

414A

AUTOVOLTMETER

OPERATING AND SERVICE MANUAL

HEWLETT  *PACKARD*



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OPERATING AND SERVICE MANUAL

(HP PART NO. 00414-90001)

MODEL 414A AUTOVOLTMETER

SERIALS PREFIXED: 630-

Appendix C, Manual Backdating Changes,
adapts manual to Serials Prefixed:
605- and 531-.

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Figure 1-1. Model 414A Autovoltmeter

Table 1-1. Specifications

<u>DC VOLTMETER</u>	<u>GENERAL</u>
Voltage Range: ± 5 millivolts to ± 1500 volts full scale in twelve ranges (manual or auto-ranging).	Automatic Range Selection: Automatically selects correct voltage or resistance range in less than 300 milliseconds.
Accuracy: $\pm(0.5\% \text{ of reading} + 0.5\% \text{ of full scale})$.	Manual Range Selection: Downranges one range each time DOWNRANGE button is pressed. Starts over at 1500 v range from 5 mv range.
Input Resistance: 10 megohms on 5 and 15 mv ranges. 100 megohms on 50 mv range and above.	Polarity Selection: Automatic in either manual or auto mode.
Superimposed AC Rejection: In manual mode, insensitive to 60 cps signal with peak value less than 7 times full scale value of range in use. In auto mode, insensitive to 60 cps signal with peak value less than 20% of dc being measured.	Meter: Individually calibrated taut-band meter with linear mirror scales of 0 to 5 and 0 to 15 in both VDC and OHMS functions.
<u>OHMMETER</u>	<u>Isolation Resistance: 100 megohms shunted by 0.1 μf between common terminal and case (power line ground).</u>
Resistance Range: 5 ohms to 1.5 megohms in 12 ranges (manual or auto-ranging with linear scale).	Floating Input: May be operated up to 500 vdc above power line ground.
Accuracy: $\pm(1\% \text{ of reading} + 0.5\% \text{ of full scale})$.	Power: 115 or 230 volts $\pm 10\%$, 50 to 1000 cps. Approximately 18 watts.
Source Current: 1 ma on ranges up to 5 K Ω and 1 μa on higher ranges.	Weight: Net: 10-1/4 lbs. (4,6 kg). Shipping: 13 lbs. (6,4 kg).

SECTION I

GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This section contains general information about the Model 414A Autovoltmeter. Included are a discussion of the description and purpose of the instrument, the instrument identification, and a table of specifications.

1-3. DESCRIPTION AND PURPOSE.

1-4. The Model 414A Autovoltmeter is used to accurately measure dc volts and ohms with immediate, automatic range selection. Operation is simply "touch and read." Automatic, overload protection circuits insure that the instrument will not be damaged by an overrange voltage before upranging can occur. Both range and polarity are displayed in illuminated characters above the meter.

1-5. In the AUTO mode, a downrange to the next lowest range occurs when the measured voltage or resistance falls below 25% of full scale; and an uprange to the next highest range occurs when the measured voltage or resistance rises above 96% of full scale.

1-6. A HOLD mode provides manual downranging, a step at a time, using the DOWNRANGE switch and also adds a noise filter to the input. When measuring voltage in this mode, an automatic uprange to the

1500 v range will occur if the measured voltage exceeds full scale by 40%. On resistance measurements in the HOLD mode, upranging will never occur, even when the measured resistance becomes infinite, such as when the probes are removed from a resistor.

1-7. SPECIFICATIONS.

1-8. Table 1-1 contains the specifications for the Model 414A.

1-9. INSTRUMENT IDENTIFICATION.

1-10. Hewlett-Packard uses a two-section, eight-digit serial number (000-00000). The serial number is on a plate on the rear panel of the instrument. If the first three digits of the serial number on your instrument do not agree with those on the title page in this manual, then Appendix C, Backdating Changes, will define the differences between your instrument and the Model 414A described in this manual.

1-11. ACCESSORY EQUIPMENT AVAILABLE.

1-12. Accessory equipment available for troubleshooting the 414A are an extender board, -hp- Part No. 5060-0630, and a board extractor, -hp- Part No. 8830-0032. There are no accessories supplied, other than the power cord and this manual.

SECTION II

INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary for the installation and shipping of the Model 414A Autovoltmeter. 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 that might have occurred in transit. If the instrument was damaged in transit, file a claim with the carrier. Check for supplied accessories and test the electrical performance of the instrument using the procedures 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 Model 414A can be operated from a 50 to 1000 cps voltage source of 115 v or 230 v ($\pm 10\%$). With the instrument disconnected from the ac power source, move the rear panel slide switch until the desired line voltage appears. Power dissipation is about 18 watts.

2-7. GROUNDING REQUIREMENTS.

2-8. To protect operating personnel, the National Electrical Manufacturer's 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 414A is fully transistorized; therefore, no special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 55°C (140°F) or the relative humidity exceeds 95%.

2-12. BENCH MOUNTING.

2-13. The Model 414A 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 414A 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 414A may be mounted in combination with other submodular units by using a Combining Case -hp- Model 1051A. 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

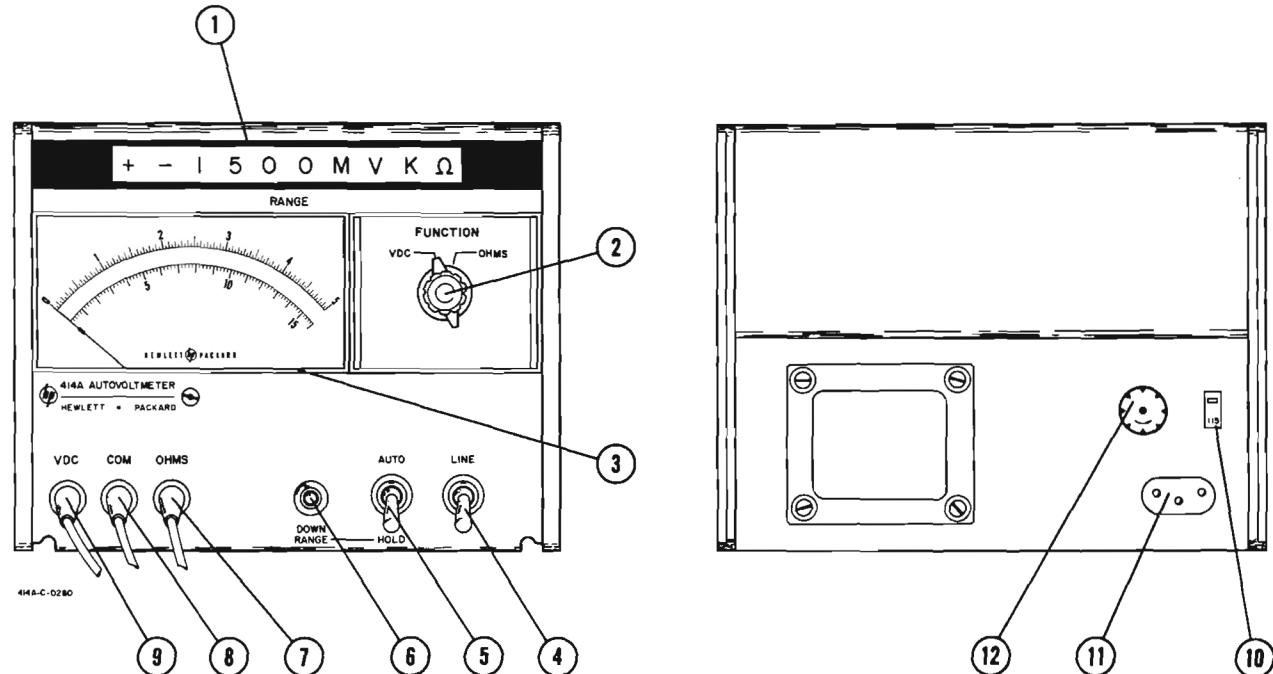
If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished; include the model number and full serial number of the instrument. In any correspondence, identify the instrument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

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

- a. Place instrument in original container if available. If original container is not available, one can be purchased from your nearest -hp- Sales and Service Office.
- b. Ensure that container is well sealed with strong tape or metal bands.

2-21. 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.



- ① RANGE Indicator: Indicates the present range of the instrument, whether in VDC or OHMS mode, and indicates the polarity of the input voltage.
- ② FUNCTION Switch: Selects either the dc voltmeter (VDC) or ohmmeter (OHMS) function.
- ③ Meter: Indicates voltage or ohmic values within the indicated range.
- ④ LINE Switch: Turns on the instrument.
- ⑤ AUTO-HOLD Switch: Selects either automatic (AUTO) or manual (HOLD) mode of operation.
- ⑥ DOWNRANGE Pushbutton: Downranges the instrument, a range at a time, in the HOLD mode.
- ⑦ ⑧ ⑨ OHMS, COM, and VDC probes: OHMS and COM probes are used for resistance measurements; VDC and COM probes for voltage measurements.
- ⑩ Voltage Selection Switch: Selects line voltage of 115 volts or 230 volts ac.
- ⑪ AC Power Receptacle: Provides for ac line voltage connection.
- ⑫ Fuse Holder: Holds 1/4 ampere slow-blow fuse for protection of primary power circuits.

Figure 3-1. Controls, Indicators, and Connectors

SECTION III

OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This section contains the information necessary for operation of the Model 414A Autovoltmeter. Included are turn-on procedures, operating instructions, and identification of controls, indicators and connectors.

3-3. CONTROLS, INDICATORS AND CONNECTORS.

3-4. Each operating control, indicator, and connector on the front and rear panels is identified and described in Figure 3-1.

3-5. TURN-ON PROCEDURE.

3-6. To turn on the Model 414A, proceed as follows:

- a. Ensure that the two-position Voltage Selection Switch (10) is set for available line voltage.
- b. Connect AC Power Receptacle (11) to power line voltage.
- c. Push up LINE Switch (4). The "5" lamp in the RANGE Indicator (1) should illuminate.

3-7. OPERATING INSTRUCTIONS.

3-8. DC VOLTMETER.

3-9. To make dc voltage measurements with the 414A, proceed as follows:

- a. Set FUNCTION Switch (2) to VDC.
- b. Set AUTO-HOLD Switch (5) to AUTO.
- c. Connect COM and VDC probes (8) and (9) to voltage to be measured.

— NOTE —

COM probe may be used up to 500 volts above power line (chassis) ground.

- d. Obtain the value of the measured voltage from the Meter (3), assuming the full scale meter value shown on RANGE Indicator (1). Read polarity on RANGE.

— NOTE —

If input voltage is noisy, causing unfavorable ranging, or if repetitive readings on one range are desired, then proceed with step e.

- e. Set AUTO-HOLD Switch (5) to HOLD.

— NOTE —

If a different range in HOLD is desired, proceed with step f.

- f. Successively depress DOWNRANGE Pushbutton (6) until desired range is selected.

3-10. OHMMETER.

3-11. To make resistance measurements with the 414A, proceed as follows:

— NOTE —

The output current of the 414A in OHMS is 1 ma on ranges up to 5K ohms, and 1 μ a on higher ranges. COM probe is positive in respect to OHMS probe.

- a. Set FUNCTION Switch (2) to OHMS.
- b. Set AUTO-HOLD Switch (5) to AUTO.
- c. Connect COM and OHMS probes (8) and (7) to resistance to be measured.
- d. Obtain the value of the measured resistance from the Meter assuming the full scale meter value shown on RANGE Indicator (1).

— NOTE —

If repetitive readings on one range are desired, proceed with step e.

- e. Set AUTO-HOLD Switch (5) to HOLD.

— NOTE —

If a different range in HOLD is desired, proceed with step f.

- f. Successively depress DOWNRANGE Pushbutton (6) until desired range is selected.

SECTION IV

THEORY OF OPERATION

4-1. GENERAL.

4-2. The -hp- Model 414A consists of an Analog Measuring Circuit, an Analog-to-Digital Converter, and a Digital Control Circuit.

4-3. The Analog Measuring Circuit provides a current to the meter that is proportional to the input voltage. The Digital Control Circuit varies the input attenuation and transconductance of the Analog Measuring Circuit to range the instrument. The Analog-to-Digital Converter uses the output of the Analog Measuring Circuit to develop digital control pulses which operate the Digital Control Circuit.

4-4. BLOCK DIAGRAM ANALYSIS (FIGURE 4-2, 4-3 AND 6-2).

4-5. ANALOG MEASURING CIRCUIT.

4-6. The Analog Measuring Circuit comprises the Input Attenuator (p/o A1), the Amplifier Assembly (A2), and the Feedback Attenuator (p/o A3). Its function is to supply a current to the meter that is directly proportional to the measured voltage or resistance, and that varies between 0 and 1 ma, giving zero to full scale meter deflection.

4-7. See Figure 4-2. The Input Attenuator provides input voltage attenuation of 0 db or 60 db, as determined by K1 and K2. Relays K4 through K8 vary the transconductance, G_m , of the Analog Measuring Circuit by connecting different points of the Feedback Attenuator to signal common. The resistance of the attenuator between signal common and power supply common will be referred to as the feedback resistance, R_f .

4-8. In this application, transconductance is defined as $G_m = I_m/V_i$, where I_m is the meter current and V_i is the voltage from the Input Attenuator. Due to the high voltage gain of the Amplifier Assembly, the degenerative feedback voltage, V_f , across R_f is very nearly equal to V_i . Thus, there is practically no current drawn from the Input Attenuator and I_m is the only significant current through R_f . Hence, $I_m = V_i/R_f$.

4-9. The feedback resistance varies from 5000 ohms when K8 is energized, to 5 ohms when K4 is energized. Resistors R1, R2 and R3 are effectively reduced to one third of their value when K7 is not energized. If the 414A is on the 1500 v range, K2, K6 and K7 will be energized. See Table 5-6. An input voltage of 1500 v will be attenuated 1000 to 1 and R_f will equal 1500 ohms. I_m will equal $V_i/R_f = 1.5 \text{ v}/1500 \Omega = 1 \text{ ma}$, giving a full scale meter deflection. If the input voltage is 5 v on the 5 v range, then K1 and K8 will be energized, giving no input attenuation and 5000 ohms for R_f . I_m will equal $5 \text{ v}/5000\Omega = 1 \text{ ma}$. On the 5 mv range, K1, K3, and K4 will be energized. I_m at full scale meter deflection will equal $0.005 \text{ v}/5 \Omega$, which again equals 1 ma.

4-10. Since there is essentially no current drawn from the Input Attenuator, the input resistance of the 414A is determined only by the resistance of the Input Attenuator, which is 100 megohms on all ranges except the lowest two. On the 15 mv and 5 mv ranges, K3 connects a resistor in parallel to the Input Attenuator which reduces the input resistance to 10 megohms. If the input resistance were higher on these low ranges, there would be an objectionable amount of instrument ranging and meter movement due to stray electromagnetic fields, while the probes are open.

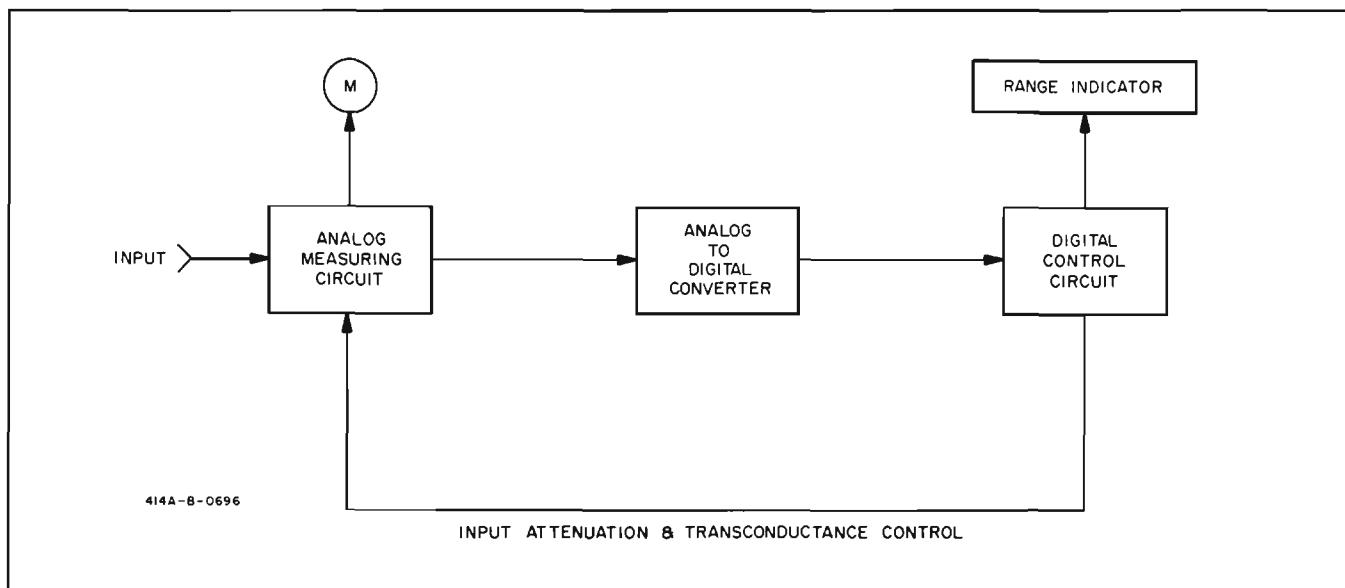


Figure 4-1. Simplified Block Diagram

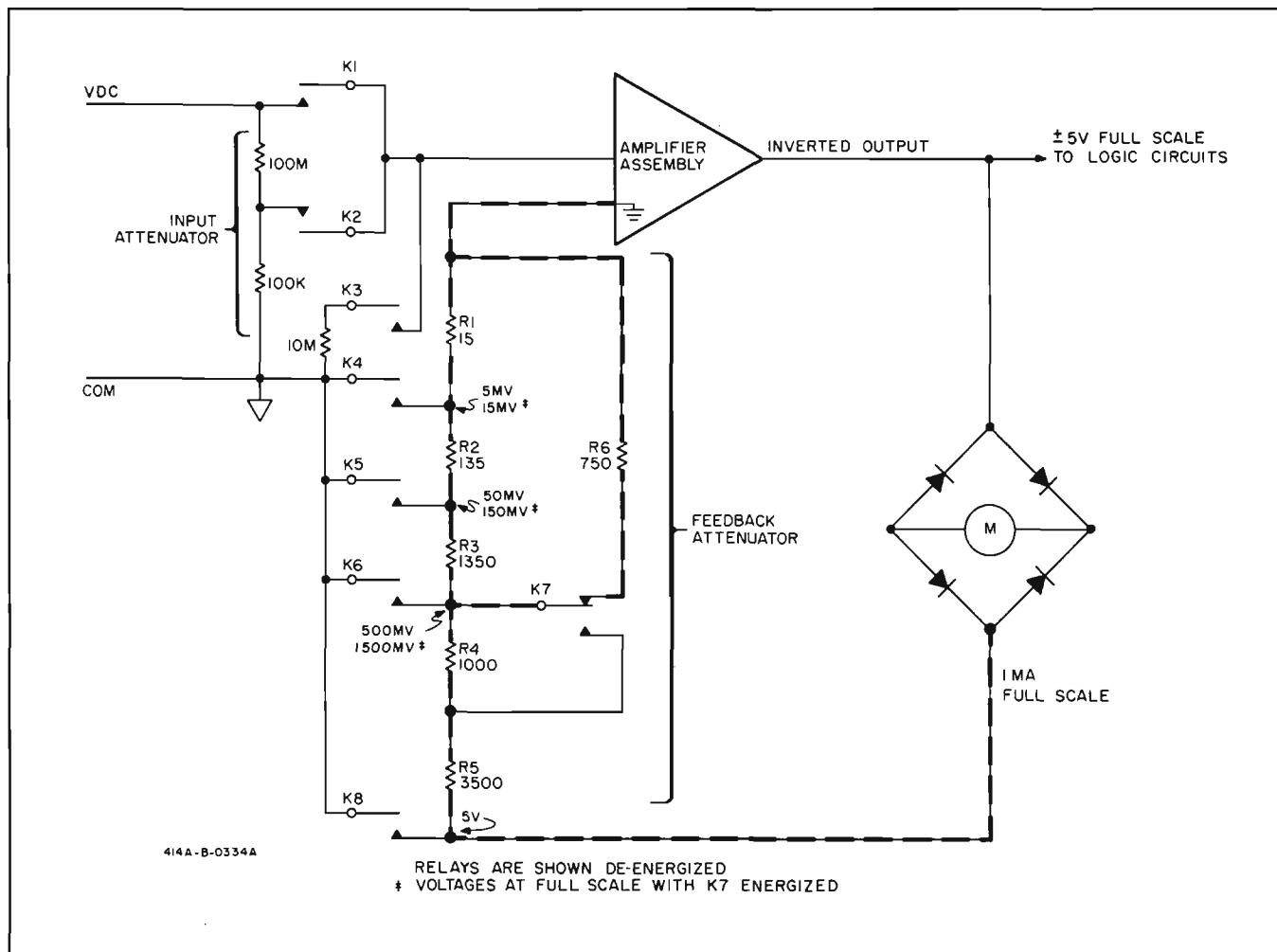


Figure 4-2. Analog Measuring Circuit in VDC mode

4-11. To achieve a high degree of accuracy and to allow the use of the same linear meter scale used in the VDC mode, the constant-current method of resistance measurement is used. The voltage across the OHMS and COM probes is adjusted so as to produce a current through the unknown resistance that is constant and independent of the value of the resistance. This voltage (input voltage), which is directly proportional to the resistance, is then measured using the same circuits (except the Input Attenuator) used in the VDC mode to give an accurate measurement of the unknown resistance.

4-12. A block diagram of the Analog Measuring Circuit for the OHMS mode is shown in Figure 4-3. A few circuits have been added to the basic voltmeter: a current generator, a zener diode, a unity-gain amplifier, and a series resistor, R_S . R_f is the same feedback resistance used in the VDC mode. The zener diode supplies a constant offset voltage, V_O , between the current generator and R_f . The current generator develops a voltage across R_S and the unknown resistance, R_x .

4-13. It can be seen that the voltage across the current generator will remain greater than V_f by the value of V_O . From Paragraph 4-8, V_f is essentially

equal to the input voltage across R_x . Hence, the voltage across the current generator will be greater than the input voltage by the value of V_O , whatever the size of R_x . Thus, V_O must be dropped across R_S , giving a constant current through R_S and R_x , which is the required condition. Notice that the OHMS probe is negative in respect to the COM probe.

4-14. Since the entire ohmmeter operation is dependent upon the zener diode voltage, it is necessary to insure that this voltage will not be affected by current changes through the finite resistance of the diode. To do this, the current generator is used as a constant-current circuit to maintain the diode current at a constant level on each resistance range, regardless of the input voltage.

4-15. The unity-gain amplifier, which has a high input impedance, is used so that current will not flow into the ohmmeter section from the Feedback Attenuator and cause an error in V_f .

4-16. When measuring small resistances, the resistance of the probes would cause an appreciable error. To eliminate this, the four-lead method of measurement is used; so that lead resistance is not a part of R_x .

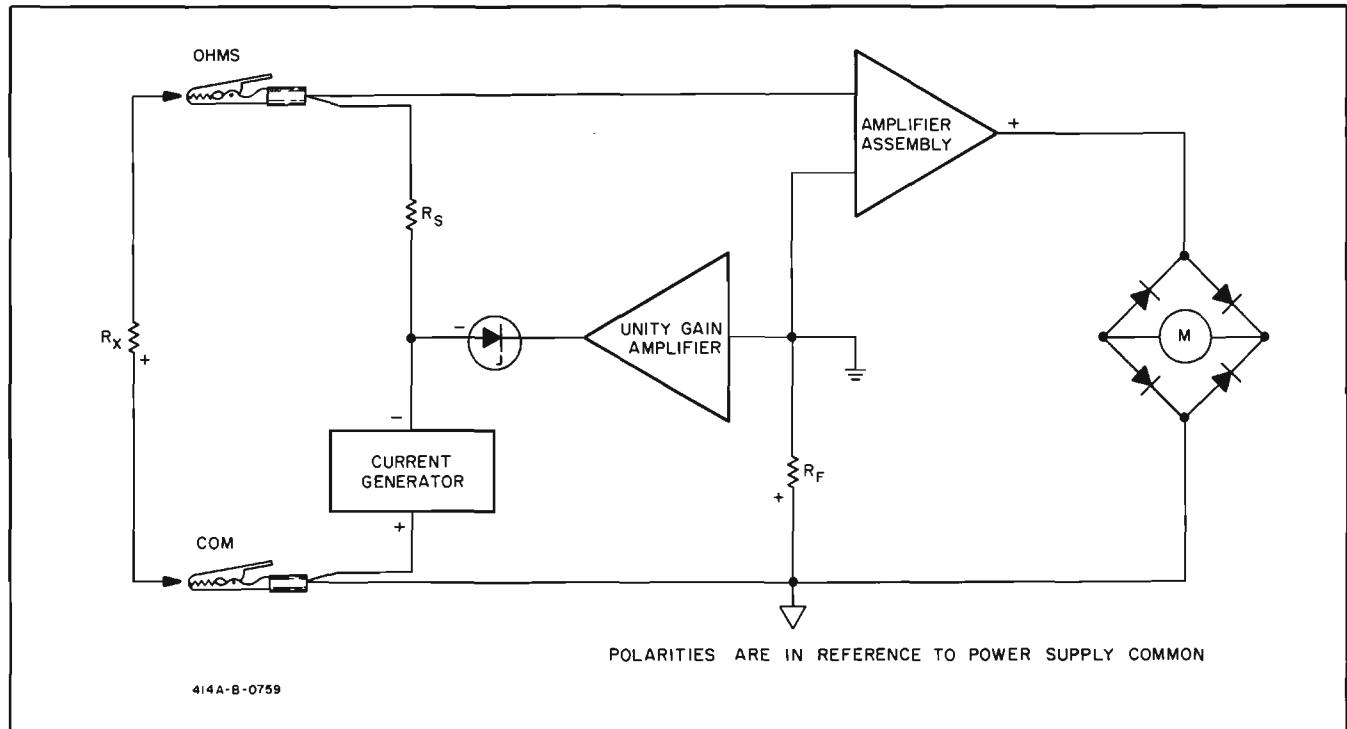


Figure 4-3. Analog Measuring Circuit in OHMS mode

4-17. Since the Amplifier Assembly operates as a dc instrument, it is necessary to insure that unavoidable dc drift will not produce an error in the output. Drift stabilization is achieved by using a Chopper Amplifier for initial ac amplification, along with the overall dc feedback. See Figure 6-2.

4-18. Within the Chopper Amplifier, the input voltage is chopped into pulses which are amplified and inverted by ac amplifiers and then synchronously rectified for conversion back to dc for final amplification by the dc amplifier. Drift in the ac amplifiers will not affect the Amplifier Assembly output and any drift in the output caused by dc amplifier drift will be degenerated to a negligible value by the Chopper Amplifier.

4-19. ANALOG-TO-DIGITAL CONVERTER (Figure 6-2).

4-20. This section comprises the circuits of the Power Supply and Control Assembly, other than the power supplies. Its function is to determine the polarity of the Amplifier Assembly output and to generate pulses which operate the Digital Control Circuit.

4-21. The Polarity Detector senses the polarity of the Amplifier Assembly output to light the (-) or (+) lamp of the Range Indicator. The Polarity Converter provides a positive voltage to the Amplitude Detector that is proportional to the magnitude of the voltage from the Amplifier Assembly.

4-22. The Amplitude Detector determines whether the input voltage is below 25% of full scale or above 96% of full scale. If the 414A is in the AUTO mode and the input voltage is below 25% of full scale, then the Amplitude Detector starts the multivibrator which

sends downranging pulses to the Digital Control Circuit. If the input voltage is greater than 96% of full scale, then the Amplitude Detector activates the Schmitt Trigger, giving a pulse to "set" the Digital Control Circuit, causing an uprange to the 1500 v range.

4-23. For example, if the 414A is on the 150 v range in the AUTO mode and 10 volts is applied to the input, which is below 25% of full scale, then the multivibrator will be turned on. The first pulse from the multivibrator will cause a downrange to the 50 v range, where the meter will still read below 25% of full scale. A second pulse will give a downrange to the 15 v range, where the meter will read above 25% of full scale; so a third pulse will not be generated. If the input voltage now increases from 10 v to about 145 v, the Schmitt Trigger will be activated, initiating an uprange.

4-24. DIGITAL CONTROL CIRCUIT (Figure 6-2).

4-25. The purpose of the Digital Control Circuit is to operate the Input and Feedback Attenuators of the Analog Measuring Circuit, and to operate the Range Indicator. It is a binary apparatus, in that only two discrete voltages, called logic levels, are utilized at each point of the circuit. At most points, the level used to initiate a circuit operation is the more positive of the two (positive logic), and is designated "1"; the other level, "0".

4-26. A binary counter is advanced one count by each downranging pulse from the Analog-to-Digital Converter. Only 12 of the 16 possible counter states are used, each of which results in a different combination of energized relays. These relays, K1 through K8, set the input attenuation and transconductance of the Amplifier Assembly and light the lamps of the Range Indicator, to give the 12 instrument ranges.

4-27. Four bistable multivibrators, called flip-flops, form the counter. Each flip-flop has two logic outputs, called the "set" and "reset" outputs. These two outputs, indicated by A and \bar{A} (called "not A") respectively on FF1, are always inverted relative to each other; i.e., the "set" output is "1" when the "reset" output is "0," and vice-versa. The three logic inputs are the "set," "trigger" and "reset." Inputs to all logic elements, like the flip-flop, are on the left or top of the symbols, and outputs on the right or bottom.

4-28. Logic level "1" applied to the various inputs of a flip-flop will alternate its outputs. A "1" at the T input will trigger the flip-flop regardless of its state, to alternate the outputs. The arrow at the T input indicates ac coupling. A "1" at the S input will alternate the outputs only if the "set" output is not already "1"; and a "1" at the R input will give a "1" at the "reset" output.

4-29. The A output of FF1 is connected to the T input of FF2; likewise, B is connected to the T input of FF3, and C to the T input of FF4. When output A changes from "0" to "1," FF2 will change state; likewise for output B and FF3, and C and FF4. So, if the counter is initially "set" to give a "1" from each "set" output, it will binarily count from 1111 to 0000 upon receiving enough downranging pulses from the Analog-to-Digital Converter. A feedback from the "set" output of FF3, through a logic inverter (indicated by a small circle), to the "reset" input of FF2 will cause the counter to skip two counts each of the two times that output C changes from "1" to "0." See Table 5-6 for this sequence.

4-30. AND gates and OR gates are other logic elements used. An OR gate has a "1" output, if and only if, at least one input is a "1." Whereas, an AND gate has a "1" output, if and only if, each input is a "1." As seen in the Figure 6-2, logic inverters are used at the inputs of AG2 through AG5. Logical inversion means that a "1" is inverted to a "0" and vice-versa. So a "0" is required at each inverter to give a "1" output from the gate.

4-31. The logic necessary to give the 12 combinations of energized relays is acquired by using OG2, AG2 through AG5, and inverter-drivers 4, 6 and 7 along with the counter. Each relay is energized by a "1" only when the counter outputs are as described below:

RELAY	ENERGIZES WHEN AND ONLY WHEN
K1	D is "0" OR when A AND C AND \bar{D} are "0"
K2	\bar{D} is "0" AND either A OR C is "1"
K3	C is "0" AND either A OR \bar{D} is "1"
K4	Same as K3
K5	B AND \bar{C} are "0"
K6	\bar{B} is "0"
K7	\bar{A} is "0"
K8	A AND C AND \bar{D} are "0"

4-32. Normally, downranging pulses will trigger the counter to downrange the 414A when the measured voltage becomes less than 25% of the present range. However, when the 414A is on the lowest range, the output of the counter will be 0000 and one more downranging pulse would change its output to 1111 and return the 414A to the 1500 v range. This action is inhibited by AG1 and OG1 so that the lowest part of the 5 mv scale can be utilized. OG1 supplies a "0" to one input of AG1 when the counter outputs, A, C and D are "0," which occurs only on the 5 mv range. With a "0" at one input, AG1 cannot supply a "1" to trigger the counter when a downranging pulse arrives from the Analog-to-Digital Converter.

4-33. SCHEMATIC ANALYSIS.

4-34. INPUT ATTENUATOR AND AMPLIFIER ASSEMBLY (Figure 6-3).

4-35. The input voltage to be measured is applied across voltage divider, R1 through R3, which provides attenuation of 1000 to 1 or zero attenuation as determined by K1 and K2. Photoconductors V1 and V2 of the chopper convert the voltage from the Input Attenuator into a square wave. This is accomplished by alternating the resistances of V1 and V2 between high and low values, so that V1 is low while V2 is high and vice-versa. Pulses of light from lamps DS1 and DS3 of the relaxation oscillator cause the resistance changes.

4-36. After ac amplification and phase inversion by Q1, Q2 and Q3, the square wave is rectified by V3 and V4 of the chopper to obtain the negative half cycle if the input voltage is positive, and the positive half cycle if the input voltage is negative. V1 and V4 are operated by the same lamp for synchronization and V2 and V3 by the other lamp. Low-pass filter, R16 and C9, produces a dc voltage from the rectified 205 cps square wave.

4-37. Capacitor C10 provides a high frequency bypass around the slow responding Chopper Amplifier, so that input-voltage changes will produce output-current changes with minimum delay. A summation of the bypass voltage and the Chopper Amplifier output voltage is accomplished by the differential amplifier. This fast response of the Amplifier Assembly to input-voltage changes is especially required for the rapid auto-ranging capabilities of the 414A.

4-38. The voltage from the differential amplifier at the collector of Q6 is further amplified by Q8 and Q9. Q10 and Q11 provide a low impedance output to the meter while CR11 through CR14 give the correct polarity.

4-39. The emitter-follower output is also applied through pin 12 to the Feedback Attenuator located on the Ranging Assembly, and through pin 13 to the Analog-to-Digital Converter for instrument ranging. This output voltage will have the opposite polarity of the input voltage and a proportional amplitude.

4-40. Overload protection diodes, CR9 and CR10, provide a feedback through CR7 and CR8 to the input of

the Chopper Amplifier during overloads occurring before the instrument can uprange and while long recovery transients are fading. CR7 and CR8 prevent the leakage current of CR9 and CR10 from appearing as input signal. Further amplifier protection is afforded by CR1 and CR2. Meter protection is by CR4.

4-41. In the OHMS mode, R_x , is connected between signal common and either R43 or R40 as selected by K1 or K2. Current of 1 ma or 1 μ A flows from the collector of the constant-current generator through R_x and a series resistance, either R39 and R40 or R42 and R43. The Feedback Resistance, R_f , is connected between power supply common at the base of QCR1, and signal common. QCR1, Q13 and Q14 are the zener diode and unity-gain amplifier discussed in paragraphs 4-12 through 4-15. A very stable voltage is developed between the anode and base terminals of QCR1, which is used as the offset voltage between the constant-current generator and R_f .

4-42. Since the voltage across R_f is essentially equal to the input voltage across R_x , the voltage across the series resistance must equal the constant offset voltage. This means a constant current through R_x , independent of the value of R_x .

4-43. R_x is also connected to the Chopper Amplifier input through S1R1 and A2R1 to give an input voltage that is measured just as in the VDC mode, except without the Input Attenuator, to give an accurate indication of the value of R_x .

4-44. Transistors Q13 and Q14 increase the input resistance of QCR1 so that current will not flow from R_f into the base of QCR1 and cause an error in the voltage across R_f . Q12 is used to prevent any current changes through QCR1 which would change the offset voltage.

4-45. RANGING ASSEMBLY (Figure 6-5).

4-46. Transistors Q1, Q2, Q4, Q5, Q7, Q8, Q11 and Q12 comprise the four flip-flops of the counter. The left base of each flip-flop is the "set" input, the right base is the "reset" input, the left collector and right emitter are "set" outputs, and the right collector and left emitter are "reset" outputs. The junctions of C1 and C4, C5 and C6, C7 and C8, and C9 and C10 are the "trigger" inputs.

4-47. As the flip-flops change state, their collectors alternate between 0 v and -18 v, and their emitters between 0 v and +1.4 v. Positive logic is used here. A "1" output from the collectors will be the 0 v, and a "0" output will be the -18 v. At the emitters, a "1" output will be the +1.4 v, and a "0" output will be the 0 v (Q2 and Q5 emitters excepted).

4-48. Transistors Q3, Q6, Q9 and Q13 are relay and lamp drivers. When FF1 changes state so that Q1 conducts, the base of Q3 will change from +1.4 v to 0 v and Q3 will conduct to energize K7 and light DS3. Since Q3 inverts the "reset" output of FF1 to operate K7, it is correct logically to show Q3 as an amplifier having an inverted output as seen in Figure 6-2.. Q6, Q9 and Q13 operate in the same manner to respectively control K6 and DS6, DS5, and DS7 and OG2.

4-49. The transistor of AG5, Q17, conducts to energize K5 only when Q4 and Q8 are cut off, giving -18 v (logic "0") to CR19 and CR18. If Q7 or Q8 conducts, then 0 v (logic "1") is applied to CR19 or CR18, increasing the current through R73. This cuts off Q17 and deenergizes K5. Since Q17 energizes K5 only when a "0" is present at both inputs, the symbol for the gate is drawn with input inverters as seen in Figure 6-2. Transistors Q15 and Q16 of AG2 work in the same manner to operate K8 and to supply inputs to AG3, AG4 and OG2.

4-50. Transistor Q10 of AG4 will energize K3 and K4 only when Q8 is conducting and Q16 is cut off. Likewise, Q14 of AG3 will conduct to energize K2 only when Q11 is conducting and Q16 is cut off.

4-51. If the collectors of Q1, Q7 and Q11 are at the -18 v level, then CR3, CR4 and CR5 of OG1 transmit the -18 v to CR16 of AG1, which becomes reversed biased so that downranging pulses cannot arrive at the trigger input of FF1. If one or more of the three diodes of OG1 receive 0 v, then the others become reversed biased and CR16 receives 0 v, allowing it to pass downranging pulses.

4-52. The Feedback Attenuator is composed of R1 through R13 and accepts the output of the Amplifier Assembly (see Figure 6-3) through pin 12. K4 through K8 connect different points of the attenuator to signal common.

4-53. Downrange switch S3 is used to discharge C3, providing a trigger to the counter through C2 for manual downranging in the HOLD mode.

4-54. POWER SUPPLY AND CONTROL ASSEMBLY (Figure 6-4).

4-55. A voltage proportional to the input voltage but of opposite polarity comes from the Analog Measuring Circuit through pin 16 to the bases of Q1 and Q2. Either Q1 or Q2 conducts, depending on the polarity of the voltage, causing Q6 to conduct, giving a positive voltage to the bases of Q7 and Q8. If the input voltage increases above 96% of the present range, then Q8 conducts; if it falls below 25%, then Q7 conducts.

4-56. When Q8 conducts, it draws current through CR13 causing Q9 to turn on and Q10 off. The negative pulse from the collector of Q10, then "sets" the counter in the Digital Control Circuit, upranging the 414A to the 1500 v range. But this reduces the output voltage from the Analog Measuring Circuit, cutting off Q8. So Q8 conducts only momentarily to cause the upranging.

4-57. When Q7 conducts, it reduces the current through CR11 and R21, allowing the astable multivibrator, Q11-Q12, to free run at 40 cps. The negative pulses from the collector of Q11 are inverted by Q19 to become downranging pulses to the Digital Control Circuit. Each pulse causes a downrange, and enough downranges take place so that the voltage from the Analog Measuring Circuit increases enough to cut off Q7 and stop the multivibrator. So Q7 conducts only momentarily to downrange the 414A. When Q12 cuts

off, giving a downranging pulse, CR14 conducts enough current through R23 and R22 to insure that the Schmitt Trigger will not be triggered by relay switching transients and "set" the counter.

4-58. Resistors R12 and R14 are adjusted to give the 96% and 25% upranging and downranging points. They are adjusted using a positive voltage from the Analog Measuring Circuit through pin 16 (negative measured voltage), which cuts off Q1 and turns on Q2. R2 and R6 are adjusted to give the same upranging and downranging points with a negative voltage at pin 16. They affect the voltage to Q6 only when Q1 is conducting and Q2 is cut off.

4-59. In the VDC-AUTO mode, Q5 conducts current through R11 to increase the voltage drop across R11 and decrease the voltage drop across resistors R12 through R16. When in the VDC-HOLD mode, Q5 cuts off, and the voltage applied to Q8 becomes less positive. An input voltage of 140% of the range being held is now required to cause Q8 to conduct and uprange the 414A. In the OHMS-HOLD mode, Q5 remains cut off and in addition, the sum of R9 and R10 is added in parallel to R11, which further lowers the voltage applied to Q8. Now, Q8 will never conduct, even with an infinite input resistance (probes open).

4-60. The Polarity Detector, Q3 and Q4, indicates the polarity of the measured voltage by lighting lamp DS2 (-polarity) or DS1 (+polarity).

4-61. A positive voltage at pin 16 cuts off Q3, extinguishing DS1. Current from the -24 v supply, through DS1, R49 and R48, causes Q4 to conduct, lighting DS2. This current through DS1 is too small to light DS1.

4-62. A negative voltage at pin 16 turns on Q3 to light DS1. Q3 is in parallel to R49, R48 and the +28 v supply, so when it conducts, the current through R49 and R48 reduces and Q4 cuts off, extinguishing DS2.

4-63. POWER SUPPLIES (Figure 6-6).

4-64. The full wave rectifier, CR1 through CR4, and the filter, C11 and C12, supply 26.8 v across R44 and R45. The zener diode CR8 regulates the voltage at pin 18 to be +6.8 v in respect to signal common. The emitter of Q18 is connected to signal common through A4(20), A1(12), A1(11) and the COM probe. Q17 and Q18 regulate the voltage at pin 19 to be -26.8 v in respect to the voltage at pin 18, which gives -20 v at pin 19 in respect to signal common.

4-65. Any change in voltage across R44 and R45 is degenerated to an insignificant value by a proportional change in the collector resistance of Q17. The resistance of Q17 is controlled by Q18, which uses the zener diode reference voltage to detect any change in the voltage across R44 and R45. An increase in voltage across R44 and R45 increases the base and collector currents of Q18, making the base of Q17 more positive, to increase the collector resistance of Q17 and oppose the voltage increase across R44 and R45. Exactly the opposite occurs if the voltage across R44 and R45 decreases.

4-66. The full wave rectifier, CR1 through CR4, and the filter, C1 and C2, supply 52 v across R40, CR16, and R41. Q14, Q13 and Q1 use the reference voltage across CR7 to regulate the voltage at pin 2 to be +24 v in respect to the voltage at pin 11. Q15 and Q16 regulate the voltage at pin 9 to be +52 v in respect to the voltage at pin 11, giving +28 v at pin 9 in respect to pin 2. An extra amplifier, Q13, is used in the -24 v regulator because of the large current changes that take place when the lamps and relays operate.

4-67. A voltage of about 300 v across R4 is adjusted by R2 to set the frequency of the relaxation oscillator of the chopper.

Table 5-1. Test Equipment Required

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
DC Variable Power Supply	Output: 0 to ± 15 volts, continuously variable	Performance Checks, Adjustment and Calibration Procedure	-hp- Model 726AR Power Supply
DC Standard	Output: 5 millivolts to 1000 volts Accuracy: $\pm 0.1\%$	Performance Checks, Adjustment and Calibration Procedure	-hp- Model 741A AC-DC Differential Voltmeter/DC Standard
Resistance Box	Range: 5 ohms to 1.5 megohms Accuracy: $\pm 0.2\%$	Performance Checks, Adjustment and Calibration Procedure	General Radio 1432-B Decade Resistor
Resistors	1K $\Omega \pm 0.02\% 1/4$ w 10M $\Omega \pm 0.5\% 1/4$ w 50M $\Omega \pm 0.5\% 1/4$ w	Performance Checks, Adjustment and Calibration Procedure	-hp- Part No. 0811-0402 -hp- Part No. 0760-0025 -hp- Part No. 0730-0150
DC Digital Voltmeter	Range: 0 to 1.5 volts Accuracy: $\pm 0.1\%$	Adjustment and Calibration Procedure	-hp- Model 3440A/3443A Digital Voltmeter
Frequency Counter	Range: 150 to 250 cps Accuracy: $\pm 0.5\%$	Adjustment and Calibration Procedure	-hp- Model 5211A Electronic Counter
DC Voltmeter	Range: 0 to 350 volts Accuracy: $\pm 1\%$	Troubleshooting	-hp- Model 412A DC Voltmeter-Ohmmeter
Ohmmeter	Range: 0 to 10K ohms Accuracy: $\pm 5\%$	Troubleshooting	-hp- Model 412A DC Voltmeter-Ohmmeter

SECTION V

MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains the information, necessary for maintenance of the 414A Autovoltmeter. Included are performance checks, the adjustment and calibration procedure, troubleshooting techniques, and parts replacement procedures.



DO NOT REMOVE COVERS FROM INSTRUMENT UNLESS NECESSARY FOR MAINTENANCE. AN ACCUMULATION OF DUST OR OTHER FOREIGN MATTER CAN CAUSE IMPROPER OPERATION. ALSO, NEVER USE CARBON TETRACHLORIDE OR ANY COMMERCIAL TELEVISION AND RADIO SWITCH CLEANERS IN THIS INSTRUMENT. THESE AGENTS ARE VERY CONTAMINATING.

5-3. TEST EQUIPMENT.

5-4. Test equipment having the required characteristics for maintenance of the 414A is listed in Table 5-1. Other equipment having the required characteristics may be used rather than the equipment listed.

5-5. PERFORMANCE CHECKS.

5-6. The performance checks described in the following paragraphs are front-panel procedures that can be used to compare the performance of a 414A with the published specifications. These checks may be incorporated in a periodic maintenance, post-repair, or incoming quality control inspection. These tests should be conducted before any attempt is made at instrument calibration.

5-7. MANUAL RANGE CHECK.

5-8. Test equipment required: none

- Set FUNCTION to VDC and AUTO-HOLD to AUTO.
- Short VDC and COM probes. Instrument should be on the 5 mv range.
- Now set AUTO-HOLD to HOLD and depress DOWNRANGE button 12 times. If RANGE does not follow the sequence below, then troubleshoot in accordance with Paragraph 5-43.

1. 1500V	5. 15 V	9. 150MV
2. 500V	6. 5 V	10. 50MV
3. 150 V	7. 1500MV	11. 15 MV
4. 50 V	8. 500MV	12. 5 MV

5-9. VOLTMETER ACCURACY.

5-10. Test equipment required: dc standard

- Set FUNCTION to VDC and AUTO-HOLD to HOLD.
- Put 414A on 1500 v range using DOWNRANGE button.
- Connect VDC and COM probes to output of dc standard as shown in Figure 5-1.
- Vary dc standard output and downrange 414A in accordance with Table 5-2. If the 414A meter does not give the listed indications, then perform Adjustment and Calibration Procedure (Paragraph 5-19).

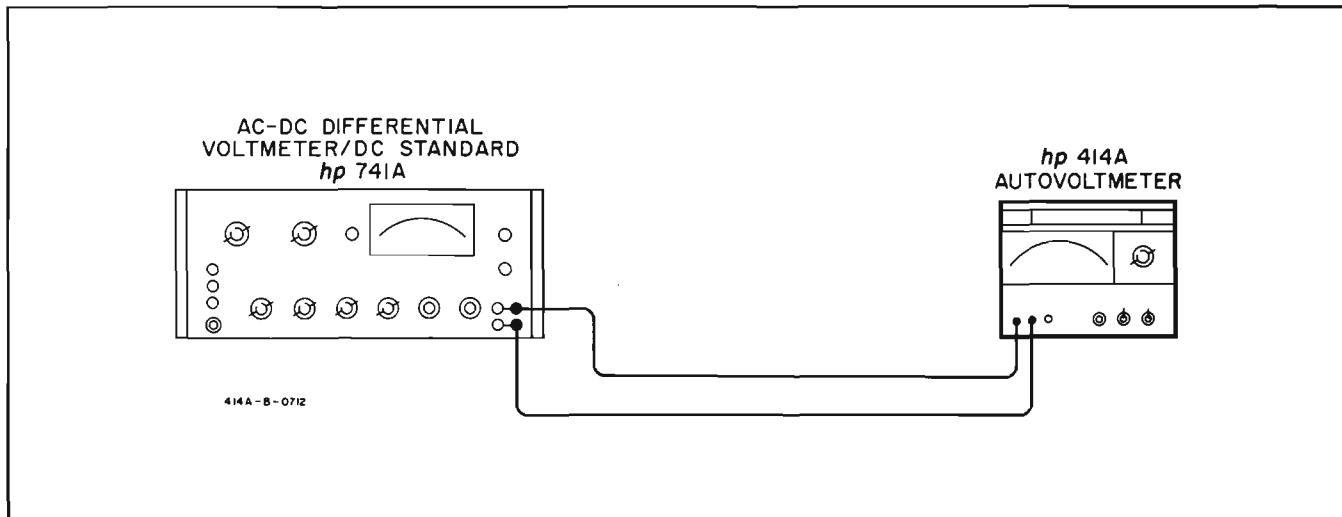


Figure 5-1. Voltmeter Check and Calibration

Table 5-2. Voltmeter Accuracy Data

DC Standard Output	414A Range	414A Meter Indication
1000V	1500 V	9.87 to 10.13
500V	500 V	4.95 to 5.05
150V	150 V	14.85 to 15.15
120V	150 V	11.86 to 12.14
90V	150 V	8.88 to 9.12
60V	150 V	5.90 to 6.10
30V	150 V	2.91 to 3.09
50V	50 V	4.95 to 5.05
15V	15 V	14.85 to 15.15
5V	5 V	4.95 to 5.05
1.5V	1500MV	14.85 to 15.15
0.5V	500MV	4.95 to 5.05
0.15V	150 MV	14.85 to 15.15
0.05V	50 MV	4.95 to 5.05
0.015V	15 MV	14.85 to 15.15
0.005V	5 MV	4.95 to 5.05

5-11. OHMMETER ACCURACY.

5-12. Test equipment required: resistance box

- Set FUNCTION to OHMS and AUTO-HOLD to HOLD.
- Connect OHMS and COM probes to resistance box as shown in Figure 5-2.
- Use the DOWNRANGE button to change the range of the 414A and set the resistance box to the values listed in Table 5-3. If the 414A meter does not give the listed indications, then perform Ohmmeter Calibration (Paragraph 5-32).

5-13. INPUT RESISTANCE.

5-14. Test equipment required: power supply and 50 and 10 megohm resistors.

- Set FUNCTION to VDC and AUTO-HOLD to HOLD.
- Connect 414A, power supply, and 50 megohm resistor in series as shown in Figure 5-3.

Table 5-3. Ohmmeter Accuracy Data

Resistance Box Setting	414A Range	414A Meter Indication
1.5 MΩ	1500 KΩ	14.8 to 15.2
0.5 MΩ	500 KΩ	4.92 to 5.08
150 KΩ	150 KΩ	14.8 to 15.2
50 KΩ	50 KΩ	4.92 to 5.08
15 KΩ	15 KΩ	14.8 to 15.2
5 KΩ	5 KΩ	4.92 to 5.08
1.5 KΩ	1500 Ω	14.8 to 15.2
500 Ω	500 Ω	4.92 to 5.08
400 Ω	500 Ω	3.93 to 4.07
300 Ω	500 Ω	2.94 to 3.06
200 Ω	500 Ω	1.95 to 2.05
100 Ω	500 Ω	0.96 to 1.04
150 Ω	150 Ω	14.8 to 15.2
50 Ω	50 Ω	4.92 to 5.08
15 Ω	15 Ω	14.8 to 15.2
5 Ω	5 Ω	4.92 to 5.08

- Set 414A on the 15 v range and increase the output of power supply to 15 volts. 414A meter should indicate at least 10 volts to verify an input resistance of 100 megohms on the 15 v range, as given by the following formula:

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

where R_{in} is the 414A input resistance, R_s is the series resistance, E_m is the 414A meter indication, and E_o is the power supply output voltage.

- Decrease output of power supply to 5 volts and downrange 414A to the 5 v range. 414A meter should now indicate at least 3.3 volts to verify an input resistance of 100 megohms on this range.
- Decrease output of power supply to 15 millivolts and downrange 414A to 15 mv range.
- Replace 50 megohm resistor with 10 megohm resistor. 414A meter should indicate at least 7.5 millivolts to verify an input resistance of 10 megohms on this range.

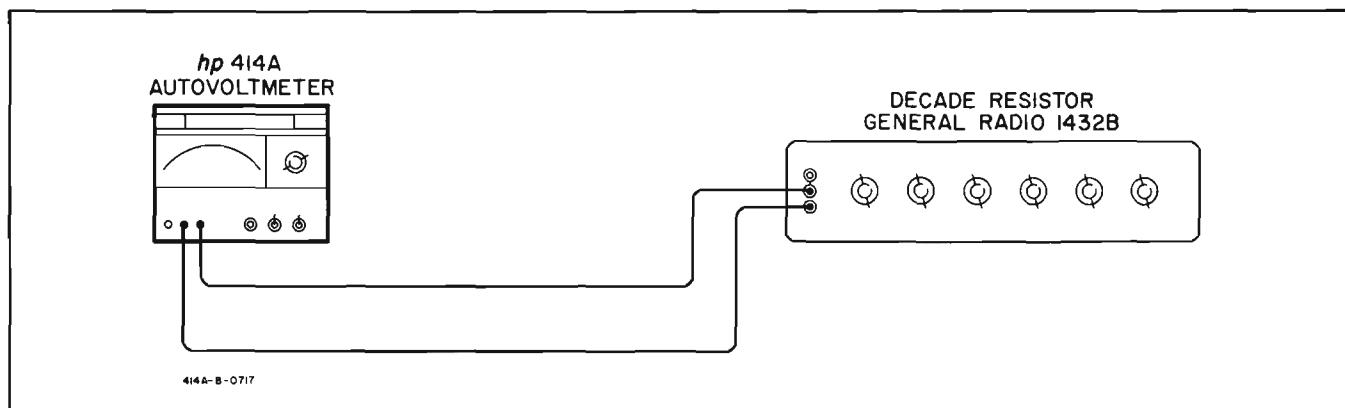


Figure 5-2. Ohmmeter Check and Calibration

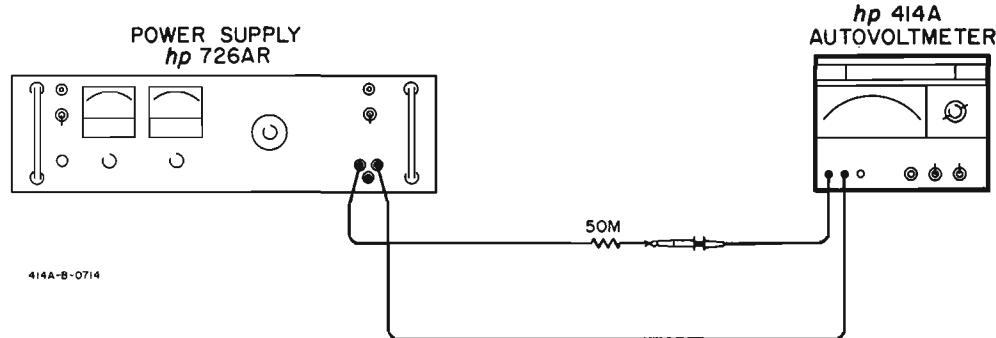


Figure 5-3. Input Resistance Check

5-15. AUTORANGING CHECK.

5-16. Test equipment required: variable power supply

- Set FUNCTION to VDC and AUTO-HOLD to AUTO.
- Apply approximately 3 volts from power supply to VDC and COM probes as shown in Figure 5-4.
- Slowly increase output voltage of power supply and watch 414A meter pointer move upscale. If the 414A does not uprange to the 15 v range when the pointer is between 4.75 and 4.85, perform the Upranging Point Adjustment (Paragraph 5-39).
- Decrease output of power supply and watch the meter pointer move downscale. If the 414A does not downrange to the 5 v range when the pointer is between 3.95 and 4.05, perform the Downranging Point Adjustment (Paragraph 5-40).

5-17. OVERLOAD PROTECTION.

5-18. Test equipment required: power supply

- Set AUTO-HOLD to HOLD and manually downrange to 5 v range.
- Apply an overload voltage of 8 volts to VDC and COM probes as shown in Figure 5-4. This should cause the 414A to uprange to the 1500 v range.

5-19. ADJUSTMENT AND CALIBRATION PROCEDURE.

5-20. The following paragraphs describe the complete adjustment and calibration procedure for the Model 414A. This procedure should be accomplished if the instrument does not perform as described in Performance Checks (Paragraph 5-5). The instrument should be turned on for at least 45 minutes before this procedure is begun and the listed sequence should be followed. Adjustment points are shown in Figure 6-1.

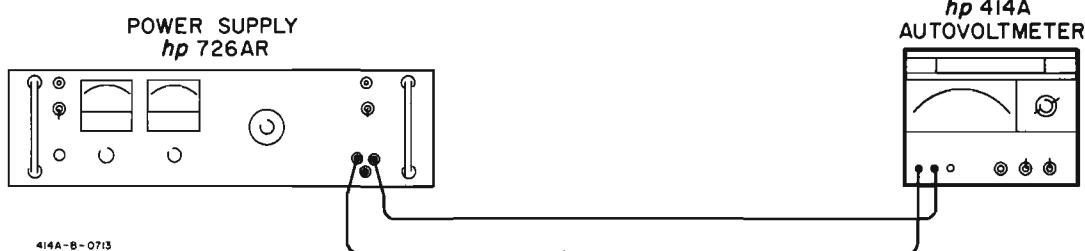


Figure 5-4. Autoranging Check and Adjustment

5-21. METER MECHANICAL ZERO ADJUSTMENT.

5-22. Test equipment required: none

- a. Turn off the instrument and allow one minute for all capacitors to discharge.
- b. Rotate the front panel zero adjustment screw clockwise until the meter pointer is to the left of zero and moving upscale.
- c. Continue to rotate adjustment screw until pointer is exactly on zero. If pointer overshoots zero, start over at step c.
- d. When pointer is exactly on zero, rotate the adjustment screw very slightly counterclockwise. If the screw is rotated too far in this direction so that the pointer moves, then start over at step b.

5-23. METER CURRENT ADJUSTMENT.

5-24. Test equipment required: digital voltmeter, power supply, and 1K Ω resistor. This adjustment is to ensure that the meter deflects to full scale when the output current of the Analog Measuring Circuit is 1 ma.

- a. With power off, remove Amplifier Assembly (A2).
- b. Connect test equipment to 414A meter terminals as shown in Figure 5-5.
- c. Increase output of power supply until digital voltmeter reads 1.000 volts. The current through the meter circuit is now 1 ma.

- d. Adjust R3 (Meter Current Adj) until meter reads exactly full scale on the top scale.

5-25. CHOPPER FREQUENCY ADJUSTMENT.

5-26. Test equipment required: frequency counter and power supply.

- a. Replace A2 assembly, turn on instrument, and short VDC and COM probes.
- b. Apply 1.5 volts across A2R36 from the power supply and connect the frequency counter between chopper side of A2C7 and power supply common as shown in Figure 5-6.
- c. Adjust A5R2 (Chopper Frequency) for 205 ± 1 cps.

5-27. AMPLIFIER ZERO ADJUSTMENT.

5-28. Test equipment required: power supply

- a. Set AUTO-HOLD to HOLD and FUNCTION to VDC.
- b. Downrange to the 5 mv range.
- c. Apply 3 mv from power supply to VDC and COM probes as in Figure 5-4, and note exact meter reading on 414A.
- d. Reverse VDC and COM probes and note any difference in meter reading from that in step c.
- e. Adjust A2R45 (zero) until meter reads the same as in step c.

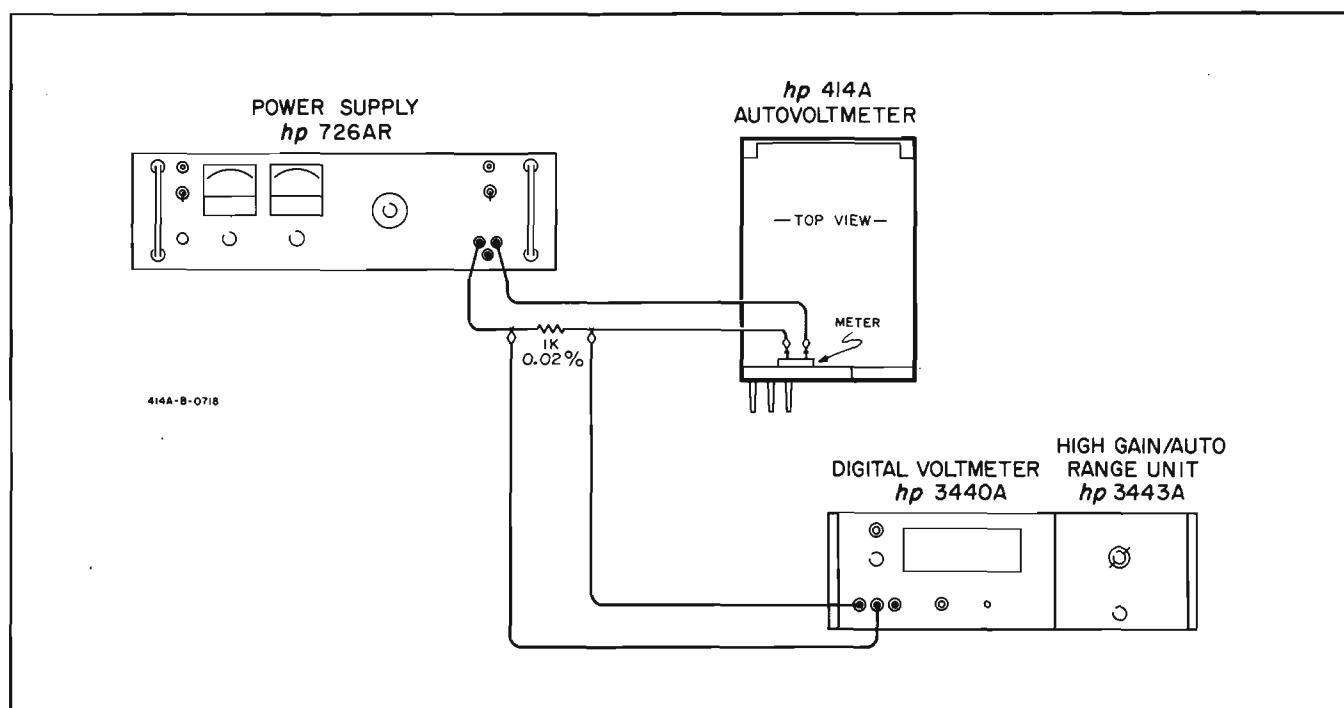


Figure 5-5. Meter Current Adjustment

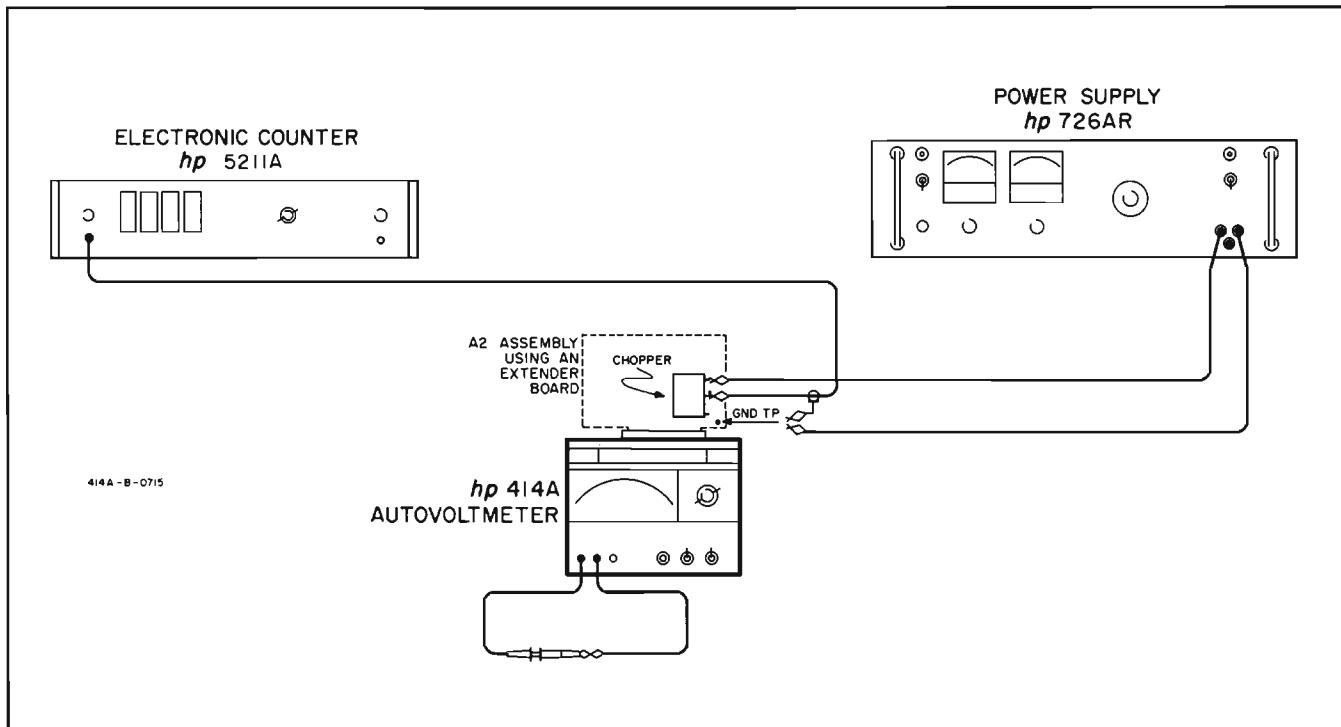


Figure 5-6. Chopper Frequency Adjustment

- f. Continue to reverse VDC and COM probes and adjust A2R45 until meter deflects the same with both input polarities (zero turnover).

5-32. OHMMETER CALIBRATION.

5-33. Test equipment required: resistance box

5-29. VOLTMETER CALIBRATION.

5-30. Test equipment required: dc standard

- Set FUNCTION to VDC and AUTO-HOLD to HOLD.
- Connect the dc standard to VDC and COM probes as shown in Figure 5-1.
- In the sequence below, with the 414A on the proper range, adjust the calibration resistors for the correct meter reading when the dc standard output is as listed.

5-31. After completing voltage calibration, perform Voltmeter Accuracy check (Paragraph 5-9).

- Set FUNCTION to OHMS and AUTO-HOLD to HOLD.

- Connect the resistance box to COM and OHMS probes as shown in Figure 5-2.
- Perform the following calibrations:

5-34. 1 K Ω CALIBRATION.

- Set 414A to 1500 Ω range and resistance box to 1K Ω .
- Adjust A2R42 (1K CAL) for a meter reading of 10.

CALIBRATION RESISTOR	METER READING	414A RANGE	DC STANDARD OUTPUT
1. A3R3 (15MV CAL)	15	15 MV	15 MV
2. A3R7 (1500MV CAL)	15	1500MV	1500MV
3. A3R1 (500MV CAL)	5	500MV	500MV
4. A3R6 (150MV CAL)	15	150 MV	150 MV
5. A3R11 (5V CAL)	5	5 V	5 V
6. A1R3 (50V CAL)	5	50 V	50 V

5-35. 1 M Ω CALIBRATION.

- a. Set 414A to 1500K Ω range and resistance box to 1M Ω .
- b. Adjust A2R39 (1 meg CAL) for a meter reading of 10.

5-36. After completing ohmmeter calibration, perform Ohmmeter Accuracy check (Paragraph 5-11).

5-37. AUTOMATIC RANGING ADJUSTMENTS.

5-38. Test equipment required: power supply. The following calibration sequence must be used:

5-39. UP RANGING POINT ADJUSTMENT.

- a. With 414A turned off,
 1. Set AUTO-HOLD to AUTO
 2. Center A4R2 (HI MAG ADJ) and A4R6 (LO MAG ADJ)
 3. Turn A4R12 (UP ADJ) fully clockwise and A4R14 (DN ADJ) fully counterclockwise.
- b. Turn on 414A and connect VDC and COM probes to power supply in reverse polarity to that shown in Figure 5-4.
- c. Adjust power supply output until negative 4.8 volts is indicated on the 414A 5 v range.
- d. Slowly turn UP ADJ counterclockwise until 414A upranges to the 15 v range.
- e. Decrease power supply output until 414A downranges back to the 5 v range.
- f. Slowly increase power supply output and note the meter reading at which upranging occurs.
- g. If the upranging point is not between 4.75 and 4.85, then readjust UP ADJ and start over at step e.

5-40. DOWN RANGING POINT ADJUSTMENT.

- a. Adjust power supply output until negative 1.25 volts is indicated on the 414A 5 v range.
- b. Slowly adjust DN ADJ until 414A downranges to 1500 mv range.
- c. Increase power supply output until 414A upranges back to the 5 v range.
- d. Slowly decrease power supply output and note the meter reading at which downranging occurs.
- e. If the downranging point is not between 1.2 and 1.3, then readjust DN ADJ and start over at step c.

5-41. POLARITY CONVERTER SYMMETRY ADJUSTMENTS.

- a. Reverse VDC and COM probes to obtain positive input polarity as shown in Figure 5-4, and adjust power supply output to a value on the 414A 5 v range.
- b. Decrease power supply output and note the downranging point.
- c. If this downranging point is not within one minor meter division of the downranging point established in Paragraph 5-40, then adjust L0 MAG ADJ.
- d. Increase power supply output and note the upranging point on the 5 v range.
- e. If this upranging point is not within one minor meter division of the upranging point established in Paragraph 5-39, then adjust HI MAG ADJ.
- f. These two adjustments interact, so continue to check the ranging points and make adjustments until both ranging points are within tolerance.

5-42. Reverse VDC and COM probes to provide a negative input voltage, and recheck ranging points as in Paragraphs 5-39 and 5-40.

5-43. TROUBLESHOOTING.

5-44. This section is intended to aid in the isolation of the cause of malfunction, and need not be consulted unless it has been established that the cause is due to something other than maladjustment or calibration. However, further insight into operational theory can be gained by reading this section after Section IV.

5-45. In this section are a front-panel troubleshooting tree, a list of possible malfunctions, check-out procedures for different parts of the circuit, and logic charts.

5-46. When troubleshooting circuits, it will be necessary to gain access to components on the boards for voltage and resistance measurements. Use an extender board, -hp- Part No. 5060-0630, for this purpose. All of the voltages on the boards, except those of the Ohmmeter Section, are referenced to power supply common, which may be reached at all GND test points on the boards or at pins 2 and 3 on A2, pins 3, 4 and 5 on A3, and at pin 2 on A4. The inner-chassis is signal common.

WARNING

THE CHOPPER BLOCK ON A2 IS SUPPLIED WITH +300 VOLTS, SO BE VERY CAREFUL WHEN WORKING AROUND THIS SIDE OF THE BOARD. AN EXTENDER BOARD USED UNDER A2 WILL ALSO HAVE +300 VOLTS ON THE SAME SIDE.

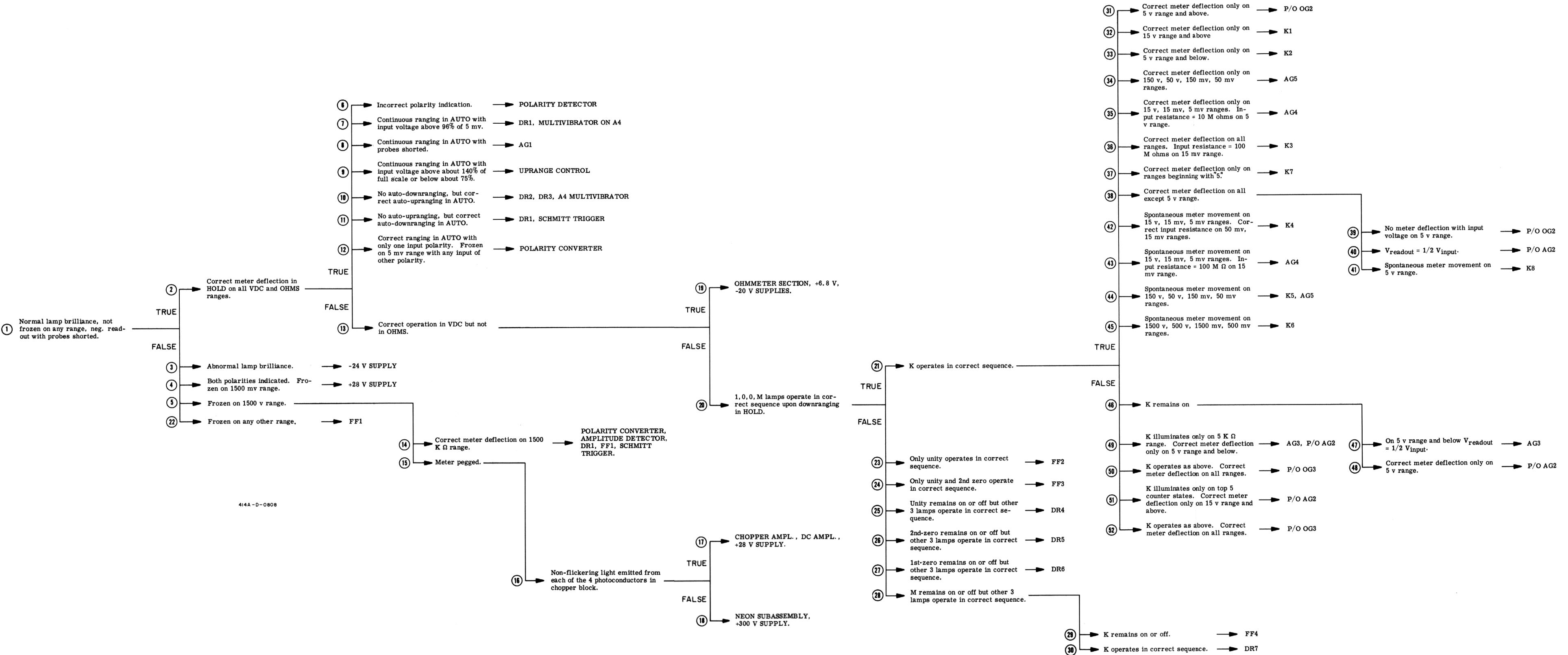


Figure 5-7. Troubleshooting Tree


CAUTION

WHEN PERFORMING CHECKS OR MEASUREMENTS ON THE 414A, BE EXTREMELY CAREFUL NOT TO SHORT BOARD PINS OR CONNECT A TEST INSTRUMENT TO WRONG POINTS ON THE BOARDS, AS SEVERE DAMAGE CAN RESULT. BE PARTICULARLY CAREFUL NOT TO SHORT THE SIGNAL AND POWER SUPPLY COMMONS, AS THIS SHORTS THE FEEDBACK ATTENUATOR, PUTTING A SEVERE OVERLOAD CURRENT THROUGH THE METER. PINS 9 THROUGH 12 OF A2 ARE PARTICULARLY DANGEROUS PINS TO SHORT, BECAUSE THEY ARE DIRECT CONNECTIONS TO THE POWER SUPPLIES AND THE METER. ALSO, PINS 1 AND 2 OF A2 ARE RESPECTIVELY +300 VOLTS AND COMMON.

5-47. Since the Input Attenuator is a very high impedance network, care must be exercised in not contaminating A1R1 and R2 with finger prints or dust.

5-48. When making resistance checks on transistors or diodes, use an ohmmeter having a short-circuit current output not greater than 1 ma. Do not use ranges below the 1K ohm range on the -hp- 412A.

5-49. TROUBLESHOOTING TREE.

5-50. The troubleshooting tree is a logical diagnosis of symptoms, and names circuits that are probably at fault for each of several specific front-panel symptoms. It cannot be emphasized too much that the tree is not a strict elimination procedure, and that other circuits than those listed could be at fault. The tree is based on the assumptions that only one particular circuit is at fault and that the Range Indicator lamps are good. If any of the lamps should fail to illuminate when they should, then they should be checked as in Paragraph 5-67, for the first step in troubleshooting, before the tree is consulted.

5-51. To use the tree, simply decide whether ① is true or false and then proceed along the correct branch. After each true-false question there is a choice of symptoms of another true-false question. For each symptom is listed a circuit or circuits that are probable causes of the malfunction. Use the appropriate instrument mode to identify a symptom.

5-52. POSSIBLE MALFUNCTIONS.

5-53. This section is to be used with the troubleshooting tree. For each of several possible component failures, a resultant malfunction is described which can give rise to the symptoms on the tree.

- ① If these conditions are true, then the Analog Measuring Circuit and the +28 v, -24 v and +300 v supplies are probably all right.
- ② It must be decided at this point whether the malfunction involves incorrect ranging or inaccurate measurement. Autoranging malfunctions are

assumed to be due to faulty components in the Analog-to-Digital Converter.

- ③ Dim lamps on the Range Indicator could be caused by a leaky control transistor or amplifier, A4Q13 or Q14. Also, if the zener diode voltage drops, the collector currents of these two transistors will increase, increasing the collector resistance of the series regulator Q1, reducing the lamp brilliance. If the lamps become brighter than normal, then A4Q13 or Q14 could be open.
- ④ If the output of the +28 v supply becomes too low, then the Analog Measuring Circuit has a negative output which allows A4Q3 to conduct, but Q4 does not cut off as usual because current through R48 is reduced. Hence, both polarity indicators remain on.
- ⑤ The instrument upranges to the highest range and holds, when the power is turned on, even though the probes are shorted.
- ⑥ If this is the only symptom, then A4Q3 or Q4 is probably open or leaky.
- ⑦ This symptom will appear if the multivibrator on A4 does not turn off as it should when the input voltage is below 25% of full scale. The down-ranging pulses cannot reach the counter on the 5 mv range due to AG1, but if the input voltage is above 96% of 5 volts, the counter will "set" to the 1500 v range and then begin downranging. It will downrange all the way to the 5 mv range, where it will again "set" due to the overload voltage. Thus, continuous ranging occurs. A4Q7 or Q11 might be leaky.
- ⑧ With the probes shorted A4Q7 conducts, allowing the multivibrator to free-run. If A3CR16 of AG1 is leaky, then the counter will continue to be triggered causing this continuous ranging.
- ⑨ This symptom will appear if A5Q5 is open. A4Q5 normally conducts in AUTO to give Q7 and Q8 a more positive voltage. With Q5 open, the voltage to the Polarity Converter must increase to a greater positive potential before Q8 will conduct, causing an uprange. So an uprange will now occur in AUTO at about 140% of full scale. Also, the operation of Q7 will be affected. It will now conduct causing a downrange at a point considerably above the normal 25% point, as the input voltage is reduced from full scale value. Continuous ranging will result with an input voltage above the upranging point of a particular range, but below the downranging point of the next higher range.
- ⑩ This symptom appears when no downranging pulses reach the counter. A4Q12 or Q19 might be open or leaky, A5Q7 or A3CR16 might be open.
- ⑪ This can be caused by A5Q8 or Q9 being open, or A5Q10 leaky, so that a "set" pulse will never be generated.

- (12) If one of the transistors of the Polarity Converter is open then only one input polarity can cause A4Q6 to conduct, giving the proper ranging points. On the other polarity, a "set" pulse will never be generated and the multivibrator will never turn off, and so the instrument will downrange to the 5 mv range and hold.
- (13) Some circuits are used only in the OHMS mode, so they are probably, but not necessarily, the source of trouble if the instrument operates properly in VDC but not in OHMS. It is possible that components in the Digital Control Circuit, or other circuits, will malfunction only in the OHMS mode.
- (14) If the meter pegs with the probes open and has zero deflection with the probes shorted, in OHMS as it should, then the instrument is probably being held in the top range by a continuous "set" voltage from the Analog-to-Digital Converter. This can be caused by A4Q1, Q2, Q6, Q8 or Q9 being leaky, A4Q10 open, or FF1 frozen.
- (15) Meter is pegged even with probes shorted, in either OHMS or VDC.
- (16) The light shining through the four photoconductors in the chopper block on A2 should appear continuous and nonvarying. The instrument top cover must be removed to observe this.
- (17) If the instrument is frozen on the 1500 v range with the meter pegged and the chopper seems to be working properly as in (6), then the dc or chopper amplifier or +28 v regulator is probably at fault. A transistor in the amplifier might be open or leaky, the series regulator A4Q16 might be leaky, or A5Q15 might be open. A faulty chopper amplifier transistor will open the feedback loop, allowing the dc amplifier to drift and peg the meter on the highest range; and a faulty dc amplifier transistor will upset the bias of the entire amplifier, pegging the meter and causing the chopper amplifier to saturate. An increase in the voltage output of the +28 v supply would also give this symptom.
- (18) If the relaxation oscillator or +300 v supply is faulty, then the chopper amplifier will not pass a signal and the dc amplifier will operate open-loop and peg the meter.
- (19) If something is wrong with the unity-gain amplifier, the instrument will probably malfunction on each OHMS range; whereas a faulty constant-current generator may cause incorrect readout on only the 5K Ω range or on this range plus any number of successively lower ranges.
- (20) If the 1, 0, 0, M lamps operate in the correct sequence as given in the Logic Charts, when the instrument is downranged in HOLD-VDC, this indicates that the counter and four drivers on the Ranging Assembly are operating properly.
- (21) If in OHMS, the K lamp illuminates only on the top six counter states, as the instrument is downranged in HOLD, then AG2, AG3 and OG3 are operating correctly.
- (22) If all of the 1, 0, 0, M lamps fail to alternate correctly as the DOWNRANGE switch is successively depressed, then A3Q1 or Q2 of FF1 is probably open or leaky, holding the flip-flop in one state so that the counter cannot be triggered by downranging pulses.
- (23) If the first-zero, second-zero and M lamps fail to alternate as the DOWNRANGE is successively depressed, then A4Q4 or Q5 of FF2 is probably open or leaky, which holds the flip-flop in one state.
- (24) A3Q7 or Q8 of FF3 is probably open or leaky, prohibiting an alternation of the flip-flop.
- (25) Driver A3Q3 is probably open or leaky.
- (26) Driver A3Q6 is probably open or leaky.
- (27) Driver A3Q9 is probably open or leaky.
- (28) M does not alternate during downranging in VDC-HOLD.
- (29) A3Q11 or Q12 of FF4 is probably open or leaky, holding the flip-flop in one state.
- (30) Driver A3Q13 is probably open or leaky.
- (31) An input voltage will give the correct meter deflection only on the 5 v range or higher. (In OHMS, 5K ohms range or higher). A1CR1 is probably open so that K1 will be energized only on the 5 v range, by the output of AG2 through A1CR2.
- (32) In OHMS, 5K ohms range or higher. K1 is probably open.
- (33) In OHMS, 5K ohms range or lower. K2 is probably open.
- (34) If A3Q17 is leaky, K5 will remain closed.
- (35) If A3Q10 is leaky, K3 and K4 will remain energized. The input resistance will be 10 megohms on the 5 v range and below, because K3 reduces the input resistance only when K1 is energized. In OHMS, K3 is not used.
- (36) AG4 and K4 are operating properly if the meter deflection is correct on the 15 v, 15 mv and 5 mv ranges. This means that K3 is open if the input resistance does not reduce to 10 megohms as it should on the 15 mv range.
- (37) K7 must energize to give the ranges beginning with unity. K7 is probably open.
- (38) In OHMS, 5K ohms range.

- (39) Correct operation in ranges other than 5 v. A1CR2 is probably open, so that AG2 cannot energize K1 on the 5 v range.
- (40) On the 5 v range the meter deflects to only one half the correct value; correct meter deflection on all other ranges. A3Q16 is probably open, which makes K2 energize on the 5 v range. With both K1 and K2 closed on this range, the Inout Attenuator resistor A1R1 will be shorted, leaving only the resistance of the probe (100K ohms) in series with A1R2 and R3 as the input resistance.
- (41) Meter moves up and down scale as though signal were present, even with probes shorted. K8 is probably open.
- (42) Meter moves up and down scale as though signal were present, even with probes shorted. Correct input resistance on both 50 mv and 15 mv ranges indicates that K3 is operating properly, leaving only K4 as a probable cause of malfunction. K3 does not operate in OHMS, so AG4 or K4 could be at fault in OHMS.
- (43) These symptoms indicate that both K3 and K4 are not operating. This means that A3Q10 of AG4 is probably open. In OHMS, K3 is not used, so the fault might be with K4.
- (44) K5 or A3Q17 of AG5 might be open.
- (45) K6 is probably open.
- (46) K remains illuminated during downranging in OHMS-HOLD.
- (47) On 5 v range and lower, the meter deflects to only one half the correct value. A3Q14 is probably leaky, holding K2 closed, shorting A1R1.
- (48) All ranges except 5 v range give erroneous readings. A3Q15 is probably leaky, holding K8 and K1 energized.
- (49) To check for this symptom, put instrument on 5 v range and then switch to OHMS. K will illuminate on this range, but no other range, when the DOWNRANGE button is successively depressed. Check meter deflection on 15 v and 5 v ranges. A3Q14 is probably open or A3Q16 leaky, so that K2 will not energize.
- (50) Check for this symptom like in (49). S1CR1 is probably open.
- (51) To check for this symptom, put instrument in 1500K ohms range on HOLD and successively depress DOWNRANGE to see when K illuminates. Check meter deflection on 5 v and 15 v ranges. A3Q15 is probably open, so that K8 and K1 will not energize on the 5 v range, and the K lamp will illuminate only when K2 energizes.
- (52) Check for this symptom like in (51). S1CR2 is probably open.

5-54. CHECK-OUT PROCEDURES.

5-55. These procedures supplement (1), (2), (13), (16), (20) and (21) of Paragraph 5-52, as methods to check out different parts of the circuit for proper operation. They are not perfect checks, but they give evidence of a high probability of correct operation.

5-56. COUNTER, DR4, DR5, AG2, AG4, AG5, K4 THROUGH K8, AND FEEDBACK ATTENUATOR.

5-57. Remove A2 board and check the resistance between power supply common and signal common. Power supply common can be reached at A3(3); and signal common is at the inner-chassis. From the 1500 v range, manually downrange to the 5 mv range. The measured resistance for each range should agree with the table below:

RANGE	RESISTANCE
1500 V	1500 Ω
500 V	500 Ω
150 V	150 Ω
50 V	slightly less than 150 Ω
15 V	15 Ω
5 V	5K Ω
1500MV	1500 Ω
500MV	500 Ω
150 MV	150 Ω
50 MV	slightly less than 150 Ω
15 MV	15 Ω
5 MV	slightly less than 15 Ω

5-58. A deviation from this chart indicates that a relay is not properly energizing. On all except the 50 v, 50 mv and 5 mv ranges, the resistance measured here is the R_f discussed in Section IV.

5-59. DC AMPLIFIER.

5-60. If the dc amplifier is operated open-loop (no dc feedback), it will drift and peg the meter on the 1500 v range. Since the direction of drift is random, either polarity can be indicated. However, if any component in the amplifier is faulty, the bias arrangement will be upset and the amplifier output will hold at one polarity even when operating closed-loop.

5-61. So, if under open-loop conditions, the amplifier can be made to switch polarity, this is an indication that Q4 through Q11 and all the associated components are operating properly. To open the feedback loop, it is only necessary to remove the +300 volts from the relaxation oscillator, crippling the chopper amplifier. This can easily be done by removing the connector from pin 5 on A5 board with a pair of needle nose pliers.

5-62. If the amplifier is operating properly, the readout polarity can be changed by shorting the emitter and base of A2Q4 or the base and power supply common. The former will charge C9 to give a positive input to the amplifier and a negative readout. It will be necessary to hold this short a few seconds to allow C9 to charge through R17. The latter short will forward bias Q4, giving a positive readout. If the appropriate

short will not cause the polarity to change, then one of the transistors is probably leaky or open.

5-63. SCHMITT TRIGGER AND DR1.

5-64. To check these circuits, short the base of A4Q8 to power supply common and measure the voltage at TP3 in respect to power supply common. If the voltage jumps from 0 to at least -14 volts when the short is accomplished, then these two circuits are probably all right.

5-65. POLARITY CONVERTER.

5-66. Observe voltage at TP2 (MAG OUT). It should vary between 0 and +6 volts as in input voltage deflects the meter from zero to full scale in HOLD.

5-67. LAMPS.

5-68. Short from GND, at the top of A4, to each bulb. This shorts the drivers to light the lamps.

5-69. POWER SUPPLIES.

5-70. The +28 and -24 voltages can be measured at the top of board A4 across the appropriate test pins. The "GND" pin is the common for these two voltages. To measure the +6.8 and -20 voltages at the test pins on A4, it will probably be necessary to use an extender board. Remember that these latter two voltages are referenced to signal common, which is the inner-chassis, not to the "GND" pins. All of the power supply voltages, including the +300, can be measured at the appropriate board pins from the bottom of the instrument. The +300 can most easily be measured across pins 1 and 2 of A2.

5-71. LOGIC CHARTS.

5-72. The logic charts describe the flip-flop outputs and list the energized relays for each instrument range.

Also, Boolean Algebra statements are given which describe the counter state necessary for a "1" output from each gate. A gate will have a "1" output only when its Boolean statement is equal to "1". The dot between expressions indicates the AND gate function, and the plus sign indicates the OR gate function. A bar above an expression indicates logical inversion. For example, OG3 will light the K lamp only when

$$\overline{A} \text{ AND } \overline{C} \text{ AND } D = 1, \text{ OR when } D \text{ AND } \overline{A} \cdot \overline{C} \cdot D = 1$$

This can be simplified to the following conditions:

$$A = O \text{ AND } C = O \text{ AND } D = 1, \text{ OR when } A \text{ OR } C = 1 \\ \text{AND } D = 1.$$

5-73. Further information about logic circuit operation can be deduced from Figure 6-2. For instance, it can be seen that OG3 will have a "1" output only when both K8 and K2 operate, and OG2 will have a "1" output only when the M lamp is illuminated and K8 is energized.

LOGIC CHART 1

GATE	OUTPUT
AG1	$(A + C + D) \cdot \text{downranging pulse}$
AG2	$\overline{A} \cdot \overline{C} \cdot D$
AG3	$D \cdot \overline{A} \cdot \overline{C} \cdot D$
AG4	$\overline{C} \cdot \overline{A} \cdot \overline{C} \cdot D$
AG5	$C \cdot \overline{B}$
OG1	$A + C + D$
OG2	$(\overline{A} \cdot \overline{C} \cdot D) + \overline{D}$
OG3	$(\overline{A} \cdot \overline{C} \cdot D) + (D \cdot \overline{A} \cdot \overline{C} \cdot D)$

LOGIC CHART 2

RANGE INDICATOR	FLIP-FLOP OUTPUTS	ENERGIZED RELAYS										
		A	B	C	D	K1	K2	K3	K4	K5	K6	K7
1 5 0 0	V K Ω	1	1	1	1		X			X	X	
5 0 0	V K Ω	0	1	1	1		X			X		
1 5 0	V K Ω	1	0	1	1		X			X	X	
5 0	V K Ω	0	0	1	1		X			X		
1 5	V K Ω	1	0	0	1		X	X	X			X
5	V K Ω	0	0	0	1							X
1 5 0 0	M V Ω	1	1	1	0		X			X	X	
5 0 0	M V Ω	0	1	1	0		X			X		
1 5 0	M V Ω	1	0	1	0		X			X	X	
5 0	M V Ω	0	0	1	0		X			X		
1 5	M V Ω	1	0	0	0		X		X	X		X
5	M V Ω	0	0	0	0		X		X	X		

5-74. PARTS REPLACEMENT PROCEDURES.**5-75. REPLACEMENT OF RANGE INDICATOR LAMPS.**

- a. Remove instrument top cover.
- b. Remove the aluminum bar just behind the lamps.
- c. Pull the plastic lamp assembly away from the front of the instrument to gain access to lamps.
- d. Push the lamp out of the assembly with a wire inserted through the hole behind the lamp.
- e. Replace parts in reverse order.

5-76. REPLACEMENT OF PHOTOCOPPER NEON SUBASSEMBLY.

- a. Remove Amplifier Assembly A2.
- b. Unsolder from the printed circuit board, the three wires (black, white, and white/brown) coming from top of chopper. Remember the wire positions.
- c. Remove two screws on top of chopper.
- d. Remove metal chopper top and neon printed circuit subassembly.
- e. Replace parts in reverse order.
- f. Adjust chopper frequency in accordance with Paragraph 5-25, and perform Voltmeter Accuracy Check (Paragraph 5-9).

5-77. REPLACEMENT OF COMPONENTS ON PC BOARDS.

- a. To remove a component, place a heat sink (long nose pliers, tweezers, commercial heat sink, etc.) on a component lead as close to the component as possible.

- b. Heat the lead using a low-heat (25 to 45 watts) soldering iron, and pull the lead out of the board.

- c. If a component is never to be used again, then clip the leads close to the component and remove the leads from the board.



EXCESSIVE OR PROLONGED HEAT WILL DAMAGE THE COMPONENT AND THE PC BOARD.

AVOID TOUCHING THE COMPONENTS AND THE CONDUCTIVE AREAS OF THE PC BOARD. ACIDS FROM FINGERS ARE VERY CONTAMINATING AND MIGHT CAUSE CURRENT LEAKAGE PATHS, RESULTING IN INSTRUMENT MALFUNCTION.

- d. To install a new component, clean the component-lead holes using the soldering iron and a toothpick.
- e. Shape the component leads and insert them in the holes so that the component is in the same position as the original component.
- f. Place a heatsink on a lead as close to the component as possible.
- g. Heat the lead and apply solder to the lead, letting the solder flow into the hole around the lead.
- h. Clip off the excess length of the leads and clean the connection and adjoining area with a weak solution of warm water and mild dishwashing detergent. Rinse thoroughly with clean water.



USE ONLY SMALL DIAMETER, 1-2% FLUX, ROSIN CORE SOLDER. NEVER USE ACID CORE SOLDER OR ACID FLUX.

SECTION VI

CIRCUIT DIAGRAMS

6-1. INTRODUCTION.

6-2. This section contains a block diagram, schematics, component location diagrams, and voltage level charts for transistor elements.

6-3. BLOCK DIAGRAM.

6-4. This is a "black box" functional diagram of the 414A. It is intended to show the overall relationship between circuits, and does not necessarily reflect actual circuitry. Only inputs and outputs of each circuit block are relevant; no internal functioning is considered.

6-5. SCHEMATICS.

6-6. These are "perfect circuit" electrical equivalent diagrams which name components and indicate in most instances, the actual component interconnections. They do not consider the wire resistance and stray capacitance in the actual circuit, and do not always indicate actual wiring. An example of the latter occasion is on the A5 schematic, where only one "G"

pin is shown—there are actually nine. It is electrically equivalent to show only one, because they are all connected together and to power supply common. Hence, the true wiring is not shown.

6-7. COMPONENT LOCATION DIAGRAMS.

6-8. Figure 6-1 is an instrument top view drawing which shows the location of components not on pc boards and components used in adjustment and calibration. Along with this are component location photographs for the pc boards.

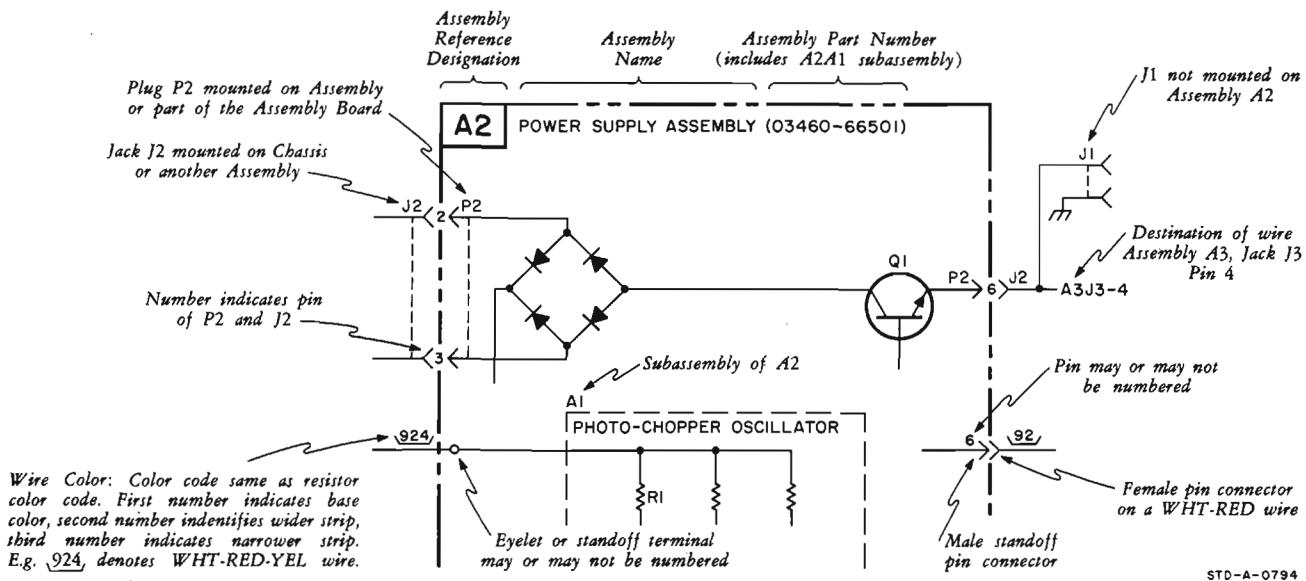
6-9. VOLTAGE LEVEL CHARTS.

6-10. These charts give the voltage level measured at the transistor pins of a particular 414A using an -hp- 412A and an extender board, with the 414A in HOLD and the input probes shorted. The voltages are approximate and will vary according to the instrument. Some entries are missing because the voltages at these pins will drift while the input probes are shorted, even with zero meter deflection.

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



STD-A-0794

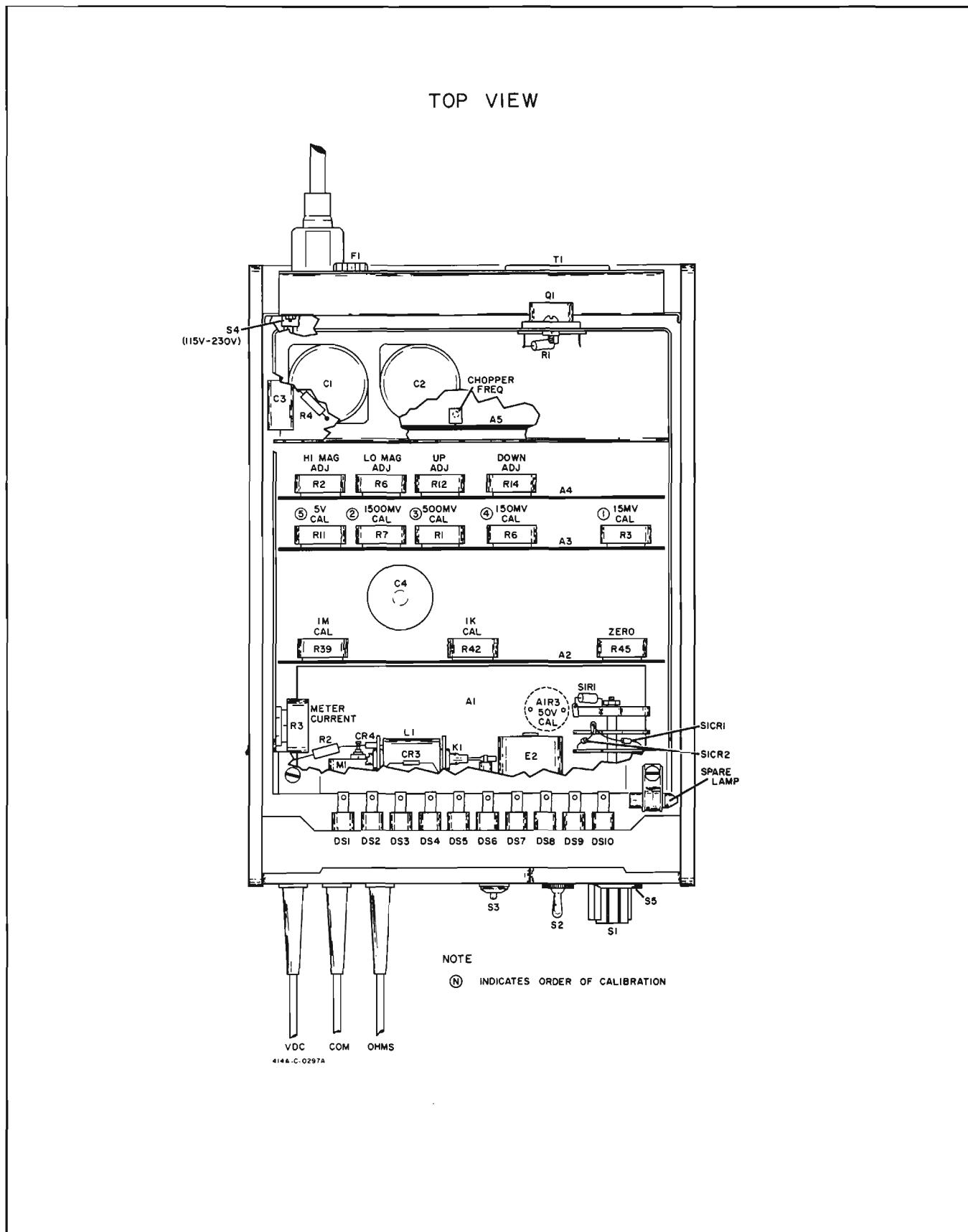


Figure 6-1. Adjustment and Calibration Points

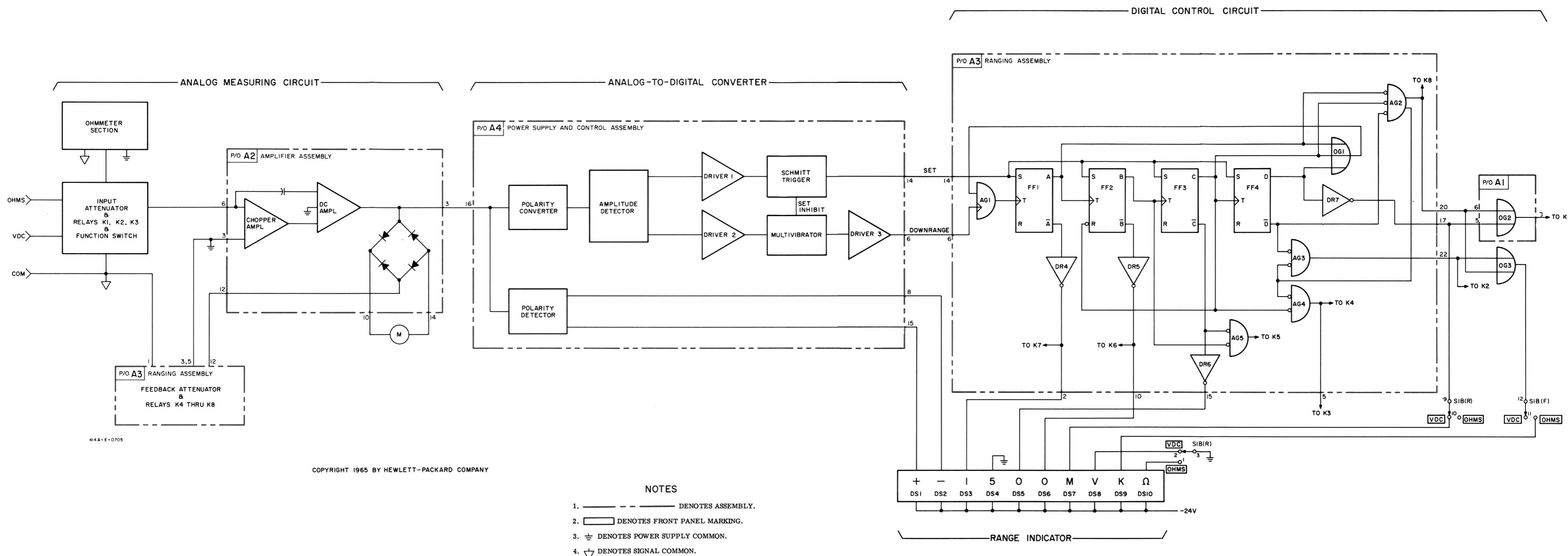
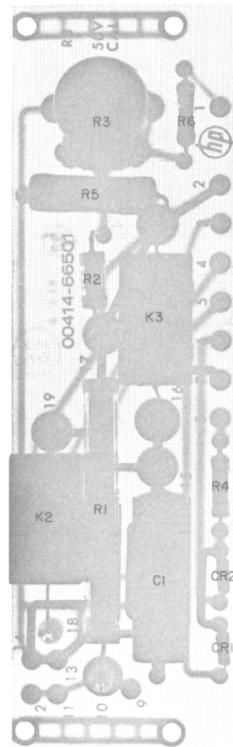


Figure 6-2. Block Diagram

A2
VOLTAGE CHART

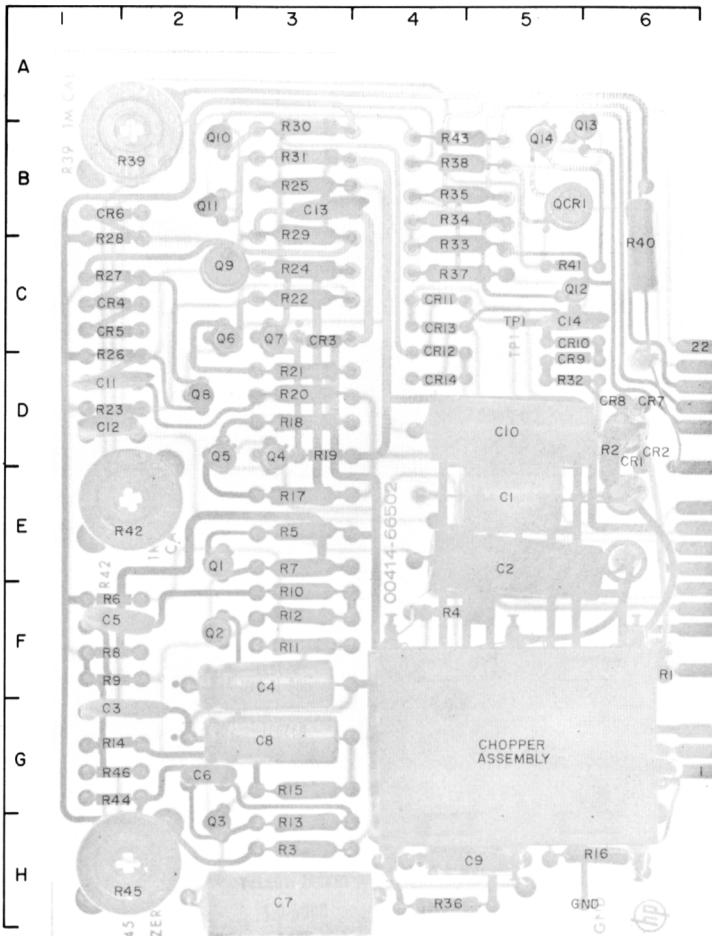
TRANSISTOR	E	B	C	STATE
Q1	+1.5	+0.85	-0.65	500 V RANGE
Q2	0	-0.65	-13	500 V RANGE
Q3	-13.5	-13	+12	500 V RANGE
Q4	+0.6	+0.07	-0.65	500 V RANGE
Q5	+1.2	+0.6	-0.7	500 V RANGE
Q6	+1.2	+0.6	-0.7	500 V RANGE
Q7	+0.6	+0.035	-0.7	500 V RANGE
Q8	-1.3	-0.7	+12	500 V RANGE
Q9	+12.5	+12	----	500 V RANGE
Q10	----	----	+28	500 V RANGE
Q11	----	----	-24	500 V RANGE
Q12	-15	-14	-6.5	500K Ω RANGE
Q13	-0.4	+0.2	+7	500K Ω RANGE
Q14	+7	+6	+0.2	500K Ω RANGE
QCR1	-0.4, Anode -7.0	0	+6	500K Ω RANGE

A1
(00414-66501)



414A-A-0782

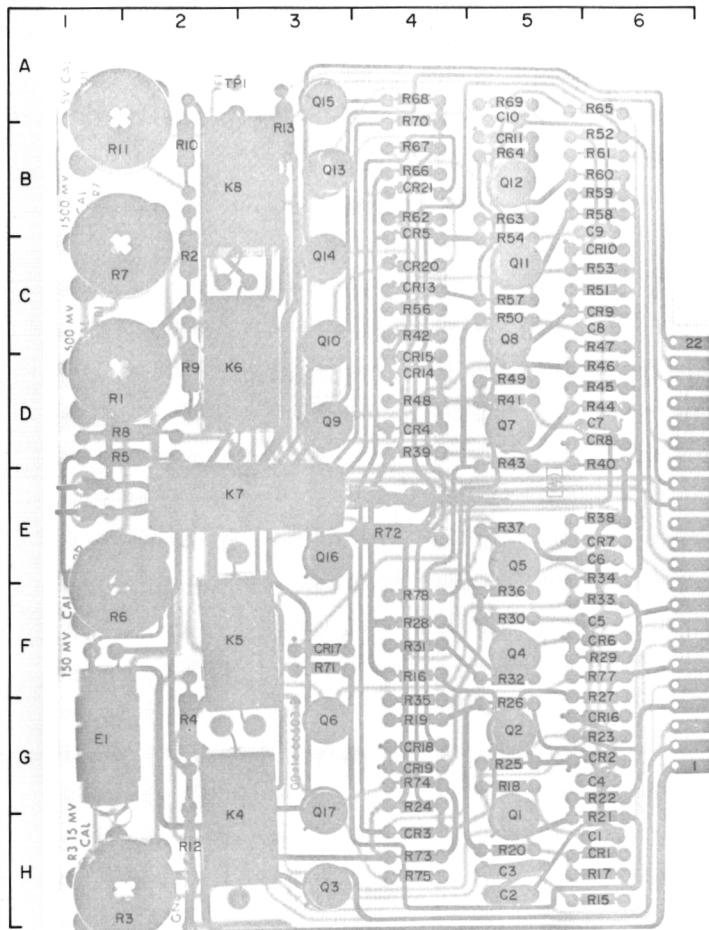
A2
(00414-66502)



A2
COMPONENT LOCATION

	C	CR	Q	QCR	R		R
1	E5	D6	E2	B5	F6	25	B3
2	E5	D6	F2		D6	26	D1
3	G1	C3	H2		H3	27	C1
4	F3	C1	D3		F4	28	C1
5	F1	C1	D2		E3	29	B3
6	G2	B1	C2		F1	30	B3
7	H3	D6	C3		E3	31	B3
8	G3	D6	D2		F1	32	D5
9	H5	D5	C2		F1	33	C4
10	D5	C5	B2		F3	34	B4
11	D1	C4	B2		F3	35	B4
12	D1	C4	C5		F3	36	H4
13	B3	C4	B6		H3	37	C4
14	C5	D4	B5		G1	38	B4
15					G3	39	B2
16					H6	40	C6
17					E3	41	C5
18					D3	42	E2
19					D3	43	B4
20					D3	44	G1
21					D3	45	H2
22					C3	46	G1
23					D1	47	
24					C3	48	

A3
(00414-66503)



A3
COMPONENT LOCATION

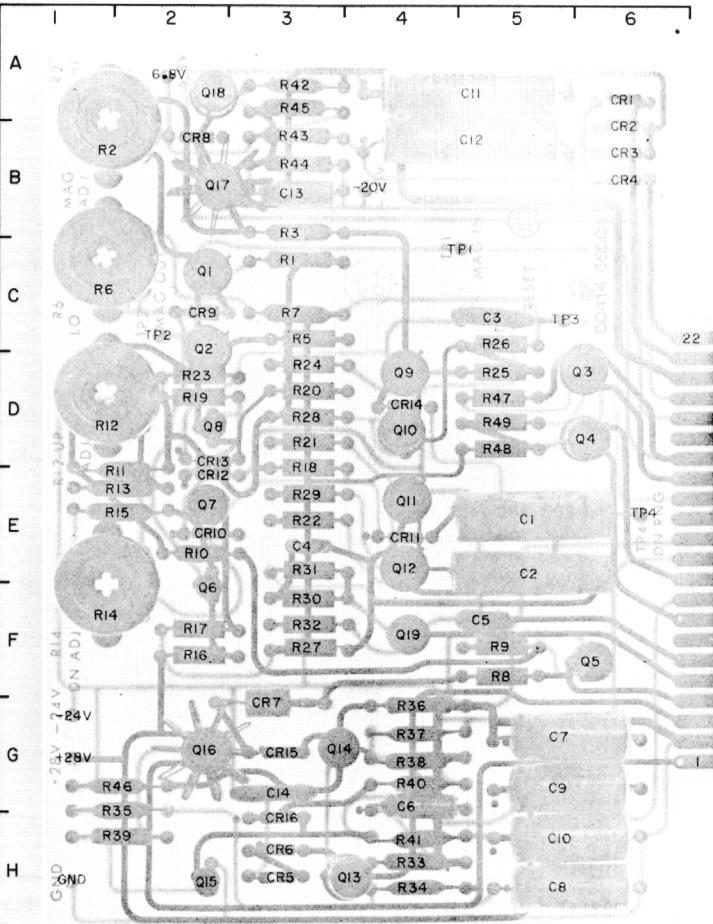
	C	CR	E	K	Q	R		R		R
1	H6	H6	G1	--	H5	D1	28	F4	55	--
2	H5	G6	--	--	G5	C2	29	F6	56	C4
3	H5	H4	--	--	H3	H1	30	F5	57	C5
4	G6	D4		H2	F5	G2	31	F4	58	B6
5	F6	B4		F2	E5	D1	32	F5	59	B6
6	E6	F6		D2	G3	F1	33	F6	60	B6
7	D6	E6		E3	D5	C1	34	E6	61	B6
8	C6	D6		B2	C5	D1	35	G4	62	B4
9	B6	C6		D3	D2	36	F5	63	B5	
10	A5	C6			C3	B2	37	E5	64	B5
11		B5			C5	B1	38	E6	65	A6
12		--			B5	H2	39	D4	66	B4
13		C4			B3	B3	40	D6	67	B4
14		D4			C3	--	41	D5	68	A4
15		D4			A3	H6	42	C4	69	A5
16		G6			E3	F4	43	D5	70	A4
17		F3			G3	H6	44	D6	71	F3
18		G4			G5	G5	45	D6	72	E4
19		G4						G4	46	D6
20		C4						H5	47	C6
21		B4						H6	48	D4
22								G6	49	D5
23								G6	50	C5
24								G4	51	C6
25								G5	52	B6
26								G5	53	C6
27								F6	54	C5

NOTES

- PARTIAL REFERENCE DESIGNATIONS ARE SHOWN. PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.
- COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED.
 - RESISTANCE IN OHMS
 - CAPACITANCE IN MICROFARADS
- — — — — DENOTES ASSEMBLY.
- — — — — DENOTES FEEDBACK PATH.
- DENOTES FRONT PANEL MARKING.
- DENOTES SCREWDRIVER ADJUST.
- DENOTES COMPONENTS NOT MOUNTED ON ASSEMBLY.
- ALL RELAYS ARE SHOWN DEENERGIZED.
- ▽ DENOTES SIGNAL COMMON.
- ± DENOTES POWER SUPPLY COMMON.

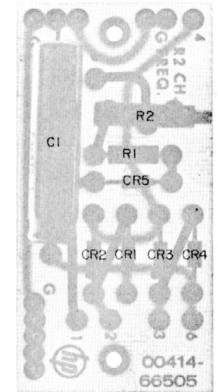
A4
COMPONENT LOCATION

	C	CR	Q	R		R
1	E5	A6	C2	C3	28	D3
2	E5	B6	C2	B1	29	E3
3	C5	B6	D6	B3	30	F3
4	E3	B6	D6	--	31	E3
5	F5	H3	F6	C3	32	F3
6	G4	H3	F2	C1	33	H4
7	G5	G3	E2	C3	34	H4
8	H5	B2	D2	F5	35	G2
9	G5	C2	D4	F5	36	G4
10	H5	E2	D4	E2	37	G4
11	A5	E4	E4	E2	38	G4
12	B5	E2	E4	D1	39	H2
13	B3	D2	H4	E2	40	G4
14	G3	D4	G3	F1	41	H4
15	G3	H2	E2	E2	42	A3
16		H3	G2	F2	43	B3
17			B2	F2	44	B3
18			A2	D3	45	A3
19		F4	D2	46	46	G2
20			D3	47	47	D5
21			D3	48	48	D5
22				E3	49	D5
23				D2	50	
24				D3	51	
25					D5	
26					C5	
27					F3	

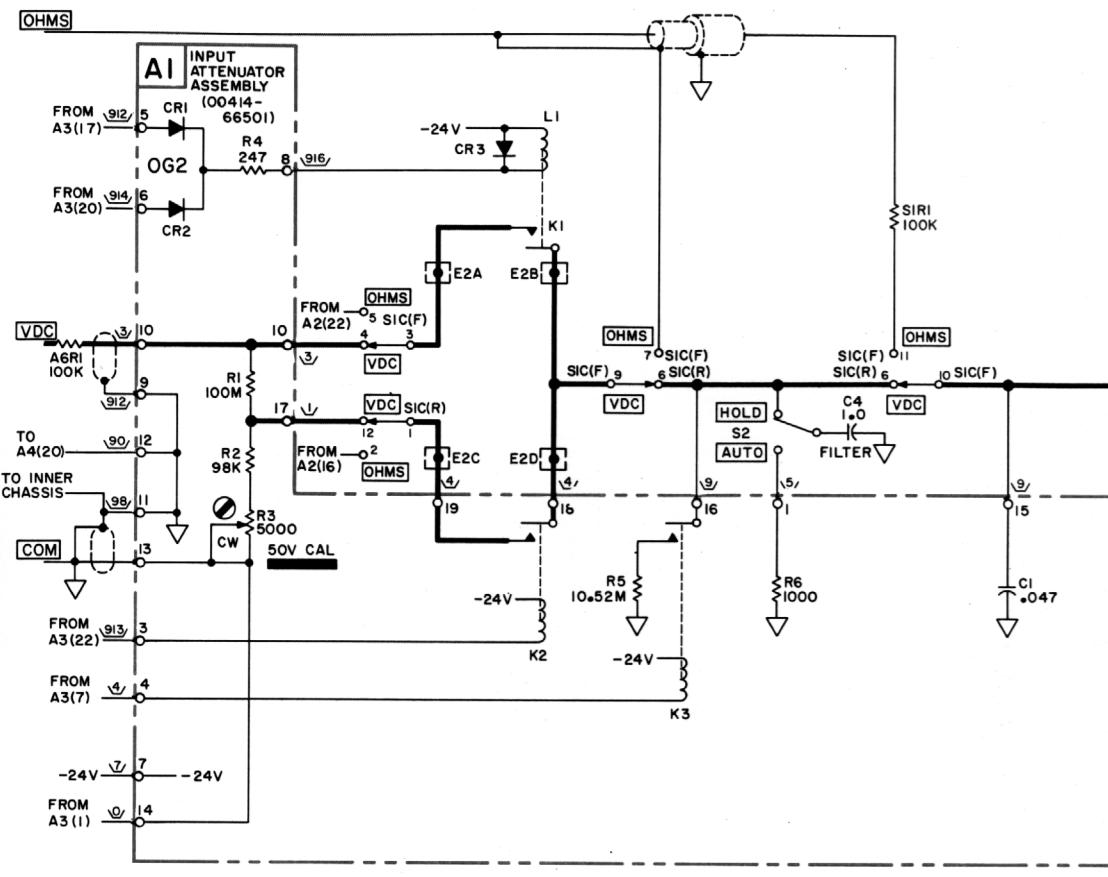


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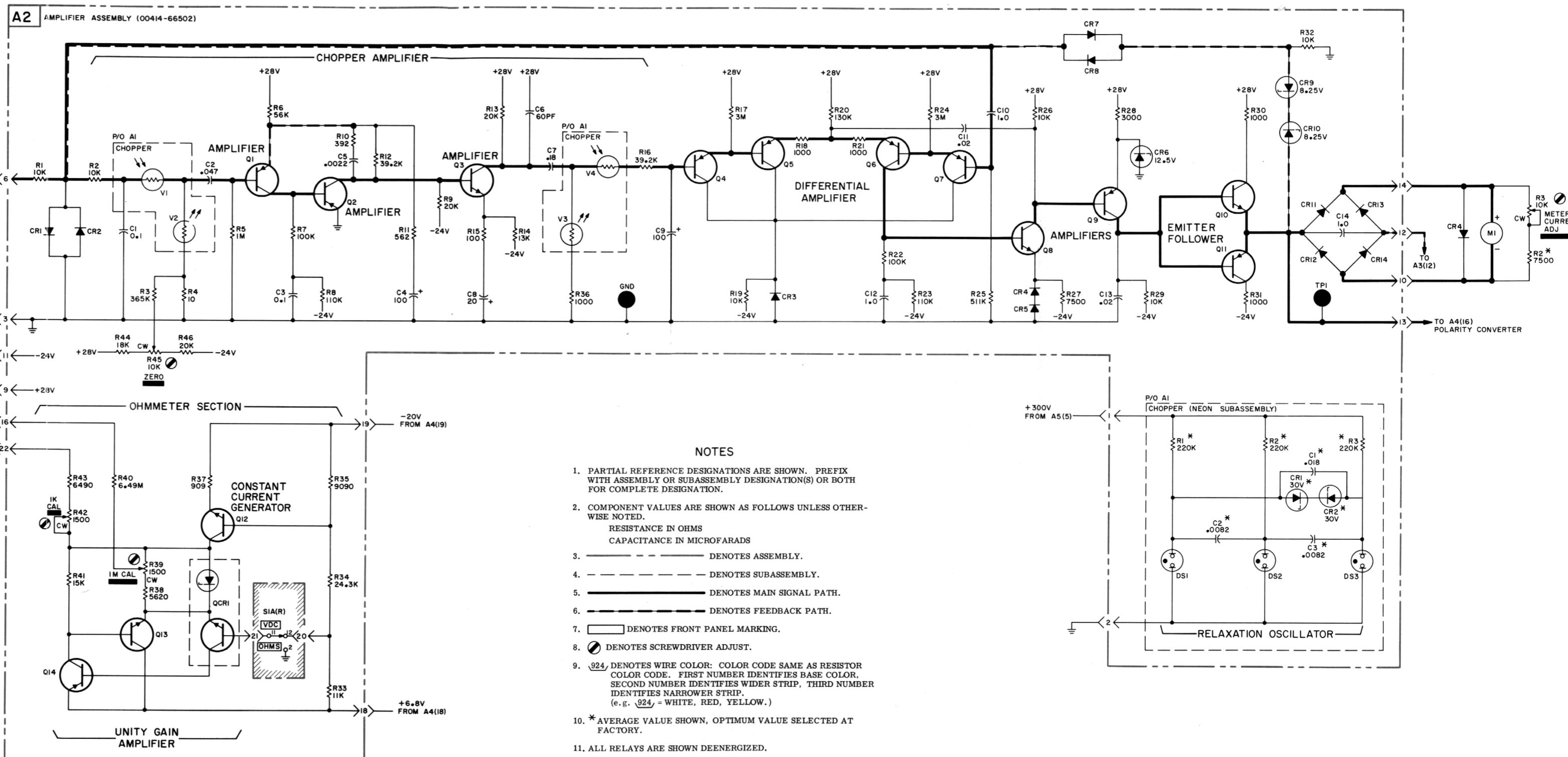
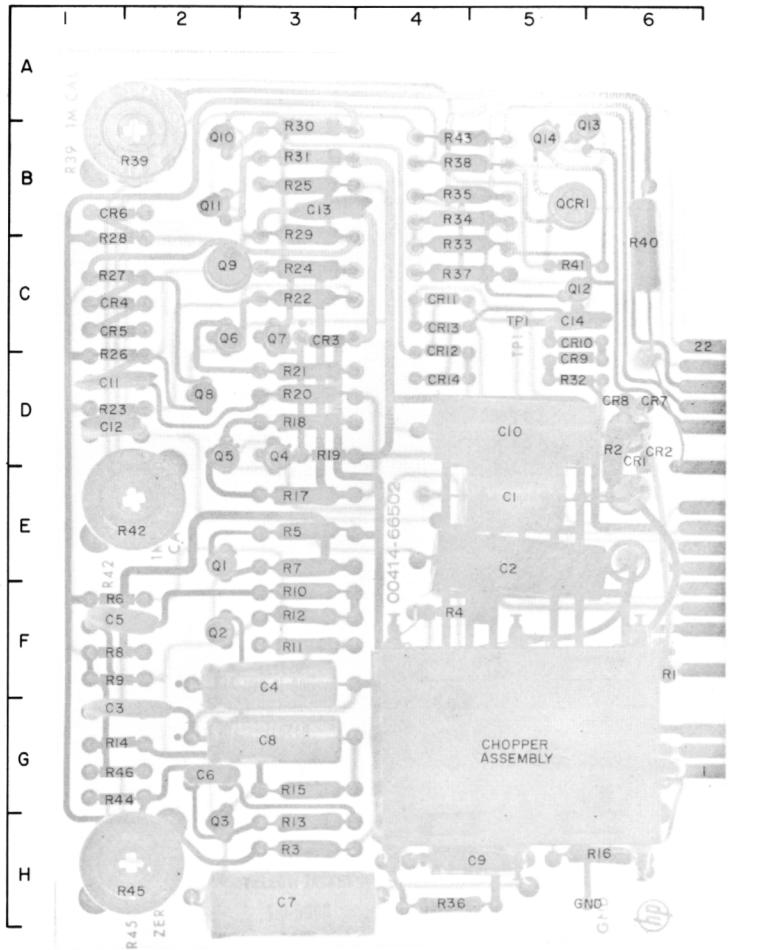
A5
(00414-66505)



414A-A-0780



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A2
(00414-66502)

A4
VOLTAGE CHART

TRANSISTOR	E	B	C	STATE
Q5	0	0	-3.5	ANY RANGE
Q7	+0.6	-0.05	+0.55	ANY RANGE
Q8	-0.65	-3	+18	ANY RANGE
Q9	0	+17	-8	ANY RANGE
Q10	0	-0.25	-0.02	ANY RANGE
Q11	0	-5	+11	ANY RANGE
Q12	0	-6.5	+11	ANY RANGE
Q19	-0.45	0	-24	ANY RANGE

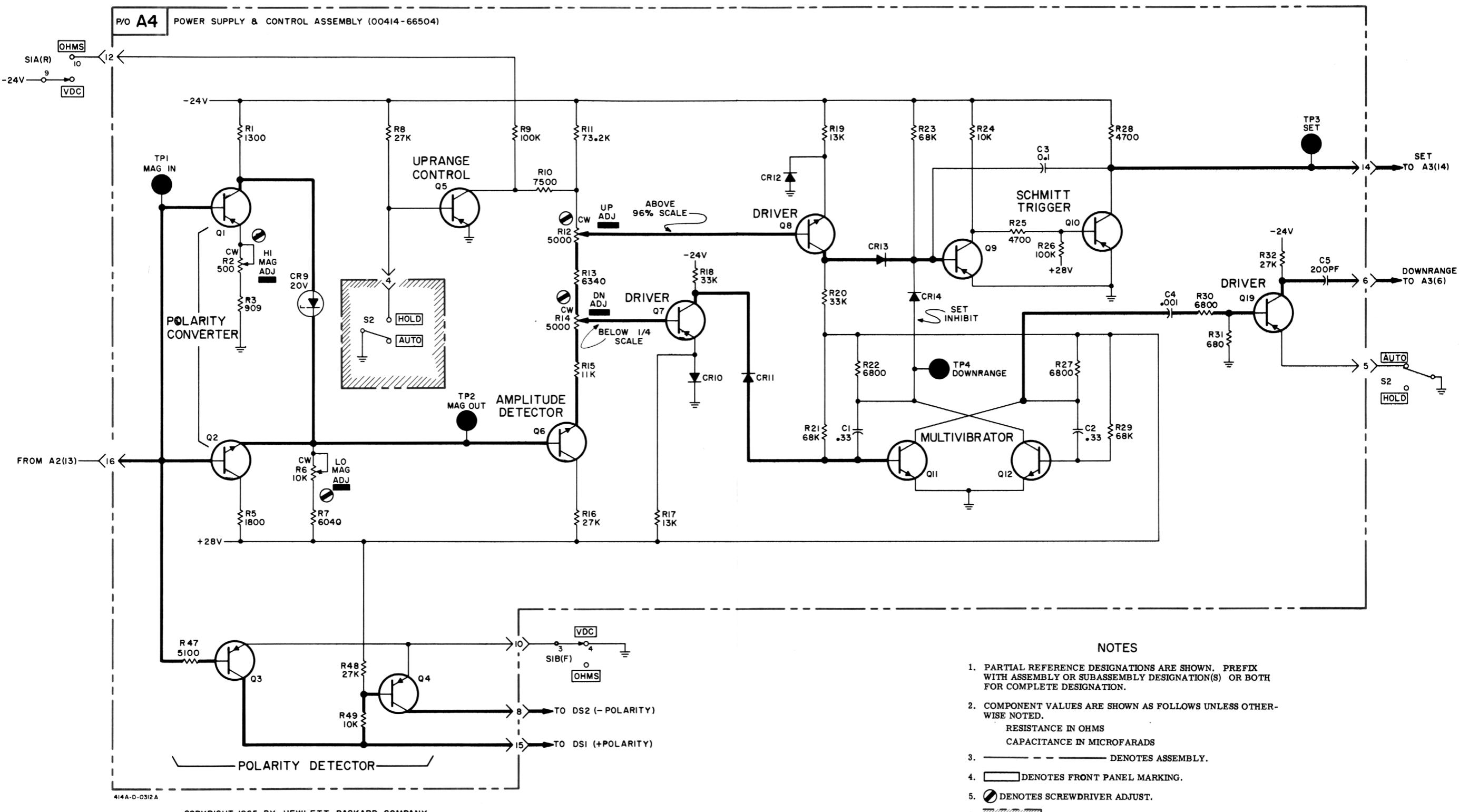


Figure 6-4. Analog-to-Digital Converter

A3
VOLTAGE CHART

TRANSISTOR	E	B	C	STATE
Q1	-0.35 +1.4	-0.55 +3.5	-0.36 -18	ON OFF
Q2	0 0	-0.22 +6.5	-0.04 -18	ON OFF
Q3	0 0	-0.35 +1.4	-0.045 -24	Q1 ON Q1 OFF
Q4	-0.35 +1.4	-0.55 +3.5	-0.36 -18	ON OFF
Q5	0 0	-0.20 +4.0	-0.04 -18	ON OFF
Q6	0 0	-0.35 +1.4	-0.04 -24	Q4 ON Q4 OFF
Q7	-0.35 +1.4	-0.55 +3.5	-0.35 -18	ON OFF
Q8	-0.3 +1.4	-0.55 +7	-0.35 -18	ON OFF
Q9	0 0	-0.35 +1.4	-0.05 -24	Q7 ON Q7 OFF
Q10	0 0	+1.4 -0.3	-24 -0.04	Q7 ON Q7 OFF
Q11	-0.3 +1.4	-0.50 +3.5	-0.3 -18	ON OFF
Q12	-0.35 +1.4	-0.55 +7	-0.4 -18	ON OFF
Q13	0 0	-0.35 +1.4	-0.07 -24	Q11 ON Q11 OFF
Q14	0 0	+1.4 -0.3	-24 -0.03	Q11 ON Q11 OFF
Q15	0 0	-0.3 +1	-0.07 -24	5 V RANGE ALL OTHER RANGES
Q16	+0.75 +0.75 +0.7 +0.75 +0.75	+2.4 +2.4 +0.45 +2.4 +2.4	-0.24 -0.27 +0.6 +1.4 -0.27	1500 V—50 V RANGES 15 V RANGE 5 V RANGE 1500 MV—50 MV RANGES 15 MV—5 MV RANGES
Q17	0 0	-0.26 +0.3	-0.07 -24	150 V, 50 V, 150 MV, 50 MV RANGES ALL OTHER RANGES

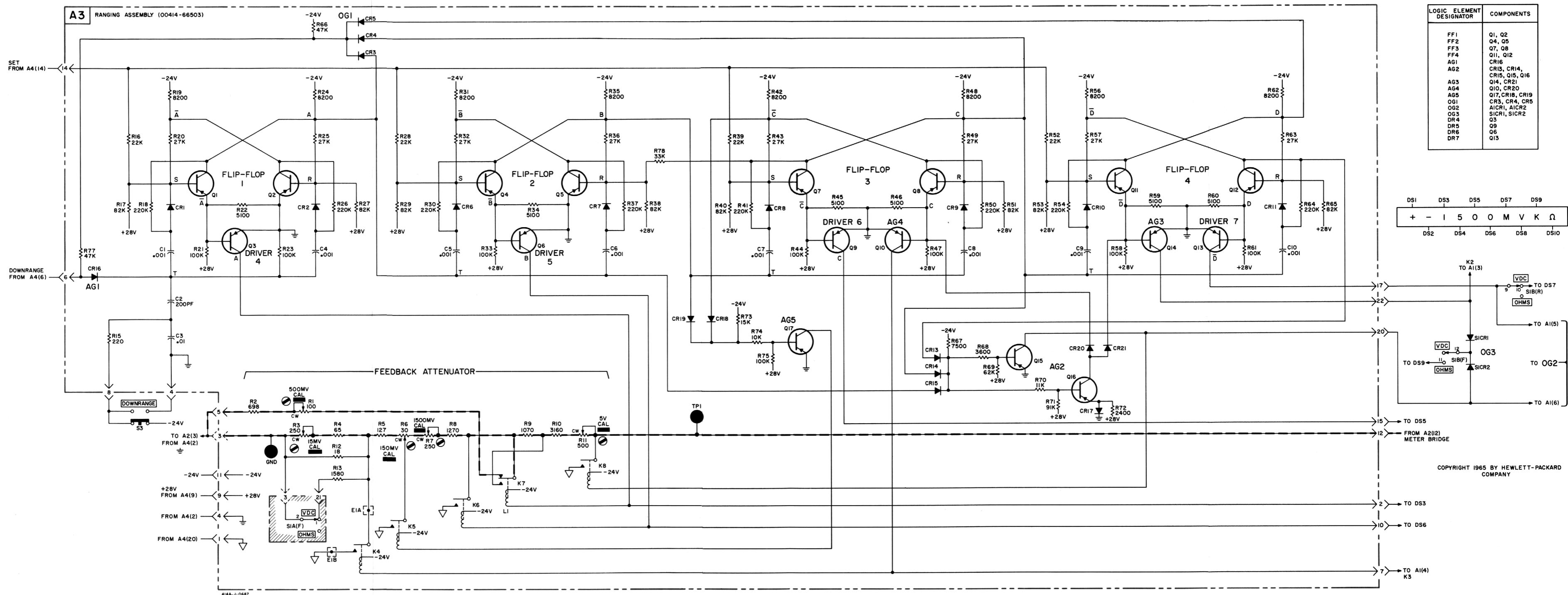
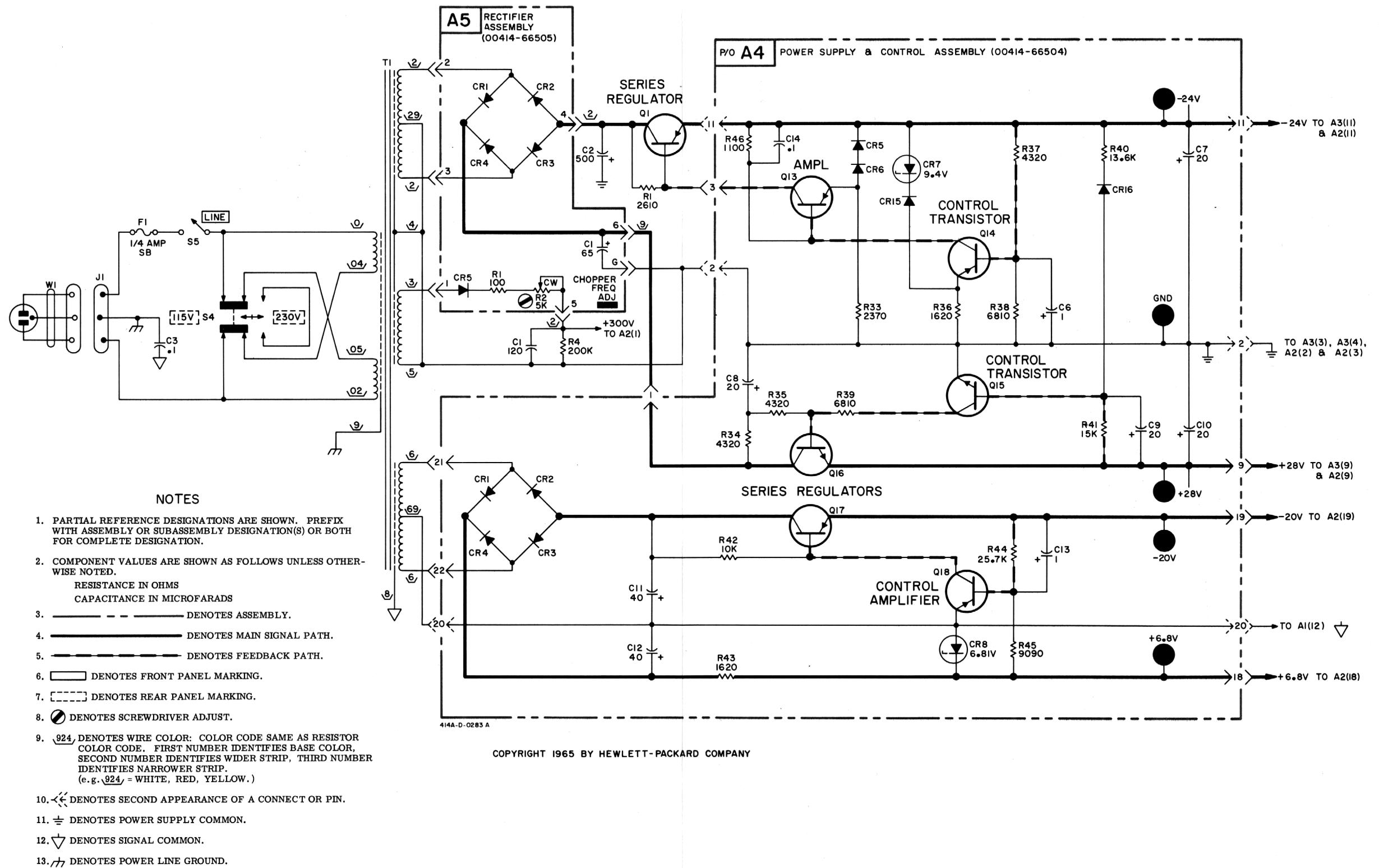


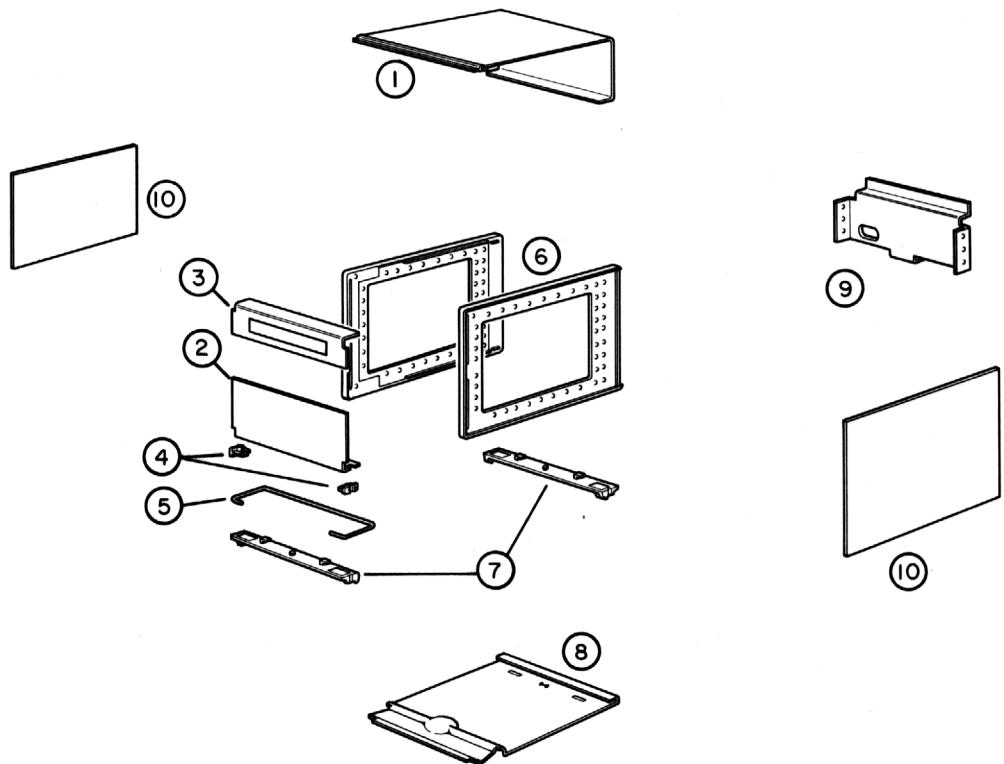
Figure 6-5. Digital Control Circuit and P/O Analog Measuring Circuit

A4
VOLTAGE CHART

TRANSISTOR	E	B	C	STATE
Q1 OFF BOARD	-24	-24	-42	ANY RANGE
Q13	-23	-23	-24	ANY RANGE
Q14	-14	-15	-23	ANY RANGE
Q15	0	+0.6	+17	ANY RANGE
Q16	+28	+29	+46	ANY RANGE
Q17	-20	-20	-29	ANY RANGE
Q18	0	-0.1	-20	ANY RANGE



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INDEX NUMBER	-hp- PART NO.	DESCRIPTION	TQ
1	00414-00601	Top cover assembly	1
2	00414-00201	Panel, front	1
3	00414-00203	Panel, readout	2
4	5040-0700	Hinge	2
5	1490-0032	Stand: half module	1
6	5060-0703	Frame assembly	2
7	5060-0728	Foot assembly: half module	2
8	5000-0717	Bottom cover assembly: 7 x 11 SM	1
9	00414-00202	Panel, rear	1
10	5000-0703	Side cover, 6 x 11 SM	2

Figure 7-1. Modular Cabinet Parts

Table 7-1. Reference Designation Index

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A1	00414-66501	Attenuator board assembly includes C1 K1 thru K3 CR1, CR2 R1 thru R6 C: fxd poly 0.047 μ f $\pm 20\%$ 50 vdcw Diode: Si 100 ma at +1 v 100 piv 12 pf	
A1C1 A1CR1, A1CR2	0160-0744 1901-0025		
A1K1 A1K2, A1K3	0490-0182	Not assigned Relay: hermetically sealed dry reed	
A1R1, A1R2 A1R3 A1R4 A1R5	0698-3461 2100-0091 0757-0721 0730-0144	R: set fxd 100 meg 98 K R: var comp pot lin 5 K $\pm 30\%$ 0.15 w R: fxd prec met flm 247 ohms $\pm 1\%$ 1/4 w R: fxd prec carbon flm 10.52 meg $\pm 1\%$ 1 w	
A1R6	0757-0338	R: fxd prec met flm 1000 ohms $\pm 1\%$ 1/4 w	
A2	00414-66506	Amplifier board assembly includes A2A1 (Photocopper) Q1 thru Q14 C1 thru C14 QCR1 CR1 thru CR14 R1 thru R46	
A2A1	1990-0218	Photocopper assembly (includes neon subassembly) Note: The neon subassembly may be ordered under -hp- Part No. 1990-0213.	
A2C1 A2C2 A2C3 A2C4	0170-0022 0160-0744 0150-0084 0180-0061	C: fxd my 0.1 μ f $\pm 20\%$ 600 vdcw C: fxd my 0.047 μ f $\pm 10\%$ 50 vdcw C: fxd cer 0.1 μ f +80% -20% 50 vdcw C: fxd elect 100 μ f +100% -10% 15 vdcw	
A2C5 A2C6 A2C7 A2C8	0150-0085 0140-0214 0160-2136 0180-0142	C: fxd cer 0.0022 μ f $\pm 20\%$ 500 vdcw C: fxd mica 60 pf $\pm 5\%$ C: fxd my 0.18 μ f $\pm 10\%$ 200 vdcw C: fxd elect 20 μ f +10% -100% 25 vdcw	
A2C9 A2C10 A2C11 A2C12	0180-0137 0160-0859 0150-0024 0160-0127	C: fxd Ta elect 100 μ f 10 vdcw C: fxd my 1.0 μ f $\pm 10\%$ 50 vdcw C: fxd cer 0.02 μ f +80% -20% 600 vdcw C: fxd cer 1.0 μ f $\pm 20\%$ 25 vdcw	
A2C13 A2C14	0150-0024 0160-0127	C: fxd cer 0.02 μ f +80% -20% 600 vdcw C: fxd cer 1.0 μ f $\pm 20\%$ 25 vdcw	
A2CR1, A2CR2 A2CR3 thru A2CR5 A2CR6 A2CR7, A2CR8	1901-0044 1901-0025 1902-0031 1901-0156	Diode: 20 ma at +1 v 10 na at -10 v/50 wiv 2 pf 6 ns Diode: Si 100 ma at +1 v 100 piv 12 pf Diode: breakdown 12.5 v $\pm 5\%$ 400 mw Diode: 50 ma at +1 v 20 wiv	
A2CR9, A2CR10 A2CR11 thru A2CR14	1902-3139 1901-0044	Diode: Si breakdown 8.25 v $\pm 5\%$ 400 mw Diode: 20 ma at +1 v 10 na at -10 v/50 wiv 2 pf 6 ns	
A2Q1 A2Q2	1853-0007 1853-0010	TSTR: Si PNP 2N3251 TSTR: Si PNP **	

Table 7-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A2Q3	1854-0087	TSTR: Si NPN 2N3417	
A2Q4 thru A2Q7	1853-0010	TSTR: Si PNP **	
A2Q8	1854-0033	TSTR: Si NPN 2N3391	
A2Q9	1853-0020	TSTR: Si PNP 2N3702	
A2Q10	1854-0087	TSTR: Si NPN 2N3417	
A2Q11	1853-0023	TSTR: Si PNP 2N3703	
A2Q12, A2Q13	1854-0033	TSTR: Si NPN 2N3391	
A2Q14	1853-0010	TSTR: Si PNP **	
A2QCR1	1820-0010	Amplifier: reference Si NPN transistor with 7 v zener	
A2R1, A2R2	0757-0340	R: fxd prec met film 10 K $\pm 1\%$ 1/4 w	
A2R3	0757-0786	R: fxd prec met film 365 K $\pm 1\%$ 1/4 w	
A2R4	0757-0346	R: fxd prec met film 10 ohms $\pm 1\%$ 1/8 w	
A2R5	0757-0344	R: fxd prec met film 1 meg $\pm 1\%$ 1/4 w	
A2R6	0683-5635	R: fxd comp 56 K $\pm 5\%$ 1/4 w	
A2R7	0757-0342	R: fxd prec met film 100 K $\pm 1\%$ 1/4 w	
A2R8	0686-1145	R: fxd comp 110 K $\pm 5\%$ 1/4 w	
A2R9	0683-2035	R: fxd comp 20 K $\pm 5\%$ 1/4 w	
A2R10	0757-0724	R: fxd prec met film 392 ohms $\pm 1\%$ 1/4 w	
A2R11	0757-0727	R: fxd prec met film 562 ohms $\pm 1\%$ 1/4 w	
A2R12	0757-0766	R: fxd prec met film 39.2 K $\pm 1\%$ 1/4 w	
A2R13	0757-0760	R: fxd prec met film 20 K $\pm 1\%$ 1/4 w	
A2R14	0683-1335	R: fxd comp 13 K $\pm 5\%$ 1/4 w	
A2R15	0757-0178	R: fxd prec met film 100 ohms $\pm 1\%$ 1/4 w	
A2R16	0757-0766	R: fxd prec met film 39.2 K $\pm 1\%$ 1/4 w	
A2R17	0727-0292	R: fxd prec met film 3 meg $\pm 1\%$ 1/2 w	
A2R18	0757-0338	R: fxd prec met film 1000 ohms $\pm 1\%$ 1/4 w	
A2R19	0683-1035	R: fxd 10 K $\pm 5\%$ 1/4 w	
A2R20	0757-0778	R: fxd prec met film 130 K $\pm 1\%$ 1/4 w	
A2R21	0757-0338	R: fxd prec met film 1000 ohms $\pm 1\%$ 1/4 w	
A2R22	0757-0342	R: fxd prec met film 100 K $\pm 1\%$ 1/4 w	
A2R23	0686-1145	R: fxd comp 110 K $\pm 5\%$ 1/4 w	
A2R24	0727-0292	R: fxd prec met film 3 meg $\pm 1\%$ 1/2 w	
A2R25	0757-0169	R: fxd prec met film 511 K $\pm 1\%$ 1/4 w	
A2R26	0683-1035	R: fxd 10 K $\pm 5\%$ 1/4 w	
A2R27	0683-7525	R: fxd comp 7500 ohms $\pm 5\%$ 1/4 w	
A2R28	0683-3025	R: fxd comp 3000 ohms $\pm 5\%$ 1/4 w	
A2R29	0757-0340	R: fxd prec met film 10 K $\pm 1\%$ 1/4 w	
A2R30, A2R31	0757-0338	R: fxd prec met film 1000 ohms $\pm 1\%$ 1/4 w	
A2R32	0683-1035	R: fxd 10 K $\pm 5\%$ 1/4 w	
A2R33	0757-0754	R: fxd prec met film 11 K $\pm 1\%$ 1/4 w	
A2R34	0757-0762	R: fxd prec met film 24.3 K $\pm 1\%$ 1/4 w	
A2R35	0757-0753	R: fxd prec met film 9090 ohms $\pm 1\%$ 1/4 w	
A2R36	0757-0338	R: fxd prec met film 1000 ohms $\pm 1\%$ 1/4 w	

Table 7-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A2R37	0757-0732	R: fxd prec met flm 909 ohms $\pm 1\%$ 1/4 w	
A2R38	0698-3473	R: fxd prec met flm 5.62 K $\pm 1\%$ 1/4 w	
A2R39	2100-0330	R: var ww 1500 ohms $\pm 10\%$ 1-1/2 w	
A2R40	0698-3475	R: fxd prec met flm 6.49 meg $\pm 1\%$ 1 w	
A2R41	0757-0757	R: fxd prec met flm 15 K $\pm 1\%$ 1/4 w	
A2R42	2100-0330	R: var ww 1500 ohms $\pm 10\%$ 1-1/2 w	
A2R43	0698-3474	R: fxd prec met flm 6490 ohms $\pm 1\%$ 1/4 w	
A2R44	0683-1835	R: fxd comp 18 K $\pm 5\%$ 1/4 w	
A2R45	2100-0396	R: var ww 10 K $\pm 20\%$ 1-1/2 w	
A2R46	0683-2035	R: fxd comp 20 K $\pm 5\%$ 1/4 w	
A3	00414-66503	Ranging board assembly includes C1 thru C10 L1 CR1 thru CR21 Q1 thru Q17 E1 R1 thru R78 K1 thru K8	
A3C1	0150-0050	C: fxd cer 0.001 μ f 600 vdcw	
A3C2	0140-0198	C: fxd mica 200 pf $\pm 5\%$ 300 vdcw	
A3C3	0150-0012	C: fxd cer 0.01 μ f $\pm 20\%$ 1000 vdcw	
A3C4 thru A3C10	0150-0050	C: fxd cer 0.001 μ f 600 vdcw	
A3CR1 thru A3CR11	1901-0025	Diode: Si 100 ma at +1 v 100 piv 12 pf	
A3CR12		Not assigned	
A3CR13 thru A3CR15	1910-0016	Diode: Ge 1 microsecond 60 wiv	
A3CR16 thru A3CR19	1901-0025	Diode: Si 100 ma at +1 v 100 piv 12 pf	
A3CR20, A3CR21	1910-0016	Diode: Ge 1 microsecond 60 wiv	
A3E1	5080-0623	Compensator: thermal	
A3K1 thru A3K3		Not assigned	
A3K4 thru A3K6	0490-0182	Relay: hermetically sealed dry reed	
A3K7	0490-0171	Relay: reed	
A3K8	0490-0182	Relay: hermetically sealed dry reed	
A3L1	9160-0018	Coil: electromagnetic	
A3Q1 thru A3Q14	1850-0062	TSTR: Ge PNP 2N404	
A3Q15, A3Q16	1850-0173	TSTR: Ge PNP 2N1307	
A3Q17	1850-0070	TSTR: Ge PNP 21373	

Table 7-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A3R47	0683-1045	R: fxd 100 K $\pm 5\%$ 1/4 w	
A3R48	0683-8225	R: fxd comp 8200 ohms $\pm 5\%$ 1/4 w	
A3R49	0683-2735	R: fxd comp 27 K $\pm 5\%$ 1/4 w	
A3R50	0683-2245	R: fxd comp 220 K $\pm 5\%$ 1/4 w	
A3R51	0683-8235	R: fxd comp 82 K $\pm 5\%$ 1/4 w	
A3R52	0683-2235	R: fxd comp 22 K $\pm 5\%$ 1/4 w	
A3R53	0683-8235	R: fxd comp 82 K $\pm 5\%$ 1/4 w	
A3R54	0683-2245	R: fxd comp 220 K $\pm 5\%$ 1/4 w	
A3R55		Not assigned	
A3R56	0683-8225	R: fxd comp 8200 ohms $\pm 5\%$ 1/4 w	
A3R57	0683-2735	R: fxd comp 27 K $\pm 5\%$ 1/4 w	
A3R58	0683-1045	R: fxd 100 K $\pm 5\%$ 1/4 w	
A3R59, A3R60	0683-5125	R: fxd comp 5100 ohms $\pm 5\%$ 1/4 w	
A3R61	0683-1045	R: fxd 100 K $\pm 5\%$ 1/4 w	
A3R62	0683-8225	R: fxd comp 8200 ohms $\pm 5\%$ 1/4 w	
A3R63	0683-2735	R: fxd comp 27 K $\pm 5\%$ 1/4 w	
A3R64	0683-2245	R: fxd comp 220 K $\pm 5\%$ 1/4 w	
A3R65	0683-8235	R: fxd comp 82 K $\pm 5\%$ 1/4 w	
A3R66	0683-4735	R: fxd comp 47 K $\pm 5\%$ 1/4 w	
A3R67	0683-7525	R: fxd comp 7500 ohms $\pm 5\%$ 1/4 w	
A3R68	0683-3625	R: fxd comp 3600 ohms $\pm 5\%$ 1/4 w	
A3R69	0683-6235	R: fxd comp 62 K $\pm 5\%$ 1/4 w	
A3R70	0683-1135	R: fxd comp 11 K $\pm 5\%$ 1/4 w	
A3R71	0683-9135	R: fxd comp 91 K $\pm 5\%$ 1/4 w	
A3R72	0757-0826	R: fxd prec met flm 2430 ohms $\pm 1\%$ 1/2 w	
A3R73	0683-1535	R: fxd comp 15 K $\pm 5\%$ 1/4 w	
A3R74	0683-1035	R: fxd 10 K $\pm 5\%$ 1/4 w	
A3R75	0683-1045	R: fxd 100 K $\pm 5\%$ 1/4 w	
A3R76		Not assigned	
A3R77	0683-4735	R: fxd comp 47 K $\pm 5\%$ 1/4 w	
A3R78	0683-3335	R: fxd comp 33 K $\pm 5\%$ 1/4 w	
A4	00414-66504	Power supply and control board assembly includes C1 thru C14 Q1 thru Q19 CR1 thru CR16 R1 thru R49	
A4C1, A4C2	0160-0209	C: fxd my 0.33 μ f $\pm 20\%$ 200 vdcw	
A4C3	0150-0084	C: fxd cer 0.1 μ f +80% -20% 50 vdcw	
A4C4	0150-0050	C: fxd cer 0.001 μ f 600 vdcw	
A4C5	0140-0198	C: fxd mica 200 pf $\pm 5\%$ 300 vdcw	
A4C6	0180-0119	C: fxd Al elect 1 μ f 25 vdcw	
A4C7 thru A4C10	0180-0049	C: fxd Al elect 20 μ f 50 vdcw	
A4C11, A4C12	0180-0050	C: fxd Al elect 40 μ f +100% -15% 50 vdcw	
A4C13	0180-0119	C: fxd Al elect 1 μ f 25 vdcw	
A4C14	0150-0084	C: fxd cer 0.1 μ f +80% -20% 50 vdcw	

Table 7-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A4CR1 thru A4CR6	1901-0025	Diode: Si 100 ma at +1 v 100 piv 12 pf	
A4CR7	1902-0763	Diode: breakdown 9.4 v IN2163A	
A4CR8	1902-0048	Diode: breakdown 6.81 v $\pm 5\%$ 400 mw	
A4CR9	1902-0566	Diode: breakdown 20 v Si temperature compensated	
A4CR10 thru A4CR16	1901-0025	Diode: Si 100 ma at +1 v 100 piv 12 pf	
A4Q1	1850-0173	TSTR: Ge PNP 2N1307	
A4Q2	1851-0017	TSTR: Ge NPN 2N1304	
A4Q3, A4Q4	1850-0062	TSTR: Ge PNP 2N404	
A4Q5	1853-0016	TSTR: Si PNP 2N3638	
A4Q6	1854-0033	TSTR: Si NPN 2N3391	
A4Q7	1853-0020	TSTR: Si PNP 2N3702	
A4Q8	1854-0033	TSTR: Si NPN 2N3391	
A4Q9, A4Q10	1850-0062	TSTR: Ge 2N404	
A4Q11, A4Q12	1851-0017	TSTR: Ge NPN 2N1304	
A4Q13	1850-0054	TSTR: Ge PNP 2N652A	
A4Q14	1853-0016	TSTR: Si PNP 2N3638	
A4Q15	1854-0033	TSTR: Si NPN 2N3391	
A4Q16	1854-0039	TSTR: Si NPN 2N3053	
	1205-0033	Heat dissipator	
A4Q17	1850-0070	TSTR: Ge PNP 2N1373	
	1205-0033	Heat dissipator	
A4Q18	1850-0062	TSTR: Ge PNP 2N404	
A4Q19	1853-0016	TSTR: Si PNP 2N3638	
A4R1	0757-0735	R: fxd prec met flm 1300 ohms $\pm 1\%$ 1/4 w	
A4R2	2100-0328	R: var ww 500 ohms $\pm 10\%$ 1-1/2 w	
A4R3	0757-0732	R: fxd prec met flm 909 ohms $\pm 1\%$ 1/4 w	
A4R4		Not assigned	
A4R5	0686-1825	R: fxd comp 1800 ohms $\pm 5\%$ 1/2 w	
A4R6	2100-0396	R: var ww 10 K $\pm 20\%$ 1-1/2 w	
A4R7	0757-1023	R: fxd prec met flm 6040 ohms $\pm 1\%$ 1/4 w	
A4R8	0686-2735	R: fxd comp 27 K $\pm 5\%$ 1/2 w	
A4R9	0686-1045	R: fxd comp 100 K $\pm 5\%$ 1/2 w	
A4R10	0757-0751	R: fxd prec met flm 7500 ohms $\pm 1\%$ 1/4 w	
A4R11	0757-0116	R: fxd prec met flm 73.2 K ohms $\pm 1\%$ 1/4 w	
A4R12	2100-0331	R: var ww 5000 ohms $\pm 10\%$ 1-1/2 w	
A4R13	0757-0880	R: fxd prec met flm 6340 ohms $\pm 1\%$ 1/4 w	
A4R14	2100-0331	R: var ww 5000 ohms $\pm 10\%$ 1-1/2 w	
A4R15	0757-0754	R: fxd prec met flm 11 K $\pm 1\%$ 1/4 w	
A4R16	0686-2735	R: fxd comp 27 K $\pm 5\%$ 1/2 w	
A4R17	0686-1335	R: fxd comp 13 K $\pm 5\%$ 1/2 w	
A4R18	0686-3335	R: fxd comp 33 K $\pm 5\%$ 1/2 w	
A4R19	0686-1335	R: fxd comp 13 K $\pm 5\%$ 1/2 w	
A4R20	0686-3335	R: fxd comp 33 K $\pm 5\%$ 1/2 w	

Table 7-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A4R21	0686-6835	R: fxd comp 68 K $\pm 5\%$ 1/2 w	
A4R22	0686-6825	R: fxd comp 6800 ohms $\pm 5\%$ 1/2 w	
A4R23	0686-6835	R: fxd comp 68 K $\pm 5\%$ 1/2 w	
A4R24	0686-1035	R: fxd comp 10 K $\pm 5\%$ 1/2 w	
A4R25	0686-4725	R: fxd comp 4700 ohms $\pm 5\%$ 1/2 w	
A4R26	0686-1045	R: fxd comp 100 K $\pm 5\%$ 1/2 w	
A4R27	0686-6825	R: fxd comp 6800 ohms $\pm 5\%$ 1/2 w	
A4R28	0686-4725	R: fxd comp 4700 ohms $\pm 5\%$ 1/2 w	
A4R29	0686-6835	R: fxd comp 68 K $\pm 5\%$ 1/2 w	
A4R30	0686-6825	R: fxd comp 6800 ohms $\pm 5\%$ 1/2 w	
A4R31	0686-6815	R: fxd comp 680 ohms $\pm 5\%$ 1/2 w	
A4R32	0686-2735	R: fxd comp 27 K $\pm 5\%$ 1/2 w	
A4R33	0698-0079	R: fxd prec met film 2370 ohms $\pm 1\%$ 1/4 w	
A4R34, A4R35	0757-0745	R: fxd prec met film 4320 ohms $\pm 1\%$ 1/4 w	
A4R36	0757-0737	R: fxd prec met film 1620 ohms $\pm 1\%$ 1/4 w	
A4R37	0757-0745	R: fxd prec met film 4320 ohms $\pm 1\%$ 1/4 w	
A4R38, A4R39	0757-0750	R: fxd prec met film 6810 ohms $\pm 1\%$ 1/4 w	
A4R40	0757-0756	R: fxd prec met film 13 K $\pm 1\%$ 1/4 w	
A4R41	0757-0840	R: fxd prec met film 11 K $\pm 1\%$ 1/2 w	
A4R42	0757-0340	R: fxd prec met film 10 K $\pm 1\%$ 1/4 w	
A4R43	0757-0737	R: fxd prec met film 1620 ohms $\pm 1\%$ 1/4 w	
A4R44	0757-0112	R: fxd prec met film 25.7 K $\pm 1\%$ 1/4 w	
A4R45	0757-0753	R: fxd prec met film 9090 ohms $\pm 1\%$ 1/4 w	
A4R46	0757-0733	R: fxd prec met film 1100 ohms $\pm 1\%$ 1/4 w	
A4R47	0686-5125	R: fxd comp 5100 ohms $\pm 5\%$ 1/2 w	
A4R48	0686-2735	R: fxd comp 27 K $\pm 5\%$ 1/2 w	
A4R49	0686-1035	R: fxd comp 10 K $\pm 5\%$ 1/2 w	
A5	00414-66505	Rectifier board assembly includes C1 R1, R2 CR1 thru CR5	
A5C1	0180-0149	C: fxd Al elect 65 μ f +100% -10% 60 vdcw	
A5CR1 thru A5CR4	1901-0026	Diode: Si 200 piv	
A5CR5	1901-0030	Diode: Si 800 piv	
A5R1	0686-5615	R: fxd comp 100 ohms $\pm 5\%$ 1/4 w	
A5R2	2100-1739	R: var ww 5000 ohms $\pm 10\%$ 1 w	
A6	00414-62101	Probe assembly includes R1 mechanical parts	
A6R1	0757-0465	R: fxd prec met film 100 K $\pm 1\%$ 1/8 w	
		<u>Mechanical Parts for A6</u>	
	8120-0038	Cable: miniature low-noise coaxial	

Table 7-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
		<u>Mechanical Parts for A6 (Cont'd)</u> 5040-0414 Capacitor: probe 5040-0405 Handle assembly: red 5040-0407 Lock nut 5060-0407 Probe assembly: jaw 425A-21A-5 Sleeve: cable terminal 5040-0408 Sleeve: outer probe 425A-21A-4 Sleeve: probe	
A7	00414-62102	Probe assembly includes mechanical parts <u>Mechanical Parts for A7</u> 8120-0041 Cable: miniature triaxial with red jacket 1400-0088 Clip: alligator solid copper 2" long 1400-0089 Insulator: alligator black poly	
A8	00414-62103	Probe assembly includes mechanical parts <u>Mechanical Parts for A8</u> 8120-0042 Cable: miniature with high flexibility and controlled outer conductor resistance 1400-0088 Clip: alligator solid copper 2" long 1400-0089 Insulator: alligator black poly	
C1 C2 C3 C4	0180-0042 0180-0047 0170-0022 0170-0037	C: fxd elect 120 μ f 350 vdcw C: fxd Al elect 500 μ f 75 vdcw C: fxd my 0.1 μ f \pm 20% 600 vdcw C: fxd poly 1 μ f \pm 10% 50 vdcw	
CR1 thru CR3 CR4 DS1 thru DS10, spare	1901-0025 1901-0156 2140-0075	Diode: Si 100 ma at +1 v 100 piv 12 pf Diode: 50 ma at +1 v 20 wiv Lamp: incd 24 v 15-20 ma	
E2A thru E2D	00414-05501	Can: isothermal	
F1 J1 K1	2110-0018 1251-0148 0490-0049	Fuse: slow-blow 0.25 amps 125 volts Connector: ac power cord receptacle Relay: reed SPST normally open	
L1	9100-0352	Coil: electromagnetic	
M1	1120-0389	Meter	
Q1	1850-0160	TSTR: Ge PNP 2N2147	
R1	0698-0024	R: fxd prec met flm 2610 ohms \pm 1% 1/2 w	

Table 7-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
R2*	0757-0751	R: fxd prec met film 7500 ohms $\pm 1\%$ 1/4 w	
R3	2100-1567	R: var ww 10 K $\pm 10\%$ 2 w	
R4	0757-0128	R: fxd prec met film 200 K $\pm 1\%$ 1/4 w	
S1	3100-1714	Switch: rotary includes R1	
S1R1	0757-0342	R: fxd prec met film 100 K $\pm 1\%$ 1/4 w	
S2	3101-0806	Switch: DPDT	
S3	3101-0180	Switch: pushbutton SPDT non-shorting 7/16" diameter red	
S4	3101-0033	Switch: slide DPDT 0.5 amp 125 vdc 3 amp 125 vac	
S5	3101-0001	Switch: tog SPST 250 v 3 amp molded phenolic body	
T1	9100-1312	Transformer: power	
XF1	1400-0084	Holder: fuse extractor post type	
		<u>MISCELLANEOUS</u>	
	412A-83A	Boot: cable	
	00414-01202	Bracket: capacitor	
	00414-01203	Bracket: shield	
	00414-01204	Bracket: switch	
	00414-01201	Bracket: transistor	
	0340-0039	Bushing: insulator for stand-off and feed-thru terminals	
	0340-0122	Bushing: insulator nylon shoulder	
	1410-0003	Bushing: threaded panel	
	8120-0078	Cable: power black extra limp 7.5' long	
	0510-0786	Clip: resistor	
	1251-0208	Connector: 22 pin contacts "Twisted-U" terminals	
	00414-04101	Cover: shield bottom	
	0340-0060	Insulator: feed-thru teflon bushing with clover leaf receptacles	
	0340-0092	Insulator: feed-thru teflon cloverleaf type accepts 5 leads	
	0370-0077	Knob: skirted bar w/bar (FUNCTION)	
	00414-90001	Manual: operating and service	
	00414-01206	Shield: reed	
	1200-0044	Socket: transistor	
	1460-0218	Spring: tubular	
	00414-09901	Strip: symbol	
	5040-0646	Support: readout	
	0360-0499	Terminal: insulator teflon insulated	
	0340-0128	Terminal: standoff teflon insulated	
	1000-0025	Window: polaroid	

Table 7-2. Replaceable Parts

-hp- PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ
412A-83A	Boot: cable	28480	412A-83A	3
425A-21A-4	Sleeve: probe	28480	425A-21A-4	1
425A-21A-5	Sleeve: cable terminal	28480	425A-21A-5	1
0140-0198	C: fxd mica 200 pf $\pm 5\%$ 300 vdcw	00853	RDM15F201J3C	2
0140-0214	C: fxd mica 60 pf $\pm 5\%$	14655	RDM15E600J3C	1
0150-0012	C: fxd cer 0.01 μ f $\pm 20\%$ 1000 vdcw	71590	13C obd	1
0150-0024	C: fxd cer 0.02 μ f $+80\% -20\%$ 600 vdcw	72982	841-000-Z5U-203 Z	2
0150-0050	C: fxd cer 0.001 μ f 600 vdcw	01281	Type E obd	9
0150-0084	C: fxd cer 0.1 μ f $+80\% -20\%$ 50 vdcw	72982	845-222 Y5V0 104Z	3
0150-0085	C: fxd cer 0.0022 μ f $\pm 20\%$ 500 vdcw	56289	29C332	1
0160-0127	C: fxd cer 1.0 μ f $\pm 20\%$ 25 vdcw	56289	5C13 obd	2
0160-0209	C: fxd my 0.33 μ f $\pm 20\%$ 200 vdcw	72354	F307C334M	2
0160-0744	C: fxd poly 0.047 μ f $\pm 20\%$ 50 vdcw	56289	194P4730R5	1
0160-2136	C: fxd my 0.18 μ f $\pm 10\%$ 200 vdcw	56289	148P18492	1
0170-0022	C: fxd my 0.1 μ f $\pm 20\%$ 600 vdcw	56289	148P175A	2
0170-0037	C: fxd poly 0.1 μ f $\pm 10\%$ 50 vdcw	56289	114P1059R5S25	1
0180-0042	C: fxd elect 120 μ f 350 vdcw	56289	D32353	1
0180-0047	C: fxd Al elect 500 μ f 75 vdcw	56289	D32443	1
0180-0049	C: fxd Al elect 20 μ f 50 vdcw	56289	30D206G050DC6 M1	4
0180-0050	C: fxd Al elect 40 μ f $+100\% -15\%$ 50 vdcw	56289	30D406G050DF6 M1	2
0180-0061	C: fxd elect 100 μ f $+100\% -10\%$ 15 vdcw	56289	30D107G0150D4	1
0180-0119	C: fxd Al elect 1 μ f 25 vdcw	56289	30D105G025AA4	2
0180-0137	C: fxd Ta elect 100 μ f 10 vdcw	56289	150D107X0010R2	2
0180-0142	C: fxd Al elect 20 μ f $+100\% -10\%$ 25 vdcw	56289	(type D) D36039	1
0180-0149	C: fxd Al elect 65 μ f $+100\% -10\%$ 60 vdcw	56289	Type 30D D36978	1
0340-0039	Bushing: insulator for stand-off and feed-thru terminals	98291	X-B-04176-12	3
0340-0060	Insulator: feed-thru teflon bushing with cloverleaf receptacles	98291	FT-E-15 obd	2
0340-0092	Insulator: feed-thru teflon cloverleaf type accepts 5 leads	98291	FT-E-12 obd	4
0340-0122	Bushing: insulator nylon shoulder	26365	974-303	2
0340-0128	Terminal: standoff teflon insulated	98291	ST-1500 SL obd	8
0360-0499	Terminal: insulator teflon insulated	98291	ST 2500 SL obd	4
0370-0077	Knob: skirted bar w/bar (FUNCTION)	28480	0370-0077	1
0490-0049	Relay: reed SPST normally open	95348	MR830-1 obd	1
0490-0171	Relay: reed	99208	DRR-DTH obd	1
0490-0182	Relay: hermetically sealed dry reed	28480	0490-0182	6
0510-0786	Clip: resistor	91506	6080-32CT	1
0683-1035	R: fxd 10 K $\pm 5\%$ 1/4 w	01121	CB1035	4

Table 7-2. Replaceable Parts (Cont'd)

-hp- PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	
1400-0088	Clip: alligator solid copper 2" long	76545	60-CS		
1400-0089	Insulator: alligator black poly	76545	6-1 41648	obd	2
1410-0003	Bushing: threaded panel	28480	1410-0003		2
1460-0218	Spring: tubular	28480	1460-0218		1
1820-0010	Amplifier: reference Si NPN transistor with 7 v zener	24446	4JX19A555		1
1850-0054	Transistor: Ge PNP 2N652A	82647	2N652A		1
1850-0062	Transistor: Ge PNP 2N404	82647	GA287	obd	19
1850-0070	Transistor: Ge PNP 2N1373	82647	2N1373		2
1850-0160	Transistor: Ge PNP 2N2147	86684	2N2147		1
1850-0173	Transistor: Ge PNP 2N1307	24446	2N1307		3
1851-0017	Transistor: Ge NPN 2N1304	82647	2N1304		3
1853-0007	Transistor: Si PNP 2N3251	04713	2N3251		1
1853-0010	Transistor: Si PNP **	28480	1853-0010		6
1853-0016	Transistor: Si PNP 2N3638	07263	2N3638		3
1853-0020	Transistor: Si PNP **	28480	1853-0020		2
1853-0023	Transistor: Si PNP 2N3703	82647	2N3703		1
1854-0033	Transistor: Si NPN 2N3391	24446	2N3391		6
1854-0039	Transistor: Si NPN 2N3053	04713	2N3053		1
1854-0087	Transistor: Si NPN 2N3417	24446	2N3417		2
1901-0025	Diode: Si 100 ma at +1 v 100 piv 12 pf	93332	D3072	obd	35
1901-0026	Diode: Si 200 piv	72699	obd		4
1901-0030	Diode: Si 800 piv	72699	obd		1
1901-0044	Diode: 20 ma at +1 v 10 na at -10 v/50 wiv 2 pf 6 ns	07910	obd		6
1901-0156	Diode: 50 ma at +1 v 20 wiv	03877	SG 328S	obd	3
1902-0031	Diode: breakdown 12.5 v $\pm 5\%$ 400 mw	04713	SZ10939-212		1
1902-0048	Diode: breakdown 6.81 v $\pm 5\%$ 400 mw	06486	SZ10939-134		1
1902-0566	Diode: breakdown 20 v Si temperature compensated	12954	DT 50323M		1
1902-0763	Diode: breakdown 9.4 v IN2163A	04713	IN2163A		1
1902-3139	Diode: Si breakdown 8.25 v $\pm 5\%$ 400 mw	07263	obd		2
1910-0016	Diode: Ge 1 microsecond 60 wiv	03877	S3185G		5
1990-0218	Photocopper assembly (includes neon subassembly) Note: The neon subassembly may be ordered under -hp- Part No. 1990-0213	28480	1990-0218		1
2100-0091	R: var comp pot lin 5 K $\pm 30\%$ 0.15 w	11237	UPE 70RE (-hp-)	obd	1
2100-0281	R: var ww 100 ohms $\pm 20\%$ 1-1/2 w	79727	E-870	obd	1
2100-0328	R: var ww 500 ohms $\pm 10\%$ 1-1/2 w	79727	E-870	obd	2
2100-0330	R: var ww 1500 ohms $\pm 10\%$ 1-1/2 w	79727	E-870	obd	2
2100-0331	R: var ww 5000 ohms $\pm 10\%$ 1-1/2 w	79727	E-870	obd	2

Table 7-2. Replaceable Parts (Cont'd)

-hp- PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	
2100-0396	R: var ww 10 K $\pm 20\%$ 1-1/2 w	11237	X110	obd	2
2100-0439	R: var ww 250 ohms $\pm 20\%$ 1-1/2 w	79727	E-870	obd	2
2100-1560	R: var ww 30 ohms $\pm 10\%$ 1-1/2 w	79727	E-870	obd	1
2100-1567	R: var ww 10 K $\pm 10\%$ 2 w	08984	FFF-1-XYZ	obd	1
2100-1739	R: var ww 5 K $\pm 10\%$ 1 w	96791	2600 Series	obd	1
2110-0018	Fuse: slow-blow 0.25 amps 125 volts	75915	313.250		1
2140-0075	Lamp: incd 24 v 15-20 ma	82219	24CSB	obd	11
3100-1714	Switch: rotary	28480	3100-1714		1
3101-0001	Switch: tog SPST 250 v 3 amp molded phenolic body	04009	80994-H		1
3101-0033	Switch: slide DPDT 0.5 amp 125 vdc 3 amp 125 vac	79727	G-326;6510		1
3101-0180	Switch: pushbutton SPDT non-shorting 7/16" diameter red	82389	No. 923	obd	1
3101-0806	Switch: DPDT	28480	3101-0806		1
5040-0405	Handle assembly: red	28480	5040-0405		1
5040-0407	Lock nut	28480	5040-0407		1
5040-0408	Sleeve: outer probe	28480	5040-0408		1
5040-0414	Capacitor: probe	28480	5040-0414		1
5040-0646	Support: readout	28480	5040-0646		1
5060-0407	Probe assembly: jaw	28480	5060-0407		1
5080-0623	Compensator: thermal	28480	5080-0623		1
8120-0038	Cable: miniature low-noise coaxial	28480	8120-0038		1
8120-0041	Cable: miniature triaxial with red jacket	28480	8120-0041		1
8120-0042	Cable: miniature with high flexibility and controlled outer conductor resistance	92607	obd		1
8120-0078	Cable: power black extra limp 7.5' long	70903	KH-4147	obd	1
9100-0352	Coil: electromagnetic	28480	9100-0352		1
9100-1312	Transformer: power	28480	9100-1312		1
9160-0018	Coil: electromagnetic	28480	9160-0018		1
00414-01201	Bracket: transistor	28480	00414-01201		1
00414-01202	Bracket: capacitor	28480	00414-01202		1
00414-01203	Bracket: shield	28480	00414-01203		1
00414-01204	Bracket: switch	28480	00414-01204		1
00414-01206	Shield: reed	28480	00414-01206		1
00414-04101	Cover: shield bottom	28480	00414-04101		1
00414-05501	Can: isothermal	28480	00414-05501		1
00414-09901	Strip: symbol	28480	00414-09901		1
00414-62101	Probe assembly	28480	00414-62101		1
00414-62102	Probe assembly	28480	00414-62102		1
00414-62103	Probe assembly	28480	00414-62103		1
00414-66501	Attenuator board assembly	28480	00414-66501		1
00414-66506	Amplifier board assembly	28480	00414-66506		1

Table 7-2. Replaceable Parts (Cont'd)

-hp- PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ
00414-66503	Ranging board assembly	28480	00414-66503	1
00414-66504	Power supply and control board assembly	28480	00414-66504	1
00414-66505	Rectifier board assembly	28480	00414-66505	1
00414-82601	R: fxd prec ww 18. 2 ohms 1/4 w	28480	00414-82601	1
00414-90001	Manual: operating and service	28480	00414-90001	1

hp MANUAL BACKDATING CHANGES

MODEL 414A

AUTOVOLTMETER

Manual Serial Prefixed: 630-
-hp- Part No. 00414-90001

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
531-00275 and below	1, 2, 3, 4		
*	2, 3, 4		
below 605-	3, 4		
below 630-	4		

* 531-00283, 531-00284, 531-00289, 531-00319, 531-00350

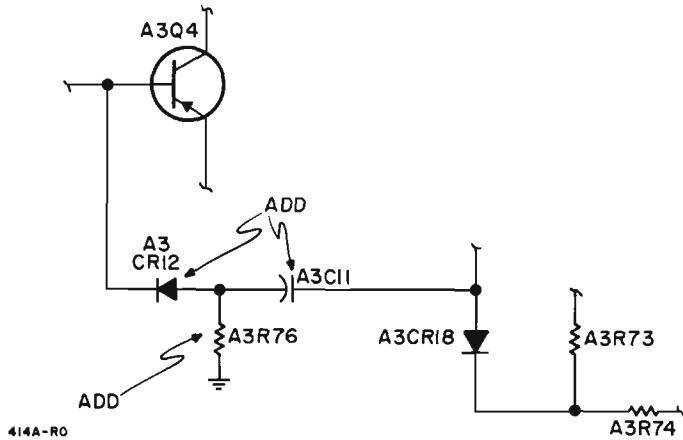
Change #1 Delete CR4, Diode: Si -hp- Part No. 1901-0156 across + and - terminal of M1.

NOTE

This meter protection diode can be added to an instrument in accordance with Service Note 414A-3 which may be obtained from your nearest -hp- Sales and Service Office.

Change #2 Change A5R2 to R: var lin 5K ohms $\pm 30\%$ 1/4 w -hp- Part No. 2100-0383.

Change #3 Delete A3R78, R: fxd comp 33K ohms $\pm 5\%$ 1/4 w -hp- Part No. 0683-3335.
Add A3C11, C: fxd cer 0.005 μ f 500 vdcw -hp- Part No. 0150-0014.
Add A3CR12, Diode: Si 100 ma at +1 v 100 piv 12 pf -hp- Part No. 1901-0025.
Add A3R76, R: fxd 100K $\pm 5\%$ 1/4 w -hp- Part No. 0683-1045.



Change #4 Change A2 Amplifier board assembly to -hp- Part No. 00414-66502, and change A2A1 photochopper to -hp- Part No. 1990-0203.

hp MANUAL CHANGES

MODEL 414A AUTOVOLTMETER

Manual Serial Prefixed: 630-
-hp- Part No. 00414-90001

- New item

Instrument Serial Number	Make Manual Changes	Instrument Serial Number	Make Manual Changes
All	ERRATA	811-00926 and above	CHANGE #1, 2, 3, 4
630-00801 and above	CHANGE #1		
811-00826 and above	CHANGE #1, 2		
811-00901 and above	CHANGE #1, 2, 3		

ERRATA

- Page 1-0: GENERAL: Power: change "1000 cps" to "400 cps."

Section III: Add Table: OHMS-TO-COM OPEN-CIRCUIT VOLTAGE

Range	Open-Ckt V	Range	Open-Ckt V	Range	Open-Ckt V
5 Ω	- 6.2	500 Ω	- 7.0	50 kΩ	- .18
15 Ω	- 6.2	1.5 kΩ	- 8.6	150 kΩ	- .34
50 Ω	- 6.3	5 kΩ	- 13.6	500 kΩ	- .83
150 Ω	- 6.5	15 kΩ	- .13	1.5 MΩ	- 2.4

Page 4-1: Paragraph 4-8, second to last line; Paragraph 4-10, second line: change "Input Attenuator" to "source by the Amplifier Assembly."

Pages 4-1, 4-4: Paragraph 4-9, sixth line; Paragraph 4-29, last sentence: change "Table 5-6" to "Logic Chart 2."

Page 4-3: Paragraph 4-23, next to last line: change "145 V" to "14.5 V."

Page 4-4: Paragraph 4-31, third line: change "6" to "5."

Section V: add following warning: DANGER

AFTER REMOVING OR REPLACING CONTROL KNOBS, REFILL SET-SCREW
HOLES WITH GE TRANSLUCENT SILICON RUBBER RTV-108 (-hp- Part No. 0470-0304).

Pages 5-9, 5-10: Paragraph 5-51, fourth line: change "of" to "or." Paragraph 5-52 (9), (10), (11), (17): change all "A5" prefixes to "A4." (9), third from last line: change "in" to "an." (23): change "A4" prefix to "A3."

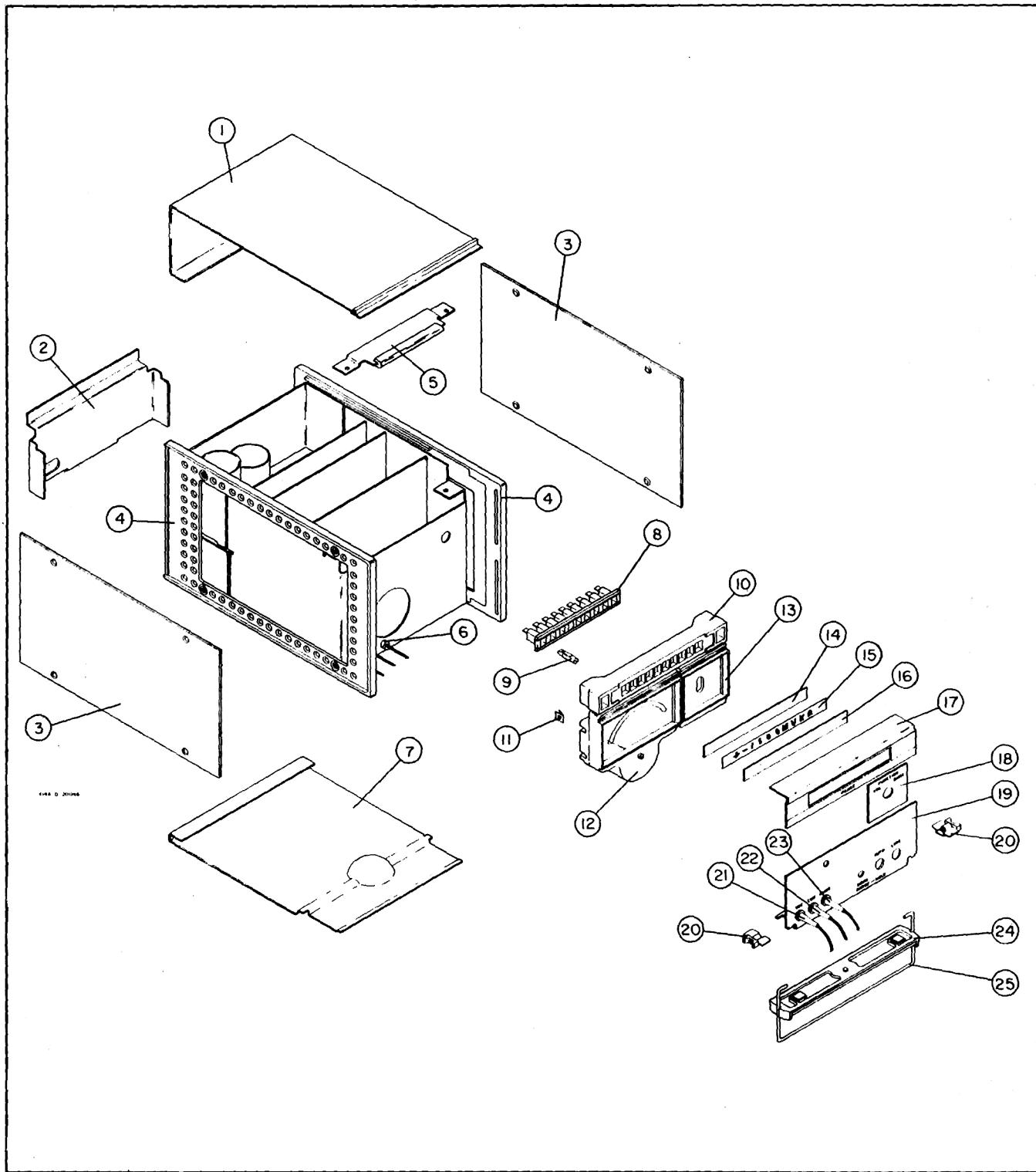
Page 6-5: change A2 Part No. to 00414-66506.

► Page 6-11: change A4R40 from "13.6 k" to "13 k."

► Page 7-8: change A4R41 to 0757-0757 R: fxd met flm 15.0 k ±1% 1/4 W

Pages 7-8, 7-9: A6: add description "VDC Assembly (grey)." A7: add description "COM Assembly (black)." A8: add description "OHMS Assembly (red)."

SUPPLEMENTARY MECHANICAL PARTS



INDEX NUMBER	REFERENCE DESIGNATOR	-hp- PART NO.	DESCRIPTION	TQ
1	MP1	00414-00601 2460-0008	Top cover assembly Screw: Phillips, 6-32 x 3/8 in. long	1 2
2	MP2	00414-00202	Panel: rear	1
3	MP3	5000-0703 2370-0020	Side cover: 6 x 11 SM Screw: Flat head Phillips, 6-32 x 3/16 in. long. Hardware for MP3	2 8
4	MP4	5060-0703 2370-0012 2190-0047 2370-0013	Side frame Screw: Flat head Phillips, 6-32 x 1/4 in. long. Hardware for fastening MP4 to MP2 Washer: Lock, countersink No. 6 Hardware for bolting MP4 to MP2 Screw: Flat head Phillips, 6-32 x 3/8 in. long. Hardware for fastening MP4 to chassis, M1, and MP11	2 8 16
5	MP5	00414-01205 4320-0014 Hardware for fastening MP5 to chassis	Bar: Lamp retainer Insulator: rubber Screw: Machine, 6-32 x 1 3/4 Pan H Washer: Split lock for No. 6 screw Washer: Flat, 3/8 in. O.D., 0.147 I.D. Clamp: Cable, nylon 5/16 in. diameter holds spare lamp Screw: Phillips, 6-32 x 3/8 in. long Washer: Int. lock for No. 6 screw Clamp: plastic cable	1 1 1 2 1
6	MP6	0400-0019	Bottom cover assembly, 7 x 11 SM	3
7	MP7	5000-0717 2370-0016	Screw: Flat head Phillips, 6-32 x 5/16 in. long. Hardware for MP7	1 2
8	MP8	1450-0129	Socket: lamp (for DS1 thru DS9)	1
9	DS1 thru DS10	2140-0075	Lamp: Incandescent	10
10	MP9	5040-0646	Block: Readout support	1
11	MP10	0590-0039 2390-0003 3050-0066	Nut: Sheet metal, tinnerman Screw: Machine 6-32 x 0.875 in. long Washer: flat, fits No. 6 screw. Hardware for fastening M1 to MP11	6 2 6
12	M1	1120-0389	Meter	1
13	MP11	5040-0701	Switch panel: black plastic, function	1
14	MP12	00414-04102	Light diffuser: white frosted	1
15	MP13	00414-09901	Strip: symbol	1
16	MP14	1000-0025	Window: Polaroid, orange	1
17	MP15	00414-00203	Panel: readout, RANGE	1
18	MP16	00414-00204	Insert: Function, VDC-OHMS	1
19	MP17	00414-00201	Panel: Front (does not include probes)	1
20	MP18	5040-0700	Hinge	2
21	A6	00414-62101	Probe assembly: grey VDC	1
22	A7	00414-62102	Probe assembly: black, COMMON	1
23	A8	00414-62103	Probe assembly: red, OHMS	1
24	MP19	5060-0728	Foot assembly: half module	2
25	MP20	1490-0032	Stand: half module	1

CHANGE #1

Page 7-2: Change A1K2, K3 to Part No. "0490-0343."

Page 7-4: Change A3K4 thru K6 and K8 to Part No. "0490-0343."

CHANGE #2

Figure 6-6 and Tables 7-1, 7-2: Add

A4R50

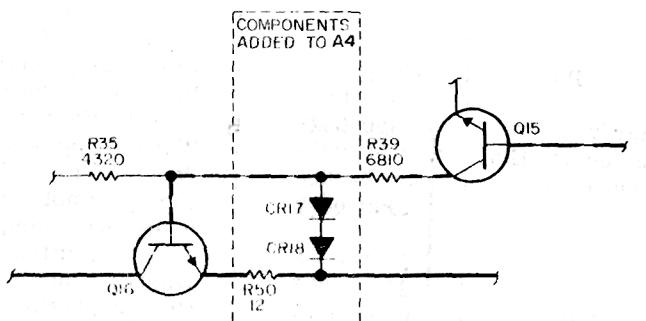
0683-0685

R: fxd comp $6.8 \Omega \pm 5\%$ 1/4 W

A4CR17, CR18

1901-0025

Diode: Si 100 piv 12 pF 100 mA



CHANGE #3

Page 7-6: Change A4C1, C2 to Part No. "0160-2128."

CHANGE #4

A4R51 added from Q19 collector on A4 to power supply common. R51: fxd $82 \text{ k}\Omega$ 1/4 W $\pm 10\%$ 0684-8231.



00414-90001

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