0687-2221			R: fxd comp 2200 Ω ±10% 1/2 W	01121	EB2221
A4R37	0687-1041			R: fxd comp 100 kΩ ±10% 1/2 W	01121	EB1041
A4R38	0687-3951		2	R: fxd comp 3.9 MΩ ±10% 1/2 W	01121	EB3951
A4R39	0687-1031			R: fxd comp 10 kΩ ±10% 1/2 W	01121	EB1031
A4R40	0687-1011			R: fxd comp 100 Ω ±10% 1/2 W	01121	EB1011
A4R41 thru A4R44	2100-1795			R: var comp lin 250 kΩ ±20% 1/8 W	71450	QS 200
A4R45	2100-1470		1	R: var lin 500 kΩ ±30% 1/10 W	71450	XQS-200 obd
A4R46	0687-3941		1	R: fxd comp 390 kΩ ±10% 1/2 W	01121	EB3941
A4R47*				See Paragraph 5-55		
A4R48	0687-6831		1	R: fxd comp 68 kΩ ±10% 1/2 W	01121	EB6831
A4R49	0687-2221			R: fxd comp 2200 Ω ±10% 1/2 W	01121	EB2221
A4R50	0687-1031			R: fxd comp 10 kΩ ±10% 1/2 W	01121	EB1031
A4R51	0687-2221			R: fxd comp 2200 Ω ±10% 1/2 W	01121	EB2221
BT1 thru BT4	1420-0015		4	Battery: rechargeable nickel cadmium 6.25 V	61637	Y-5201
BT5	1420-0004		1	Battery: mercury 1.34 V cylindrical	09569	316469
DS1	2140-0008		1	Lamp: glow type NE-2 neon	28480	2140-0008
F1	2110-0027		1	Fuse: cartridge 1/8 amp 250 V	75915	312.125
J1	1251-0148		1	Connector: ac power cord receptacle	0000U	H-1061-2
J2	5080-1278		1	Binding Post: red with solder turret (+ INPUT)	28480	5080-1278
	0340-0159		2	Insulator Cup: binding post	28480	0340-0159
	0340-0100		2	Insulator Spacer: binding post	28480	0340-0100
	00419-21701		2	Guard: binding post, threaded	28480	00419-21701
J3	5080-1277			Binding Post: black with solder turret (- INPUT)	28480	5080-1277
	0340-0159			Insulator Cup: binding post	28480	0340-0159
	0340-0100			Insulator Spacer: binding post	28480	0340-0100
	00419-21701			Guard: binding post, threaded	28480	00419-21701
J4	1510-0011		3	Binding Post: black with solder turret (⏚)	28480	1510-0011
	0340-0099		1	Insulator: binding post	28480	0340-0099
J5	1510-0010		1	Binding Post: red with solder turret (+ OUTPUT)	28480	1510-0010
J6	1510-0011			Binding Post: black with solder turret (- OUTPUT)	28480	1510-0011
J7	1510-0011			Binding Post: black with solder turret (⏚)	28480	1510-0011
	0340-0086		*1*	*Insulator: binding post, dual*	*28480*	*0340-0086*
	0340-0091		1	Insulator: binding post, triple	28480	0340-0091
L1, L2	9100-1318		1	Inductor: input	28480	9100-1318
M1	1120-0312		1	Meter	28480	1120-0312
R1	2100-1557		1	R: var prec ww 10 turn 100 kΩ ±5% 2 W	12697	Series 62 CM 33147
R2	2100-2200		1	R: var lin 20 kΩ ±20% 1/3 W	71450	Series 45
R3	0698-3463		1	R: fxd prec c flm 90 MΩ ±1% 2 W	03888	HV2000 obd
R4, R5	2100-2199		2	R: var comp 2 sect lin tandem ganged 1500 Ω and 5000 Ω ±20%	12697	Series 53M
R6, R7	0687-2221			R: fxd comp 2200 Ω ±10% 1/2 W	01121	EB2221
R8	0687-1041			R: fxd comp 100 kΩ ±10% 1/2 W	01121	EB1041
R9	0687-2721		1	R: fxd comp 2700 Ω ±10% 1/2 W	01121	EB2721

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
S1	00419-61901		1	Switch Assembly: range	28480	00419-61901
S1R1	0683-6845		1	R: fxd comp 680 kΩ ±5% 1/4 W	01121	CB6845
S1R2	0684-2241		1	R: fxd 220 kΩ ±10% 1/4 W	01121	CB2241
S1R3	0684-6831		1	R: fxd comp 68 kΩ ±10% 1/4 W	01121	CB6831
S1R4	0684-2231		1	R: fxd comp 22 kΩ ±10% 1/4 W	01121	CB2231
S1R5	0683-1255		1	R: fxd comp 1.2 MΩ ±5% 1/4 W	01121	CB1255
S1R6	0684-3941		1	R: fxd comp 390 kΩ ±10% 1/4 W	01121	CB3941
S1R7	0683-1245		1	R: fxd comp 120 kΩ ±5% 1/4 W	01121	CB1245
S1R8	0683-3935		1	R: fxd comp 39 kΩ ±5% 1/4 W	01121	CB3935
S1R9	0684-1231		1	R: fxd comp 12 kΩ ±10% 1/4 W	01121	CB1231
S1R10	0684-3321		1	R: fxd comp 3300 Ω ±10% 1/4 W	01121	EB3321
S1R11	0687-1031			R: fxd 10 kΩ ±10% 1/2 W	01121	EB1031
S1R12	0811-1505			R: fxd prec ww 100 Ω ±0.1% 1/2 W	01686	E-20 obd
S1R13	0698-3373		1	R: fxd met flm 140 kΩ ±0.25% 1/4 W	19701	MF6C T-O obd
S1R14	0698-3372		1	R: fxd prec met flm 40 kΩ ±0.25% 1/4 W	19701	MF6C T-O obd
S1R15	0698-3371		1	R: fxd prec met flm 14 kΩ ±0.25% 1/4 W	19701	MF6C T-O obd
S1R16	0698-3370		1	R: fxd prec met flm 4000 Ω ±0.25% 1/4 W	19701	MF6C T-O obd
S1R17	0698-3369		1	R: fxd prec met flm 1400 Ω ±0.25% 1/4 W	19701	MF6C T-O obd
S1R18	0811-1506		1	R: fxd prec ww 400 Ω ±0.1% 1/4 W	01686	E-20 obd
S1R19	0686-3051		1	R: fxd 3.0 MΩ ±5% 1/2 W	01121	EB3055
S1R20	0698-3363		1	R: fxd prec c flm 100 Ω ±0.5% 1/2 W	94459	CVS obd
S1R21	0698-3364		1	R: fxd prec c flm 900 Ω ±0.5% 1/2 W	94459	CVS obd
S1R22	0698-3365		1	R: fxd prec c flm 9000 Ω ±0.5% 1/2 W	94459	CVS obd
S1R23	0698-3366		1	R: fxd prec c flm 90 kΩ ±0.5% 1/2 W	94459	CVS obd
S1R24	0698-3367		1	R: fxd prec c flm 906 kΩ ±0.5% 1/2 W	94459	CVS obd
S1R25	0698-3368		1	R: fxd prec c flm 9.06 MΩ ±0.5% 1 W	91637	DC-1 obd
S1R26	0686-1025		1	R: fxd comp 1000 Ω ±5% 1/2 W	01121	EB1025
S1R27	0687-1531		1	R: fxd comp 15 kΩ ±10% 1/2 W	01121	EB1531
S2	3101-0803		1	Switch: pushbutton function	76854	obd
S3	3101-0033		1	Switch: slide DPDT non-shorting 0.5 amp 125 Vdc 3 amp 125 Vac	42190	4633
W1	8120-0078		1	Cable Assembly: power	70903	KH-4147
				<u>MISCELLANEOUS</u>		
	1251-0172		1	Connector: 22 ribbon type contacts	07233	250-22-30-210
	5000-0716		1	Cover: bottom 7 x 8	28480	5000-0716
	5000-0702		2	Cover: side 6 x 8	28480	5000-0702
	5060-0717		1	Cover: top 7 x 8	28480	5060-0717
	241A-44A		1	Foot Assembly: half module	28480	241A-44A
	5060-0728		1	Foot Assembly: half module (front)	28480	5060-0728
	5040-4524		1	Holder: battery (BT1 thru BT4)	28480	5040-4524
	5040-0615		1	Holder: battery phenolic base (BT5)	28480	5040-0615
	1400-0084		1	Holder: fuse extractor post type	74915	342014
	00419-04301		1	Insert: RANGE	28480	00419-04301
	0370-0121		7	Knob: pushbutton rectangular gray plastic	28480	0370-0121
	0370-0137		2	Knob: round 5/8" diam black (ZERO and NULL)	28480	0370-0137
	0370-0112		1	Knob: skirted bar 3/4" diam black (RANGE)	28480	0370-0112
	5000-3217		1	Label: pushbutton BAT. TEST	28480	5000-3217
	5000-3216		1	Label: pushbutton FAST CHG.	28480	5000-3216

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
	5000-0251		1	Label: pushbutton OFF	28480	5000-0251
	5000-3213		1	Label: pushbutton READ NULL	28480	5000-3213
	5000-3214		1	Label: pushbutton SET NULL	28480	5000-3214
	5000-3345		1	Label: pushbutton VM/ AM	28480	5000-3345
	5000-3215		1	Label: pushbutton ZERO	28480	5000-3215
	00419-90002		1	Manual: Operating and Service	28480	00419-90002
	00419-00201		1	Panel: front	28480	00419-00201
	00419-00202		1	Panel: rear	28480	00419-00202
	00419-00606		1	Shield: bottom	28480	00419-00606
	00419-00601		1	Shield: front	28480	00419-00601
	00419-00602		1	Shield: rear	28480	00419-00602
	00419-00604		1	Shield: side left	28480	00419-00604
	00419-00603		1	Shield: side right	28480	00419-00603
	00419-00605		1	Shield: top	28480	00419-00605
	1490-0032		1	Stand: half module tilt stainless steel rod	91260	obd

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

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

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00334	Humidail Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	*Sangamo Electric Company, Ordill Division (Capacitors)*	*Marion, Ill.*
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp	Rockford, Ill.
01961	*Pulse Engineering Co.*	*Santa Clara, Calif.*
02114	*Ferroxcube Corp. of America*	*Saugerties, N.Y.*
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	*Pyrofilm Resistor Co.*	*Morristown, N.J.*
03954	*Air Marine Motors, Inc.*	*Los Angeles, Calif.*
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04354	Precision Paper Tube Co.	Chicago, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	*Motorola, Inc., Semiconductor Prod. Div.*	Phoenix, Arizona
04732	Filtron Co., Inc., Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04777	Automatic Electric Sales Corp.	Northlake, Ill.
04796	Sequoia Wire & Cable Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P. M. Motor Company	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	*Illumitronic Engineering Co.*	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metropolitan Telecommunications Corp., Metro Cap. Division	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06475	Western Devices, Inc.	Inglewood, Calif.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06751	U. S. Semcor Division of Nuclear Corp. of America	Phoenix, Arizona
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07115	*Corning Glass Works* Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	*Filmohm Corp.*	*New York, N.Y.*
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	The Birtcher Corp.	Los Angeles, Calif.
07700	*Technical Wire Products*	*Springfield, N.J.*
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	*U.S. Engineering Co.*	*Los Angeles, Calif.*
08289	Blinn, Delbert, Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada.
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co., Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S., Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atohm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	*Mallory Battery Co. of* Canada, Ltd.	Toronto, Ontario, Canada
09664	The Bristol Co.	Waterbury, Conn.
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronic, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation *Semiconductor Division*	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N.J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13103	Thermolloy	Dallas, Texas
13396	Telefunken (G.M.B.H.)	Hannover, Germany
13835	Midland Mfg. Co.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14655	*Cornell Dubilier Elec. Corp.*	*So. Plainfield, N.J.*
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co. Inc.	Brooklyn, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15909	The Daven Co.	Livingston, N.J.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16352	Computer Diode Corp.	Lodi, N.J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	*Tranex Company*	*Mountain View, Calif.*
18486	Radio Industries	Des Plaines, Ill.
18583	Curtis Instrument Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21226	Executive, Inc.	New York, N.Y.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	*Fed. Telephone and Radio Corp.*	*Clifton, N.J.*
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	*General Radio Co.*	*West Concord, Mass.*
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	*Lectrohm Inc.*	*Chicago, Ill.*
36196	Stanwyck Corp.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	*Ohmite Mfg. Co.*	*Skokie, Ill.*
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Baltimore, Md.
63743	*Ward Leonard Electric*	*Mt. Vernon, N.Y.*
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	*St. Paul, Minn.*
59730	Thomas & Betts Co.	Elizabeth 1, N.J.
60741	Tripplett Electrical Inc.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	*Mt. Vernon,* N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66295	Wittek Manufacturing Co.	Chicago 23, Ill.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70319	*Allmetal Screw Prod. Co., Inc.*	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C.P. Clare & Co.	*Chicago, Ill.*
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72092	Eitel-McCullough, Inc.	San Bruno, Calif.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
71707	*Coto Coil Co., Inc.*	*Providence, R.I.*
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72699	General Instrument Corp., Semiconductor Div.	Newark, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	*Chicago, Ill.*
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	*Hughes Products Division of* Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co, Inc.	Hicksville, N.Y.
73490	Beckman Helipot Corp.	So. Pasadena, Calif.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Prod. Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	*Jennings Radio Mfg. Co.*	*San Jose, Calif.*
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	*Littlefuse Inc.*	*Des Plaines, Ill.*
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phaostran Instrument and *Electronic Co.*	*South Pasadena, Calif.*
77250	Phoell Mfg. Co.	Chicago, Ill.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	*Struthers-Dunn Inc.*	*Pitman, N.J.*
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	*Mepco Division of Sessions* Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association. Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W.L. Maxson Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	*All Star Products Inc.*	*Defiance, Ohio*
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.

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APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

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

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

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

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SALES AND SERVICE OFFICES
UNITED STATES and CANADA

ALABAMA
Huntsville, 35802
2003 Byrd Spring Rd. S.W.
(205) 881-4591
TWX: 510-579-2204

ALASKA
Bellevue, Wash. 98004
11656 N.E. 8th Street
(206) 454-3971
TWX: 910-443-2303

ARIZONA
Scottsdale, 85251
3009 No. Scottsdale Rd.
(602) 945-7601
TWX: 602-949-0111

Tucson, 85716
232 So. Tucson Blvd.
(602) 623-2564
TWX: 602-792-2759

CALIFORNIA
North Hollywood, 91604
3939 Lankershim Blvd.
(213) 877-1282 and 766-3811
TWX: 910-499-2170

Sacramento, 95821
2591 Carlsbad Ave.
(916) 482-1463
TWX: 916-444-8683

San Diego, 92106
1055 Shafter Street
(714) 223-8103
TWX: 714-276-4263

Palo Alto, 94303
1101 Embarcadero Rd.
(415) 327-6500
TWX: 910-373-1280

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

CONNECTICUT
Middletown, 06457
589 Saybrook Rd.
(203) 346-6611
TWX: 710-428-2036

FLORIDA
Miami, 33125
2907 Northwest 7th St.
(305) 635-6461

Orlando, 32803
621 Commonwealth Ave.
(305) 425-5541
TWX: 305-841-2568

St. Petersburg, 33708
410-150th Ave., Madeira Beach
(813) 391-0211 and 391-1829
TWX: 813-391-0666

GEORGIA
Atlanta, 30305
3110 Maple Drive, N.E.
(404) 233-1141
TWX: 810-751-3283

HAWAII
North Hollywood, Calif. 91604
3939 Lankershim Blvd.
(213) 877-1282
TWX: 910-499-2170

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

INDIANA
Indianapolis, 46205
3919 Meadows Dr.
(317) 546-4891
TWX: 317-635-4300

LOUISIANA
New Orleans
(504) 522-4359

MARYLAND
Baltimore, 21207
6660 Security Blvd.
(301) 944-5400
TWX: 710-862-0850

Rockville, 20852
12303 Twinbrook Pkwy.
(301) 427-7560
TWX: 710-828-9684

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

MICHIGAN
Southfield, 48076
24315 Northwestern Hwy.
(313) 353-9100
TWX: 313-357-4425

MINNESOTA
St. Paul, 55114
2459 University Ave.
(612) 646-7881
TWX: 910-563-3734

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

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

NEW JERSEY
Eatontown, 07724
(201) 747-1060

Englewood, 07631
391 Grand Avenue
(201) 567-3933
TWX: 510-230-9709

NEW MEXICO
Albuquerque, 87108
6501 Lomas Blvd., N.E.
(505) 255-5586
TWX: 910-989-1655

Las Cruces, 88001
114 S. Water Street
(505) 526-2486
TWX: 910-983-0550

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

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

Poughkeepsie, 12601
82 Washington Street
(914) 454-7330
TWX: 914-452-7425

Syracuse, 13211
5858 East Molloy Rd.
(315) 454-2486
TWX: 710-541-0482

Endicott, 13764
1219 Campville Rd.
(607) 754-0050
TWX: 510-252-0890

NORTH CAROLINA
High Point, 27262
1923 N. Main Street
(919) 882-6873
TWX: 510-926-1516

OHIO
Cleveland, 44129
5579 Pearl Road
(216) 884-9209
TWX: 216-888-0715

Dayton, 45409
1250 W. Dorothy Lane
(513) 298-0351
TWX: 513-944-0090

OKLAHOMA
Oklahoma City
(405) 235-7062

PENNSYLVANIA
Camp Hill
(717) 737-6791

West Conshohocken, 19428
144 Elizabeth Street
(215) 248-1600 and 828-6200
TWX: 518-660-8715

Monroeville, 15146
Monroe Complex
Building 2
Suite 2
Moss Side Blvd.
(412) 271-5227
TWX: 710-797-3650

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

Houston, 77027
P.O. Box 22813, 4242 Richmond Ave.
(713) 667-2407
TWX: 713-571-1353

UTAH
Salt Lake City, 84115
1482 Major St.
(801) 486-8166
TWX: 801-521-2604

VIRGINIA
Richmond, 23230
2112 Spencer Road
(703) 282-5451
TWX: 710-956-0157

WASHINGTON
Bellevue, 98004
11656 N.E. 8th St.
(206) 454-3971
TWX: 910-443-2303

GOVERNMENT CONTRACTING OFFICE
San Antonio, Texas 78226
Hewlett-Packard
Contract Marketing Division
225 Billy Mitchell Road
(512) 434-4171
TWX: 512-571-0955

CANADA
Montreal, Quebec
Hewlett-Packard (Canada) Ltd.
8270 Mayrand Street
(514) 735-2273
TWX: 610-421-3484
Telex: 01-2819

Ottawa, Ontario
Hewlett-Packard (Canada) Ltd.
1762 Carling Avenue
(613) 722-4223
TWX: 610-562-1952

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

Vancouver, B.C.
Hewlett-Packard (Canada) Ltd.
2184 W. Broadway
(604) 738-7520
TWX: 610-922-5059

SALES AND SERVICE OFFICES
INTERNATIONAL - Electronic Equipment

ARGENTINA
Mauricio A. Suarez
Telecommunicaciones
Carlos Calvo 224
Buenos Aires
Tel. (30-6312) (34-9087)

AUSTRALIA
Sample Electronics (Vic) Pty., Ltd.
9-11 Cremorne Street
Richmond E.1, Victoria
Tel. 42-4757

Sample Electronics (N.S.W.) Pty, Ltd.
4 Grose Street
Glebe, New South Wales
Tel. 69-6338

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

BELGIUM
Hewlett-Packard Benelux S.A.
20-24 rue de l'Hopital
Brussels
Tel. 11 22 20

BRAZIL
Ciental Importacao e Comercio Ltda.
Rua des Eliseu Guilherme, 62
Sao Paulo 8
Tel. 70-2318

CHILE
Hector Calcagni
Casilla 13942
Santiago
Tel. 6.42.26

DENMARK
Tage Olsen A/S
Ronnegade 1
Copenhagen 0
Tel. 29 48 00

FINLAND
INTO O/Y
Meritullinkatu 11
P.O. Box 153
Helsinki
Tel. 6 11 33

FRANCE
Hewlett-Packard France
150 Boulevard Massena
Paris 13
Tel. 707 97 19

Hewlett-Packard France
2 rue Tete d'Or
Lyon, 6 - Rhone
Tel. 52 35 66

GERMANY
Hewlett-Packard Vertriebs-GmbH
Kurhessenstrasse 95
Frankfurt a. Main
Tel. 52 00 36

Hewlett-Packard Vertriebs-GmbH
Reginfriedstrasse 13, Munich 9
Tel. 49 51 21

Hewlett-Packard Vertriebs-GmbH
Beim Strohhause 26/28
Hamburg 1
Tel. 24 05 51

Hewlett-Packard Vertriebs-GmbH
(Technisches Buro)
Herrenberger Strasse 110
Böblingen, Wurttemberg
Tel. 6971

Hewlett-Packard Vertriebs-GmbH
Lietzenburger Strasse 30
1 Berlin W 30
Tel. 24 86 36

Hewlett-Packard Vertriebs-GmbH
Achenbachstrasse 15
4 Dusseldorf 1,
Tel. 68 52 58

GREECE
K. Karayannis
Klaftmonos Square
Athens 124
Tel. 230 301

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

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

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

The Scientific Instrument Co., Ld.
30 Mount Road, Madras 1
Tel. 86339

The Scientific Instrument Co., Ld.
B-7, Ajmeri Gate Extn.
New Delhi 1
Tel. 271053

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

ISRAEL
Electronics & Engineering Ltd.
Division of Motorola Israel Ltd.
16, Kremenetski Street, Tel-Aviv
Tel. 35021

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

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

JAPAN
Yokogawa-Hewlett-Packard Ltd.
#59, 1-chome
Yoyogi
Shibuya-ku
Tokyo,
Tel. 370-2281

Yokogawa-Hewlett-Packard Ltd.
#8, Umeda
Kita-ku, Osaka City
Tel. 313-0091

Yokogawa-Hewlett-Packard Ltd.
#4, 3-chome
Himeikedori
Chigusa-ku, Nagoya City
Tel. 751-8545

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

LEBANON
Constantin E. Macridis
Clemenceau Street
Clemenceau Center
Beirut
Tel. 220846

NETHERLANDS
Hewlett-Packard Benelux, N.V.
23 Burg, Roellstraat
Amsterdam, W.
Tel. (020) 13 28 98

NEW ZEALAND
Sample Electronics (N.Z.) Ltd.
8 Matipo Street
Onehunga S.E. 5, Auckland
Tel. 565-361

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

PAKISTAN
Mushko & Company, Ltd.
Oosman Chambers
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5/66

MANUAL BACKDATING CHANGES

MODEL 419A

DC NULL VOLTMETER

Manual Serial Prefixed: 707-
-hp- Part No. 00419-90002

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

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
646-	1		
532-0401 and above	1, 2		
532-0400 and below	1, 2, 3		
514-	1, 2, 3, 4		

CHANGE 1

Figures 6-1 and 6-3:
Substitute Figures C-1 and C-2 for the ones in Figures 6-1 and 6-3.

Table 7-1:
Change all "A4" reference designators to "A1."
Change -hp- Part No. of A1 to 00419-66504.
Change A1C13 to -hp- Part No. 0180-0022, C: fxd, elect 3.9 μF 35 vdcw.
Delete A1C14 thru A1C17.
Change "A1CR1 thru A1CR16" to "A1CR1 thru A1CR14."
Change A1R38 to -hp- Part No. 0686-3055, R: fxd comp 3 MΩ ±5% 1/2 W.
Change A1R41 thru A1R44 to -hp- Part No. 2100-1410, R: var lin 20 kΩ ±30% 1/8 W.
Change A1R48 to -hp- Part No. 0687-6821, R: fxd comp 6.8 kΩ ±10% 1/2 W.
Delete A1R50 and A1R51.
Add C1, -hp- Part No. 0180-0283, C: fxd Al elect 60 μF +75% -10% 10 vdcw.

CHANGE 2

Table 7-1:
Change J2 to -hp- Part No. 1510-0010.
Change J3 to -hp- Part No. 1510-0011.
Change J5 to -hp- Part No. 1510-0026.
Change J6 to -hp- Part No. 1510-0027.

CHANGE 3

Figure 6-3:
Change A1R26* (10 K) to A1R26* (22 K).
Move A1R26 between A1CR3 and 4 and Q8 Base.
Delete C10 (3.7 μF) in emitter of Q12 and Q13.
Add C10 (20 μF) between A1-13 and ⏚ .
Short R40 (100 Ω) in base of A1Q10.
Add R40 (39 kΩ) between A1C13 and A1R39.

Table 7-1:
Change A1C10 to C: fxd Al elect 20 μF +75% -10% 25 vdcw; -hp- Part No. 0180-0045.
Change A1R26* to R: fxd 22 K ±10% 1/2 W; -hp- Part No. 0687-1031.
Change A1R40 to R: fxd 39 K ±10% 1/2 W; -hp- Part No. 0687-3931.

MANUAL BACKDATING CHANGES

CHANGE 4

Change Paragraph 5-34 steps d and e as follows:

d. A2R12, CHOPPER CURRENT, affects both the chopper frequency and current. Adjust A2R12 for waveshape shown in Figure 5-3 with peak amplitude of 140 to 160 mV and frequency of 320 to 340 pps (this corresponds to chopper rate of 160 to 170 pps as counter also counts smaller pulses).

e. . . . A1R26 should be between 10 KΩ and 39 KΩ with a typical value of 22 KΩ.

Figure 6-4:
Substitute Figure C-3 and C-4 for the ones in Figure 6-4.

Table 7-1:
Change A2Q1 to -hp- Part No. 1854-0039, Transistor: NPN, Si, 2N3053
Change A2Q2, A2Q3 to -hp- Part No. 1854-0033, Transistor: NPN, Si, 2N2925
Change A2Q4, A2Q5 to -hp- Part No. 1854-0039, Transistor: NPN, Si, 2N3053
Change A2R1 to -hp- Part No. 0687-5611, R: fxd, comp, 560 ohms ±10%, 1/2 w
Change A2R2 to -hp- Part No. 0687-6811, R: fxd, comp, 680 ohms ±10%, 1/2 w
Change A2R3 to -hp- Part No. 0687-3331, R: fxd, comp, 33 K ohms ±10%, 1/2 w
Change A2R4 to -hp- Part No. 0687-3321, R: fxd, comp, 3300 ohms ±10%, 1/2 w
Change A2R5 to -hp- Part No. 0687-6801, R: fxd, comp, 68 ohms ±10%, 1/2 w
Change A2R6 to -hp- Part No. 0687-2731, R: fxd, comp, 27 K ohms ±10%, 1/2 w
Change A2R7 to -hp- Part No. 0687-4731, R: fxd, comp, 47 K ohms ±10%, 1/2 w
Change A2R8, A2R9 to -hp- Part No. 0687-4701, R: fxd, comp, 47 ohms ±10%, 1/2 w
Change A2R10 to -hp- Part No. 0687-1511, R: fxd, comp, 150 ohms ±10%, 1/2 w
Change A2R11 to -hp- Part No. 0687-3341, R: fxd, comp, 330 K ohms ±10%, 1/2 w
Change A2R12 to -hp- Part No. 2100-0227, R: var, ww, 20 ohms ±10%, 1-1/2 w
Change A2T1 to -hp- Part No. 9100-0172, Transformer: power
Change A2T2 to -hp- Part No. 9100-1314, Transformer: neon driver

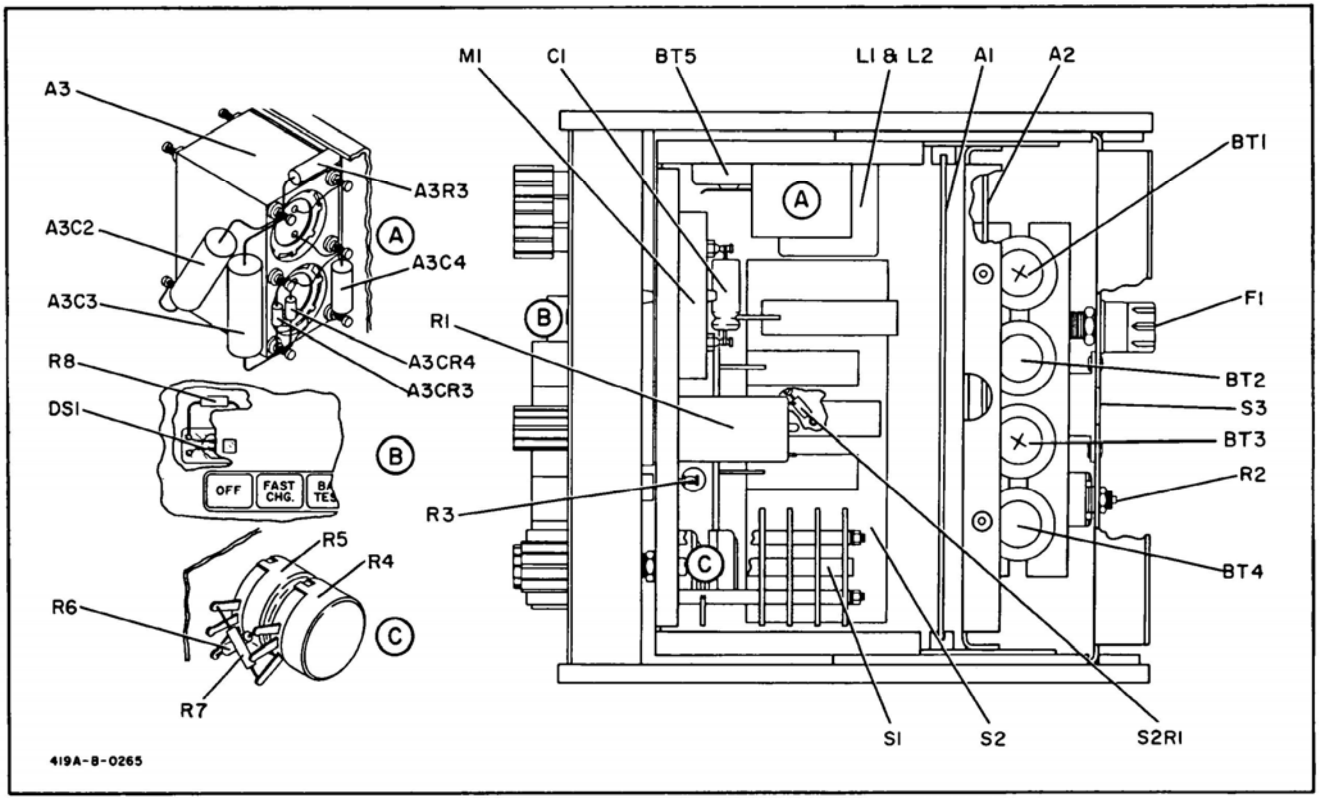
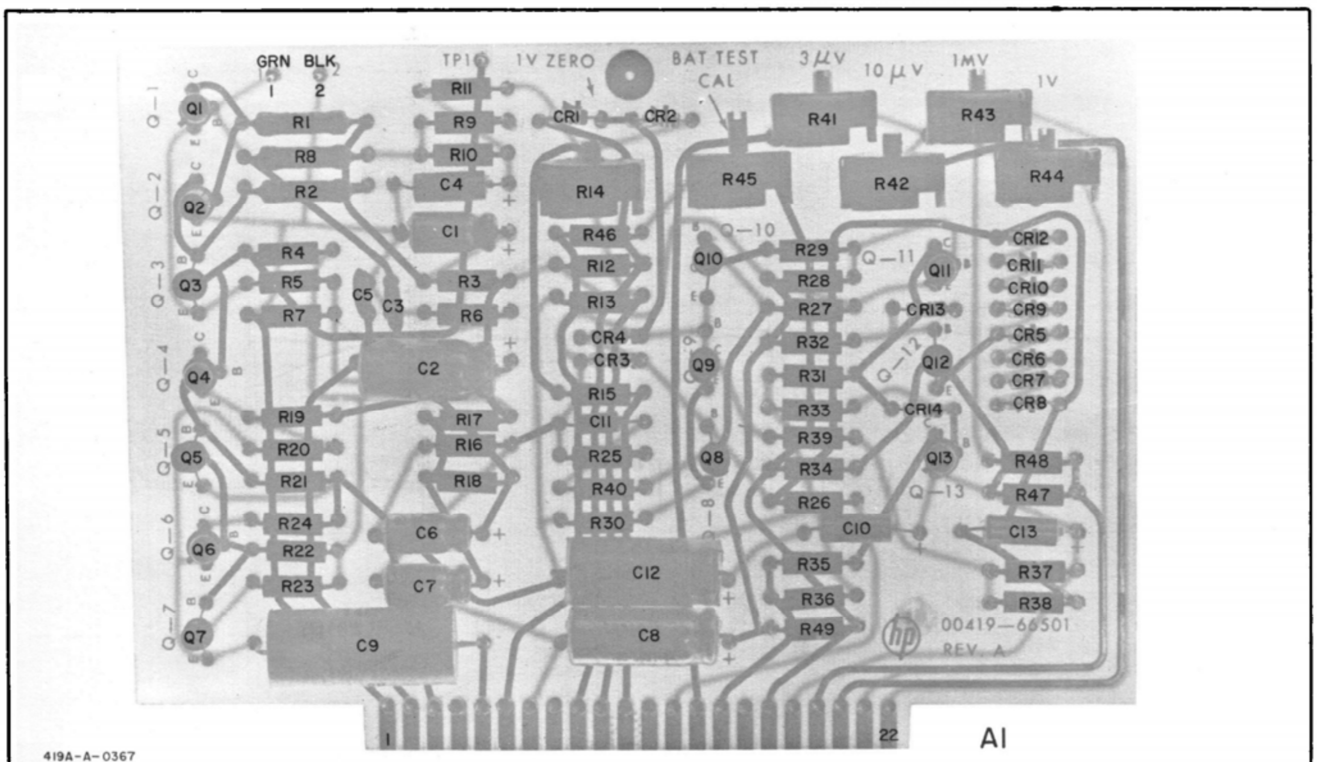


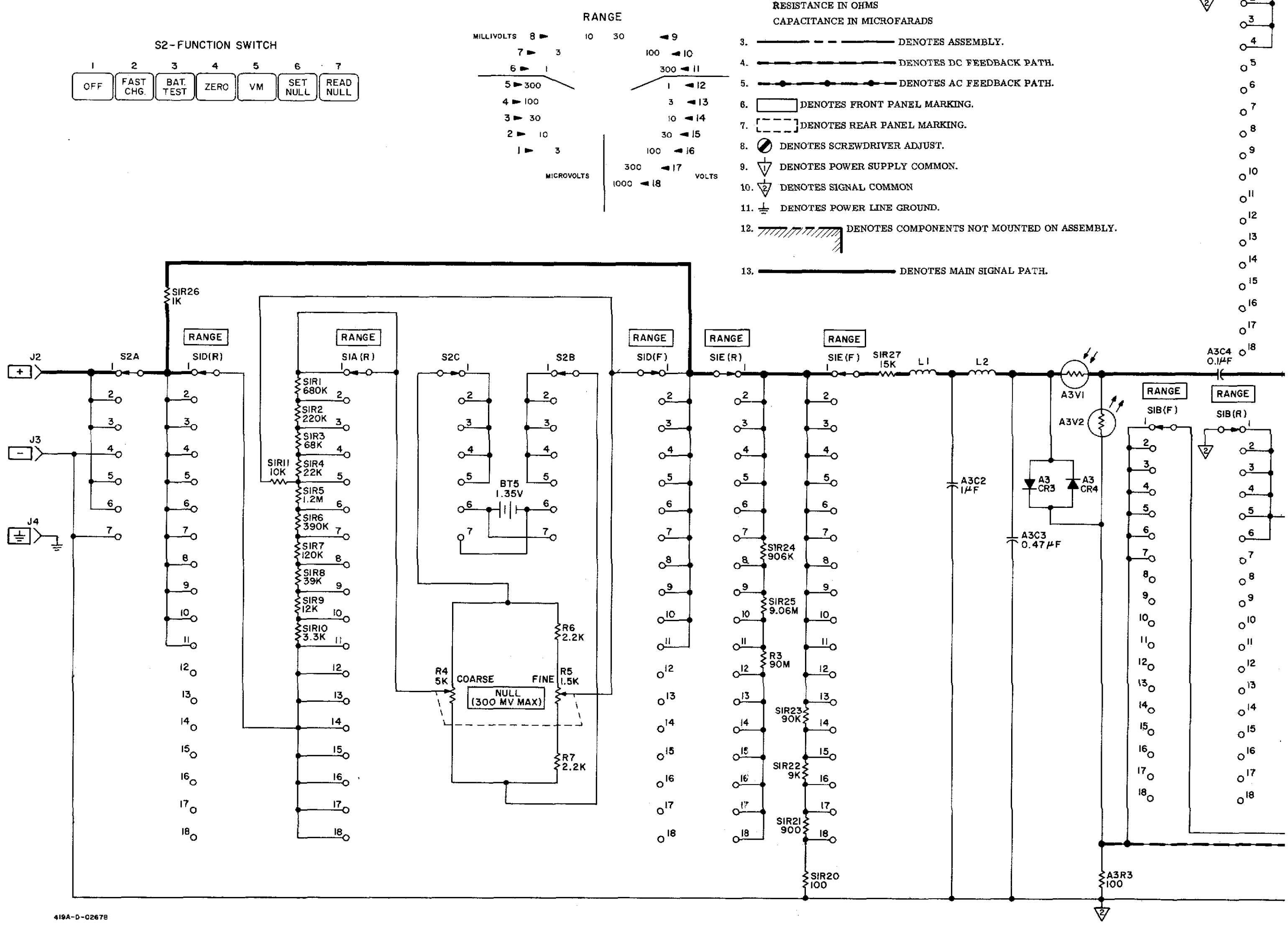
Figure C-1. Model 419A, Component Location Diagram
(Serials Prefixed 514-, 532-, 646-)



Part of Figure C2. A1 Amplifier (00419-66501)
(Serials Prefixed 514-, 532-, 646-)

NOTES

1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN: PREFIX WITH ASSEMBLY OR SUB-ASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.
2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED:
   RESISTANCE IN OHMS
   CAPACITANCE IN MICROFARADS
3. DENOTES ASSEMBLY.
4. DENOTES DC FEEDBACK PATH.
5. DENOTES AC FEEDBACK PATH.
6. DENOTES FRONT PANEL MARKING.
7. DENOTES REAR PANEL MARKING.
8. DENOTES SCREWDRIVER ADJUST.
9. DENOTES POWER SUPPLY COMMON.
10. DENOTES SIGNAL COMMON
11. DENOTES POWER LINE GROUND.
12. DENOTES COMPONENTS NOT MOUNTED ON ASSEMBLY.
13. DENOTES MAIN SIGNAL PATH.



419A-D-02678

'N: PREFIX WITH ASSEMBLY OR SUB-
'LETE DESIGNATION.

UNLESS OTHERWISE NOTED:

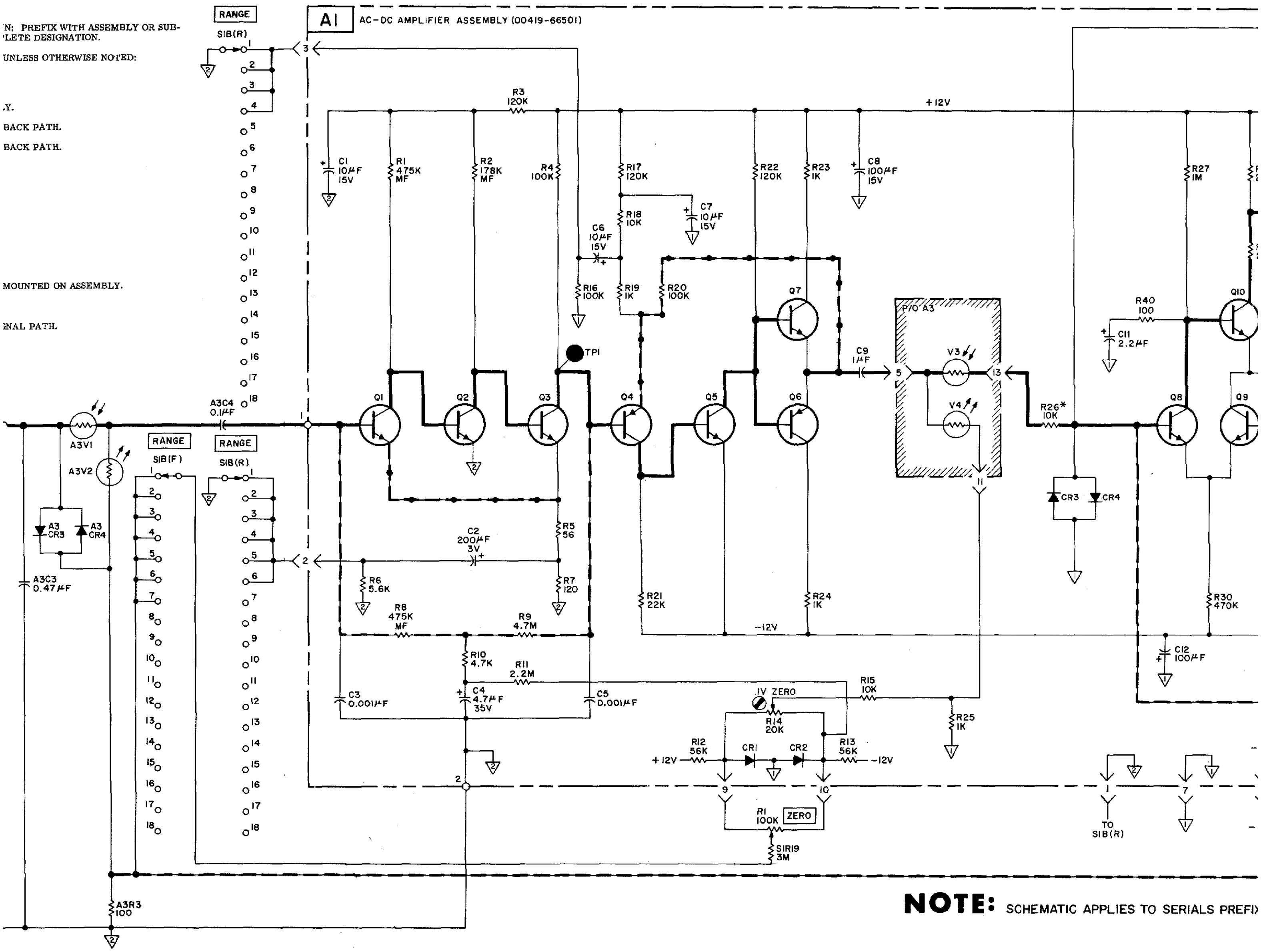
.Y.

BACK PATH.

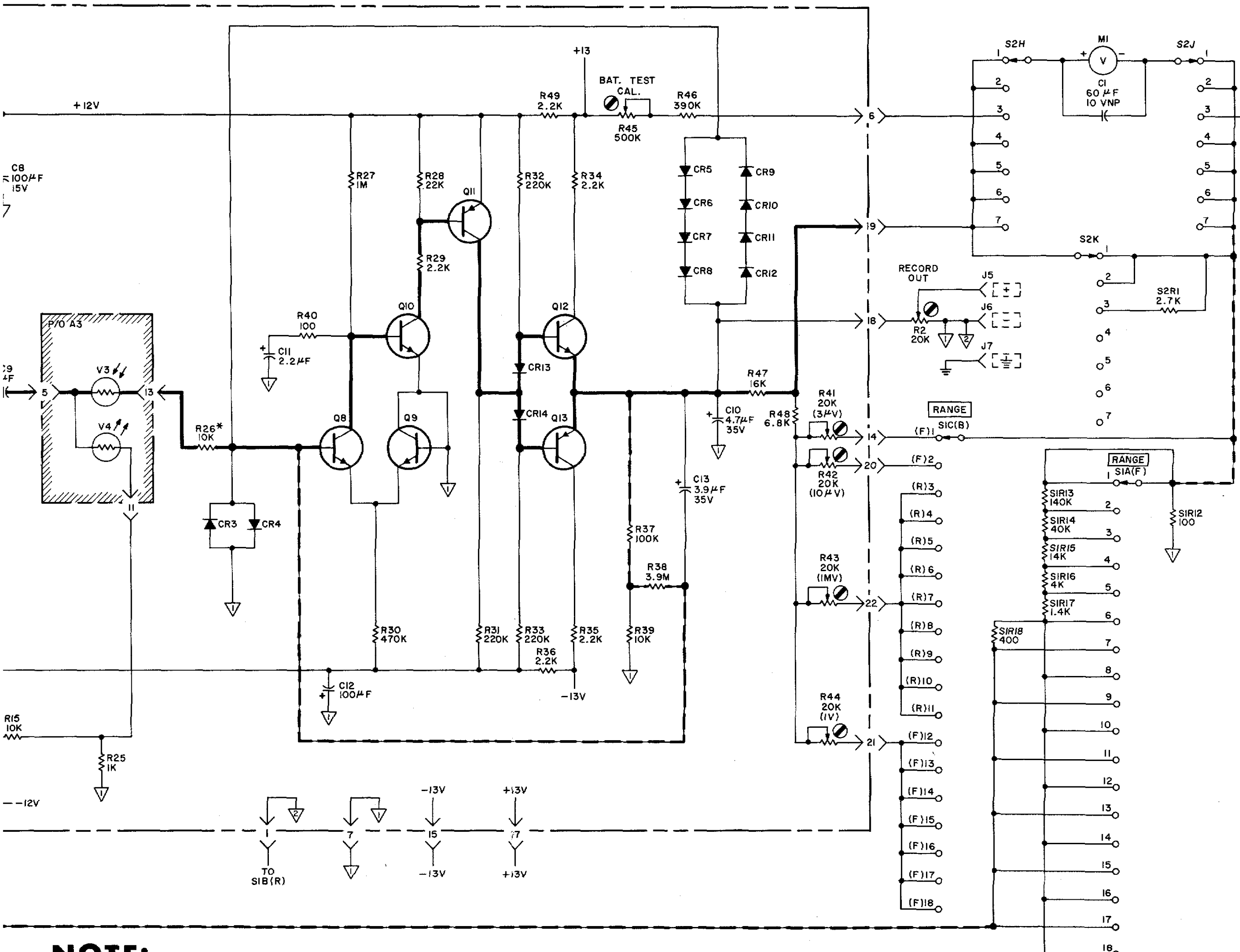
BACK PATH.

MOUNTED ON ASSEMBLY.

ENAL PATH.



NOTE: SCHEMATIC APPLIES TO SERIALS PREFI



NOTE: SCHEMATIC APPLIES TO SERIALS PREFIXED 514-, 532- AND 646- ONLY

Figure C-2. Amplifier and Amplifier Switching, Schematic and Component Location Diagrams (Serial Prefixed 514-, 532-, 646-)

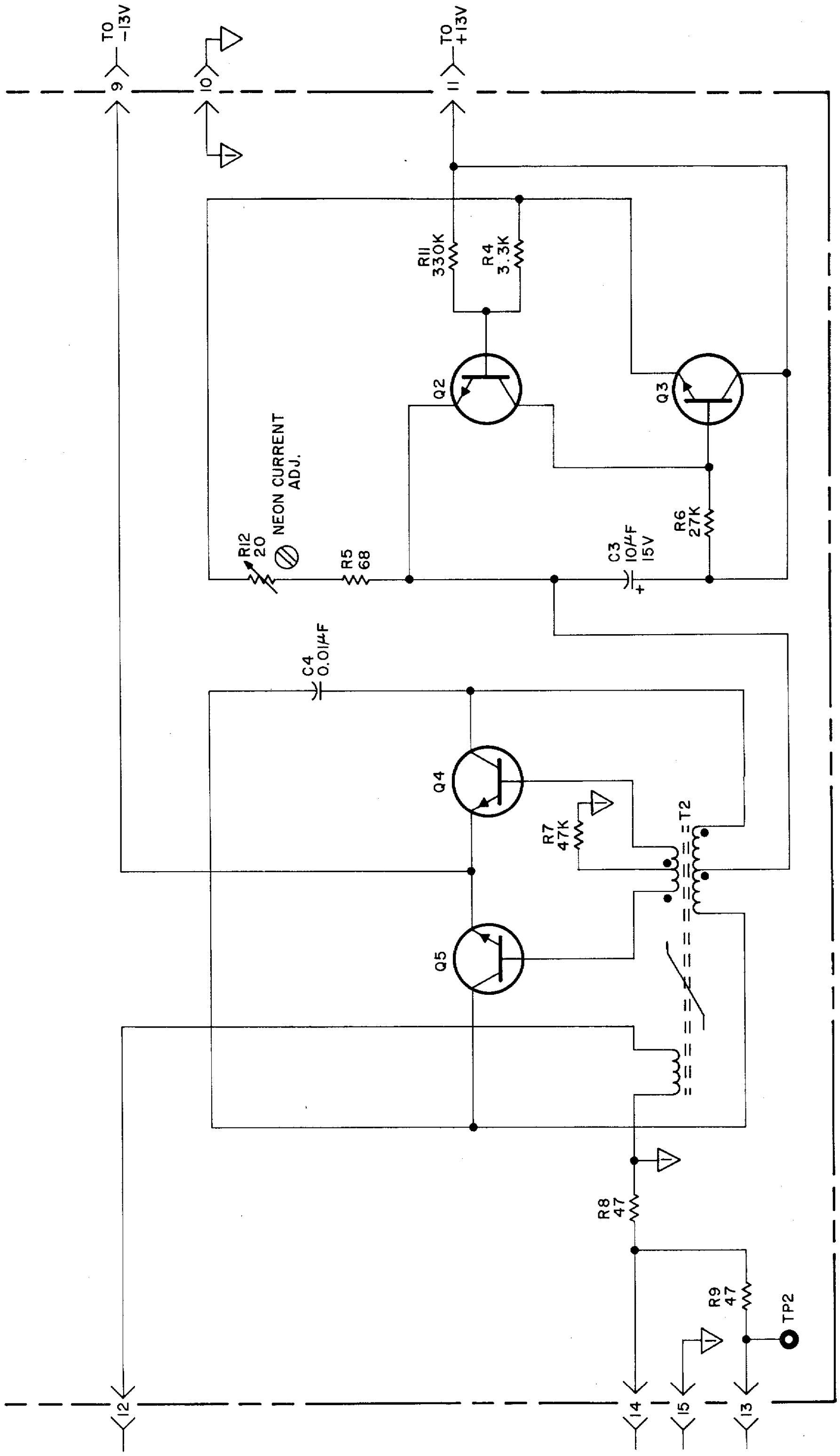


Figure C-3. Neon Driver (Serials Prefixed 514-)

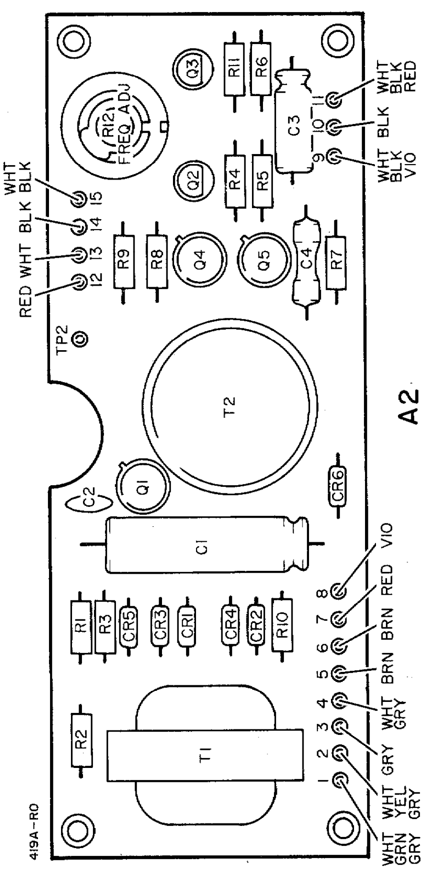


Figure C-4. A2 Board (Serials Prefixed 514-)