Errata

Title & Document Type: **3443C High Gain / Auto Range Unit Operating and Service Manual**

Manual Part Number: **03443-90004**

Revision Date: **July 1970**

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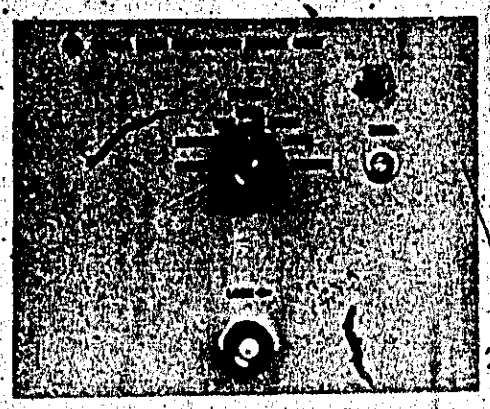
Agilent Technologies

OPERATING AND SERVICE MANUAL

HP 3443A

HIGH GAIN/ AUTO RANGE UNIT

3443A



HEWLETT hp PACKARD

HP 3443A

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CERTIFICATION

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

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

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OPERATING AND SERVICE MANUAL

-hp- Part No. 03443-90004

MODEL 3443A
HIGH GAIN/AUTO RANGE UNIT

Serials Prefixed: 819-

Appendix C, Manual Backdating Changes,
adapts manual to serials prefixed 417-, 444-.

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

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INFORMATION

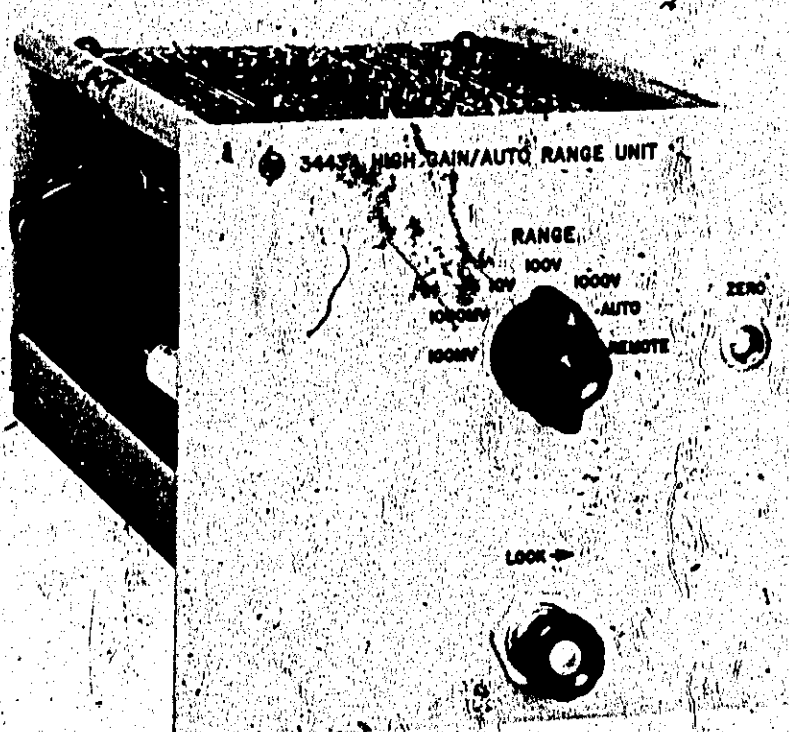


Figure 1-1. Model 3443A High Gain/Auto Range Unit

Table 1-1. Specifications

Voltage Range: 4-digit presentation of 99.99 mv, 999.9 mv, 9.999 volts, 99.99 volts, and 999.9 volts full scale with 5% overrange capability and overrange indicator.

Voltage Accuracy: 9.999 v to 999.9 v (full scale): ±0.05% of reading ±1 digit including line voltage variations of ±10% from nominal. A front panel adjustment on the 3440A insures accuracy over the temperature range between +15°C and +40°C and ±0.1% of reading ±1 digit over the temperature range of 0°C to +50°C.

99.99 mv and 999.9 mv (full scale): ±0.1% of reading ±1 digit including line voltage variations of ±10% from nominal. A front panel adjustment on the 3439A or 3440A insures accuracy over the temperature range between +15°C and +40°C and ±0.15% of reading ±1 digit over the temperature range of 0°C to +50°C.

Range Selection: Manual, Automatic and Remote.

Range Change Speed: Automatic (Max.) achieves accurate reading within 1.5 seconds after new voltage is applied. Remote (Max) will change range within 40 ms.

Voltmeter Input Impedance: Constant 10.2 megohms (to dc) all ranges.

Polarity: Automatic indication.

Input Filter Characteristics: Less than 450 msec to 99.95% of final value for full-scale step function on 10, 100 and 1000 volt ranges (without a range change).

Less than one sec to 99.95% of final value for a full-scale step function on 100 and 1000 mv ranges (without a range change).

Input Filter AC Rejection: 10, 100, and 1000 volt ranges: 30 db at 60 cps, increasing at 12 db/octave.

100 and 1000 mv ranges: maximum of 40 mv and 400 mv p-p respectively at 60 cps for rated accuracy; allowable ac increasing at 6 db/octave.

Common Mode Rejection:

	100 MV	1000 MV	10 V	100 V	1000 V
DC	130 db	110 db	90 db	70 db	50 db
60~	<10 v p-p*	<10 v p-p*	70 db	50 db	30 db

*Error <.1% full scale

Weight: NET 3.0 lbs. 1.35 kg. SHIPPING 6.5 lbs. 2.9 kg.

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The ℋ Model 3443A Gain/Auto Range Unit is a plug-in unit for the ℋ Model 3439A and 3440A Digital Voltmeters. The High Gain/Auto Range unit automatically selects ranges and prepares the voltmeter for measuring dc voltages from ±100 millivolts to ±1000 volts in the 4 significant figures. The ℋ Model 3443A Gain/Auto Range Unity is shown in Figure 1-1; specifications are given in Table 1-1.

1-3. When plugged into the compartment on front panel of digital voltmeter, the Model 3443A provides three modes of operation: a) automatic selection of proper range; b) manual range selection; and c) remote range selection. When a 3440A is used, its sampling rate can be remotely controlled if SAMPLING RATE knob of Model 3440A is in the HOLD position.

1-4. INSTRUMENT AND MANUAL IDENTIFICATION.

1-5. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 3443A described in this manual.

1-6. If the first three digits of the two-section eight-digit serial number are prefixed with a letter, your instrument was manufactured outside of the United States.

INSTALLATION

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary for the installation and shipping of the Model 3443A High Gain/Auto Range Unit. Included are initial inspection procedures, power and grounding requirements, installation information and instructions for repackaging for shipment.

2-3. INITIAL INSPECTION.

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

2-5. INSTALLATION.

2-6. Before installing Model 3443A into a Model 3440A, check the serial prefix and number of the digital voltmeter. If number is below 415-00726, a slight modification will be necessary before proceeding (see Paragraph 5-66). The Model 3443A may be installed into any Model 3439A with no modifications.

2-7. Install the Model 3443A in the compartment provided in the Model 3440A Digital Voltmeter. Make certain the instrument is properly aligned and the front panel locking screw is tightened.

2-8. REPACKAGING FOR SHIPMENT.

2-9. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-10 if the original container is to be used; 2-11 if it is not. If you have any questions, contact your local Sales and Service Office. (See Appendix B for office locations.)

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and 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.

2-10. If original container is to be used, proceed as follows:

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

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

2-11. If original container is not to be used, proceed as follows:

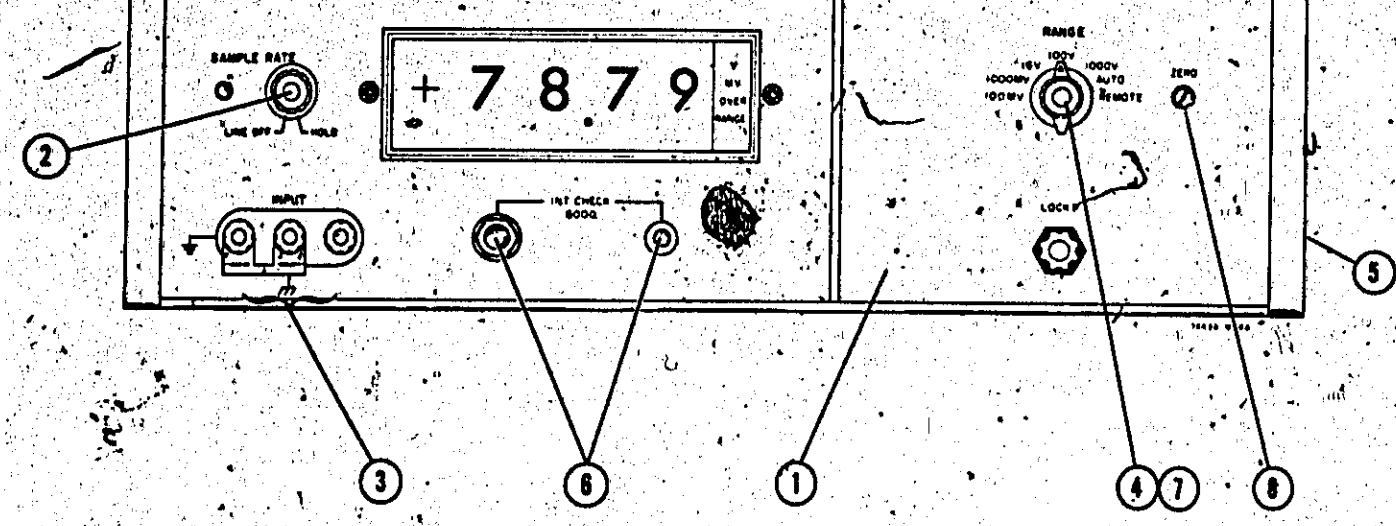
a. Wrap instrument in heavy paper or plastic before placing in an inner container.

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.

OPERATION



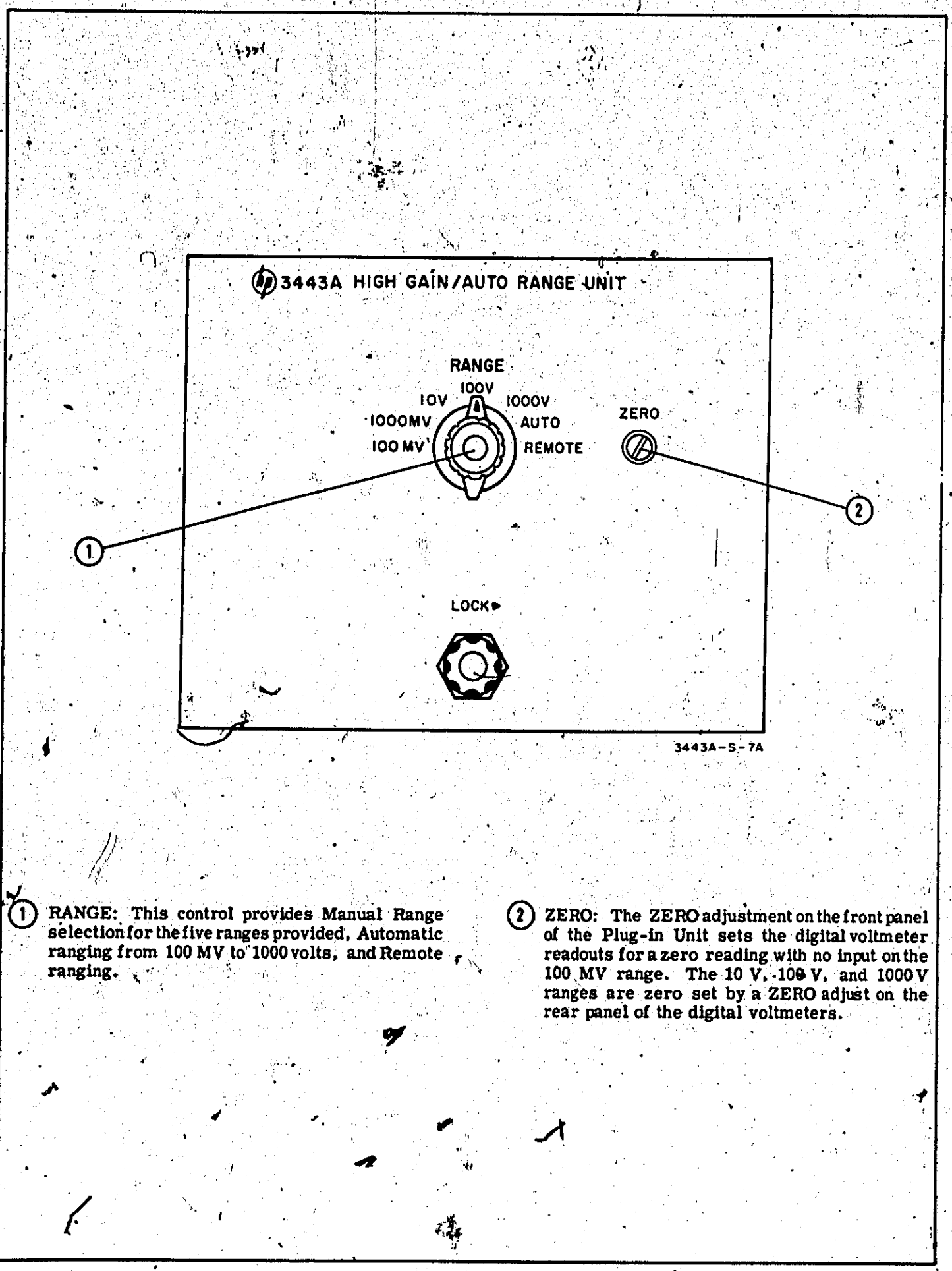
NOTE

If Model 3443A is used with Model 3440A below serial number 415-00726, see Paragraph 5-67.

1. Insert plug-in into Model 3439A or 3440A Digital Voltmeter.
2. Turn digital voltmeter on. Allow 30 minutes warmup time.
3. Short digital voltmeter INPUT terminals.
4. Set RANGE to 10 V.
5. Adjust digital voltmeter rear panel ZERO for display of 0.000. Alternate flashing of (+) and (-) indicates optimum adjustment. Remove shorting connection.
6. Depress INT CHECK 8000 pushbutton and adjust INT CHECK 8000 screwdriver adjustment for display of -8.000.
7. Set RANGE to 100 MV and short INPUT terminals.
8. Adjust ZERO control on Model 3443A for 0.000 indication. Optimum adjustment is indicated by alternate flashing of (+) and (-).
9. Disconnect short and set Model 3443A to desired range or function; instrument is now ready for use.

Figure 3-3. Operation

THEORY



(1) RANGE: This control provides Manual Range selection for the five ranges provided, Automatic ranging from 100 MV to 1000 volts, and Remote ranging.

(2) ZERO: The ZERO adjustment on the front panel of the Plug-in Unit sets the digital voltmeter readouts for a zero reading with no input on the 100 MV range. The 10 V, 100 V, and 1000 V ranges are zero set by a ZERO adjust on the rear panel of the digital voltmeters.

Figure 3-1. Description of Model 3443A Controls

SECTION III
OPERATING INSTRUCTIONS

3-1. GENERAL.

3-2. Model 3443A High Gain/Auto Range Unit provides automatic ranging, remote, and manual operation capabilities to the hp Model 3439A and 3440A Digital Voltmeters. The plug-in unit front panel range switch selects the mode of operation. Five voltage ranges can be selected manually or automatically.

3-3. PLUG-IN CONTROLS.

3-4. The Model 3443A controls are explained in Figure 3-1.

3-5. OPERATING PROCEDURE.

3-6. Operating instructions for the Model 3443A High Gain/Auto Range Unit are given in Figure 3-3. Instructions are keyed to the illustration of the front panel of the plug-in provided with the figure. Modes of operation are explained in Paragraph 3-7 through 3-12.

3-7. MANUAL RANGE SELECTION.

3-8. The five ranges can be manually selected by the front panel range switch. The voltmeter will remain on the range selected, and operate as described in the digital voltmeter manual.

3-9. AUTOMATIC RANGE SELECTION.

3-10. When the RANGE switch is set to AUTO, the Model 3443A will automatically select the proper range. If the input voltage exceeds 100% of the range setting, the instrument will uprange to the next range. If the input drops below 9% of full scale, the instrument will downrange. If the input exceeds 1000 V on the 1000 V range, the OVERRANGE indicator will flash.

3-11. REMOTE RANGE SELECTION.

3-12. Any Model 3443A range may be selected by connecting the proper pin on P4 on the rear of the digital voltmeter to circuit ground (P4, pin 32). When the RANGE switch in is the REMOTE position, the 1000 V range is automatically selected. To select another range, refer to the connections in Table 3-1.

Table 3-1. Remote Connections

Range	Connection
100 MV	P4(4) to P(4)32
1000 MV	P4(3) to P(4)32
10 V	P4(1) to P(4)32
100 V	P4(2) to P(4)32
1000 V	No connection

3-13. Any range may also be selected by connecting a transistor switch to the proper pin on P4. When the transistor voltage switches from -35 V to a voltage more positive than -1.0 V, the desired range will be selected. Resistance from the remote pin to ground should be less than 6 K ohms. Figure 3-2 shows a typical transistor switching circuit. Four such circuits would be necessary to select all five ranges.

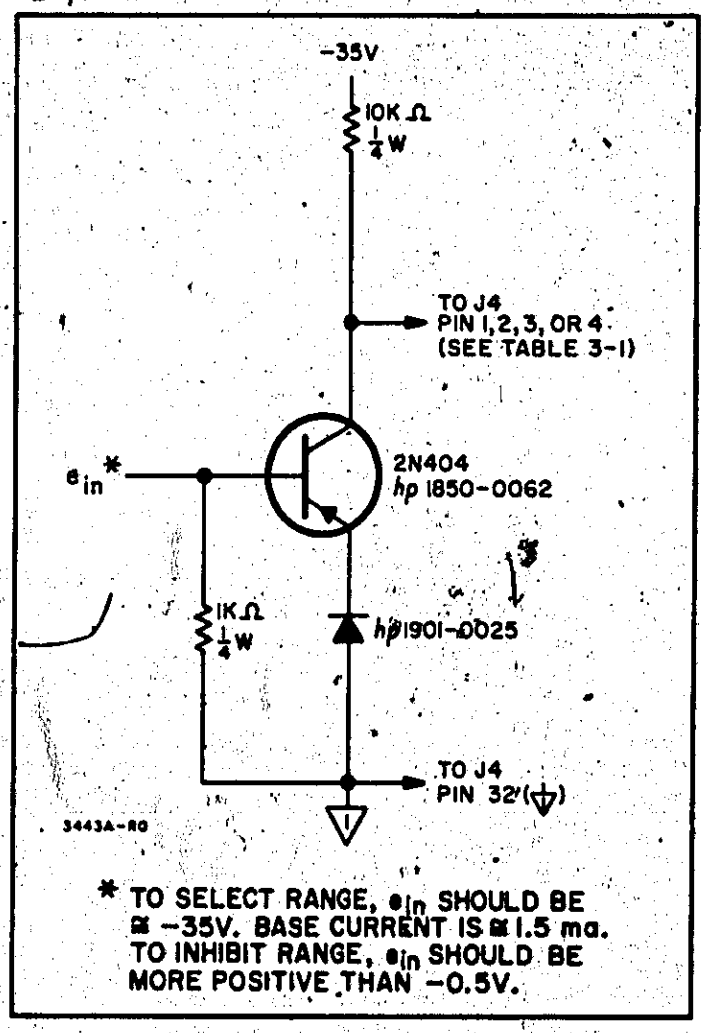
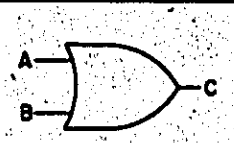
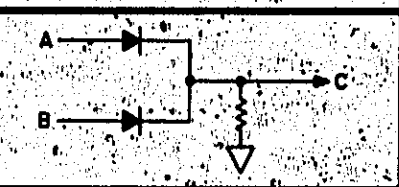
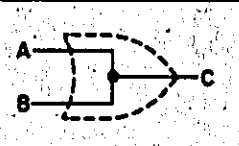
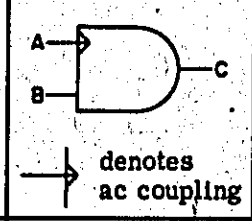
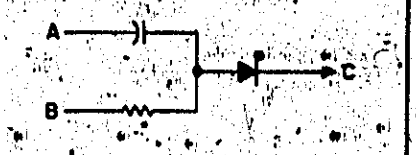
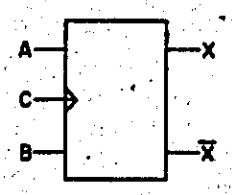
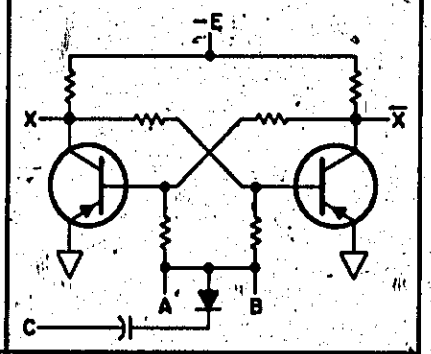
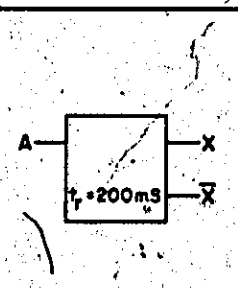
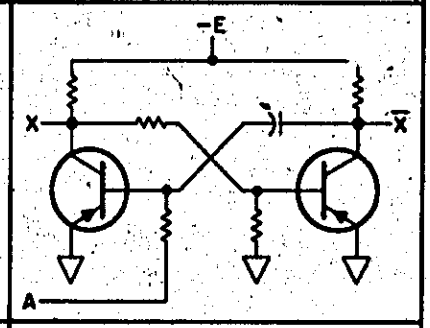
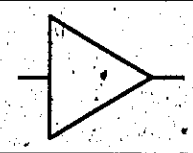
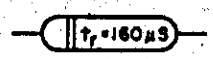
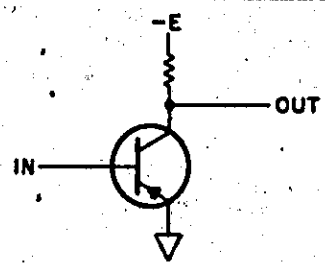


Figure 3-2. Typical Switching Circuit

3-14. RECORDER INFORMATION (3440A ONLY).

3-15. The Model 3443A gathers polarity and overrange information from the function column of the digital voltmeter. The four significant digits from the input dc voltage measurements are supplied to the digital recorder from the voltmeter. This information (polarity, overrange, and voltage magnitude) is also applied to the recorder through a 50-pin voltmeter digital recorder jack, J2.

Table 4-1. Logic Symbols

Name	Symbol	Abbreviation	Description	Typical Circuit
OR Gate		OG	If either A or B are true, the output at C will be true. Also, if A and B are applied simultaneously the output at C will be true.	
Wired OR Gate		WOG	Same as OR gate, but OR function is performed by junction of two wires rather than by active circuit.	
AND Gate		AG	Both A and B must be true simultaneously to produce a true output at C.	
Flip flop or Binary		F/F	Bistable multivibrator. Outputs X and $\overline{X}$ are always in opposite states. When input A is true, X is true. When input B is true, $\overline{X}$ is true. Flip flop may be connected to switch states with each input pulse connected at C. The flip flop is considered false when the $\overline{X}$ output is true.	
Monostable Multivibrator or One shot		MSMV	Monostable circuit. At rest condition, $\overline{X}$ is true and X is false. When a pulse is connected to A, the X output becomes true, and $\overline{X}$ becomes false. After some time T_r, the circuit switches back to original state.	
Amplifier		AMP	May be ac or dc coupled. Used to invert signal or act as a buffer.	— —
Delay Line		— —	Delays a signal by a fixed time T_r.	RC or RL coupling
Inverter		— —	Inverts a logic level.	

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. The Model 3443A provides automatic, manual or remote range selections for the 3439A and 3440A Digital Voltmeters. The functions of the 3443A are to:

a. Select the proper voltmeter range;
b. Speed up the voltmeter sampling rate while changing range;
c. Amplify the input signal to 10 volts on the 100- and 1000-millivolt ranges.

4-3. LOGIC SYMBOLOGY.

4-4. The binary circuits which allow automatic upranging and downranging are explained in terms of logic circuits (AND, OR Gates, etc.). All diagrams used in the explanation of the upranging and downranging circuits use logic symbology. When using logic symbology to explain circuits, it is necessary to know symbol meaning, logic circuit designation, and the theory of operation of the actual circuits the symbol represents. All the basic information, required to understand the logic symbology and circuits discussed in this section, is given in Table 4-1.

4-5. OVERALL CIRCUIT DESCRIPTION.

4-6. The measuring circuits within the digital voltmeter are designed to accept a maximum of 10 volts full-scale. Thus, if the 100-millivolt to 1000-volt ranges are to be available, it is necessary to either amplify or attenuate the dc signal applied to the digital voltmeter.

4-7. The Model 3443A provides amplification for the 100- and 1000-millivolt ranges and attenuation switching on the 100- and 1000-volt ranges. Switching is also provided on the 10-volt range, but there is no attenuation of the applied dc voltage since the digital voltmeter is designed to accept this voltage.

4-8. The Model 3443A includes two major assemblies: the Amplifier Assembly (A2) and the Ranging Assembly (A1). A simplified block diagram of the Model 3443A DC Amplifier provides amplification of input dc voltages on the 100- and 1000-millivolt ranges; the Ranging Assembly provides manual and automatic range switching and printer information. The information provided by the ranging section includes setting the attenuator so that a 10-volt full-scale voltage is applied to the digital voltmeter regardless of the amplitude of the voltage applied at its input. In addition, the ranging circuit provides sample speed-up information while ranging, and print commands following each sample, if the range is not changed.

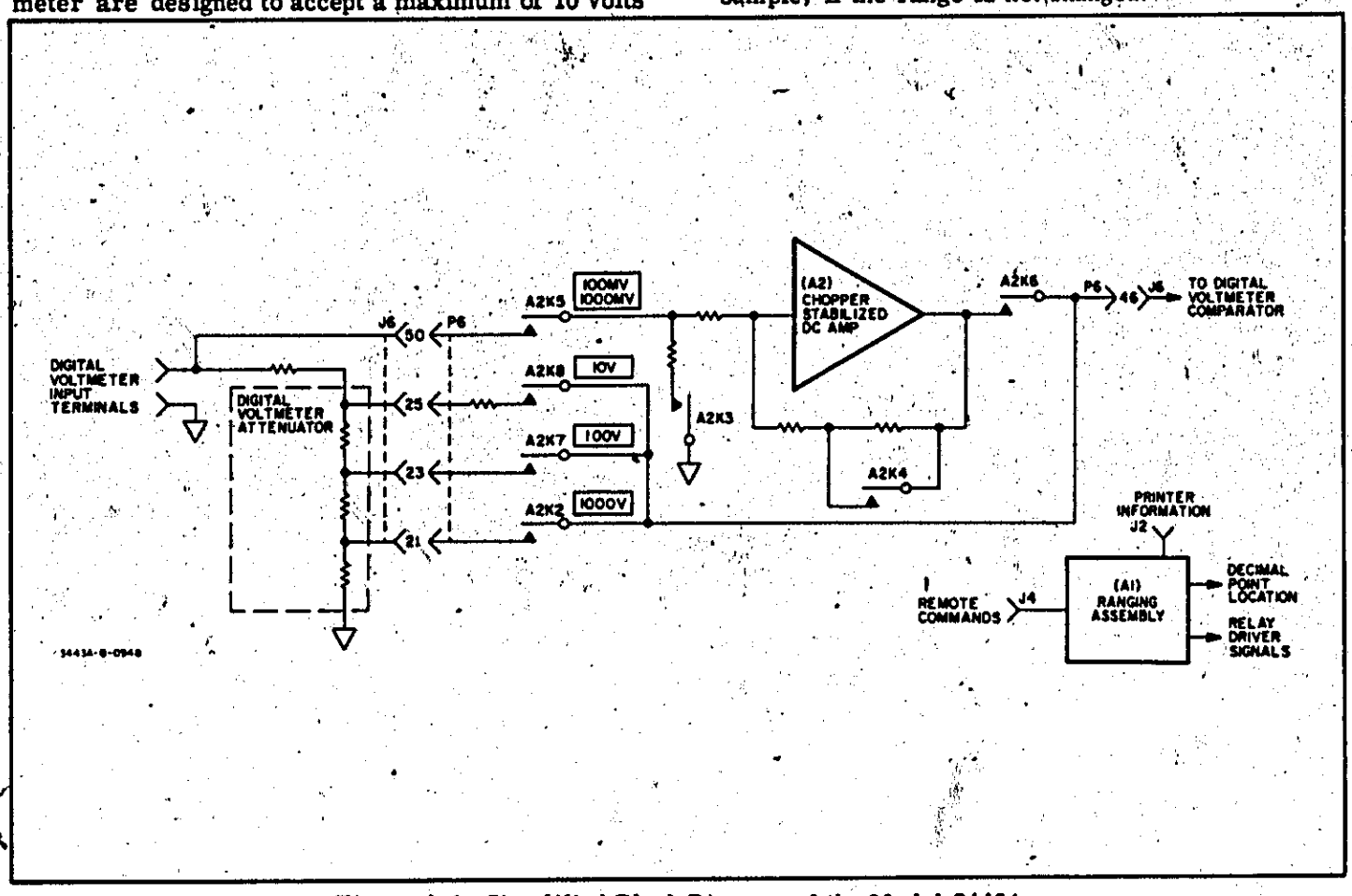


Figure 4-1. Simplified Block Diagram of the Model 3443A

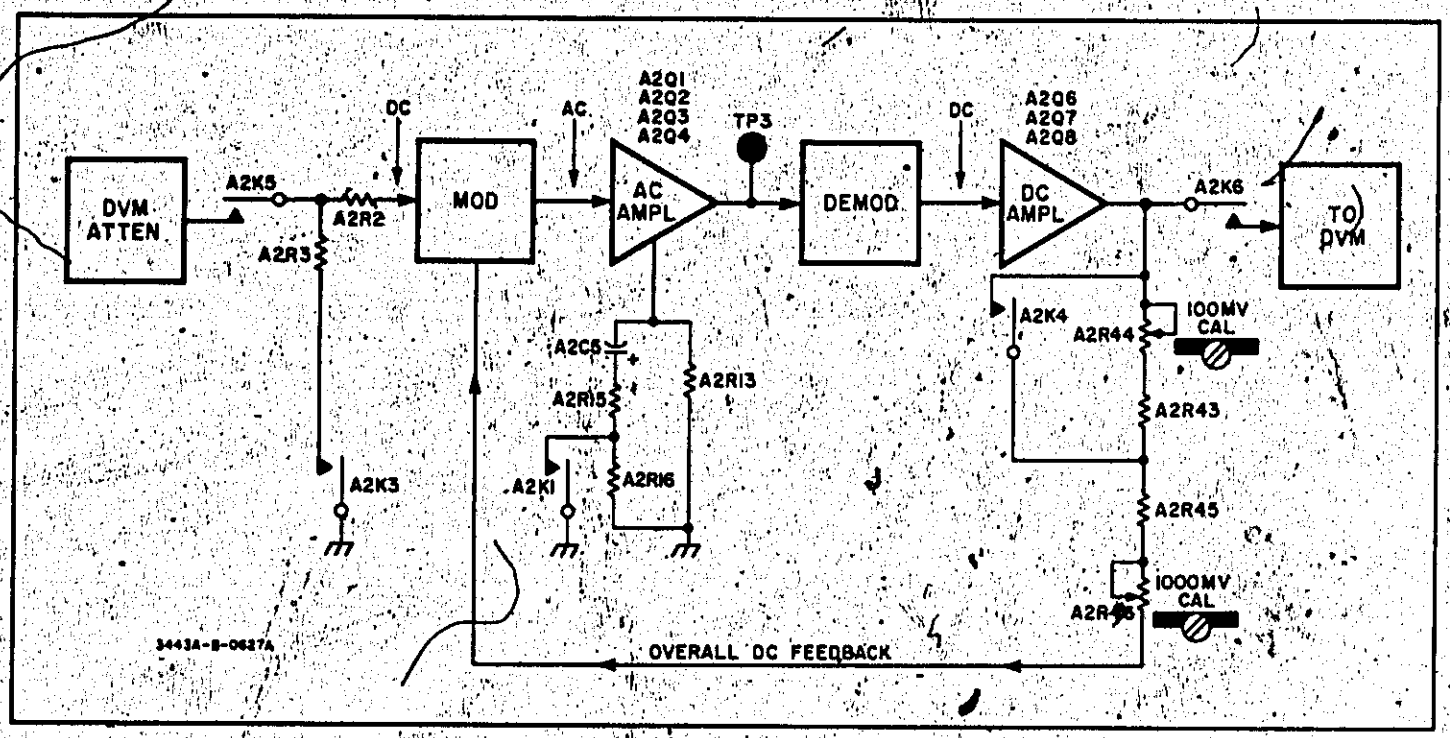


Figure 4-2. Simplified Block Diagram of the Amplifier

4-9. OVERALL AMPLIFIER DESCRIPTION.

4-10. The Amplifier Section of the Model 3443A is in the circuit only on the 100- and 1000-millivolt ranges, when relays A2K5 and A2K6 are energized. A simplified block diagram of the Amplifier Section is shown in Figure 4-2.

4-11. On the 100 MV and 1000 MV ranges, the dc input is applied through a thermal compensator assembly (Z1A and Z1B) to the amplifier input. The thermal compensator compensates for any thermal offsets in A2K5. The modulator converts the dc input to an ac voltage. This ac voltage is amplified by the ac amplifier and applied to the demodulator, where it is converted back to dc. The dc voltage is then applied to the dc amplifier (A2Q6, Q7, Q8) for further amplification. A portion of the dc amplifier output voltage is fed back to the modulator.

4-12. The amplifier section gain is set on the 100 and 1000-millivolt ranges by means of adjustable degenerative feedback. When the Model 3443A is on the 100-millivolt range, relay A2K4 is de-energized; and relay A2K1, is energized. The de-energizing of relay A2K4 adds A2R43 and A2R44 in the circuit, which in turn, decreases the overall feedback of the circuit. Relay A2K1 increases the gain of the ac carrier amplifier (ten times) by decreasing the first amplifier stage emitter impedance.

4-13. When the Model 3443A is on the 1000-millivolt range, relay A2K4 in the overall feedback circuit is energized, shunting A2R43 and A2R44, decreasing the overall dc gain by a factor of 10. Relay A2K1 is de-energized, increasing the emitter impedance of the first ac amplifier stage.

4-14. If an overload signal is applied to the digital voltmeter on the 100-millivolt range, it would take up to 1.5 seconds for the amplifier in the Model 3443A to fully recover. Assume that an overload of less than 1000 millivolts is applied on the 100-millivolt range when the Model 3443A is on automatic ranging. The instrument would step through the 1000-millivolt range to the 10-volt range, and relay A2K3 would energize, placing A2R3 across the amplifier input. The amplifier would recover, and the Model 3443A would downrange to the 1000-millivolt range and relay A2K3 would de-energize.

4-15. OVERALL DESCRIPTION OF RANGING CIRCUIT.

4-16. The ranging circuitry provides upranging and downranging in the automatic and manual modes of operation. In addition, it supplies appropriate information to the Model 3440A Digital Recorder connector at the Model 3440A rear panel.

4-17. It is important to remember, throughout this explanation of the upranging and downranging circuits, that the applied voltage to the measuring circuits in the digital voltmeter is never more than 11 volts. Thus it is the function of the Model 3443A to set the digital voltmeter attenuator and decimal position. In addition, the explanation and diagram (Figure 4-3) of the upranging and downranging circuits assumes that a positive dc voltage is applied to the digital voltmeter input.

4-18. DOWNRANGING.

4-19. The logic diagram of the upranging and downranging circuits is shown in Figure 4-3. (See Table 4-1 for Logic Symbology and circuit explanation.) The purpose of the Hysteresis multivibrator, AG1, the control multivibrator and AG2 is to allow or prevent the downranging pulse from getting to the binaries. If neither the upranging pulse nor the downranging pulse is received, the digital voltmeter will remain in the range set on the previous sampling.

4-20. The negative pulse from the Count Gate Generator (digital voltmeter) is applied to the Hysteresis multivibrator at time T_1. The negative edge sets the Hysteresis multivibrator for a negative output, which is applied to the positive AND Gate AG1. AG1 receives its second input from the ten's decade. The Hysteresis multivibrator remains in the negative mode for 2.125 ms, which is equivalent to approximately 8 counts of the ten's decade. After approximately 8 counts, the Hysteresis multivibrator switches to the positive mode allowing the 9th count, if present, to pass through AG1, to the Downrange Control Multivibrator.

4-21. At time T_0, the Downrange Control Multivibrator is set for a positive output by the reset pulse from the digital voltmeter. If the input voltage to the digital voltmeter corresponds to less than 9% of full-scale, the Downrange Control Multivibrator will still be in the above state at time T_2. The positive-going portion of the signal from the Downranging Amplifier (at time T_2) will then generate a downranging pulse and pass through AG2. If, however, the input voltage corresponds to more than 9% of full-scale, the 9th pulse from the ten's decade will pass through AG1, reversing the state of the Downrange Control Multivibrator before the end of count. The positive-going portion of the signal from the Downranging Amplifier will then be blocked at AG2 so that downranging is prevented.

4-22. DOWNRANGING BINARY OPERATION.

4-23. If the downranging pulse is allowed to pass through AG2, AG4, AG7, and AG9 to the binaries, downranging will occur. At least one of the AND Gates, AG4, AG7, or AG9 will be receptive to the downranging pulse applied. (See Table 4-2.) When downranging on the 100-volt and 1000-volt ranges, positive pulses at $\overline{Y}$ or $\overline{Z}$ OUTPUT of second and third binaries are applied through the OR Gate OG1 to the first binary.

4-24. Assuming that downranging began at the 1000-volt position and downranged to the 100-millivolt position, the following sequence of events would take place: In the 1000-volt range, the X, Y, and Z outputs of the first, second and third binaries are positive (conducting). Only positive AND Gate AG7 is receptive to the downranging pulse because only its dc input (from the second binary) is positive. The downranging pulse is applied through AG7 to the second binary, and a change in binary state occurs. The $\overline{Y}$ output of the second binary is now positive, and its output is applied through OG1 to change the state of the first binary. The change in second and first binary states sets the relays in the relay matrix for downranging to the 100-volt range of the digital voltmeter. (Refer to discussion on Relay Matrix in Paragraph 4-40.) Because of downranging pulse action, the digital voltmeter is now in the 100-volt range, and binary outputs $\overline{X}$, $\overline{Y}$, and Z are positive (conducting). Downranging again, only AG4 is receptive to the downranging pulse because only its dc input (from the first binary) is positive. The downranging pulse is applied through AG4, changing the first binary state. The change in the first binary state sets the relays in the relay matrix for the 10-volt range on the digital voltmeter.

4-25. DOWNRANGING FROM 100 V TO 10 V RANGE: Because of the action of the downranging pulse on the 100-volt range, the digital voltmeter is now on the 10 volt range; and the binary outputs X, $\overline{Y}$, and Z are positive (conducting). These binary outputs allow only AG9 to be receptive to a downranging pulse.

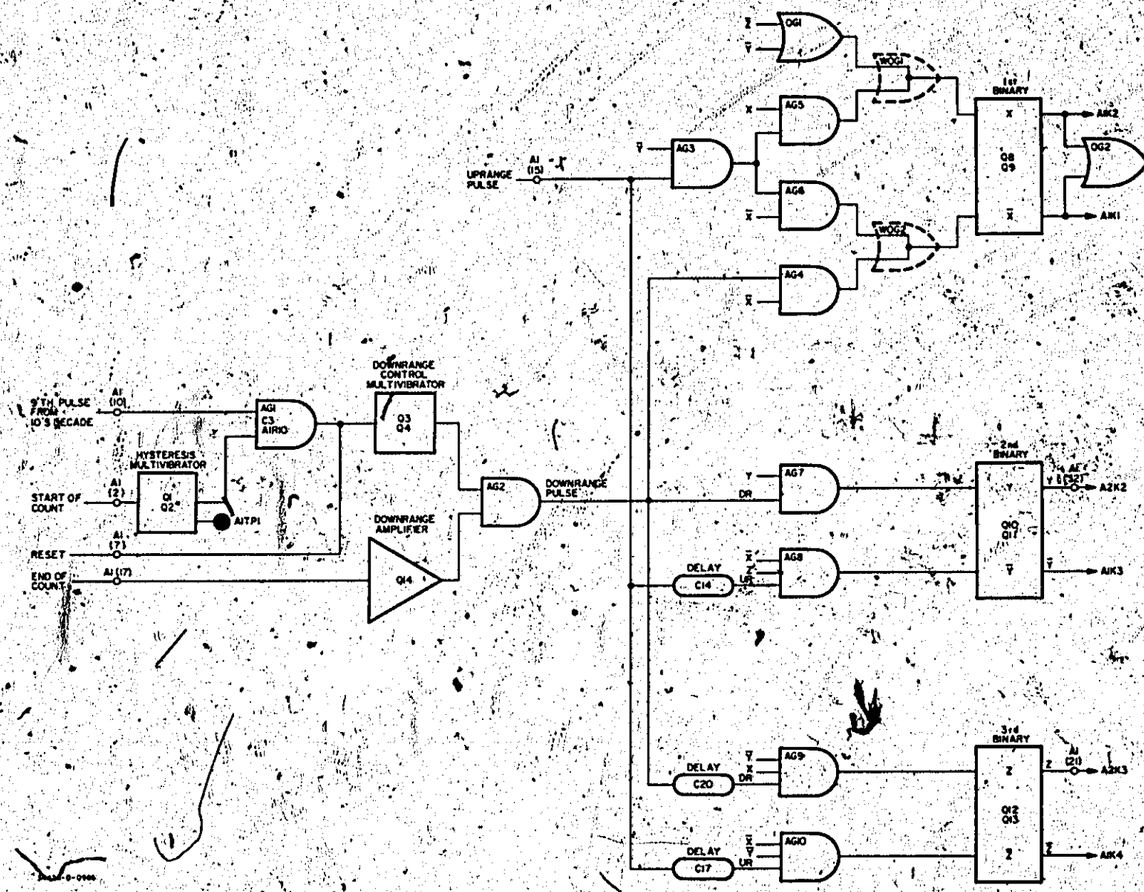
4-26. DOWNRANGING FROM 10 V to 1000 MV: When the downranging pulse is received, it is applied through AG9 to the third binary, changing its state. The positive $\overline{Z}$ output of the third binary, in turn, is applied through OG1 to the first binary, changing its state. The action of the third and first binaries sets the relays in the relay matrix for the 1000-millivolt range of the digital voltmeter.

4-27. DOWNRANGING FROM 1000 MV TO 100 MV RANGE: Because of the action of the downranging pulse on the 10 volt range, the digital voltmeter is in the

Range	"Positive" State Binaries	Working AND & OR Gates	Working Relays
1000 v	X Y Z		A2K2
		1ST DOWNRANGE RESULTS IN AG7, OG1	
100 v	$\overline{X}$ Y Z		A1K2, A1K3, A2K7
		2ND DOWNRANGE RESULTS IN AG4	
10 v	X $\overline{Y}$ Z		A1K2, A1K3, A1K4, A2K3, A2K8
		3RD DOWNRANGE RESULTS IN AG9, OG1	
1000 mv	$\overline{X}$ $\overline{Y}$ Z		A1K1, A1K4, A2K4, A2K5, A2K6
		4TH DOWNRANGE RESULTS IN AG4	
100 mv	X $\overline{Y}$ $\overline{Z}$		A1K1, A1K4, A2K1, A2K5, A2K6

NOTE: X = conducting; $\overline{X}$ = not conducting

Table 4-2. Circuit Conditions for Downranging



RELAY STATES

RANGE	RELAYS ENERGIZED
100 MV	A1K1, A1K3, A1K4, A2K1, A2K5, A2K6
1000 MV	A1K2, A1K3, A1K4, A2K4, A2K5, A2K6
10 V	A1K1, A1K3, A2K3, A2K7
100 V	A1K2, A1K3, A2K3, A2K7
1000 V	A1K1, A2K2, A2K3

Figure 4-3. Logic Diagram of Upranging and Downranging Circuits

1000-millivolt range, and the binary outputs $\overline{X}$, $\overline{Y}$, and $\overline{Z}$ are positive (conducting). With the binary outputs in these states, only AG4 is receptive to a downranging pulse.

4-28. When a downranging pulse is received, it is applied through AG4 to the first binary, changing its state. The change in binary states sets the relays in the relay matrix for the 100-millivolt range of the digital voltmeter. The resulting binary conditions are output X, $\overline{Y}$, and $\overline{Z}$ positive (conducting). The Downranging Cycle from the 1000-volt to the 100-millivolt range is complete.

4-29. UPRANGING BINARY OPERATION.

4-30. The upranging pulse is obtained from the overrange sensor multivibrator (digital voltmeter). The overrange sensor multivibrator is triggered from the output of the thousand's decade (first readout on left). Each time there is an overflow at the thousand's decade, the positive pulse is applied to AG3, AG8, and AG10. Any or all three of the AND Gates will be receptive to the incoming upranging pulse, dependent upon the input voltage applied and the binary conditions at the time the overrange command pulse is received. (See Table 4-3.)

4-31. Assuming that upranging begins at the 100-millivolt range and upranges to the 1000-volt range, the following sequence of events takes place. Initially, the condition of the 100-millivolt range is as follows: The X, $\overline{Y}$, and $\overline{Z}$ outputs of the binaries are positive (conducting). With the binaries in these states, AG3 and AG5 are receptive to the upranging pulse. The signal of the upranging pulse is applied through AG3 to AG5 to the first binary, changing its state. This action results in upranging from the 100-millivolt to the 1000-millivolt range. (Refer to Paragraph 4-40 for Relay Matrix discussion.)

4-32. UPRANGING FROM 1000 MV TO 10 V RANGE: Because of the action of the upranging pulse, the binary outputs $\overline{X}$, $\overline{Y}$, and $\overline{Z}$ are positive (conducting). With the binaries in these states, AG3, AG6, and AG10 are receptive to incoming upranging pulses. The upranging pulse is applied through AG3 to AG6 to the first binary, changing its state. The same upranging pulse is applied to AG10 to the third binary, changing its state. Because of the action of the upranging pulse on the first and third binaries, the digital voltmeter will uprange from the 1000-millivolt to the 10-volt range.

4-33. UPRANGING FROM 10 V TO 100 V RANGE: Because of the action of the upranging pulse, binary outputs X, $\overline{Y}$, and Z are positive (conducting). With the binaries in these states, AG3 and AG5 are receptive to incoming upranging pulses. When an upranging pulse is received, it is applied through AG3 and AG5 to the first binary, changing its state. The resulting binary states produce upranging from the 10-volt to the 100-volt range, and the binary outputs $\overline{X}$, $\overline{Y}$, and Z are positive (conducting).

4-34. UPRANGING FROM 100 V TO 1000 V RANGE: When the upranging pulse is received, AG3, AG6, and AG8 are receptive to the incoming upranging pulse. The upranging pulse applied to AG3 through AG6 is applied to the first binary. The upranging pulse applied to AG8 is applied to the second binary. Because of the action on these binaries, the digital voltmeter will uprange from the 100-volt to the 1000-volt range. The resulting binary output conditions will be X, Y, and Z positive (conducting). The upranging cycle from the 100-millivolt range to the 1000-volt range is complete.

4-35. DESCRIPTION OF SPEED-UP AND PRINT INHIBIT CIRCUITS (3440A ONLY).

4-36. When the Model 3443A is either upranging or downranging, it could conceivably provide erroneous information at both the front panel of the Model 3440A and to the printer. To insure that front panel and printer readouts are correct, circuitry has been provided in the Model 3443A, which disables the printer and speeds up the sample rate of the Model 3440A to its maximum rate. (See Figure 4-3.) Sample rate

Range	"Positive" State Binaries	Working AND & OR Gates	Working Relays
100 mv	X $\overline{Y}$ $\overline{Z}$	1ST UPRANGE RESULTS IN → AG3, AG5,	A1K1, A1K4, A2K1, A2K5, A2K6
1000 mv	$\overline{X}$ $\overline{Y}$ Z	2ND UPRANGE RESULTS IN → AG3, AG6, AG10,	A1K1, A1K4, A2K4, A2K5, A2K6
10 v	X $\overline{Y}$ Z	3RD UPRANGE RESULTS IN → AG3, AG5,	A1K2, A1K3, A1K4, A2K6, A2K8
100 v	$\overline{X}$ $\overline{Y}$ Z	4TH UPRANGE RESULTS IN → AG3, AG6, AG8	A1K3, A1K4, A2K7
1000 v	X Y Z		A2K2
NOTE: X = conducting; $\overline{X}$ = not conducting			

Table 4-3. Circuit Conditions for Upranging

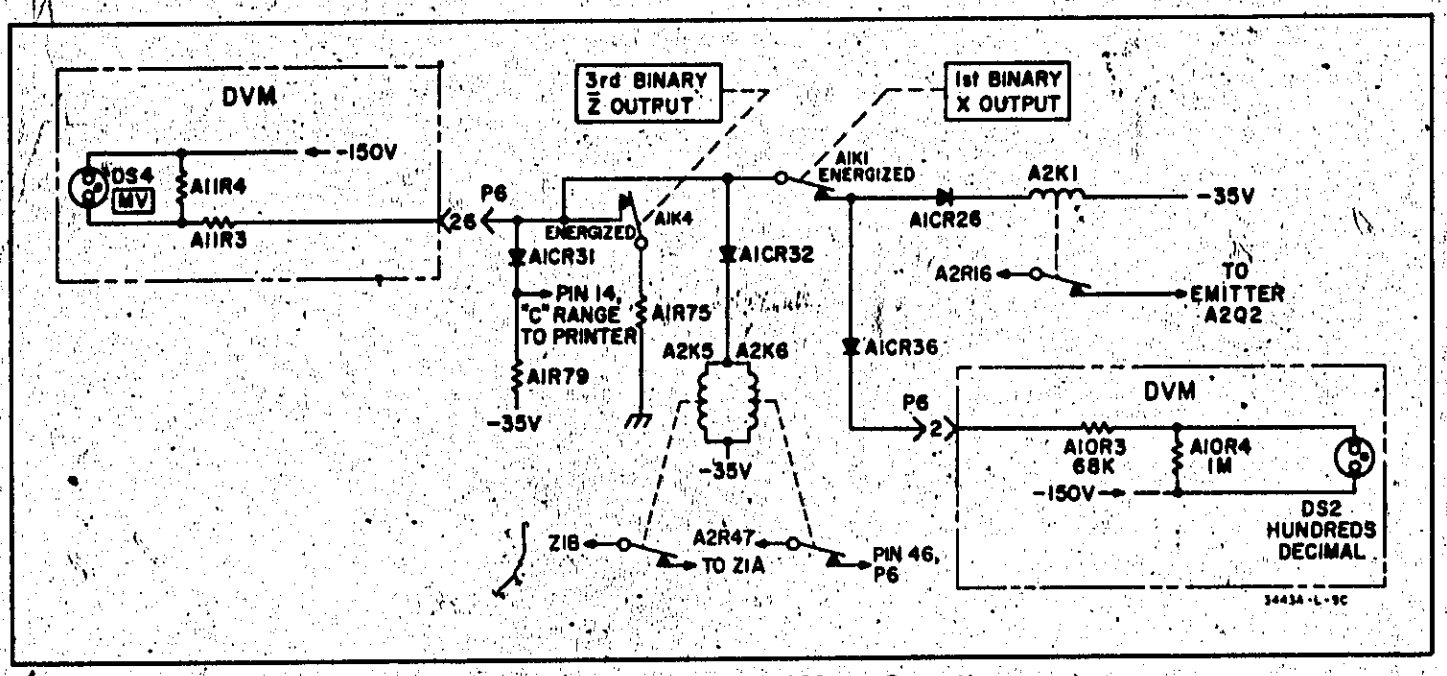


Figure 4-4. Relay Matrix, 100 mv Operation

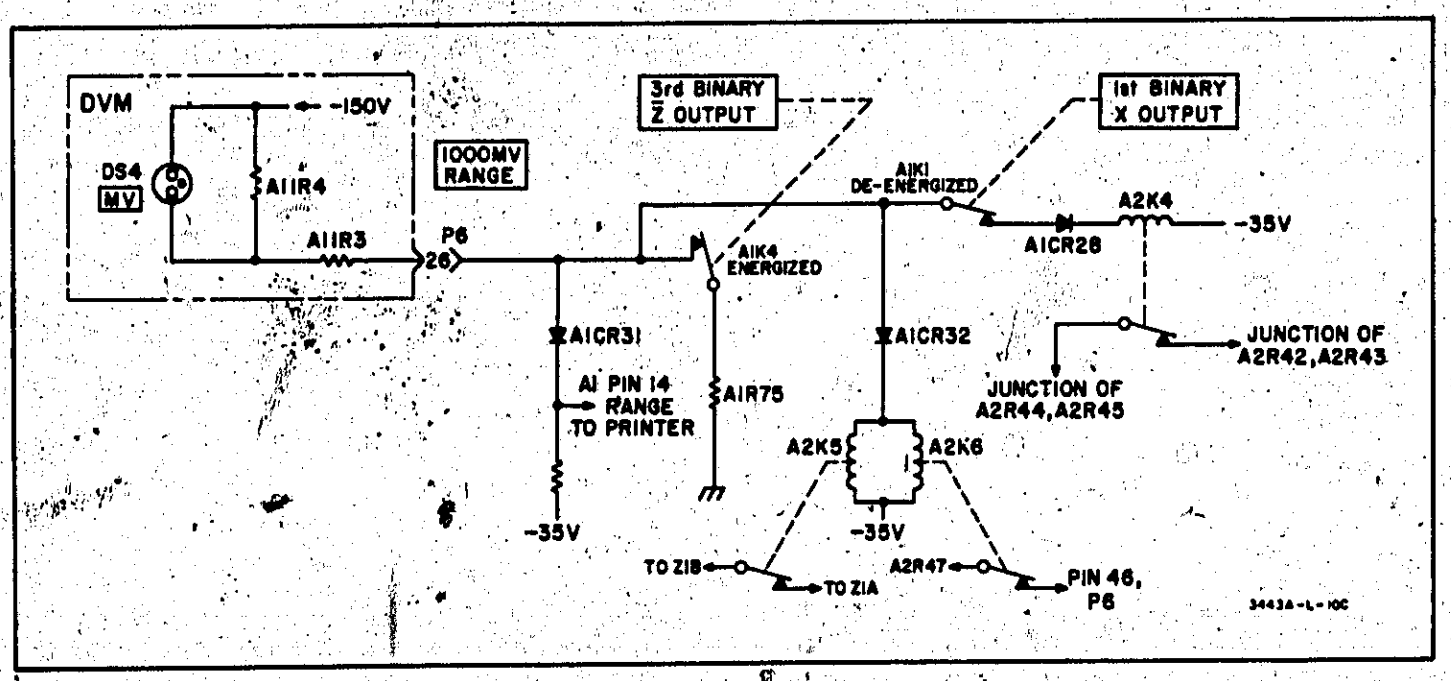


Figure 4-5. Relay Matrix, 1000 mv Operation

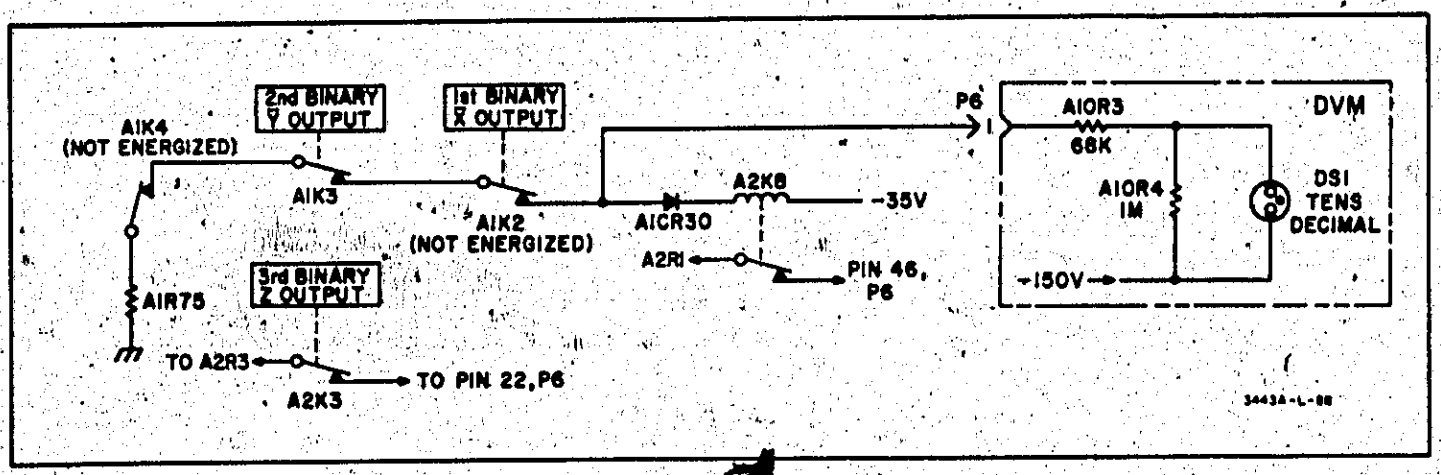


Figure 4-6. Relay Matrix, 10 v Operation

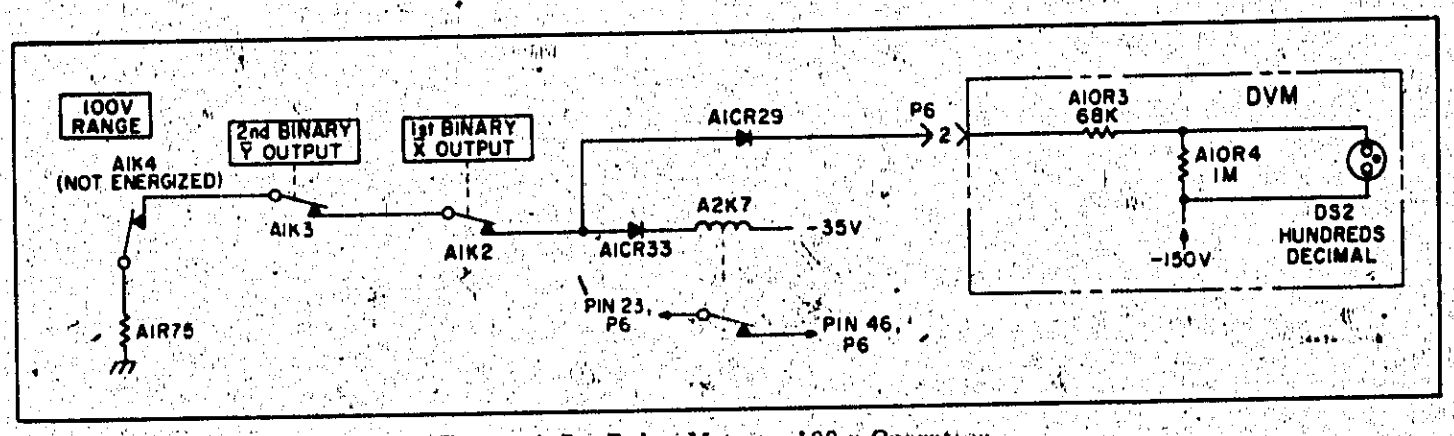


Figure 4-7. Relay Matrix, 100 v Operation

speed-up and print inhibit are maintained until the Model 3443A has settled on a specific range.

4-37. The 1st binary will change state each time an upranging or downranging pulse is applied. Each time the 1st binary changes state, a positive pulse is applied through the positive OR Gate OG2. The Inhibit Multivibrator is a monstable multivibrator that is triggered each time a positive pulse is received. The inhibit multivibrator remains in the inhibit state for approximately 1.5 seconds, which is long enough for a change to any other range. The two outputs obtained from the multivibrator are applied to a transistor switch in one case and through the Model 3440A to the printer in the other case (see Figure 4-2). The positive pulse is applied to the transistor switch, which shunts a resistor in the rc network that controls the sampling rate of the Model 3440A. Shunting has the effect of speeding up the sampling rate. The negative output prevents generation of print commands by Model 3440A, so the printer remains idle until the inhibit interval terminates.

4-38. INFORMATION TO THE PRINTER (3440A ONLY).

4-39. The function and range information are provided by the Model 3443A through the Model 3440A to the printer. The function and range information includes polarity, overload (if any), and position of the decimal point. Four outputs are required for function. They are Functions A, B, C, and D. Four range outputs are provided to the printer. They are Ranges A, B, C, and D. Function information is taken at the point where upranging and polarity information is applied to the Model 3443A. Ranging information is taken from the binaries X, Y, and Z and from relay A1K7.

4-40. DESCRIPTION OF RELAY MATRIX.

4-41. The relay matrix includes A1K1, A1K2, A2K2, A1K3, A2K3 through A2K8.

4-42. Relay matrix action begins at the binaries. The relays that are electrically connected to the binaries are instrumental in energizing the other relays in the matrix. A specific set of relays are energized in each of the five modes of operation. To simplify each mode of operation, simplified diagrams are shown in Figures 4-4 through 4-8.

4-43. RELAY MATRIX ON THE 100- AND 1000-MILLIVOLT RANGES.

4-44. The working relays in the 100-millivolt range are A1K1, A1K4, A2K1, A2K5, and A2K6. (See Figure 4-4.) The output at Pin 26, of P6 provides a ground for the MV lamp, DS4, in the digital voltmeter. The ground for the MV lamp is provided through A1K4 contact and A1R75 to ground. Since the relay A1K1 is energized as shown, ground is also applied to relay A2K1. Relays A2K5 and A2K6 are energized through the A1K4 contact. The energizing of A2K5 connects the digital voltmeter attenuator input to the amplifier; the energizing of A2K6 connects the output of the amplifier to the digital voltmeter. The energizing of A2K1 sets the gain of the ac amplifier section of the Model 3443A. In addition, the energizing of A1K1 and A1K4 provides a ground to the decimal point matrix, which causes the center decimal to be displayed at the digital voltmeter front panel.

4-45. The relay matrix working relays in the 1000-millivolt range are the same as those for the 100-millivolt range except that A2K1 is replaced by A2K4 (see Figure 4-5). The energizing of A2K4 places a short across resistors A2R44 and A2R43, thus increasing the overall feedback (reducing the gain) of the amplifier section by a factor of 10. In addition, the de-energizing of A1K1 removes the ground connection to the decimal point matrix in the digital voltmeter. The removal of the ground connection to the decimal point matrix causes the right decimal to be displayed in the digital voltmeter front panel.

4-46. RELAY MATRIX 100-, 10-, 1000-VOLT RANGES.

4-47. The working relays in the 10-volt range are A1K2, A1K3, A1K4, A2K3, and A2K8. (See Figure 4-6.) The energizing of A2K8 connects the top of the input attenuator to the comparator of the digital voltmeter. In addition, these relay contacts provide a ground to the decimal matrix, which causes the left decimal point to be displayed at the front panel of the digital voltmeter. Relay A2K3 connects the input of the Model 3443A amplifier to ground.

4-48. The relay matrix for the 100-volt range is essentially the same as that of the 10-volt range except that A2K7 replaces A2K8 (Figure 4-7). The energizing of relay A2K7 applies the attenuated output of the digital voltmeter through the Model 3443A back into the digital voltmeter. The ground connection is obtained through A1K2, A1K3, and A1K7 to the decimal point matrix, digital voltmeter. The ground to the decimal point matrix causes the center decimal point of the front panel of the digital voltmeter to be displayed.

4-49. Relay A2K2 is energized on the 1000-volt range. The A2K2 connection takes the digital voltmeter attenuator output and applies it through the Model 3443A back into the digital voltmeter (Figure 4-8).

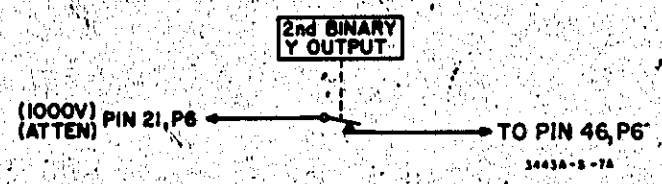


Figure 4-8. Relay Matrix, 1000 v Operation

4-50. MODULATOR-DEMODULATOR.

4-51. The modulator-demodulator circuit consists of a relaxation oscillator and four photoconductors, A3V1 through A3V4. The relaxation oscillator contains two lamps, A3DS1 and A3DS2. One lamp will ionize and light before the other. The first lamp to light will remain lit until the second one reaches its firing potential. At this time, the second lamp lights and the first one goes out. In this manner, the lamps light alternately. The frequency is controlled by A1R28, Frequency Adjust and is nominally 160 cps. The light from the lamps is absorbed by the photoconductor. Photoconductors are light-sensitive and offer low resistance when illuminated and high resistance when dark. Lamp A3DS1 illuminates A3V1 and A3V3 simultaneously, and lamp A3DS2 illuminates A3V2 and A3V4 simultaneously.

4-52. The modulator (A3V1 and A3V2) converts the attenuated dc input voltage to ac for amplification. The dc input voltage is applied to A3V1, and the feedback voltage is applied to A3V2. Photoconductors A3V1 and A3V2 are alternately lit by A3DS1 and A3DS2 respectively. Therefore, the dc input voltage and feedback voltage are alternately applied to the amplifier. The resultant to the amplifier is a square-wave signal, the amplitude of which is the voltage difference between the dc input and feedback voltages.

4-53. The amplifier is a four-stage ac amplifier consisting of A2Q1 through A2Q4. The amplified signal to the demodulator is in phase with the input to the amplifier.

4-54. The demodulator (A3V3 and A3V4) converts the amplified signal to a dc voltage which is coupled to the dc amplifier stages. Operation of the demodulator is similar to that of the modulator: A3V3 and A3V4 are alternately illuminated by A3DS1 and A3DS2 respectively. When A3V3 conducts, A2C14 discharges through A3V4. This action results in a dc voltage applied to the input stage of the DC Amplifier, having the same polarity as the input dc voltage.

4-55. The transistor A2Q5, connected as a diode, is used to provide a 300 mv reference, yet presents a low dc resistance at the base of A2Q6. Diode CR23 limits voltage applied to transistor A2Q4. Diodes CR1 and CR2 limit voltage at the input of the chopper assembly.

MAINTENANCE

Table 5-1. Test Equipment Required

Instrument Type	Critical Specifications	Use	Recommended Model
50 MC Oscilloscope	Bandwidth: DC to 50 Mc Sensitivity: 0.1 v/cm to 20 v/cm	Troubleshooting	Model 175A 50 Mc Oscilloscope
Transistorized AC Voltmeter	Voltage Range: 1 mv to 300 v Frequency Range: 5 cps to 2 Mc Battery Operated	Adjustment Procedure	Model 403B Transistorized AC Voltmeter
DC Voltmeter	Voltage Range: ±1 mv to ±1000 v Input Impedance: greater than 10 meg Input circuit isolated from case and power line ground	Adjustment Procedure	Model 412A Vacuum Tube Voltmeter
Electronic Counter	Time Interval: 1 to 10 ms Frequency: 10 cps to 200 cps	Adjustment Procedure	Model 5223L Electronic Counter
Digital Recorder	Column Capacity: six Printing Rate: 5 lines/sec	Performance Checks	Model 562A Digital Recorder
Power Supply	Regulated Output: 0 to 40 v Noise and Ripple: less than 150 μv rms Output isolated from chassis and power line ground	Troubleshooting	Model 723A Power Supply
DC Standard	Range: 0 to ±1000 vdc Accuracy: ±0.01% of setting Noise: < 0.005%	Performance Checks	Model 740B DC Standard/Differential Voltmeter
Digital Voltmeter	Calibrated on 10, 100 and 1000 volt ranges	Performance Checks	Model 3440A Digital Voltmeter
Plug-In Extender	50 pins, 10" long High isolation between channels	Adjustment Procedure	Model K01-3440A
Resistor	Fixed, carbon, film, 1 megohm ±1.0%, 1/2 watt	Performance Checks	Stock No. 0727-0276
Variable Line Voltage Transformer	Output Voltage: 103 to 127 vac	Performance Checks	Superior Electric Co. Powerstat 3pf116

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains maintenance and service information for the Model 3443A High Gain/Auto Range Unit. Included is a Performance Check, Calibration procedure, Troubleshooting procedure, and Special Modifications.

5-3. TEST EQUIPMENT REQUIRED.

5-4. The critical specifications and suggested test equipment needed in the performance and calibration procedures are given in Table 5-1.

5-5. PERFORMANCE CHECKS.

5-6. The performance checks are in-cabinet procedures that are used to check the instrument against its specifications. These procedures can be used as periodic maintenance, after repair or incoming and outgoing quality control checks. Use these procedures before attempting calibration of the instrument.

NOTE

If the Model 3443A is used with a Model 3440A below serial 415-00726, see Paragraph 5-67.

5-7. The performance checks are performed with the ac power cord connected to nominal line voltage (115 v/230 v) 50 to 1000 cps unless otherwise specified.

5-8. CALIBRATION ACCURACY.

a. Connect Model 3443A as shown in Figure 5-1.

b. Turn digital voltmeter on. Set sample rate (3440A only) to max.

c. Allow 1/2 hour warm-up. Depress digital voltmeter INT CHECK and adjust for an indication of -8000.

d. Set DC Standard to zero. Rotate 3443A RANGE switch to 1000 volts. Adjust digital voltmeter ZERO control (rear panel) for a 000.0 indication. Rotate 3443A RANGE switch to 100 mv; adjust 3443A ZERO control for 00.00 indication.

e. Set Model 3443A Range and DC Standard output to values given in Table 5-2. In each case the digital voltmeter indication should be within the tolerances shown.

NOTE

If readings on 10 v, 100 v, and 1000 v ranges are out of tolerance, check digital voltmeter accuracy using another plug-in. If digital voltmeter is within specifications, refer to paragraph 5-52 in the troubleshooting section.

f. Set digital voltmeter ac line voltage to 103.5 volts and repeat step e. Digital voltmeter indications should remain within tolerances shown.

g. Set digital voltmeter ac line voltage to 126.5 volts and repeat step e.

Table 5-2. Calibration Accuracy

3443A RANGE switch	DC Standard OUTPUT	Tolerance of DVM Reading (+15°C to +40°C)
100 mv	90.00 mv	89.90 to 90.10 mv
100 mv	50.00 mv	49.94 to 50.06 mv
100 mv	10.00 mv	09.98 to 10.02 mv
1000 mv	900.0 mv	899.0 to 901.0 mv
1000 mv	500.0 mv	499.4 to 500.6 mv
1000 mv	100.0 mv	099.8 to 100.2 mv
10 v	9.000 v	8.994 to 9.006 v
10 v	5.000	4.996 to 5.004 v
10 v	1.000	0.998 to 1.002 v
100 v	90.00	89.94 to 90.06
1000 v	900.0	899.4 to 900.6

5-9. AUTOMATIC RANGING AND HYSTERESIS CHECK.

5-10. UPRANGING.

a. Connect Model 3443A as shown in Figure 5-1.

b. Rotate 3443A RANGE switch to AUTO.

c. Set DC Standard to 90 mv.

d. Gradually increase the DC Standard OUTPUT; the digital voltmeter should uprange to the next highest range at the voltage levels indicated in Table 5-3.

5-11. DOWNRANGING.

a. Connect Model 3443A as shown in Figure 5-1.

b. Rotate 3443A RANGE switch to AUTO.

c. Set DC Standard to 110 volts.

d. Gradually decrease DC Standard OUTPUT. The digital voltmeter should downrange to next lowest range at the levels indicated in Table 5-3.

5-12. RANGING SPEED.

a. Connect 3443A as shown in Figure 5-1.

b. Rotate 3443A RANGE switch to AUTO.

c. Depress digital voltmeter INT CHECK and adjust for a digital voltmeter reading of 8000.

d. Set DC Standard OUTPUT to OFF.

e. Adjust DC Standard to 200.0 volts and turn DC Standard ON. The digital voltmeter should indicate 99.95% of final value within 1.5 sec.

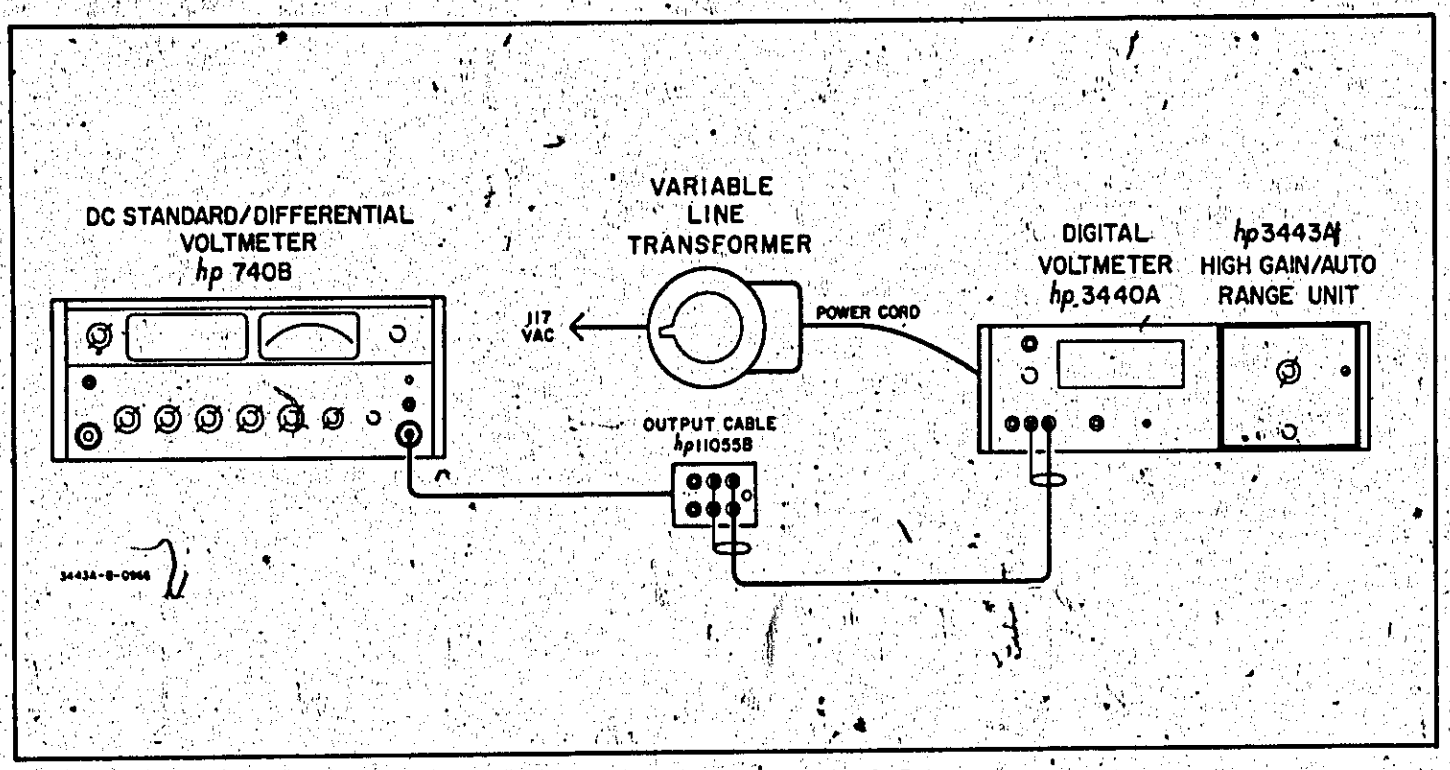


Figure 5-1. Performance Check Setup

Table 5-3. Automatic Ranging

UPRANGING		DOWNRANGING	
Range	Input Voltage Level	Range	Input Voltage Level
from 100 mv to 1000 mv	100.0 mv	from 1000 v to 100 v	90.00 to 93.00 v
from 1000 mv to 10 v	1.000 v	from 100 v to 10 v	9.000 to 9.300 v
from 10 v to 100 v	10.00 v	from 10 v to 1000 mv	900.0 to 930.0 mv
from 100 v to 1000 v	100.0 v	from 1000 mv to 100 mv	90.00 to 93.00 mv

5-13. RECORDER OUTPUT. (3440A only)

a. Connect 3443A as shown in Figure 5-1.

b. Connect a Digital Recorder (hp Model 562A) to the DIGITAL RECORDER jack (J2) located on the rear of the 3440A.

c. Rotate 3443A RANGE switch to AUTO.

d. Set the DC Standard to inputs in Table 5-4. The digital recorder printout should be as shown in Table 5-4.

Table 5-4. Recorder Output

3440A Input	Digital Recorder Columns		
	6 (Function)	5 4 3 2 (Input Voltage)	6 (Decimal)
-200.0 volts	1 (-dc)	2 0 0 0	1
+21.11 volts	0 (+dc)	2 1 1 1	2
+2.222 volts	0	2 2 2 2	3
+233.3 mv	0	2 3 3 3	4
+24.44 mv	0	2 4 4 4	5

e. Set the DC Standard to 1.050 volts. Rotate the 3443A RANGE switch to 1000 mv. The 3440A reading should be between 048.9 and 051.2 mv and 3440A OVERRANGE should flash.

f. The Digital Recorder should print a 4 in the Decimal column and a 9 (indicating OVERRANGE) in the Function column.

NOTE

The Function column will print a 7 if the 3443A and Digital Recorder have been modified for a 1-2-4-8 BDC code.

g. Rotate 3443A RANGE switch to AUTO.

h. Apply +2.000 volts to 3440A INPUT from DC Standard.

j. Adjust 3440A SAMPLE RATE to a slow sample rate (but not in HOLD position).

k. Set DC Standard to 20.00 volts; at the next sample, the 3440A should sample at maximum rate and uprange to display +20.00 volts.

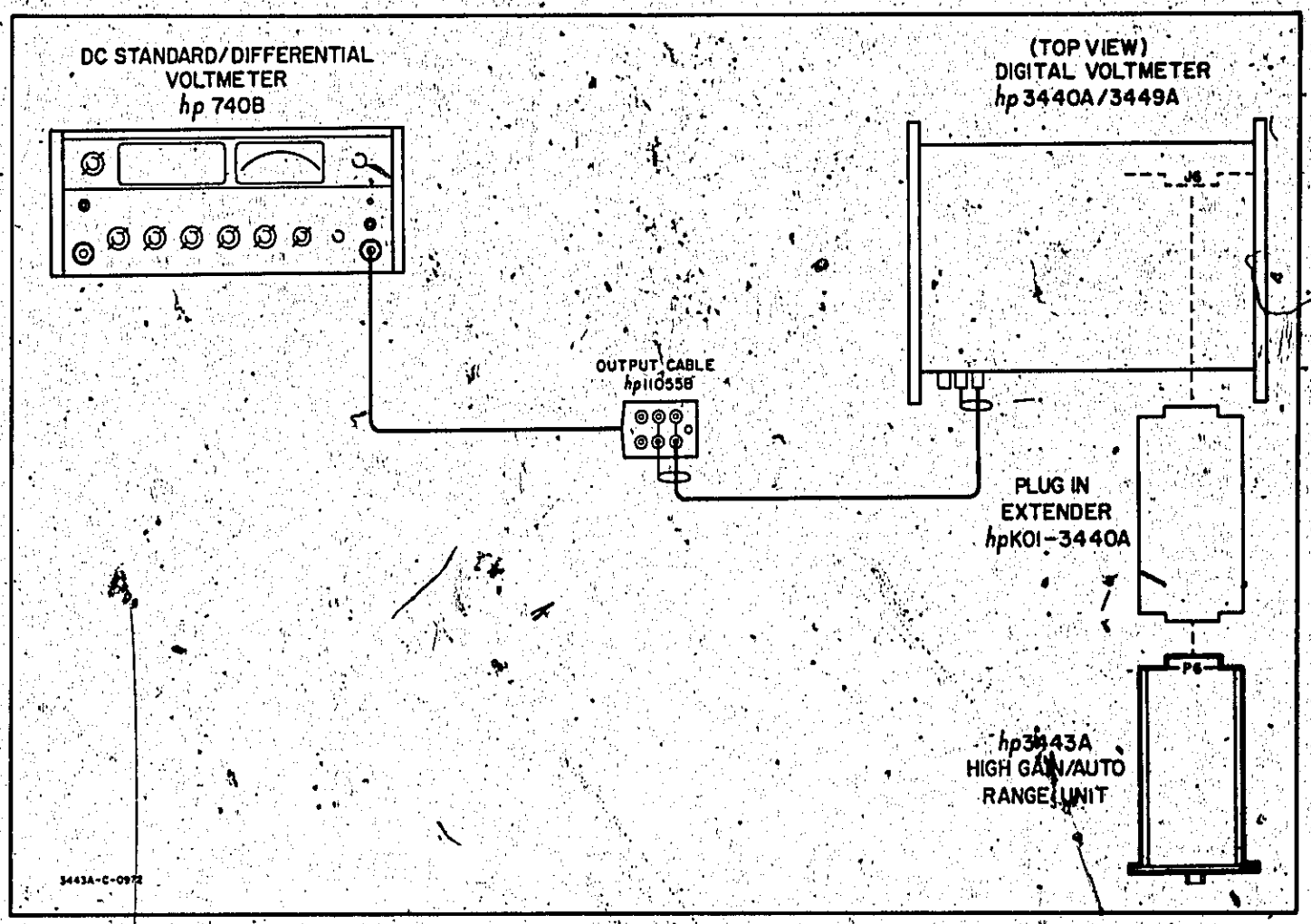


Figure 5-2. Adjustment and Calibration Setup

m. Check the print inhibit by observing that the Digital Recorder does not print during the speed-up interval. The Digital Recorder should print only +2.000 v or +20.00 v within the Model 3440A accuracy.

5-14. REMOTE OPERATION.

a. Rotate 3443A RANGE switch to REMOTE.

b. The Voltmeter range can be controlled by grounding the appropriate pins on the REMOTE CONTROL jack (J4) located on the rear panel of the digital voltmeter.

Table 5-5. Remote Control

Connection	Digital Voltmeter Indication
P4(4) to P4(36)	XX.XX
P4(?) to P4(36)	XXX.X
P4(1) to P4(36)	X.XXX
P4(2) to P4(36)	XX.XX
None	XXX.X

c. Make the connections shown in Table 5-5. In each case the digital voltmeter display should be as shown.

5-15. INPUT IMPEDANCE CHECK.

a. Connect Model 3443A as shown in Figure 5-1.

b. Connect a 1 megohm ±1.0%, 1/2 watt, fixeds carbon film resistor in series with the positive INPUT lead to the digital voltmeter.

c. Set DC Standard to 10.00 volts.

d. Rotate 3443A RANGE switch to 10 volts.

e. The digital voltmeter should indicate between 9.090 and 9.122 volts.

NOTE

This corresponds to an input resistance of 10.0 to 10.4 megohms where:

$$R_{input} = \frac{E_{displayed}}{E_{input} - E_{displayed}} \times R_{series}$$

5-16. ACCESS TO ADJUSTMENTS.

a. Remove the 3443A from the Digital Voltmeter.

b. Remove the two screws connecting the top printed circuit board to the front panel.

c. The top printed circuit board can now be folded back allowing access to the components on the bottom printed circuit board.

5-17. CALIBRATION PROCEDURE.

5-18. The following is a complete adjustment and calibration procedure and should be performed only if it has been determined by the Performance Checks, Paragraph 5-5 that the ℋ Model 3443A is out of adjustment. Perform the adjustments in the order given. If adjustment is impossible refer to troubleshooting section (Paragraph 5-30).

5-19. POWER SUPPLY.

a. Connect Model 3443A as shown in Figure 5-2.

NOTE

The Extender Board should have high isolation between channels. The use of a cable as an "extender board" is not recommended due to the cross-talk or coupling between adjacent wires.

b. Set DC Standard to zero; rotate 3443A RANGE switch to 1000 mv.

c. Connect the DC Voltmeter common lead to the chassis ground and Volts probe to test point A2TP3 (see Figure 5-3).

d. The DC Voltage should be between -35 and -50 volts.

e. Disconnect DC Voltmeter and connect AC Voltmeter (ℋ Model 403B) between test point A2TP3 and chassis ground.

f. AC Voltage at A2TP3 should be between 0.02 and 0.15 volts.

g. Repeat step e with Model 3443A RANGE switch set to 100 mv; ac voltage should be between 0.1 and 1.0 volts.

5-20. CHOPPER FREQUENCY.

a. Connect Model 3443A as shown in Figure 5-2.

b. Connect Electronic Counter to Test Point A2TP3. Set Electronic Counter to measure frequency.

c. Rotate 3443A RANGE switch to 100 mv.

d. Set DC Standard to -1 volt.

e. Adjust A2R28 (See Figure 5-3.) for an Electronic Counter reading of 160 cps ± 1 cps.

5-21. 100 mv RANGE NOISE.

a. Connect Model 3443A as shown in Figure 5-2.

b. Set DC Standard to zero, and short INPUT.

c. The last or least significant digit should not change by more than ±2 digits during a 15 sec period.

5-22. ZERO ADJUSTMENT.

a. Connect Model 3443A as shown in Figure 5-2.

b. Set DC Standard to zero, and short INPUT.

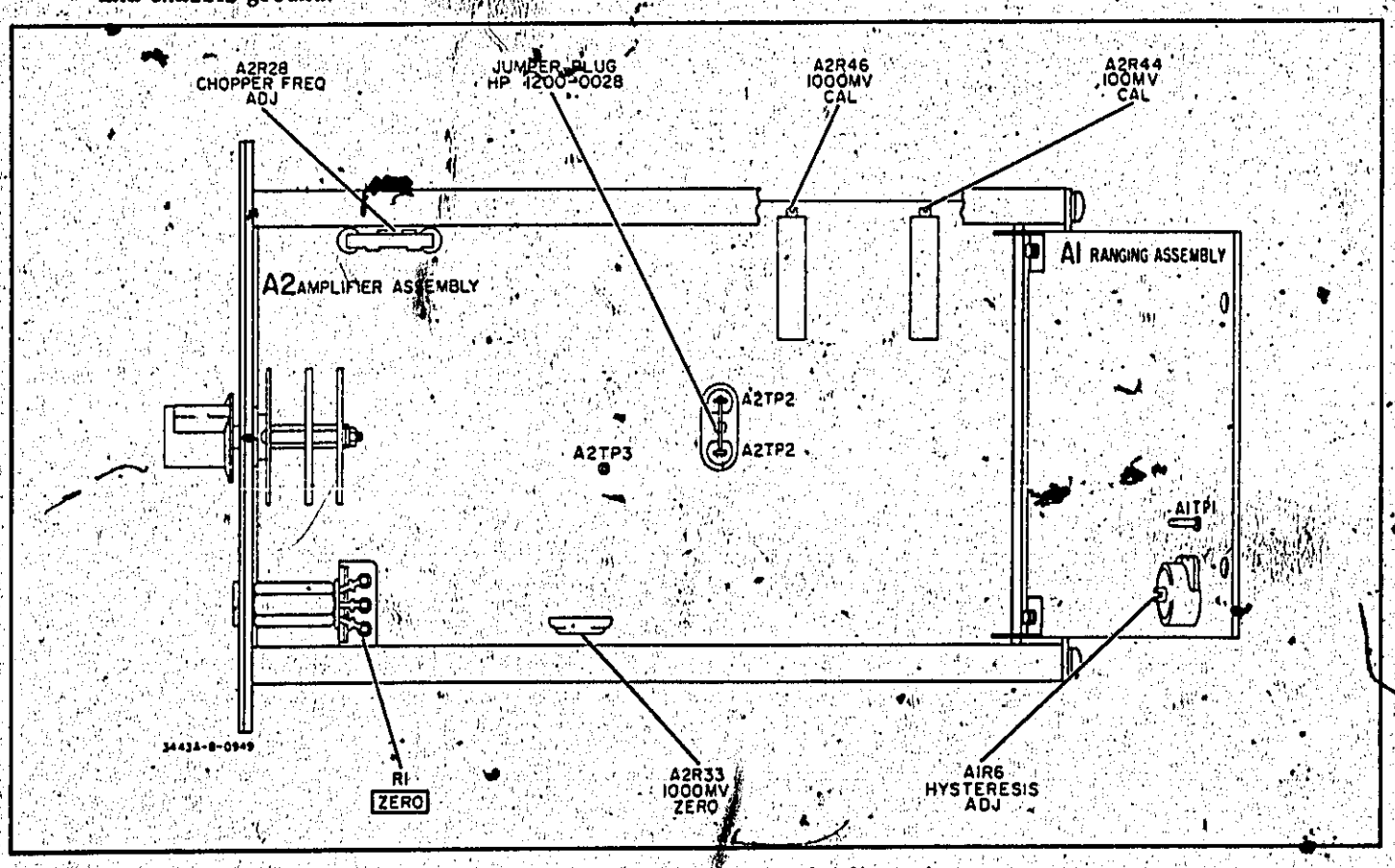


Figure 5-3. Location of Internal Adjustments

c. Rotate 3443A RANGE switch to 100 mv.

d. Rotate 3443A ZERO control fully clockwise; the digital voltmeter reading should be greater than +00.06 mv (checks range of ZERO control).

e. Rotate 3443A ZERO control fully counterclockwise; the digital voltmeter reading should be greater than -00.06 mv.

f. Adjust 3443A ZERO control for a digital voltmeter reading of 00.00 mv with the polarity indicator alternating between + and -.

5-23. 1000 mv RANGE ZERO.

a. Connect 3443A as shown in Figure 5-2.

b. Rotate 3443A RANGE switch to 1000 mv.

c. Set DC Standard to ZERO. Short INPUT.

d. Adjust A2R33 (see Figure 5-3) for a digital voltmeter reading of 000.0 mv.

5-24. AMPLIFIER CALIBRATION.

NOTE

During calibration, the last digit may occasionally change by one or two counts due to random noise. This is normal.

5-25. 1000 MV RANGE.

a. Connect 3443A as shown in Figure 5-2.

b. Depress digital voltmeter INT CHECK and adjust to 8000.

c. Rotate 3443A RANGE switch to 1000 MV. Set DC Standard to -800.0 mv.

d. Adjust A2R46 (see Figure 5-3) for a reading of +800.0 mv. Reverse the input voltage polarity. The digital voltmeter reading should be between -799.1 mv and -800.9 mv. If necessary, adjust A2R46 to split errors between positive and negative voltages.

5-26. 100 MV RANGE.

a. Set DC Standard to ZERO and short INPUT.

b. Rotate 3443A RANGE switch to 100 mv range.

c. Recheck 100 MV zero. Then remove short.

d. Set DC Standard OUTPUT to -80.00 mv.

e. Adjust A2R44 (see Figure 5-3) for a reading of -80.00 mv. Reverse the input voltage polarity. The Digital Voltmeter reading should be between -79.91 mv and -80.09 mv. If necessary, adjust A2R44 to split error between positive and negative voltages.

5-27. HYSTERESIS ADJUSTMENT.

a. Connect an Electronic Counter between Test Point A1TP1 (see Figure 5-3) and 3443A chassis ground.

b. Set Electronic Counter to measure time interval.

c. Set DC Standard OUTPUT to +1.00 volts. Rotate 3443A RANGE selector to AUTO.

d. Adjust A1R6 (see Figure 5-3) for an electronic counter indication of 2.12 milliseconds.

5-28. ETCHED CIRCUIT BOARDS.

5-29. When replacing a component on the plated-through type of etched circuit board, the component can be soldered from either side of the board.

a. Avoid applying excessible heat when soldering on the circuit board.

b. To remove a damaged component, clip the component lead near the component. Then apply heat and remove the lead with a straight upward motion.

c. Use a cup tip to remove components having multiple connections, such as potentiometers.

d. Use a toothpick to free eyelet of solder before installing a new component.

5-30. TROUBLESHOOTING PROCEDURE.

5-31. Use the Troubleshooting procedure only after determining that the difficulty cannot be removed by the Calibration Procedure, Paragraph 5-17.

5-32. Inspect the test setup used when symptoms of malfunction were observed to be certain that the source of trouble is not external of the 3443A.

5-33. The front-panel symptoms, type of difficulties encountered during the Calibration procedure, and Table 5-6 should be used to select the starting point for troubleshooting (Amplifier Calibration, Manual Ranging, Automatic Ranging). Paragraphs 5-36 thru 5-65 contain procedures that can be used to isolate malfunctions within a particular type of circuit.

5-34. Look for burned or loose components, loose connections, broken wires (particularly on A1 board) or any other similar condition which suggests a source of trouble.

5-35. A dirty or contaminated 3443A rear panel connector can cause errors on the 100 mv RANGE. Type PC Freon (Stock No. 8500-0232) is recommended for cleaning this connector.

5-36. AMPLIFIER.

5-37. The amplifier is used only on the 100 and 1000 mv ranges. The digital voltmeter attenuator is used on the 10, 100, and 1000 volt ranges. Relays are used to position the digital voltmeter attenuator, connect the amplifier, and control the gain of the amplifier.

5-38. AMPLIFIER RELAYS.

5-39. There are five relays used in the amplifier section. If any of the relays fail to meet the checks in the following paragraphs, check the Relay Control Circuitry (Paragraph 5-60) before replacing the relay.

NOTE

Since these checks are designed to verify only that the relays are switching, the absolute accuracies of the dc voltages are not critical.

5-40. Relay A2K6 (Relay A2K6 is used to connect the amplifier output to the voltage comparator).

a. Connect 3443A as shown in Figure 5-2.

b. Rotate 3443A RANGE switch to 10 volts.

c. Set DC Standard to +8.000 volts.

d. The dc voltage (use isolated DC Voltmeter such as ® Model 412A) across relay A2K6 contacts should be equal to the input voltage (±20% due to loading effect of DC Voltmeter).

e. Rotate 3443A RANGE switch to 1000 mv range; the dc voltage across relay A2K6 contact should drop to 0 ±200 microvolts.

5-41. Relay A2K5 (Relay A2K5 connects the digital voltmeter INPUT to the amplifier on the 100 and 1000 mv ranges).

a. Connect 3443A as shown in Figure 5-2.

b. Rotate 3443A RANGE switch to 10 volts.

c. Set DC Standard to 8.000 volts.

d. The dc voltage (use isolated DC Voltmeter across relay A2K5 contacts should be equal to the input voltage ±20%.

e. Rotate 3443A RANGE switch to 1000 mv; the dc voltage across relay A2K5 contacts should drop to zero ±200 microvolts.

5-42. Relay A2K3 (Relay A2K3 shorts the amplifier input to ground on the 10, 100, and 1000 volt ranges).

a. Connect 3443A as shown in Figure 5-2.

b. Rotate 3443A RANGE switch to 10 volts.

c. Set DC Standard to 0.800 volts.

d. The dc voltage across relay A2K3 contacts should be zero ±300 microvolts.

e. Rotate 3443A RANGE switch to 1000 mv.

f. The dc voltage across relay A2K3 contacts should be equal to the input voltage ±20%.

5-43. Relay A2K4 (Relay A2K4 is used to change the amplifier feedback).

a. Connect 3443A as shown in Figure 5-2.

b. Rotate 3443A RANGE switch to 1000 mv.

c. Set DC Standard to 0.0800 volts.

d. The dc voltage across relay A2K4 contacts (use isolated DC Voltmeter) should be zero ±30 microvolts.

e. Rotate 3443A RANGE switch to 100 mv range. The dc voltage across relay A2K4 contacts should be 8 volts ±2 volts.

5-44. Relay A2K1 (Relay A2K1 is used to change the gain of the amplifier between the 100 and 1000 mv ranges).

a. Connect 3443A as shown in Figure 5-2.

b. Set DC Standard to 060.0 mv.

c. Remove the shorting plug from A2TP1 and A2TP2.

d. Rotate 3443A RANGE switch to 1000 mv.

e. Connect AC Voltmeter (use Battery-Operated Voltmeter such as the ® Model 403B) across A2K1 with the positive lead connected to the junction of A2K1 and A2C1. The AC Voltmeter should indicate 20 mv ±10%.

f. Rotate 3443A RANGE switch to 100 mv. The AC Voltmeter reading should drop to zero ±100 microvolts.

5-45. DC AMPLIFIER GAIN.

a. Connect 3443A as shown in Figure 5-2.

b. Rotate 3443A RANGE switch to 1000 mv.

c. Set DC Standard to zero. Rezero digital voltmeter.

d. Remove shorting plug connecting A2TP1 to A2TP2 (see Figure 5-3); the 3440A reading should be 000.0 mv.

e. Connect the positive lead from a 5 volt dc battery or floating Power Supply (® Model 723A) to A2TP1 and the negative lead to A2TP2.

f. The digital voltmeter reading should be less than 000.5 mv. This check verifies that the amplifier open loop gain is greater than 1000. (If the digital voltmeter reading is greater than 000.5 mv, see Paragraphs 5-46 and 5-47.)

g. Rotate 3443A RANGE switch to 100 mv. Replace shorting plug across A2TP1 and A2TP2 and adjust 3443A ZERO control for a digital voltmeter indication of 00.00 mv; the digital voltmeter indication should be less than 00.05 mv.

Table 5-6. Troubleshooting Aid

Symptom	Possible Cause
a. Digital Voltmeter will not uprange in AUTO but will change ranges by manual switching. b. "OVERLOAD" does not flash when input voltage exceeds 10 v on 10 v RANGE.	OVERRANGE Binary in digital voltmeter
Decimal point does not correspond to the range attenuator setting.	Relay Matrix
Digital voltmeter ranges continuously when input voltage approaches full scale.	Hysteresis Adjustment
Continuous drift rate off zero with no input.	3440A Charge Restorer
Erratic readings (10-20 counts) on 100 volt RANGE. Erratic readings (50-100 counts) on 1000 v RANGE.	A2K8 leaky
Incorrect dc voltage at A2TP3.	A2CR3, A2Q1, A2Q2, A2Q3, A2Q4, and A2Q7
The ac-voltage at A2TP3 exceeds limits.	A2K1, A2K4 Photochopper assembly
Excessive noise on 100 mv RANGE.	A2Q1, A2C16, A2C14, A2CR3 Photochopper assembly
Calibration accuracy exceeds specifications on 100 and 1000 mv ranges.	A2K1, A2K4
Digital Recorder continues to print while 3443A is changing ranges.	Inhibit Multivibrator
a. Digital voltmeter is inoperative on all ranges. b. Digital voltmeter polarity indicator does not light.	3443A plug-in connector is not making contact with digital voltmeter.

5-46. DC AMPLIFIER OUTPUT STAGE (A2Q6 thru A2Q8).

a. Connect 3443A as shown in Figure 5-2.

b. Set 3443A RANGE to 100 mv.

c. Set DC Standard output to 50 mv.

d. Connect the common lead of a DC Voltmeter to 3443A chassis ground. Connect volts probe to junction of A2R29 and V3 and record the voltmeter reading.

e. Connect volts probe to A2TP1. The DC Voltmeter reading should be 30 times greater than that recorded in step b (gain of 30).

5-47. AC AMPLIFIER (A2Q1 thru A2Q4).

5-48. Paragraph 5-49 outlines a procedure for checking the typical waveforms in the ac carrier amplifier. Paragraph 5-50 contains a dc "bias" check of the amplifier transistors. Either technique can be used as a troubleshooting isolation procedure. The schematic diagram also contains the typical dc levels within the amplifier.

5-49. TYPICAL WAVEFORMS.

a. Connect 3443A as shown in Figure 5-2.

b. Remove the shorting plug connecting A2TP1 to A2TP2.

c. Set DC Standard to 0.8500 volts.

d. Rotate 3443A RANGE switch to 1000 mv.

e. Figures 5-5 and 5-6 illustrate the typical waveforms in the ac carrier amplifier.

f. Rotate 3443A RANGE switch to 100 mv.

g. Set DC Standard to 0.0850 volts. A comparison of Figures 5-6(a) and 5-6(c) checks the switching action of K1 in the emitter of A2Q1.

h. To check the Photochopper assembly for an open photocell, connect a 500 K resistor in parallel with the suspected photocell. If the photocell was open, the amplifier gain should now return to normal (see Paragragh 5-45). If the photocell was not at fault or if there are several malfunctions, the symptoms will not change.

5-50. DC BIAS TEST.

5-51. The following checks can be used to isolate malfunctions within the ac carrier amplifier. The purpose of the checks is to "override" the dc feedback loops in the amplifier and check one transistor at a time.

a. Connect 3443A as shown in Figure 5-2.

b. Rotate 3443A RANGE switch to 1000 mv.

c. Set DC Standard to zero.

d. Connect a short jumper wire across A2R18 (shorting out A2R18).

e. Connect the common lead of a DC Voltmeter (Model 412A) to chassis ground.

f. The dc voltage at the collector of Q4 should be -80.0 volts ±10% (A2Q4 is cut off).

g. Remove the short across A2R18 and short the base of A2Q3 to chassis ground. The dc voltage at the collector of A2Q3 should be +12 volts ±10%. The dc voltage at the collector of A2Q4 should be -80 volts ±10% (Q4 cut off).

h. Remove short from the base of A2Q3 and short the base of A2Q2 to chassis ground.

Transistor	DC Collector Voltage
A2Q2	+0.8 v ±10%
A2Q3	+0.65 v ±10%
A2Q4	-35 v ±10%

j. Remove short from the base of A2Q2 and connect a shorting jumper between the base and emitter leads of A2Q1.

Transistor	DC Collector Voltage
A2Q1	+0.61 v (increase of +0.03 v to 0.06 v from normal readings)
A2Q2	+0.08 v ±10%
A2Q3	+12.0 v ±10%
A2Q4	-80 v ±10%

5-52. RANGING CIRCUITRY.

5-53. Relays controlled by bi-stable multivibrators form a logic circuit to position the attenuator, change the decimal point and control the gain of the amplifier (see Paragraph 4-15).

5-54. MANUAL RANGE SELECTION.

5-55. With manual RANGE selection, the Range Control Binaries are controlled individually by switching the base voltage on one side of the multivibrator. If any of the relays fail to meet the prescribed tests given in Paragraphs 5-56 thru 5-59, check the position of the Relay Control circuitry (see Paragraph 5-60).

NOTE

Since these checks are designed to verify only that the relays are switching, the absolute accuracies of the dc voltages are not critical.

5-56. RELAY A2K8.

a. Connect 3443A as shown in Figure 5-2.

b. Rotate 3443A RANGE switch to 100 volts.

c. Set DC Standard to 9.0 volts.

d. The dc voltage (use isolated DC Voltmeter such as ℄ Model 412A) across relay A2K8 contacts should be 8 volts ±10%.

e. Rotate 3443A RANGE switch to 10 volts; the dc voltage across relay A2K8 should drop to zero ±300 microvolts.

5-57. RELAY A2K7.

a. Connect 3443A as shown in Figure 5-2.

b. Rotate 3443A RANGE switch to 1000 volts.

c. Set DC Standard to 90 volts.

d. The dc voltage across relay A2K7 contacts should be 8 volts ±20%.

e. Rotate 3443A RANGE switch to 100 volts; the dc voltage across relay A2K8 contacts should drop to zero volts, ±300 microvolts.

5-58. RELAY A2K2.

a. Connect 3443A as shown in Figure 5-2.

b. Rotate 3443A RANGE switch to 100 volts.

c. Set DC Standard to 90 volts.

d. The dc voltage across relay A2K2 should be 8 volts ±20%.

e. Rotate 3443A RANGE switch to 1000 volts. The dc voltage across relay A2K2 should drop to zero ±300 microvolts.

5-59. Table 5-7 can be used to check the switching of relays A1K1, A1K2, A1K3, and A1K4. Paragraphs 5-38 thru 5-44 can be used to check the switching of the amplifier relays.

5-60. RANGE CONTROL CIRCUITRY.

a. Table 5-7 can be used to check the control circuitry for the primary relays (the relays with solenoids located directly in the collectors of the control multivibrators).

b. Table 5-7 and Figures 4-4 thru 4-8 can be used to check relay matrix system.

5-61. AUTOMATIC RANGING.

5-62. UPRANGING.

5-63. The upranging pulse (7 volts peak-to-peak is provided by the OVERRANGE sensor (digital voltmeter) when there is an overflow from the last or thousand's decade. Figure 4-3 and Table 5-8 can be used to check the upranging logic circuitry.

5-64. DOWNRANGING.

5-65. Figure 5-7 illustrates the typical waveforms in the downranging circuit.

NOTE

The 3443A RANGE switch must be in AUTO. In a normal unit, downranging will take place within a few milliseconds and Figure 5-7(5) will be available only when the input voltage is less than 9 mv.

a. Channel A: The leading edge is coincident with the start of the oscillator and is used to trigger the Hysteresis Multivibrator. See Figure 4-3 and Paragraph 4-18 for a detailed description.

b. Channel B: To set up a "downranging condition," all the small pulses (from the ten's decade, A6) should be contained in the negative pulse.

c. Channel C: To set up a "downranging condition," the positive spike available at the end of the count must have a zero ac bias level.

d. Figure 4-3 can be used to trace the downranging logic circuit for the Range Control Binaries.

5-66. SPECIAL MODIFICATIONS.

5-67. POWER SUPPLY. (Model 3440A below serial 415-00726).

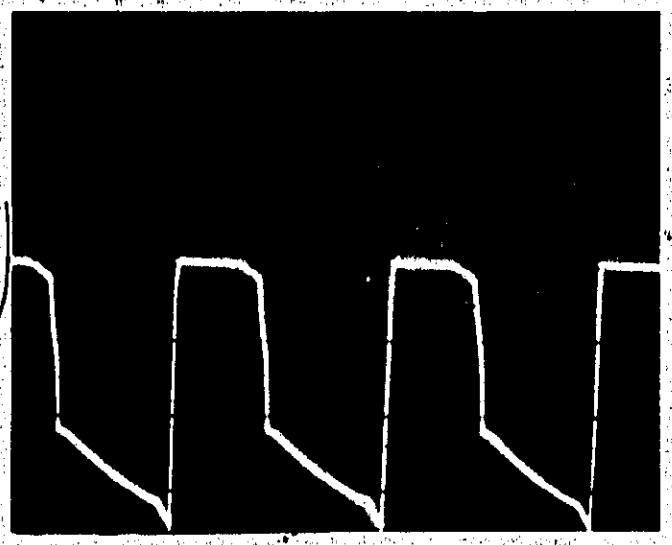
5-68. The value of A9R15 and A9R16 in ℄ Model 3440A below serial 415-00726 should be changed from 1.5 K to 1.2 K ohms fixed composition ±10% 1/2 W resistor (℄ Stock No. 0687-1221) so that the 3443A does not load the 3440A power supply. Instruments with serials 415-00726 and above have been modified during production. This modification does not require calibration of the 3440A.

5-69. RECORDER OUTPUT. (Special for 3440A only)

5-70. The 3443A can be modified for a 1-2-4-8 BCD output code (1-2-4-8 is standard code). The 3440A must have the same code as the 3443A.

a. The position of A1R78 (See Figure 6-7.) is changed from points A and B (silk screened on Board A1) to points C and D.

b. On the A1 Etched Circuit board, the connection from Pin 43 of P6 is moved from 23A to 23B. (See Figure 6-7.) Also, a jumper is connected across points E and F.



a.

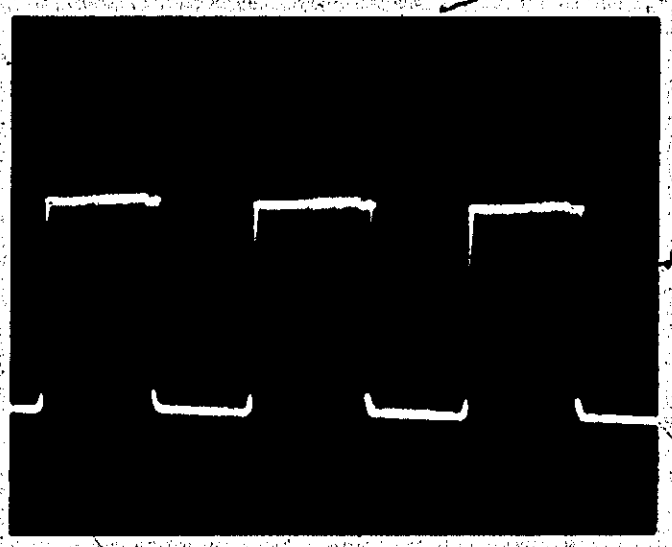
Location = A2TP3

Shorting plug removed from A2T1 and A2TP2

Input Voltage = +850 mv

Vertical Sensitivity = 20 volts/cm

Sweep = 2 ms/cm



b.

Location = collector of A2Q3

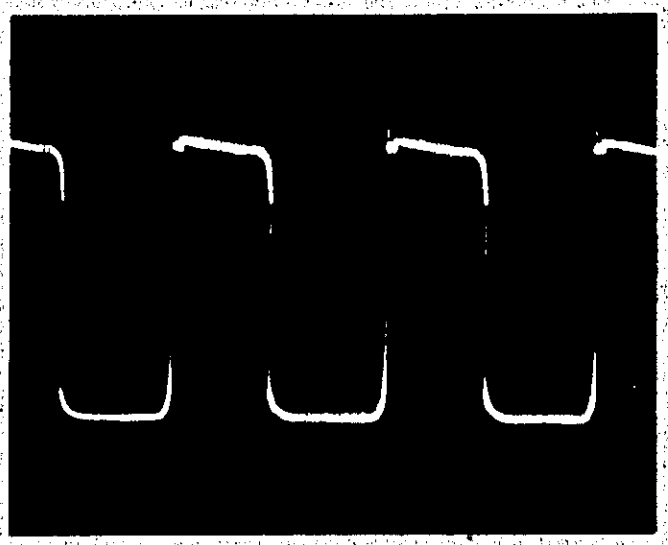
3443A RANGE = 1000 mv

Shorting plug removed from A2TP1 and A2TP2

Input Voltage = +850 mv

Vertical Sensitivity = 1.0 volts/cm

Sweep = 2 ms/cm



c.

Location = collector of A2Q2

3443A RANGE = 1000 mv

Shorting plug removed from A2TP1 and A2TP2

Input Voltage = +850 mv

Vertical Sensitivity = 0.2 volt/cm

Sweep = 2 ms/cm

Figure 5-4. Typical Amplifier Waveforms

a.

Location = collector of A2Q1

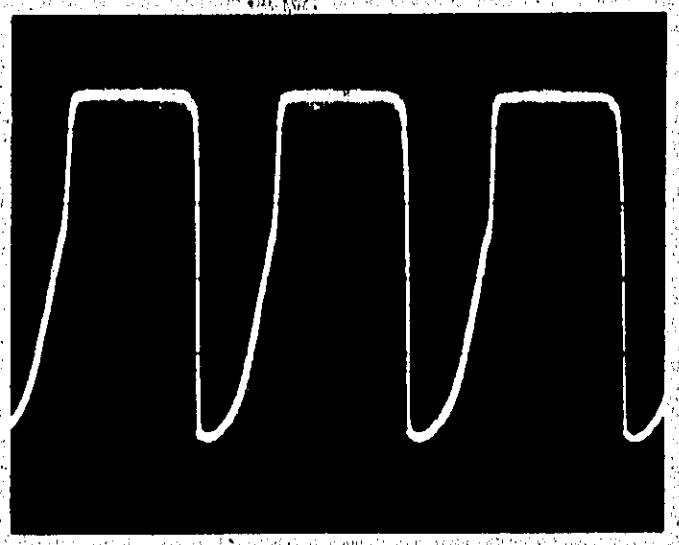
3443A RANGE = 1000 mv

Shorting plug removed from A2TP1 and A2TP2

Input Voltage = +850 mv

Vertical Sensitivity = 0.1 volt/cm

Sweep = 2 ms/cm



b.

Location = junction of A2C2 and A2C3

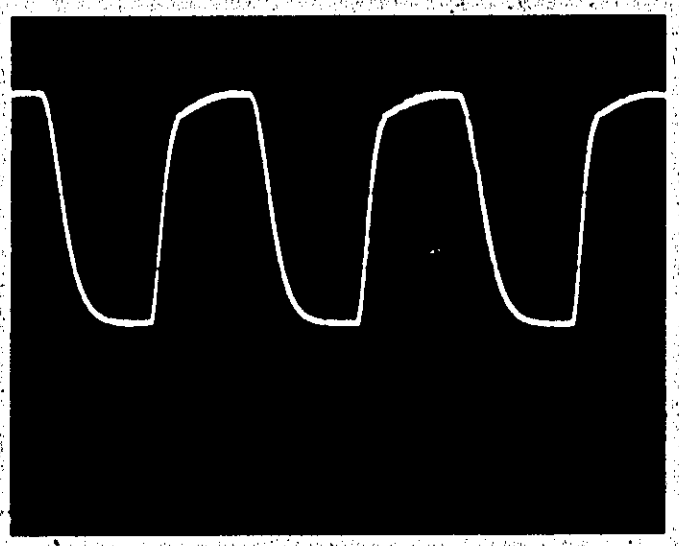
3443A RANGE = 1000 mv

Shorting plug removed from A2TP1 and A2TP2

Input Voltage = +850 mv

Vertical Sensitivity = 0.1 volt/cm

Sweep = 2 ms/cm



c.

Location = collector of A2Q1

3443A RANGE = 100 mv

Shorting plug removed from A2TP1 and A2TP2

Input Voltage = 85.00 mv

Vertical Sensitivity = 0.1 volt/cm

Sweep = 2 ms/cm

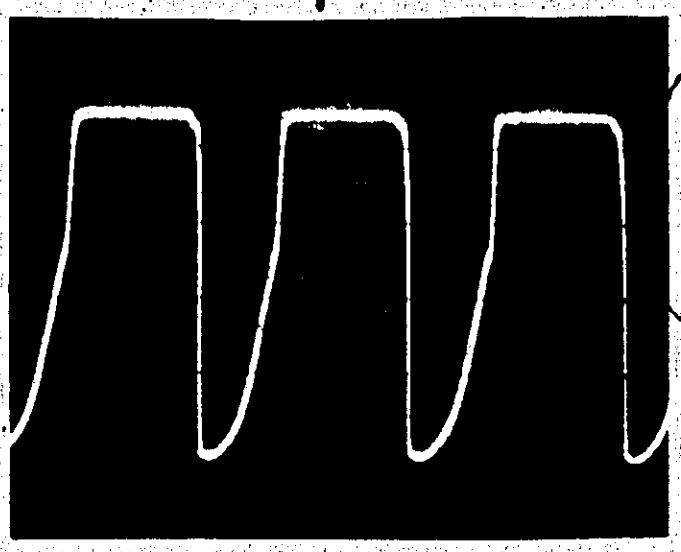
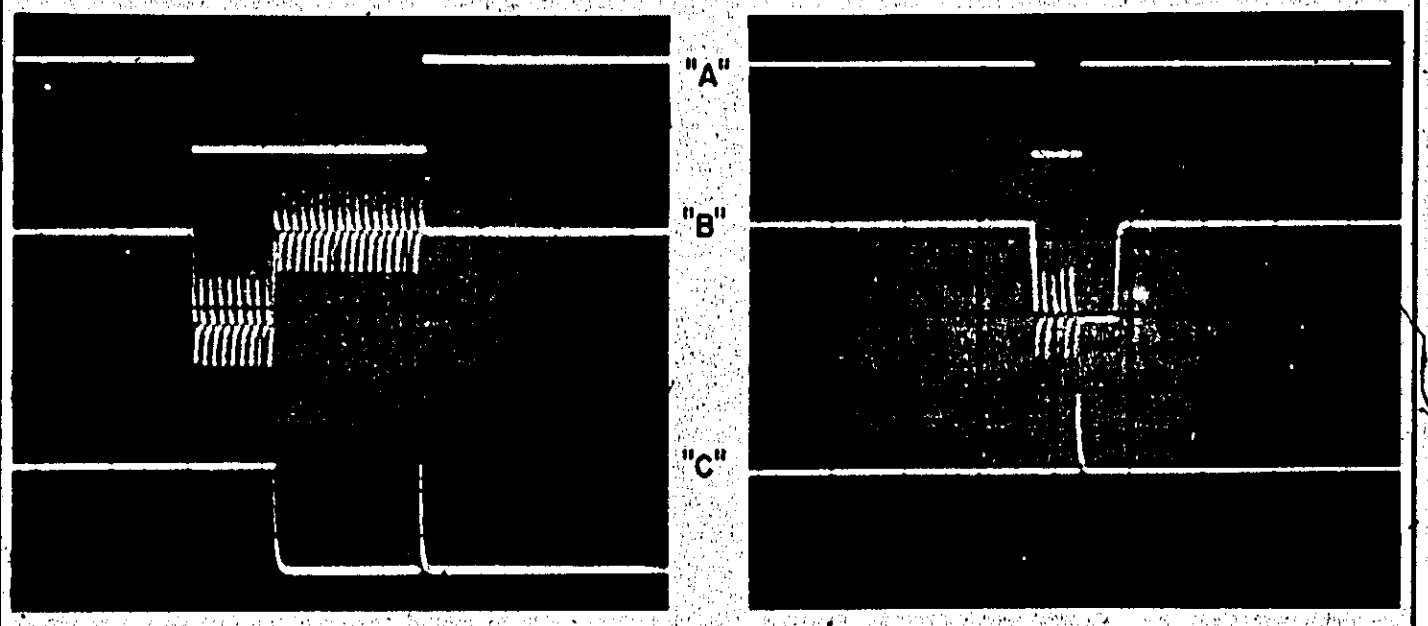


Figure 5-5. Typical Amplifier Waveforms

Table 5-7. Relay Matrix Voltages (See Figure 6-7)

	Relay Voltages	3443A RANGE				
		100 mv	1000 mv	10 v	100 v	1000 v
A1K1	X dc voltage between anode of A1CR32 and junction of A1CR26 and A1CR27	0	-150	0	+2 to 5 v	0
	$\overline{X}$ dc voltage between anode of A1CR32 and anode of A1CR28	-35	0	+0.15	0	+0.15
A1K2	X dc voltage between center tap of A1K2 and junction of A1CR29 and A1CR33	not used	not used	-150 v	0	-1 to 3 v
	$\overline{X}$ dc voltage between center tap of A1K2 and anode of CR30	not used	not used	0	-150	0
A1K3	Y not used	not used	not used	not used	not used	not used
	$\overline{Y}$ dc voltage between center tap of A1K3 and center tap of A1K2	0	0	0	0	-150
A1K4	Z dc voltage between center tap of A1K4 and center tap of A1K3	-150	-150	0	0	0
	$\overline{Z}$ dc voltage between center tap of A1K4 and center tap of A1K1	0	0	-150	-150	-150
	Energized relays	A2K5, A2K6, A2K1	A2K5, A2K6, A2K4	A2K8	A2K7	



a. Optimum Range Conditions
(2.5 volts displayed on 10 volt Range)

b. Downranging Conditions
(5 mv displayed on 100 mv Range)

Vertical: 20 volts/cm (all channels)

Sweep: 2 ms/cm

External sync from reset pulse (Pin 7)

Channel A: Count Gate, A1 pin 15

Channel B: Hysteresis Multivibrator, anode of A1CR3

Channel C: Downrange Multivibrator, anode of A1CR25

Figure 5-6. Automatic Ranging Waveforms

Table 5-8. Range Control Multivibrators and Primary Relays

RANGE	Primary Relays Energized	Matrix Relays Energized	Transistor Collector Voltages					
			Q8	Q9	Q10	Q11	Q12	Q13
100 mv	A1K1, A1K3, A1K4	A2K1, A2K5, A2K6	-1.8	-35	-30.0	-1.8	-30.0	-1.8
1000 mv	A1K2, A1K3, A1K4	A2K4, A2K5, A2K6	-30	-1.8	-30.0	-1.8	-30.0	-1.8
10 volts	A1K1, A1K3, A2K3	A2K8	-1.8	-35	-30.0	-1.8	-2.1	-35
100 volts	A1K2, A1K3, A2K3	A2K7	-30	-1.8	-30.0	-1.8	-2.1	-35
1000 volts	A1K1, A2K2, A2K3	none	-1.8	-35	2.8	-35.0	-1.6	-35

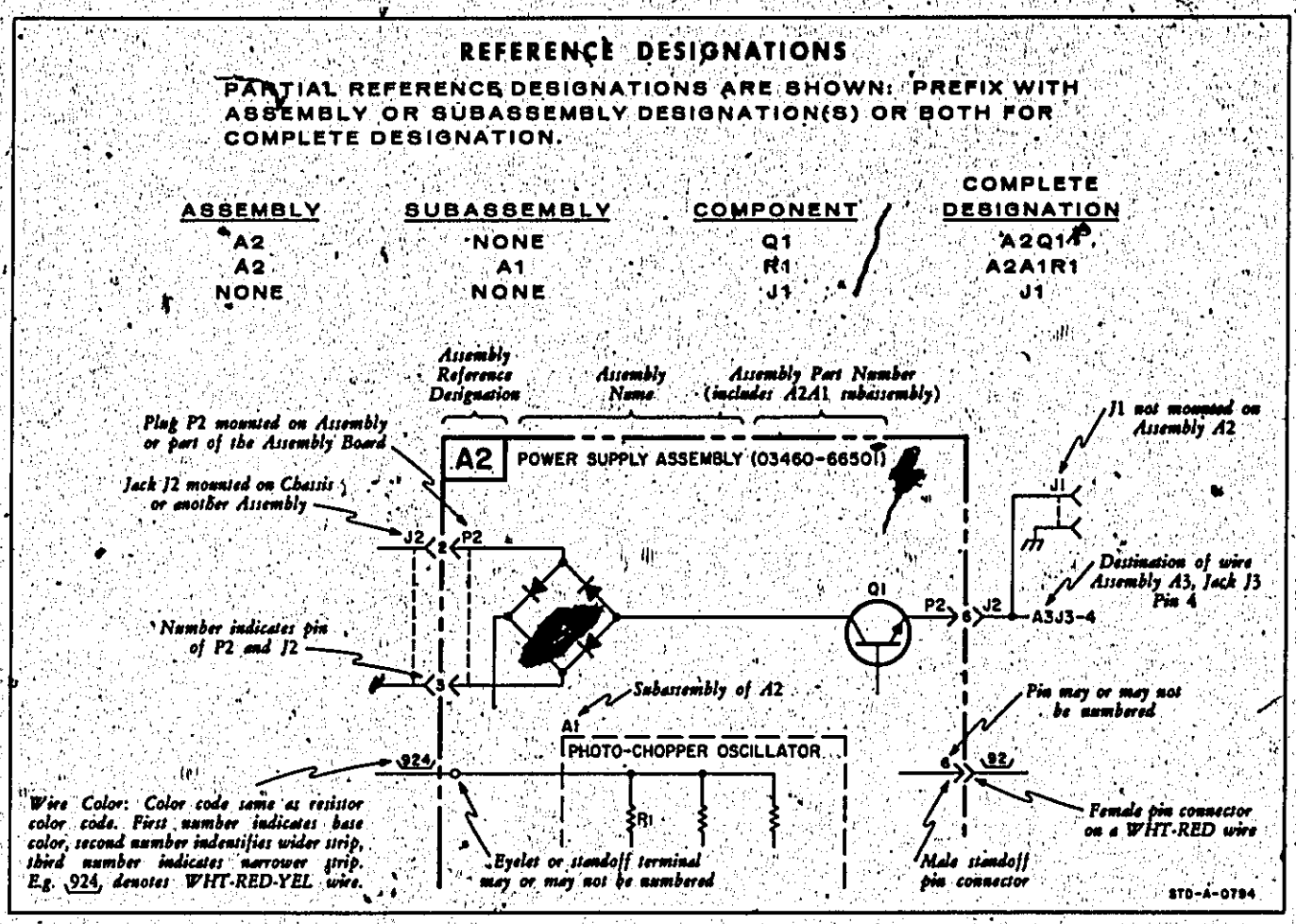
SCHEMATIC DIAGRAMS

SECTION VI
CIRCUIT DIAGRAMS

6-1. INTRODUCTION.

6-2. This section contains the diagrams necessary to maintain the Model 3443A. Both pictorial views of the circuit layout and schematic diagrams are included.

6-3. Since the relay contacts and coils are shown on different schematic diagrams, the grid locations of the coils are shown beside the contacts, and vice versa.



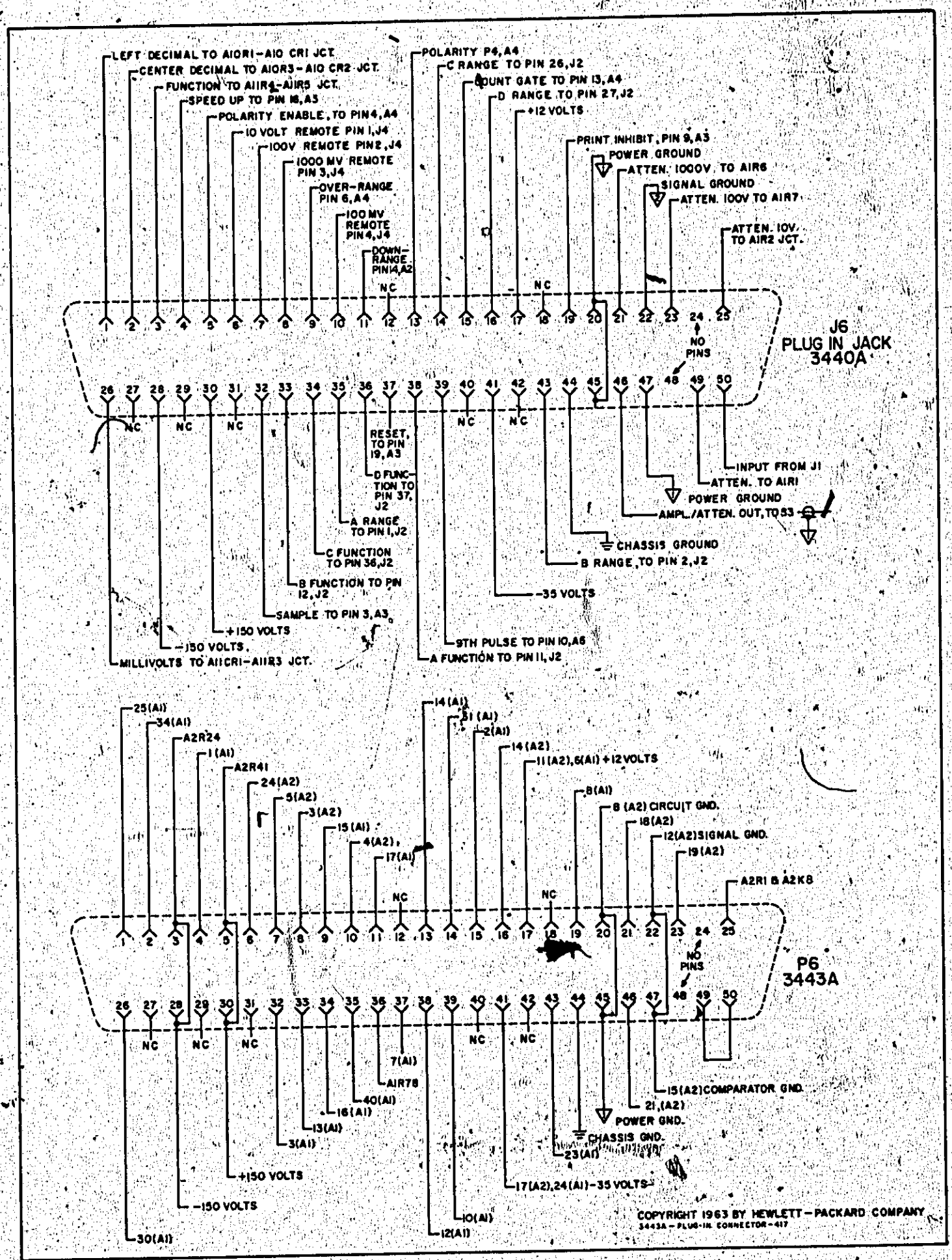


Figure 6-1. Plug-In Connectors

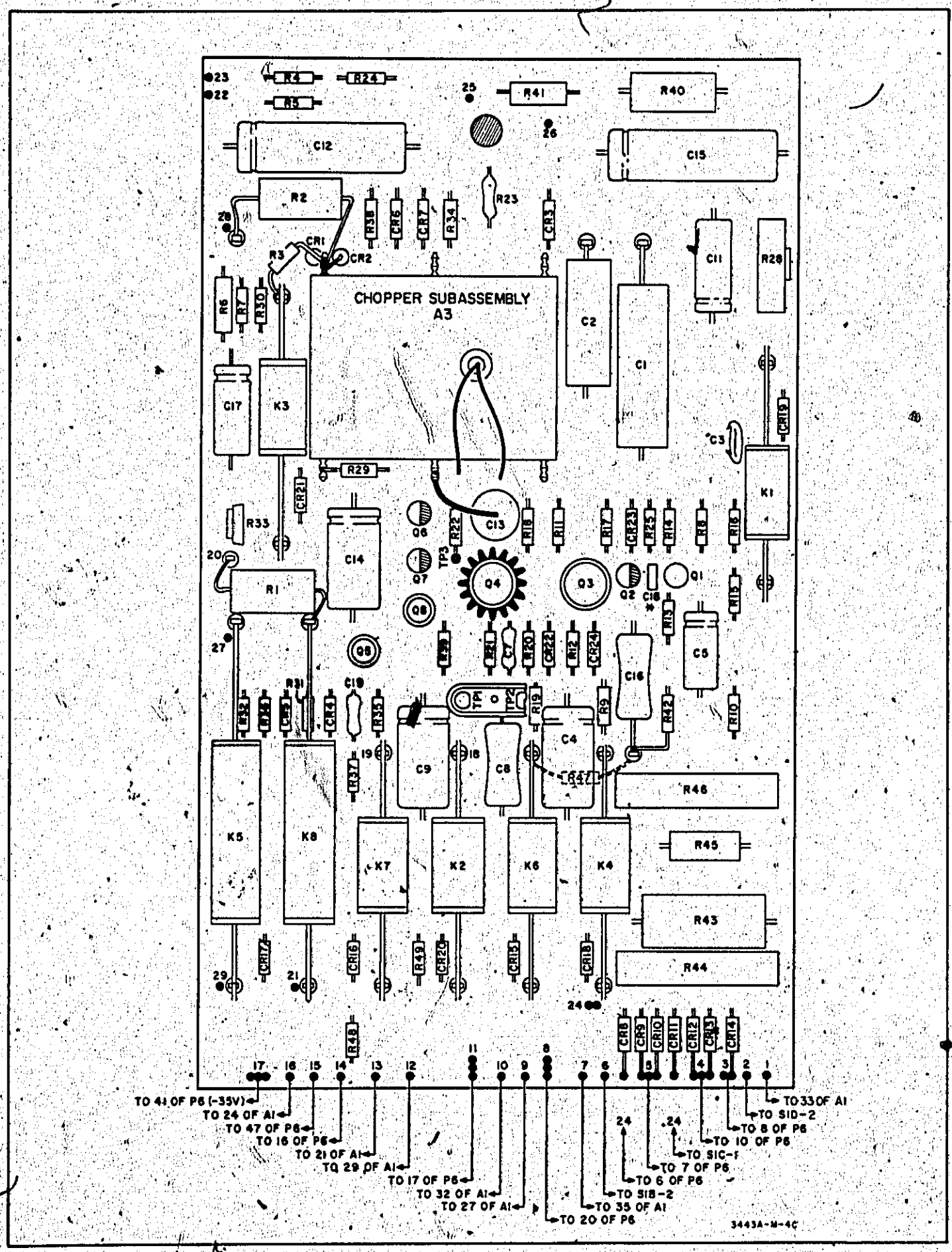


Figure 6-2. A2 Amplifier Board Parts Location Diagram

NOTES

1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN. PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.
2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED.
   RESISTANCE IN OHMS
   CAPACITANCE IN MICROFARADS
3. ——— — — ——— DENOTES ASSEMBLY.
4. — — — — — — — — DENOTES SUBASSEMBLY.
5. ——— DENOTES MAIN SIGNAL PATH.
6. — — — — — DENOTES FEEDBACK PATH.
7. ▭ DENOTES FRONT PANEL MARKING.
8. DENOTES SCREWDRIVER ADJUST.
9. DENOTES COMPONENTS NOT MOUNTED ON ASSEMBLY.
10. * AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY.
11. ALL RELAYS ARE SHOWN DEENERGIZED.
12. ▽ DENOTES INSTRUMENT COMMON.
13. ⏚ DENOTES INPUT SIGNAL COMMON.
14. (6, 26) DENOTES GRID LOCATION OF ASSOCIATED RELAY COIL.

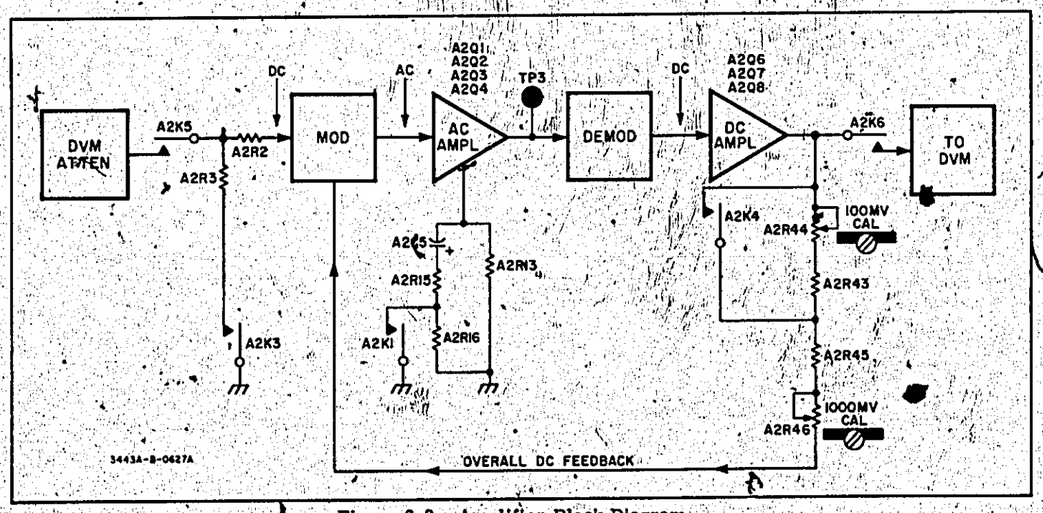
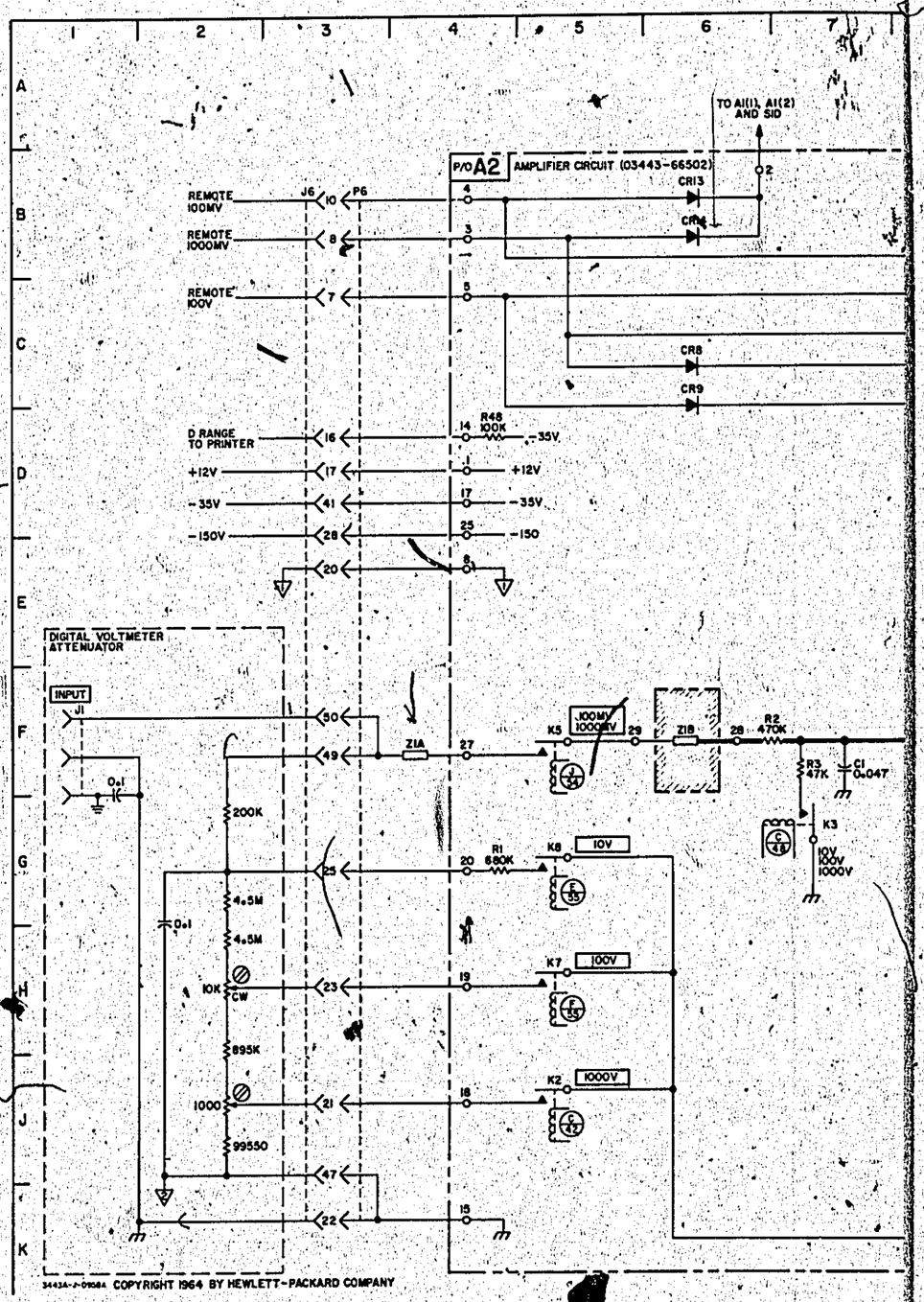


Figure 6-3. Amplifier Block Diagram



RELAY STATES

RANGE	RELAYS ENERGIZED
100 MV	A1K1, A1K3, A1K4, A2K1, A2K5, A2K6
1000 MV	A1K2, A1K3, A1K4, A2K4, A2K5, A2K6
10 V	A1K1, A1K3, A2K3, A2K6
100 V	A1K2, A1K3, A2K3, A2K7
1000 V	A1K1, A2K2, A2K3

CR24 ADDED AT SERIAL NO. 819-03726

Figure 6-4. A2 Amplifier Assembly Schematic, 01759-1

RELAY STATES	
RANGE	RELAYS ENERGIZED
100 MV	A1K1, A1K3, A1K4, A2K1, A2K5, A2K6
1000 MV	A1K2, A1K3, A1K4, A2K4, A2K5, A2K6
10 V	A1K1, A1K3, A2K3, A2K6
100 V	A1K2, A1K3, A2K3, A2K7
1000 V	A1K1, A2K2, A2K3

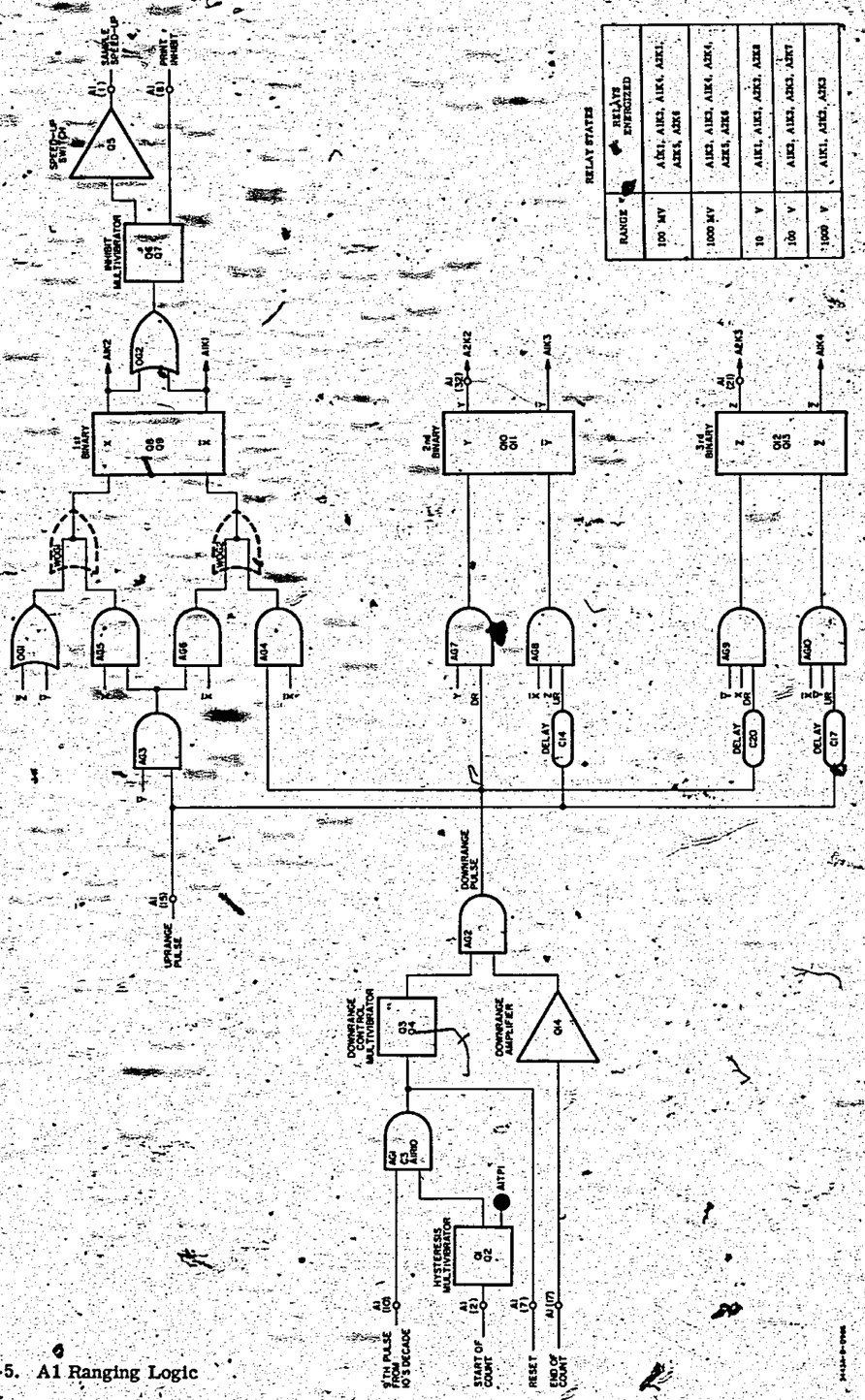


Figure 6-5. A1 Ranging Logic

01759-1

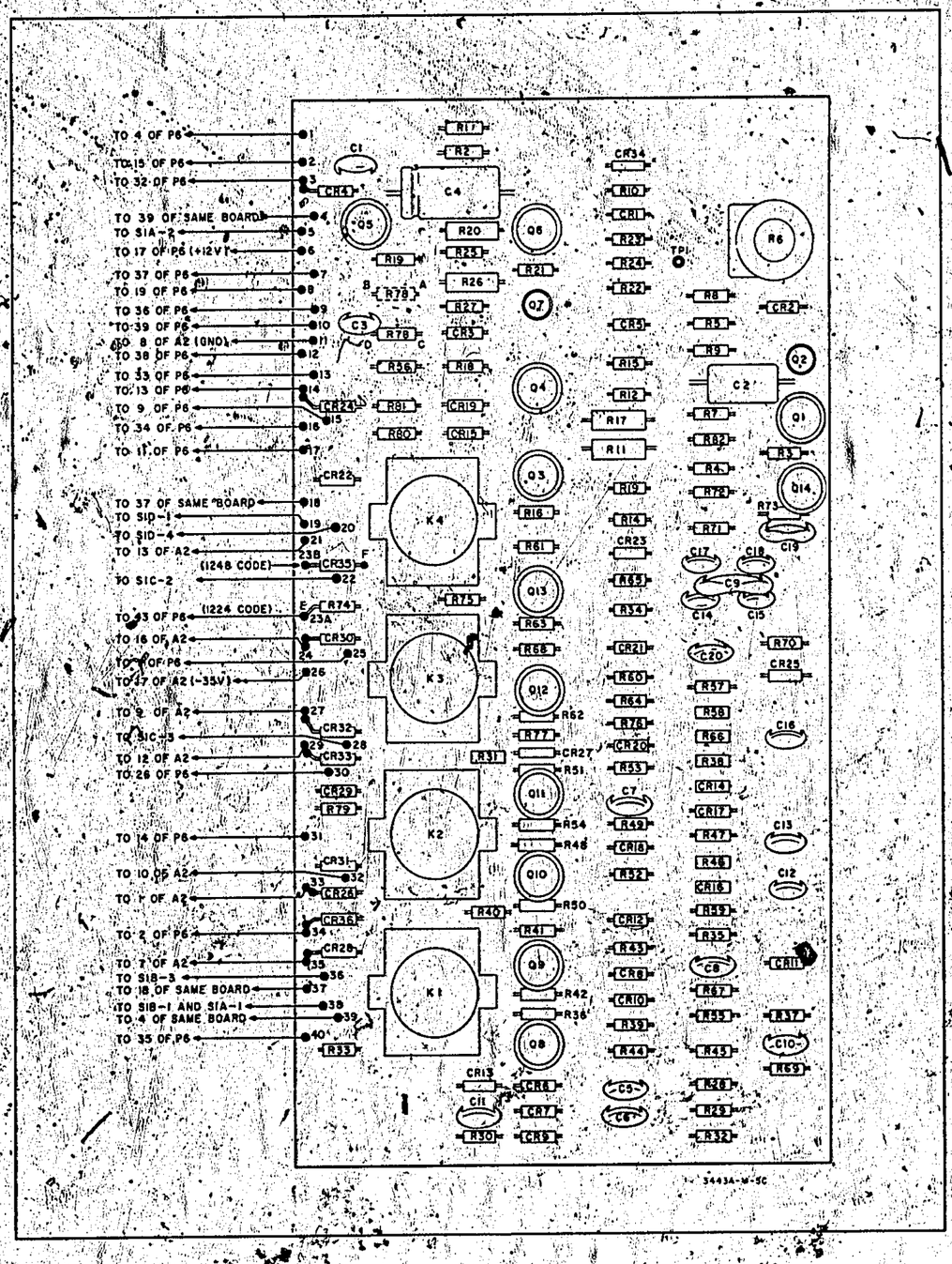
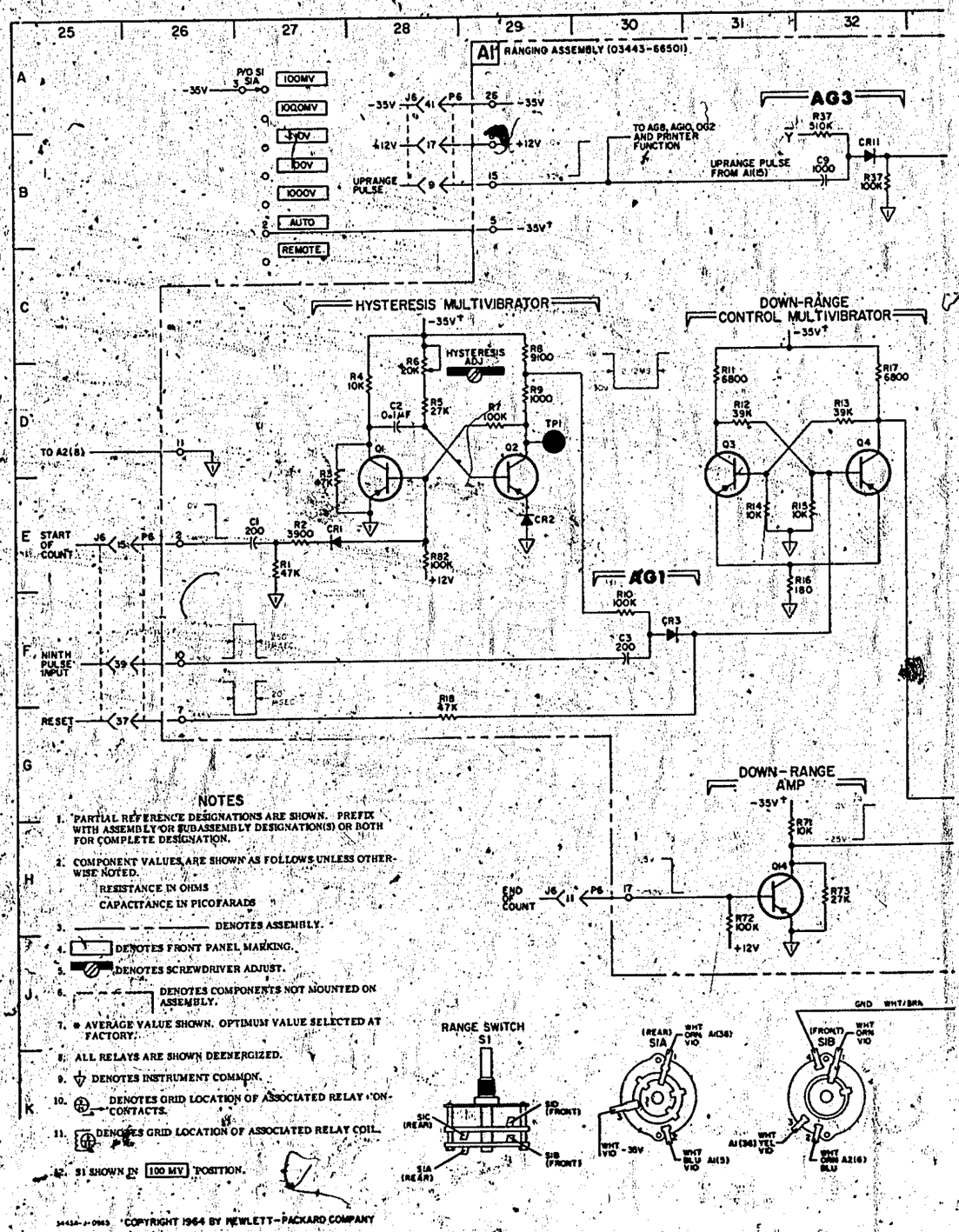
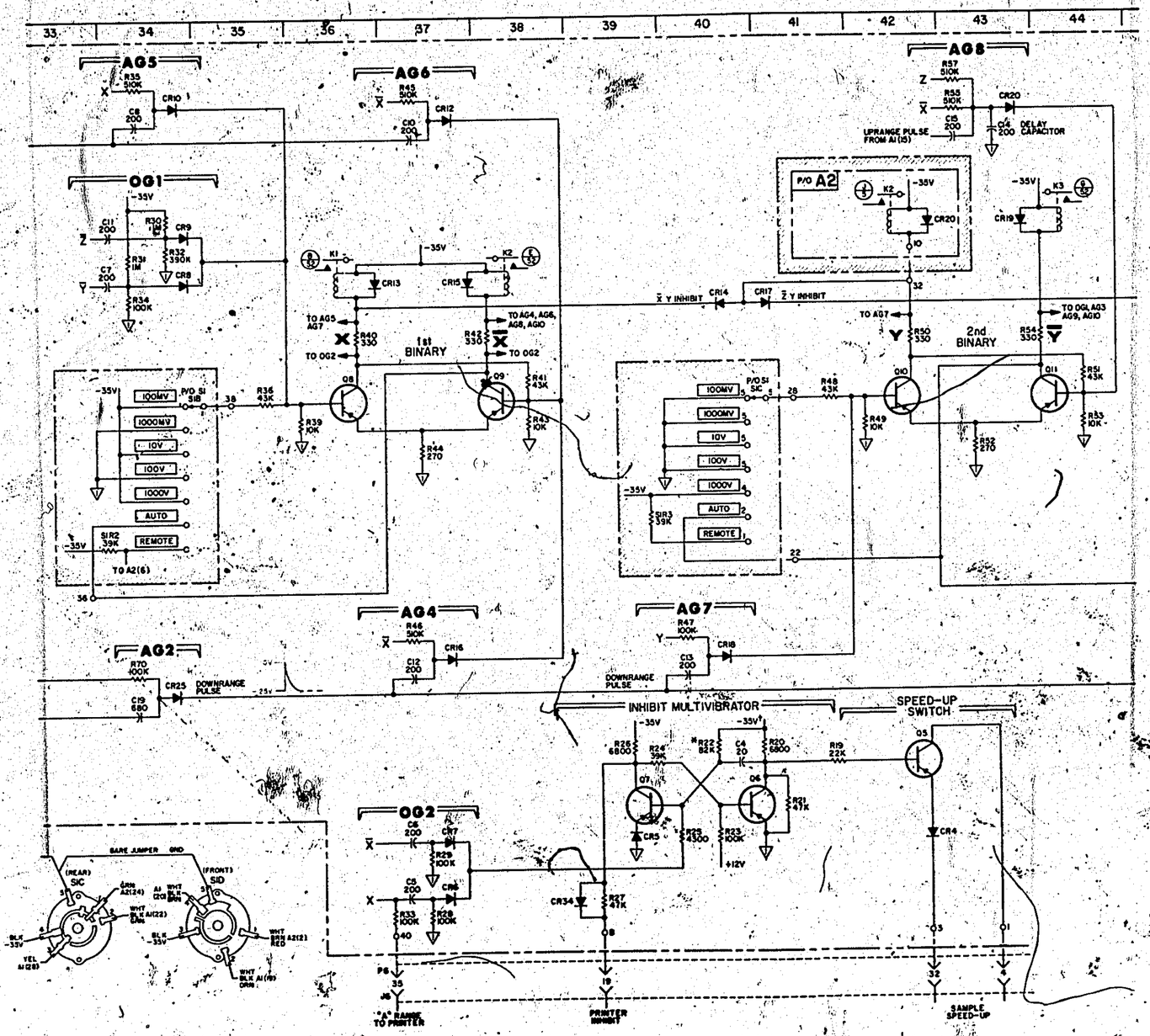


Figure 6-6. A1 Ranging Board Parts Location Diagram




AG5
AG6
AG8
OG1
OG2
AG4
AG2
AG7
P/O A2
1st BINARY
2nd BINARY
INHIBIT MULTIVIBRATOR
SPEED-UP SWITCH
DELAY CAPACITOR
DOWNRANGE PULSE
UPRANGE PULSE FROM A1(15)
X Y INHIBIT
Z Y INHIBIT
TO AG5 AG7
TO AG4, AG6, AG8, AG10
TO OG2
TO AG7
TO OG1,AG3 AG9, AG10
100MV
1000MV
10V
100V
1000V
AUTO
REMOTE
TO A2(6)
BARE JUMPER GND
(REAR) SIC
(FRONT) SID
"A" RANGE TO PRINTER
PRINTER BUSSY
SAMPLE SPEED-UP

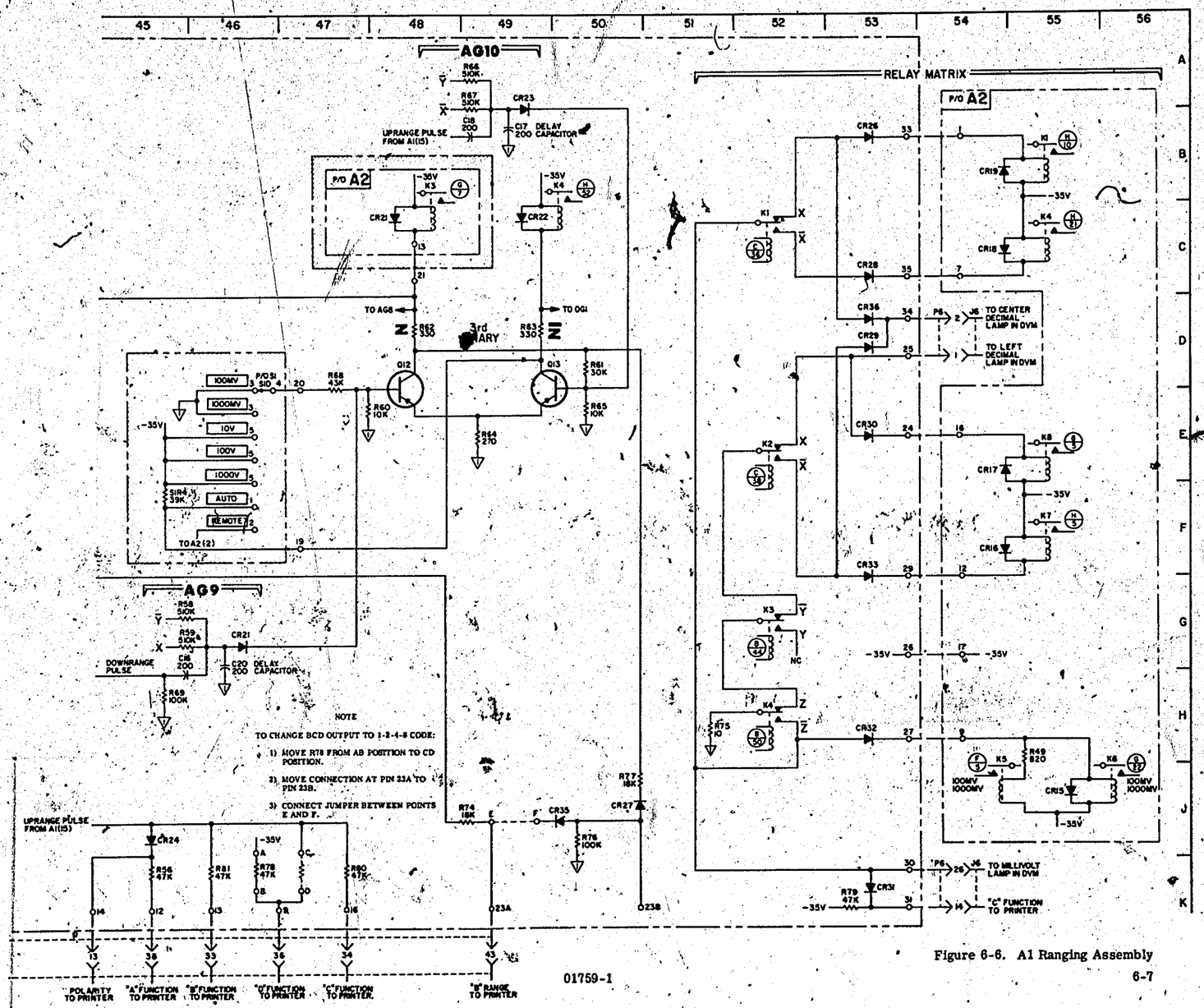


Figure 6-6. A1 Ranging Assembly

PARTS LIST

SECTION VII
REPLACEABLE PARTS

7-1. INTRODUCTION.

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

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

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

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

d. Manufacturer's part number.

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

7-4. ORDERING INFORMATION.

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

7-6. NON-LISTED PARTS.

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

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

ABBREVIATIONS

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

Ⓡ Dupont de Nemours

DECIMAL MULTIPLIERS

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

DESIGNATORS

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

Table 7-1. Replaceable Parts

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1	03443-66501		1	Assembly: control	28480	03443-66501
A1C1	0140-0198		16	C: fxd mica 200 pF ± 5% 300 vdcw	04062	DM15F201J
A1C2	0160-0168		2	C: my 0.1 μF ± 10%	28480	0160-0168
A1C3	0140-0198			C: fxd mica 200 pF ± 5% 300 vdcw	04062	DM15F201J
A1C4	0180-0049		1	C: fxd elect 20 μF 50 vdcw	56289	30D198A1
A1C5 thru A1C8	0140-0198			C: fxd mica 200 pF ± 5% 300 vdcw	04062	DM15F201J
A1C9	0140-0152		1	C: fxd 1000 pF ± 5% 300 vdcw	04062	DM16F102J
A1C10 thru A1C18	0140-0198			C: fxd mica 200 pF ± 5% 300 vdcw	04062	DM15F201J
A1C19	0140-0208		1	C: fxd mica 680 pF ± 5% 300 vdcw	04062	RDM15F681J3C
A1C20	0140-0198			C: fxd mica 200 pF ± 5% 300 vdcw	04062	DM15F201J
A1CR1 thru A1CR25	1901-0025		47	Diode: silicon	73292	HD4420A
A1CR26	1901-0033		5	Diode: silicon 1N485B	07910	1N485B
A1CR27	1901-0025			Diode: silicon	73292	HD4420A
A1CR28	1901-0033			Diode: silicon 1N485B	07910	1N485B
A1CR29	1901-0025			Diode: silicon	73292	HD4420A
A1CR30	1901-0033			Diode: silicon 1N485B	07910	1N485B
A1CR31	1901-0025			Diode: silicon	73292	HD4420A
A1CR32, A1CR33	1901-0033			Diode: silicon 1N485B	07910	1N485B
A1CR34 thru A1CR36	1901-0025			Diode: silicon	73292	HD4420A
A1K1 thru A1K4	0490-0129		4	Relay: armature SPDT 5000 ohm coil	28480	0490-0129
A1Q1	1850-0062		12	Transistor: germanium alloy	01295	GA287
A1Q2	1850-0103		2	Transistor: 2N2190	28480	1850-0103
A1Q3, A1Q4	1850-0062			Transistor: germanium alloy	01295	GA287
A1Q5	1854-0022		1	Transistor: silicon NPN	28480	1854-0022
A1Q6	1850-0062			Transistor: germanium alloy	01295	GA287
A1Q7	1850-0103			Transistor: 2N2190	28480	1850-0103
A1Q8 thru A1Q14	1850-0062			Transistor: germanium alloy	01295	GA287
A1R1	0683-4735		11	R: fxd comp 47 KΩ ± 5% 1/4 W	01121	CB4735
A1R2	0684-3921		1	R: fxd comp 3900 ohms ± 10% 1/4 W	01121	CB3921
A1R3	0683-4735			R: fxd comp 47 KΩ ± 5% 1/4 W	01121	CB4735
A1R4	0683-1035		13	R: fxd comp 10 KΩ ± 5% 1/4 W	01121	CB1035
A1R5	0683-2735		2	R: fxd comp 27 KΩ ± 5% 1/4 W	01121	CB2735
A1R6	2100-0093		1	R: var comp 20 KΩ 20 lin 1/5 W	28480	2100-0093
A1R7	0683-1045		20	R: fxd comp 100 KΩ ± 5% 1/4 W	01121	CB1045
A1R8	0683-9125		3	R: fxd comp 9100Ω ± 5% 1/4 W	01121	CB9125
A1R9	0683-1025		2	R: fxd comp 1000 Ω ± 5% 1/4 W	01121	CB1025
A1R10	0683-1045			R: fxd comp 100 KΩ ± 5% 1/4 W	01121	CB1045
A1R11	0687-6821		4	R: fxd comp 6800 Ω ± 10% 1/2 W	01121	EB6821
A1R12, A1R13	0683-3935		3	R: fxd comp 39 KΩ 1/4 W	01121	CB3935
A1R14, A1R15	0683-1035			R: fxd comp 10 KΩ ± 5% 1/4 W	01121	CB1035
A1R16	0683-1815		1	R: fxd comp 180 Ω ± 5% 1/4 W	01121	CB1815
A1R17	0687-6821			R: fxd comp 6800 Ω ± 10% 1/2 W	01121	EB6821
A1R18	0683-4735			R: fxd comp 47 KΩ ± 5% 1/4 W	01121	CB4735
A1R19	0684-2231		1	R: fxd comp 22 KΩ ± 10% 1/4 W	01121	CB2231
A1R20	0687-6821			R: fxd comp 6800 Ω ± 10% 1/2 W	01121	EB6821
A1R21	0683-4735			R: fxd comp 47 KΩ ± 5% 1/4 W	01121	CB4735
A1R22	0683-8235		1	R: fxd comp 82 KΩ ± 5% 1/4 W	01121	CB8235

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1R23	0683-1045			R: fxd comp 100 KΩ ± 5% 1/4 W	01121	CB1045
A1R24	0683-3935			R: fxd comp 39 KΩ 1/4 W	01121	CB3935
A1R25	0683-4325		1	R: fxd comp 4300 Ω ± 5% 1/4 W	01121	CB4325
A1R26	0687-6821			R: fxd comp 6800 Ω ± 10% 1/2 W	01121	EB6821
A1R27	0683-4735			R: fxd comp 47 KΩ ± 5% 1/4 W	01121	CB4735
A1R28, A1R29	0683-1045			R: fxd comp 100 KΩ ± 5% 1/4 W	01121	CB1045
A1R30, A1R31	0683-1055		2	R: fxd comp 1 MΩ ± 5% 1/4 W	01121	CB1055
A1R32	0683-3945			R: fxd comp 390 KΩ ± 5% 1/4 W	01121	CB3945
A1R33, A1R34	0683-1045			R: fxd comp 100 KΩ ± 5% 1/4W	01121	CB1045
A1R35	0683-5145		10	R: fxd comp 510 KΩ ± 5% 1/4 W	01121	CB5145
A1R36	0683-4335		6	R: fxd comp 43 KΩ ± 5% 1/4 W	01121	CB4335
A1R37	0683-1045			R: fxd comp 100 KΩ ± 5% 1/4 W	01121	CB1045
A1R38	0683-5145			R: fxd comp 510 KΩ ± 5% 1/4 W	01121	CB5145
A1R39	0683-1035			R: fxd comp 10 KΩ ± 5% 1/4 W	01121	CB1035
A1R40	0683-3315		6	R: fxd comp 330 Ω ± 5% 1/4 W	01121	CB3315
A1R41	0683-4335			R: fxd comp 43 KΩ ± 5% 1/4 W	01121	CB4335
A1R42	0683-3315			R: fxd comp 330 Ω ± 5% 1/4 W	01121	CB3315
A1R43	0683-1035			R: fxd comp 10 KΩ ± 5% 1/4 W	01121	CB1035
A1R44	0683-2715		3	R: fxd comp 270 Ω ± 5% 1/4 W	01121	CB2715
A1R45, A1R46	0683-5145			R: fxd comp 510 KΩ ± 5% 1/4 W	01121	CB5145
A1R47	0683-1045			R: fxd comp 100 KΩ ± 5% 1/4 W	01121	CB1045
A1R48	0683-4335			R: fxd comp 43 KΩ ± 5% 1/4 W	01121	CB4335
A1R49	0683-1035			R: fxd comp 10 KΩ ± 5% 1/4 W	01121	CB1035
A1R50	0683-3315			R: fxd comp 330 Ω ± 5% 1/4 W	01121	CB3315
A1R51	0683-4335			R: fxd comp 43 KΩ ± 5% 1/4 W	01121	CB4335
A1R52	0683-2715			R: fxd comp 270 Ω ± 5% 1/4 W	01121	CB2715
A1R53	0683-1035			R: fxd comp 10 KΩ ± 5% 1/4 W	01121	CB1035
A1R54	0683-3315			R: fxd comp 330 Ω ± 5% 1/4 W	01121	CB3315
A1R55	0683-5145			R: fxd comp 510 KΩ ± 5% 1/4 W	01121	CB5145
A1R56	0683-4735			R: fxd comp 47 KΩ ± 5% 1/4 W	01121	CB4735
A1R57 thru A1R59	0683-5145			R: fxd comp 510 KΩ ± 5% 1/4 W	01121	CB5145
A1R60	0683-1035			R: fxd comp 10 KΩ ± 5% 1/4 W	01121	CB1035
A1R61	0683-3035			R: fxd comp 30 KΩ ± 5% 1/4 W	01121	CB3035
A1R62, A1R63	0683-3315			R: fxd comp 330 Ω ± 5% 1/4 W	01121	CB3315
A1R64	0683-2715			R: fxd comp 270 Ω ± 5% 1/4 W	01121	CB2715
A1R65	0683-1035			R: fxd comp 10 KΩ ± 5% 1/4 W	01121	CB1035
A1R66, A1R67	0683-5145			R: fxd comp 510 KΩ ± 5% 1/4 W	01121	CB5145
A1R68	0683-4335			R: fxd comp 43 KΩ ± 5% 1/4 W	01121	CB4335
A1R69, A1R70	0683-1045			R: fxd comp 100 KΩ ± 5% 1/4 W	01121	CB1045
A1R71	0683-1035			R: fxd comp 10 KΩ ± 5% 1/4 W	01121	CB1035
A1R72	0683-1045			R: fxd comp 100 KΩ ± 5% 1/4 W	01121	CB1045
A1R73	0683-2735			R: fxd comp 27 KΩ ± 5% 1/4 W	01121	CB2735
A1R74	0683-1835		1	R: fxd comp 18 KΩ ± 5% 1/4 W	01121	CB1835
A1R75	0684-1001		1	R: fxd comp 10 Ω ± 10% 1/4 W	01121	CB1001
A1R76	0683-1045			R: fxd comp 100 KΩ ± 5% 1/4 W	01121	CB1045
A1R77	0683-1835			R: fxd comp 18 KΩ ± 5% 1/4 W	01121	CB1835
A1R78	0683-4735			R: fxd comp 47 KΩ ± 5% 1/4 W	01121	CB4735
A1R79	0683-4735			R: fxd comp 47 KΩ ± 5% 1/4 W	01121	CB4735
A1R80, A1R81	0683-4735			R: fxd comp 47 KΩ ± 5% 1/4 W	01121	CB4735
A1R82	0683-1045			R: fxd comp 100 KΩ ± 5% 1/4 W	01121	CB1045
A1TP1	0360-0124		2	Terminal: pin for 3/32 in.	71279	2970-3
A2	03443-66502		1	Assembly: amplifier	28480	03443-66502

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2C1	0160-0744		1	C: fxd poly 0.047 μF ±20% 50 vdcw	56289	194P4730R5
A2C2	0160-0743		1	C: fxd poly 0.015 μF ±20% 50 vdcw	56289	194P1530R5
A2C3	0140-0147		1	C: fxd mica 180 pF ±5% 500 vdcw	04062	DM15F181J
A2C4	0180-0076		1	C: fxd elect 20 μF 25 vdcw	56289	40D181A2
A2C5	0180-0059		1	C: fxd elect 10 μF -10% +100% 25 vdcw	56289	30D106B025BB4
A2C6				Not assigned		
A2C7	0160-0154		2	C: my 2200 pF ±10%	28480	0160-0154
A2C8	0160-0167		1	C: 8200 pF ±10%	28480	0160-0167
A2C9	0180-0039		1	C: fxd elect 100 μF 12 vdcw	56289	D32697
A2C10				Not assigned		
A2C11	0180-0089		1	C: fxd elect 10 μF 150 vdcw	56289	30D218A1
A2C12	0180-0089		2	C: fxd elect 10 μF -10% +100% 150 vdcw	56289	30D218A1
A2C13	0170-0038		1	C: fxd my 0.22 μF ±10% 200 vdcw	56289	Type 48P #148P22492
A2C14	0180-0294		1	C: fxd elect 390 μF +20% 10 vdcw	56289	109D397X0010T2
A2C15	0180-0089			C: fxd elect 10 μF -10% +100% 150 vdcw	56289	30D218A1
A2C16	0160-0168			C: my 0.1 μF ±10%	28480	0160-0168
A2C17	0180-0060		1	C: fxd elect 200 μF -10% +100% 3 vdcw	56289	30D207G003DC4
A2C18				Not assigned		
A2C19	0160-0154			C: my 2200 pF ±10%	28480	0160-0154
A2CR1, A2CR2	1901-0156		2	Diode: Si 50mA 200wiv	03877	SG3288 obd
A2CR3	1902-0197		1	Diode: breakdown 82 V	04713	IN3042B
A2CR4	1901-0025			Diode: Si	73792	HD4420A obd
A2CR5	1901-0156			Diode: Si 50mA 200wiv	03877	SG3288 obd
A2CR6	1902-0049		1	Diode: Si breakdown 6 V	99942	1N1323
A2CR7	1902-0182		1	Diode: breakdown si 20 V	06751	obd
A2CR8 thru A2CR23	1901-0025			Diode: Si	73292	HD4420A
A2CR24	1902-3002		1	Diode, breakdown si 2.37V ± 5% 400wiv	04713	SZ10939-2
A2K1 thru A2K4	0490-0050		6	Relay: reed SPST normally open	95348	MR325
	9160-0012		6	Coil: electromagnetic (A2K1 thru A2K4)	71707	U-32-P
A2K5	0490-0138		1	Relay: reed	-hp-	
A2K6, A2K7	0490-0050			Relay: reed SPST normally open	95348	MR325
A2K8	0490-0096		1	Relay: reed SPST normally open	95348	DRR25
	9161-0013		1	Coil: electromagnetic (A2K8)	71707	SP-40-P-X
	9160-0091		1	Coil: electromagnetic (A2K5)	-hp-	
A2Q1	1854-0023		1	Transistor: NPN si	07263	S-5666
A2Q2	1854-0087		1	Transistor: EIA Type 2N3417 NPN si	03508	4JX16N2989
A2Q3	1851-0017		1	Transistor: 2N1304	01295	2N1304
A2Q4	1850-0128		1	Transistor: EIA Type 2N398B PNP ge	01295	2N398B
	1205-0002		1	Heat sink: transistor, for A2Q4	07387	3AL 635-2R
A2Q5	1850-0062			Transistor: PNP ge	01295	GA287
A2Q6, A2Q7	1854-0033		2	Transistor: EIA Type 2N3391 NPN si	03508	2N3391
A2Q8	1853-0001		1	Transistor: PNP si 30 V 900 MW	28480	1853-0001
A2R1	0692-6845		1	R: fxd comp 680 KΩ ±5% 2 W	01121	HB6845
A2R2	0693-4741		1	R: fxd comp 470 KΩ ±10% 2 W	01121	HB4741
A2R3	0683-4735			R: fxd comp 47 KΩ ±5% 1/4 W	01121	CB4735
A2R4	0683-2455		1	R: fxd comp 2.4 MΩ ±5% 1/4 W	28480	0683-2455
A2R5	0683-8255		1	R: fxd comp 8.2 MΩ ±5% 1/4 W	01121	CB8255
A2R6	0811-0911		1	R: fxd ww 10.114 KΩ ±0.1% 0.1 W	28480	0811-0911
A2R7	0683-1015		1	R: fxd comp 100 Ω ±5% 1/4 W	01121	CB1015
A2R8	0683-1555		1	R: fxd comp 1.5 MΩ ±5% 1/4 W	01121	CB1555
A2R9	0683-3925		1	R: fxd comp 3900 Ω ±5% 1/4 W	01121	CB3925
A2R10	0683-1065		1	R: fxd comp 10 MΩ ±5% 1/4 W	01121	CB1065
A2R11	0683-4745		3	R: fxd comp 470 KΩ 1/4 W	01121	CB4745
A2R12	0683-6845		3	R: fxd comp 680 KΩ ±5% 1/4 W	01121	CB6845

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2R13	0683-1035			R: fxd comp 10 KΩ ±5% 1/4 W	01121	CB1035
A2R14	0683-6845			R: fxd comp 680 KΩ ±5% 1/4 W	01121	CB6845
A2R15	0683-1025			R: fxd comp 1000 Ω ±5% 1/4 W	01121	CB1025
A2R16	0683-1045			R: fxd comp 100 KΩ ±5% 1/4 W	01121	CB1045
A2R17	0683-6835		1	R: fxd comp 68 KΩ ±5% 1/4 W	01121	CB6835
A2R18	0683-1035			R: fxd comp 10 KΩ ±5% 1/4 W	01121	CB1035
A2R19	0683-3335		1	R: fxd comp 33 KΩ ±5% 1/4 W	01121	CB3335
A2R20	0683-6845			R: fxd comp 680 KΩ ±5% 1/4 W	01121	CB6845
A2R21	0683-3325		1	R: fxd comp 330 Ω ±5% 1/4 W	01121	CB3325
A2R22	0683-1235		1	R: fxd comp 12 KΩ ±5% 1/4 W	01121	CB1235
A2R23	0758-0047		1	R: fxd met flm 7500 Ω ±5% 1/2 W	07115	C20
A2R24	0683-2025		1	R: fxd comp 2000 Ω ±5% 1/4 W	01121	CB2025
A2R25	0683-2225		1	R: fxd 2200 Ω ±5% 1/4 W	01121	CB2225
A2R26, A2R27				Not assigned		
A2R28	2100-0442		1	R: var DEPC, 40 KΩ ±30%	71590	Type 701
A2R29	0683-2035		1	R: fxd comp 20 KΩ ±5% 1/4 W	01121	CB2035
A2R30	0683-9125			R: fxd comp 9100 Ω ±5% 1/4 W	01121	CB9125
A2R31	0683-1515		1	R: fxd comp 150 Ω ±5% 1/4 W	01121	CB1515
A2R32	0683-5645		1	R: fxd comp 560 KΩ ±5% 1/4 W	01121	CB5645
A2R33	2100-0962		1	R: var 3000 Ω ±30% lin 1/4 W	09569	MTC-1(3K)
A2R34	0683-3045		1	R: fxd comp 300 KΩ ±5% 1/4 W	01121	CB3045
A2R35	0683-3055		1	R: fxd comp 3 MΩ ±5% 1/4 W	01121	CB3055
A2R36	0683-9125			R: fxd comp 9100Ω ±5% 1/4 W	01121	CB9125
A2R37	0683-1045			R: fxd comp 100 KΩ ±5% 1/4 W	01121	CB1045
A2R38	0683-1035			R: fxd comp 10 KΩ ±5% 1/4 W	01121	CB1035
A2R39	0683-1045			R: fxd comp 100 KΩ ±5% 1/4 W	01121	CB1045
A2R40	0692-1235		1	R: fxd comp 12 KΩ ±5% 2 W	01121	HB1235
A2R41	0686-1825		1	R: fxd comp 1800 Ω ±5% 1/2 W	01121	EB1825
A2R42	0683-4745			R: fxd comp 470 KΩ 1/4 W	01121	CB4745
A2R43	0811-0140		1	R: fxd ww 895 KΩ ±0.2% 1/4 W	05347	510A
A2R44	2100-0888		1	R: var 10 KΩ ±10%	28480	2100-0888
A2R45	0811-0370		1	R: fxd ww 89.5 KΩ ±0.1% 0.1 W	28480	0811-0370
A2R46	2100-0889		1	R: var 1000 Ω ±10%	28480	2100-0889
A2R47	0683-4745			R: fxd comp 470 KΩ 1/4 W	01121	CB4745
A2R48	0683-1045			R: fxd comp 100 KΩ ±5% 1/4 W	01121	CB1045
A2R49	0683-8215		1	R: fxd 820 Ω ±5% 1/4 W	01121	CB 8215
A2TP1	0360-0124			Terminal: pin for 3/32 in.	71279	2970-3
A2TP2, A2TP3	0360-0435		2	Terminal: board	71279	1012-3
A2A3	1990-0025		1	Photochopper subassembly	28480	1990-0025
R1	2100-0172		1	R: fxd comp 3 MΩ 2% lin 1/4 W	28480	2100-0172
S1	3100-0805		1	Switch: rotary 7 position	76854	obd
S1R2 thru S1R4	0683-3935			R: fxd comp 39 KΩ 1/4 W	01121	CB3935
Z1A/B	03443-62801		1	Compensator Assembly	28480	03443-62801
	5080-0023		1	Compensator Resistor	28480	5080-0023
				MISCELLANEOUS		
	0340-0020		2	Insulator: stand off	72656	1023-04-3/4"
	0340-0039		23	Bushing, insulator	98291	X-B-04176-12
	0340-0058		5	Post, terminal	00866	obd
	0340-0059		18	Post, terminal	00866	obd
	0360-0005		1	Terminal, solder	79963	9
	0370-0088		1	Knob, locking	28480	0370-0088
	0400-0010		1	Grommet, vinyl	01538	#375

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
				MISCELLANEOUS (Cont'd)		
	0510-0076		1	Fastener, rt. angle, for #6-32 machine screw	78553	C8599-632-24D
	0510-0114		2	Nut, captive		
	0525-0005		2	Screw, machine #3-48 x 5/16 round head	84396	obd
	1200-0028		1	A2TP1 and A2TP2 shorting plug		
	1251-1025		1	Connector, male, 50 pin	71785	57-10500-23
	1400-0017		1	Clamp cable nylon	95987	5/16-4
	1400-0018		1	Clamp cable nylon	95987	7/16-6
	1400-0116		2	Clamp cable for snap-in mounting	28480	1400-0116
	2190-0004		2	Washer, lock phosphor bronze, nickel plated round	78452	#418-BC Everlock Washer
	2190-0016		1	Washer, lock phosphor bronze, nickel plated round	78452	1920-02-00-2480
	2190-0022		1	Washer, lock phosphor bronze, nickel plated round	28480	2190-0022
	2200-0003		2	Screw, machine, 4-40 by 1/4" lg.	80120	obd
	2360-0002		2	Screw, machine, 6-32 [illegible]	84396	obd
	2360-0006		6	Screw, machine, #6-32, [illegible]" lg.	80120	obd
	2370-0002		4	Screw, machine, #6-32 thread, 3/8" lg.	80120	obd
	2390-0006		10	Screw, machine, #6-32, 5/16" lg.	80120	obd
	2420-0001		10	Nut, hex, steel, nickel plated, 6-32	28480	2420-0001
	2630-0001		2	Screw, machine, #8-32 thread, 5/16" lg.	28480	2630-0001
	4320-0014		6"	Rubber Extrusion (specify length)	000HH	110
	8110-0052		6"	Nickel-iron alloy (used with Z1A/B)	72005	obd
	9210-0074		1	Carton, self locking	18473	obd
	9211-0286		1	Carton, corrugated	84324	obd
	9220-0358		2	Pad, foam	00904	obd
	03441-24701		2	Spacer	28480	03441-24701
	03443-00101		1	Chassis	28480	03443-00101
	03443-00201		1	Panel, front	28480	03443-00201
	03443-00202		1	Panel, rear	28480	03443-00202
	03443-00203		1	Panel, sub	28480	03443-00203
	03443-23701		1	Rod, hinge	28480	03443-23701
	03443-25101		2	Post; hinge	28480	03443-25101
	03443-61601		1	Cable assembly	28480	03443-61601

CODE LIST OF MANUFACTURERS

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

Code No.	Manufacturer	Address
00000	U.S.A Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00287	Cemco, Inc.	Danielson, Conn.
00334	Humidial	Colton, Calif.
00348	Mictron, Co., Inc.	Valley Stream, N.Y.
00373	Garlock Inc.	Cherry Hill, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00809	Crowen, Ltd.	Whitby, Ontario, Canada
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Co., Pickens Div.	Pickens, S.C.
00866	Goe Engineering Co.	City of Industry, Cal.
00891	Carl E. Holmes Corp.	Los Angeles, Cal.
00929	Microlab Inc.	Livingston, N.J.
01002	General Electric Co., Capacitor Dept.	Hudson Falls, N.Y.
01009	Alden Products Co.	Brockton, Mass.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Cal.
01281	TRW Semiconductors, Inc.	Lawndale, Cal.
01295	Texas Instruments, Inc., Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co	Alliance, Ohio
01538	Small Parts Inc.	Los Angeles, Cal.
01589	Pacific Relays, Inc.	Van Nuys, Cal.
01670	Gudebrod Bros. Silk Co.	New York, N.Y.
01930	Amerock Corp.	Rockford, Ill.
01960	Pulse Engineering Co.	Santa Clara, Cal.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02118	Wheelock Signals, Inc.	Long Branch, N.J.
02286	Cole Rubber and Plastics Inc	Sunnyvale, Cal.
02660	Amphenol-Borg Electronics Corp.	Broadview, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Division	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins EngineeringCo.	San Fernando, Cal.
02875	Hudson Tool & Die	Newark, N.J.
03296	Nylon Molding Corp.	Springfield, N.J.
03508	G.E. Semiconductor Prod. Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	Compton, Calif.
03818	Parker Seal Co.	Los Angeles, Cal.
03877	Transitron Electric Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N.J.
03954	Singer Co., Diehl Div., Finderne Plant	Somerville, N.J.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
04013	Taruus Corp.	Lambertville, N.J.
04062	Arco Electronic Inc.	Great Neck, N.Y.
04217	Essex Wire	Los Angeles, Cal.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04354	Precision Paper Tube Co.	Wheeling, Ill.
04404	Palo Alto Division of Hewlett-Packard Co.	Palo Alto, Cal.
04451	Sylvania Electric Products, Microwave Device Div.	Mountain View, Cal.
04673	Dakota Engr. Inc.	Culver City, Cal.
04713	Motorola Inc. Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Div.	Culver City, Cal.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire Co.	Redwood City, Cal.
04811	Precision Coil Spring Co.	El Monte, Cal.
04870	P.M. Motor Company	Westchester, Ill.
04919	Component Mfg. Service Co.	W. Bridgewater, Mass.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Cal.
05277	Westinghouse Electric Corp. Semiconductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Cal.
05397	Union Carbine Corp., Elect. Div.	New York, N.Y.
05574	Viking Ind. Inc.	Canoga Park, Cal.
05593	Icore Electro-Plastics Inc.	Sunnyvale, Cal.
05618	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metro-Tel Corp.	Westbury, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Cal.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	Bassick Co., Div. of Stewart Warner Corp.	Bridgeport, Conn.
06090	Raychem Corp.	Redwood City, Cal.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06540	Amatom Electronic Hardware Co., Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Components Inc., Ariz. Div.	Phoenix, Arizona
06812	Torrington Mfg. Co., West Div.	Van Nuys, Cal.
06980	Varian Assoc. Etmac Div.	San Carlos, Cal.
07088	Kelvin Electric Co.	Van Nuys, Cal.
07126	Digitran Co.	Pasadena, Cal.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp., Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Cal.
07256	Silicon Transistor Corp.	Carle Place, N.Y.
07261	Avnet Corp.	Culver City, Cal.
07263	Fairchild Camera & Inst. Corp., Semiconductor Div.	Mountain View, Cal.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	Bircher Corp, The	Monterey Park, Cal.
07397	Sylvania Elect. Prod. Inc., Mt. View Operations	Mountain View, Cal.
07700	Technical Wire Products Inc.	Cranford, N.J.
07829	Bodine Elect. Co.	Chicago, Ill.
07910	Continental Device Corp.	Hawthorne, Cal.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Cal.
07980	Hewlett-Packard Co., New Jersey Division	Rockaway, N.J.
08145	U.S. Engineering Co.	Los Angeles, Cal.
08289	Blinn, Delbert Co.	Pomona, Cal.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08524	Deutsch Fastener Corp.	Los Angeles, Cal.
08664	Bristol Co., The	Waterbury, Conn
08717	Sloan Company	Sun Valley, Cal.
08718	ITT Cannon Electric Inc., Phoenix Div.	Phoenix, Arizona
08727	National Radio Lab. Inc.	Paramus, N.J.
08792	CBS Electronics Semiconductor Operations, Div. of CBS Inc	Lowell, Mass.
08806	General Electric Co., Miniature Lamp Dept.	Cleveland, Ohio
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays Div.	Costa Mesa, Cal.
09097	Electronic Enclosures Inc.	Los Angeles, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Tech. Ind. Inc, Atohm Elect.	Burbank, Cal.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09353	C & K Components Inc.	Newton, Mass.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09795	Pennsylvania Florocarbon	Clifton Heights, Penn.
09922	Burndy Corp.	Norwalk, Conn.
10214	General Transistor Western Corp.	Los Angeles, Cal.
10411	Ti-Tal, Inc.	Berkeley, Cal.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Cal.
11242	Bay State Electronics Corp.	Waltham, Mass.
11312	Teledyne Inc., Microwave Div.	Palo Alto, Cal.
11314	National Seal	Downey, Cal.
11453	Precision Connector Corp.	Jamaica, N.Y.
11534	Duncan Electronics Inc.	Costa Mesa, Cal.
11711	General Instrument Corp., Semiconductor Division Products Group	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Cal.
11870	Melabs, Inc.	Palo Alto, Cal.
12136	Philadelphia Handle Co.	Camden, N.J.
12361	Grove Mfg. Co., Inc.	Shady Grove, Pa.
12574	Gulton Ind. Inc., Data System Div.	Albuquerque, N.M.
12697	Clarostat Mfg. Co.	Dover, N.H.
12728	Elmar Filter Corp	W. Haven, Conn.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12881	Metex Electronics Corp.	Clark, N.J.
12930	Delta Semiconductor Inc.	Newport Beach, Cal.
12954	Dickson Electronics Corp.	Scottsdale, Arizona
13019	Airco Supply Co., Inc.	Witchita, Kansas
13061	Wilco Products	Detroit, Mich.
13103	Thermalloy	Dallas, Texas
13327	Solitron Devices Inc.	Tappan, N.Y.
13396	Telefunken (GmbH)	Hanover, Germany
13835	Midland-Wright Div. of Pacific Industries, Inc.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Cal.
14193	Calif. Resistor Corp	Santa Monica, Cal.
14298	American Components, Inc.	Conshohocken, Pa.
14433	ITT Semiconductor, a Div. of Int. Telephone and Telegraph Corporation	West Palm Beach, Fla.
14493	Hewlett-Packard Company	Loveland, Colo.
14655	Cornell Dubilier Electric Corp	Newark, N.J.
14674	Corning Glass Works	Corning, N.Y.
14752	Electro Cube Inc.	San Gabriel, Cal.
14960	Williams Mfg. Co.	San Jose, Cal.
15106	The Sphere Co., Inc.	Little Falls, N.J.
15203	Webster Electronics Co.	New York, N.Y.
15287	Scionics Corp.	Northridge, Cal.
15291	Adjustable Bushing Co.	N. Hollywood, Cal.
15558	Micron Electronics.	Garden City, Long Island, N.Y.
15566	Amprobe Inst. Corp.	Lynbrook, N.Y.
15631	Cabletronics	Costa Mesa, Cal.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Cal.
15801	Fenwal Elect. Inc.	Framingham, Mass.
15818	Ameico Inc.	Mountain View, Cal.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16179	Omni-Spectra Inc.	Detroit, Ill.
16352	Computer Diode Corp.	Lodi, N.J.
16554	Electroid Co.	Union, N.J.
16585	Boots Aircraft Nut Corp.	Pasadena, Cal.
16688	Ideal Prec. Meter Co., Inc., De Jur Meter Div.	Brooklyn, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Ind.
17109	Thermonetics Inc.	Canoga Park, Cal.
17474	Tranex Company	Mountain View, Cal.
17875	Hamlin Metal Products Corp.	Akron, Ohio
17745	Angstrohm Prec. Inc.	No. Hollywood, Cal
17856	Siliconix Inc.	Sunnyvale, Cal.
17870	McGraw-Edison Co.	Manchester, N.H.
18042	Power Design Pacific Inc.	Palo Alto, Cal.
18083	Clevite Corp. Semiconductor Div.	Palo Alto, Cal.
18324	Signetics Corp.	Sunnyvale, Cal.
18476	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
18486	TRW Elect. Comp. Div.	Des Plaines, Ill.
18565	Chomerics	Plainville, Mass.
18583	Curtis Instrument, Inc.	Mt. Kisco, N.Y.
18612	Vishay Instruments Inc.	Malvern, Pa.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
18911	Durant Mfg. Co.	Milwaukee, Wis.
19315	The Bendix Corp., Navigation & Control Div.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison	West Orange, N.J.
19589	Concoa	Baldwin Park, Cal.

*From: Handbook Supplements H4-1 Dated January 1970

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
19644	LRC Electronics	Horseheads, N.Y.
19701	Electra Mfg. Co.	Independence, Kansas
20183	General Atronics Corp.	Philadelphia, Pa.
21226	Executone, Inc.	Long Island City, N.Y.
21355	Fafnir Bearing Co., The	New Britian, Conn.
21520	Fansteel Metallurgical Corp.	N. Chicago, Ill.
23020	General Reed Co.	Metuchen, N.J.
23042	Texscan Corp.	Indianapolis, Ind.
23783	British Radio Electronics Ltd.	Washington, D.C.
24455	G.E. Lamp Division, Nela Park,	Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
24681	Memcor Inc., Comp. Div.	Huntington, Ind.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobert File Co. of America, Inc.	Carlstadt, N.J.
26851	Compac/Hollister Co.	Hollister, Cal.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Cal.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
30817	Instrument Specialties Co., Inc.	Little Falls, N.J.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Coil Products, Ltd.	Hawkesbury, Ontario, Canada
36287	Cunningham, W.H. & Hill, Ltd.	Toronto, Ontario, Canada
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
40931	Honeywell Inc.	Minneapolis, Minn.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
46384	Penn Eng. & Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer & Inst. Co.	Southampton, Pa.
49956	Microwave & Power Tube Div.	Waltham, Mass.
52090	Rowan Controller Co.	Westminster, Md.
52983	H P Co., Med. Elec. Div.	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Raytheon Co. Commercial Apparatus & System Div.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
56474	Superior Elect. Co.	Bristol, Conn.
59446	Telex Corp.	Tulsa, Okla.
59730	Thomas & Betts Co.	Elizabeth, N.J.
60741	Triplett Electrical Inst. Co.	Bluffton, Ohio
61775	Union Switch and Signal Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Inc. Weston-Newark	Newark, N.J.
66295	Wittek Mfg. Co.	Chicago, Ill.
66346	Minnesota Mining & Mfg. Co. Revere Mincom Div.	St. Paul, Minn.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control	New York, N.Y.
70318	Allmetal Screw Product Co., Inc.	Garden City, N.Y.
70417	Amplex, Div. of Chrysler Corp.	Detroit, Mich.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	Union City, N.J.
70674	ADC Products Inc.	Minneapolis, Minn.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electric Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71034	Billey Electric Co., Inc.	Erie, Pa.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincey, Mass.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionics Corp.	Cambridge, Mass.
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Cardwell Condenser Corp.	Lindenhurst, L.I., N.Y.
71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71447	Calif. Spring Co., Inc.	Pico-Rivera, Cal.
71450	CTS Corp.	Elkhart, Ind.
71468	ITT Cannon Electric Inc.	Los Angeles, Cal.
71471	Cinema, Div. Aerovox Corp.	Burbank, Cal.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	Cornish Wire Co., The	New York, N.Y.
71707	Coto Coil Co., Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	Indiana General Corp., Electronics Div.	Keasby, N.J.
72699	General Instrument Corp., Cap Division	Newark, N.J.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72962	Elastic Stop Nut Corp.	Union, N.J.
72964	Robert M. Hadley Co.	Los Angeles, Cal.
72982	Erie Technological Products, Inc.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Inst., Inc.	Fullerton, Cal.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Cal.
73445	Amperex Elect. Co.	Hicksville, L.I., N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73586	Circle F Mfg. Co.	Trenton, N.J.
73682	George K. Garrett Co., Div. MSL Industries, Inc.	Philadelphia, Pa.
73734	Federal Screw Products, Inc.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	General Industries Co., The	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Corp.	San Jose, Cal.
73957	Groove-Pin Corp.	Ridgefield, N.J.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74865	R.F. Products Division of Amphenol-Borg Electronic Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.,	Philadelphia, Pa.
75263	Keystone Carbon Co., Inc.	St. Marys, Pa.
75378	CTS Knights, Inc.	Sandwich, Ill.
75382	Kulka Electric Corp.	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Cal.
76433	General Instrument Corp., Micamold Division	Newark, N.J.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Cal.
76530	Cinch-Monadnock, Div. of United Carr Fastener Corp.	San Leandro, Cal.
76545	Mueller Electric Co.	Cleveland, Ohio
76703	National Union	Newark, N.J.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	The Bendix Corp., Electrodynamics Div.	N. Hollywood, Cal.
77075	Pacific Metals Co.	San Francisco, Cal.
77221	Phaostron Instrument and Electronic Co.	So. Pasadena, Cal.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine & Foundry Co. Potter & Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77638	General Instrument Corp., Rectifier Division	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Cal.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78277	Sigma	So. Braintree, Mass.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Cal.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	San Gabriel, Cal.
78947	Ucinite Co.	Newtonville, Mass.
79136	Waldes Kohinoor Inc.	Long Island City, N.Y.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80033	Preslole Corp.	Toledo, Ohio
80120	Schnitzer Alloy Products Co.	Elizabeth, N.J.
80131	Electronic Industries Association. Standard tube or semi-conductor device, any manufacturer.	
80207	Unimax Switch, Div. Maxon Electronics Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Inc.	Riverside, Cal.
80411	Arco Div. of Robertshaw Controls Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Label Co.	Monrovia, Cal.
80583	Hammarlund Co., Inc.	Mars Hill, N.C.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
80813	Dimco Gray Co.	Dayton, Ohio
81030	International Inst. Inc.	Orange, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Cal.
81312	Winchester Elec. Div. Litton Ind., Inc.	Oakville, Conn.
81349	Military Specification	
81483	International Rectifier Corp.	El Segundo, Cal.
81541	Airpax Electronics, Inc.	Cambridge, Maryland
81860	Barry Controls, Div. Barry Wright Corp.	Watertown, Mass.
82042	Carter Precision Electric Co.	Skokie, Ill.
82047	Sperti Faraday Inc., Copper Hewitt Electric Div.	Hoboken, N.J.
82116	Electric Regulator Corp.	Norwalk, Conn.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Fairchild Camera & Inst. Corp., Space & Defense Systems Div.	Paramus, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod., Inc. Electronic Tube Division	Emporium, Pa.
82376	Astron Corp.	East Newark, Harrison, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals & Controls Inc., Spencer Products	Attleboro, Mass.
82768	Phillips-Advance Control Co.	Joliet, Ill.
82866	Research Products Corp.	Madison, Wis.
82877	Rolton Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Cal.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	General Instrument Corp., Capacitor Div.	Darlington, S.C.
83148	ITT Wire and Cable Div.	Los Angeles, Cal.
83186	Victory Eng. Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83324	Rosan Inc.	Newport Beach, Cal.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83332	Tech Labs	Palisades Park, N.J.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Union Carbide Corp., Consumer Prod. Div.	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
83942	Aeronautical Inst. & Radio Co.	Lodi, N.J.
84171	Arco Electronics Inc.	Great Neck, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Cal.
84411	TRW Capacitor Div.	Ogallala, Neb.

From: Handbook Supplements
H4-1 Dated January 1970

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
84870	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A.B. Boyd Co.	San Francisco, Cal.
85474	R.M. Bracamonte & Co.	San Francisco, Cal.
85660	Koiled Kords, Inc.	Hamden, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86174	Fafnir Bearing Co.	Los Angeles, Calif.
86197	Clifton Precision Products Co., Inc.	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America Electronic Comp. & Devices Division	Harrison, N.J.
86928	Seastrom Mfg. Co.	Glendale, Cal.
87034	Marco Industries	Anaheim, Cal.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Cal.
87664	Van Waters & Rogers Inc.	San Francisco, Cal.
87930	Tower Mfg. Corp.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Cal.
89473	G.E. Distributing Corp.	Schenectady, N.Y.
89479	Security Co.	Detroit, Mich.
89665	United Transformer Co.	Chicago, Ill.
90030	United Shoe Machinery Corp.	Beverly, Mass.
90179	U.S. Rubber Co., Consumer Ind. & Plastics Prod. Div.	Passaic, N.J.
90365	Belleville Speciality Tool Mfg., Inc.	Belleville, Ill.
90763	United Carr Fastener Corp.	Chicago, Ill.
90970	Bearing Engineering Co.	San Francisco, Cal.
91146	ITT Cannon Elect. Inc., Salem Div.	Salem, Mass.
91260	Connor Spring Mfg. Co.	San Francisco, Cal.
91345	Miller Dial & Nameplate Co.	El Monte, Cal.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Willow Grove, Pa.
91673	Epiphone Inc.	New York, N.Y.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Cal.
91886	Malco Mfg., Inc.	Chicago, Ill.
91929	Honeywell Inc., Micro Switch Division	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Cal.
92180	Tru-Connector Corp.	Peabody, Mass.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tensolite Insulated Wire Co., Inc.	Tarrytown, N.Y.
92702	IMC Magnetics Corp.	Westbury, L.I., N.Y.
92966	Hudson Lamp Co.	Kearney, N.J.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins & Myers Inc.	Palisades Park, N.J.
93410	Stemco Controls, Div. of Essex Wire Corp.	Mansfield, Ohio
93632	Waters Mfg. Co.	Culver City, Cal.
93929	G.V. Controls	Livingston, N.J.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.
94148	Scientific Electronics Products Inc.	Loveland, Colo.
94154	Wagner Elect. Corp., Tung-Sol Div.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Patterson, N.J.
94222	South Chester Corp.	Chester, Pa.
94330	Wire Cloth Products, Inc.	Bellwood, Ill.
94375	Automatic Metal Products Co.	Brooklyn, N.Y.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
94696	Magnecraft Electric Co.	Chicago, Ill.
95023	George A. Philbrick Researchers, Inc.	Boston, Mass.
95146	Alco Elect. Mfg. Co.	Lawrence, Mass.
95236	Allies Products Corp.	Diania, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	Long Island, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Rolling Meadows, Ill.
95566	Arnold Engineering Co.	Marengo, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95984	Siemon Mfg. Co.	Wayne, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Microwave Assoc., West, Inc.	Sunnyvale, Cal.
96095	Hi-Q Div. of Aerovox Corp.	Olean, N.Y.
96256	Thordarson-Meissner Inc.	Mt. Carmel, Ill.
96296	Solar Mfg. Corp.	Los Angeles, Cal.
96396	Microswitch, Div. of Minn.-Honeywell	Freeport, Ill.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96801	Excel Transformer Co.	Oakland, Cal.
96508	Xcelite, Inc.	Orchard Park, N.Y.
96733	SanFernando Elec. Mfg. Co.	San Fernando, Cal.
96881	Thomson Ind. Inc.	Long Island, N.Y.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic & Precision Mfg.	Englewood, N.J.
97979	Reon Resistor Corp.	Yonkers, N.Y.
97983	Litton System Inc., Adler-Westrex Commun. Div.	New Rochelle, N.Y.
98141	R-Tronics, Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Cal.
98220	Hewlett-Packard Co., Medical Elec. Div.	Pasadena, Cal.
98278	Microdot, Inc.	So. Pasadena, Cal.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98376	Zero Mfg. Co.	Burbank, Cal.
98410	Etc Inc.	Cleveland, Ohio
98731	General Mills Inc., Electronics Div.	Minneapolis, Minn.
98734	Paeco Division of Hewlett-Packard Co.	Palo Alto, Cal.
98821	North Hills Electronics, Inc.	Glen Cove, N.Y.
98978	International Electronic Research Corp.	Burbank, Cal.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Cal.
99378	Atlee Corp.	Winchester, Mass.
99515	Marshall Ind., Capacitor Div.	Monrovia, Cal.
99707	Control Switch Division, Controls Co. of America	El Segundo, Cal.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99928	Branson Corp.	Whippany, N.J.
99934	Rembrandt, Inc.	Boston, Mass.
99942	Hoffman Electronics Corp., Semiconductor Division	El Monte, Cal.
99957	Technology-Instrument Corp. of California	Newbury Park, Cal.

The following HP Vendors have no number assigned in the latest supplement to the Federal Supply Code for Manufacturers Handbook.

0000F	Malco Tool and Die	Los Angeles, Calif.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AB	ETA	England
000BB	Precision Instrument Comp. Co.	Van Nuys, Cal.
000CS	Hewlett-Packard Co., Colorado Springs Div.	Colorado Springs, Colorado
000MM	Rubber Eng. & Development	Hayward, Cal.
000NN	A "N" D Mfg. Co.	San Jose, Cal.
000QQ	Cooltron	Oakland, Cal.
000WW	California Eastern Lab	Burlington, Cal.
000YY	S.K. Smith Co.	Los Angeles, Cal.

MANUAL

CHANGES

MANUAL BACKDATING CHANGES

MODEL 3443A

HIGH GAIN/AUTO RANGE UNIT

Manual Serial Prefixed: 819-
-hp- Part No. 03443-90004

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
417-	1 thru 7
444-03425 and below	2 thru 7
819-03725 and below	3 thru 7
819-04325 and below	4 thru 7
819-04625 and below	5 thru 7
819-04750 and below	6, 7
819-04800 and below	7

CHANGE 1

Table of Replaceable Parts:
A1R74 and A1R77 changed from 0683-1045, 100 kΩ to 0683-1835, 18-kΩ.
[illegible]6 changed from 1251-0393 to 1251-1025.
New parts are recommended replacement in all instruments.

Schematic Diagram Figure 6-6:
A1R74 and A1R77 changed from 100 kΩ to 18 kΩ.

CHANGE 2

Schematic Diagrams and Table of Replaceable Parts:
A1R61 changed from 0683-4335, 43 kΩ to 0683-3035, 30 kΩ.
A2C11 changed from 0180-0269, 1.0 μF to 0180-0089, 10 μF.
New parts are recommended replacement in all instruments.

CHANGE 3

Schematic Diagram, Figure 6-4:
A2CR24 added between ⏚ and ▽.

Table of Replaceable Parts:
A2Q2 changed from 1854-0029 to 1854-0087.
A2CR24, 1902-3002, added.
New parts are recommended replacement for all instruments.

Manual Backdating Changes Model 3443A Page 2

CHANGE 4

Schematic Diagram, Figure 6-4, and Table of Replaceable Parts:
A2K5 changed from 0490-0138 to 0490-0817.
A2R49 changed from 0683-1225, 1200 Ω to 0683-8215, 820 Ω.
If A2K5 is replaced in instruments Serial No. 819-04325 and below, Part No. 0490-0817 should be used and A2R49 changed to 820 Ω.

CHANGE 5

Schematic Diagram, Figure 6-6, and Table of Replaceable Parts:
A1R32 changed from 0683-1045, 100 kΩ to 0683-3945, 390 kΩ.
New part is recommended replacement in all instruments.

CHANGE 6

Table of Replaceable Parts:
A2Q6, A2Q7 changed from 1854-0029 to 1854-0033.
New part is recommended replacement in all instruments.

CHANGE 7

Table of Replaceable Parts:
Coil for A2K5 changed from 9161-0013 to 9160-0091.
New part is recommended replacement in all instruments.

MANUAL CHANGES

MODEL 3443A

HIGH GAIN/AUTO RANGE UNIT

Manual Serial Prefixed: 444-
-hp- Part No. 03443-90003

► New or Revised Item

Instrument Serial Number	Make Manual Changes
ERRATA	ALL
444-03426 and up	1
819-03726 and up	1, 2
819-04326 and up	1, 2, 3
819-04626 and up	1 thru 4
819-04751 and up	1 thru 5
819-04801 and up	1 thru 6
819-05001 and up	1 thru 7

ERRATA

Page 4-7, Paragraph 4-45:
Delete A1K3 from first sentence.

Page 5-9, Paragraph 5-57e:
Change A2Ky to A2K7.

Page 5-13, Table 5-8:
Change Matrix Relay for 10 V range from A2K7 to A2K8.

Page 6-3, Figure 6-1:
Change destination of J6 pin 11 to A2 pin 14.
Change destination of P6 pin 25 to A2K8.

Page 6-4, Figure 6-2:
Change destination of A2 pin 5 to P6 pin 7.

Page 6-5, Figure 6-4, A2 Amplifier Assembly Schematic:
In RELAY STATES Table, change 10 V relay A2K7 to A2K8.
Change A2R11 to 470 kΩ.

Page 6-6, Figure 6-5:
In RELAY STATES Table, change 10 V relay A2K7 to A2K8.

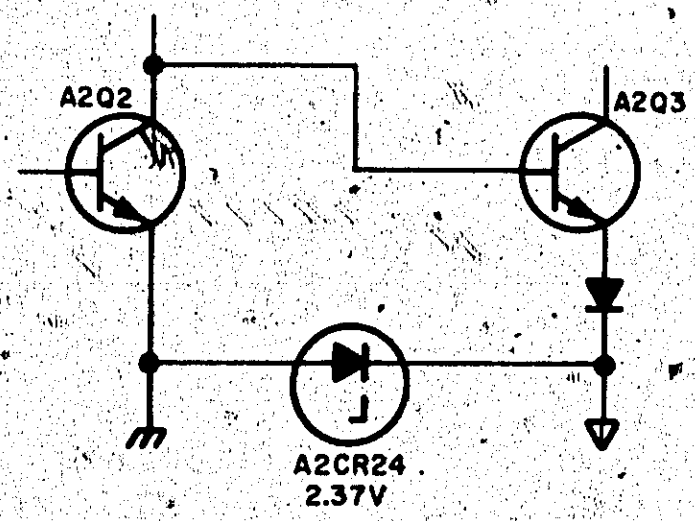
Page 6-7, Figure 6-6, A1 Parts Location Diagram:
Interchange locations of A1R80 and A1R81.

Page 6-7, A1 Ranging Assembly Schematic:
Change A1R37 at $\overline{Y}$ input of AG3 to A1R38, 510 kΩ.
Change A1R16 to 180 Ω.
Change A1R72 to 100 kΩ.
Change A1R29 to 100 kΩ.
Change A1R61 to A1R81.

ERRATA (Cont'd) Section VII, Replaceable Parts:
Change -hp- Part No. of A1C18 to 0140-0208.
Change value of A1R8 to 9100 Ω.
Change A1R41 to R: fxd comp 43 kΩ ± 5% 1/4 W -hp- Part No. 0683-4335.
Change A1R79 to R: fxd comp 47 kΩ ± 5% 1/4 W -hp- Part No. 0683-4725.
Change -hp- Part No. of A2CR4 to 1901-0025.
Change -hp- Part No. of A2Q5 to 1850-0062.
Change value of A2R21 to 3300 Ω.
Change value of A2R30 and A2R36 to 9100 Ω.

CHANGE 1 Section VI, Maintenance and Section VII, Replaceable Parts:
Change A1R61 to R: fxd 30 kΩ ± 5% 1/4 W -hp- Part No. 0683-3035.
Change A2C11 to C: fxd 10 μF -hp- Part No. 0180-0089.

CHANGE 2 Section VII, Replaceable Parts and Section VI, Circuit Diagrams:
Change A2Q2 to TSTR: NPN 2N3417 -hp- Part No. 1854-0087.
Add A2CR24, Diode: breakdown 2.37 V -hp- Part No. 1902-3002. Figure below shows connection of A2CR24.



CHANGE 3

Page 6-7, Figure 6-6:
Change value of A2R49 to 820 Ω.

Page 7-4, Replaceable Parts:
Change -hp- Part No. of A2K5 to 0490-0817.

Page 7-5, Replaceable Parts:
Change A2R49 to -hp- Part No. 0683-8215 820 Ω.

Note: Above parts are recommended replacement for all instruments. If A2K5 is replaced with Part No. 0490-0817 in instruments prior to Serial No. 819-04326, A2R49 must be replaced with 820 Ω resistor.

CHANGE 4

This change has been factory installed on instruments with serial number 819-04626 and up except the following:

819-04630	819-04649
819-04631	819-04650
819-04634	819-04656
819-04635	819-04657
819-04636	819-04659
819-04637	819-04661
819-04638	819-04666
819-04640	819-04670
819-04641	819-04671
819-04643	819-04673
819-04647	

Page 6-7, Figure 6-6:
Change value of A1R32 to 390 kΩ.

Page 7-3, Table 7-1:
Change A1R32 to -hp- Part No. 0683-3945 R: fxd comp 100 kΩ ±5% 1/4 W.

This part is recommended replacement in all instruments.

CHANGE 5

Page 7-4, Replaceable Parts:
Change A2Q6, Q7 to Part No. 1854-0033, TSTR: Si NPN 2N3391

This part is recommended replacement in all instruments.

CHANGE 6

Page 7-4, Replaceable Parts:
Change -hp- Part No. of coil (on line below A2K8) from 9160-0013 to 9161-0013 and delete A2K5 from description.

Add -hp- Part No. 9160-0091, coil: electromagnetic (A2K5). This part has been changed to correct for marginal operation under high temperature and is the recommended replacement part for all instruments.

► CHANGE 7

Page 7-2, Replaceable Parts:
Change A1Q2 and A1Q7 to -hp- Part No. 1853-0067, TSTR: Si
Recommended replacement for all instruments.

SERVICE NOTES

HEWLETT hp PACKARD

SERVICE NOTE

3442A-1A
3443A-1A

(OBSOLETES P0490-0096)

-hp- MODEL 3442A AUTOMATIC RANGE SELECTOR
(Serial Numbers Below 440-01141)

and

-hp- MODEL 3443A HIGH GAIN/AUTO RANGE UNIT
(Serial Numbers Below 444-00526)

The preferred replacement part for reed relays A1K1 in the 3442A and A2K8 in the 3443A is -hp- Part No. 0490-0096. The replacement relay is a pressurized hydrogen type which is a direct replacement for all Hewlett-Packard instruments except the -hp- Model 3442A. This substitution for the original Part No. 0490-0049 relay (an evacuated atmosphere type) is made to obtain longer life. Substitution should be made only if a failure occurs.

For installation in the -hp- Model 3442A, a minor modification must be made. The modification consists of crimping the end of the round mounting extension for approximately 1/8" (0.3 cm), as in Figure 1, to allow the relay to fit between the mounting brackets.

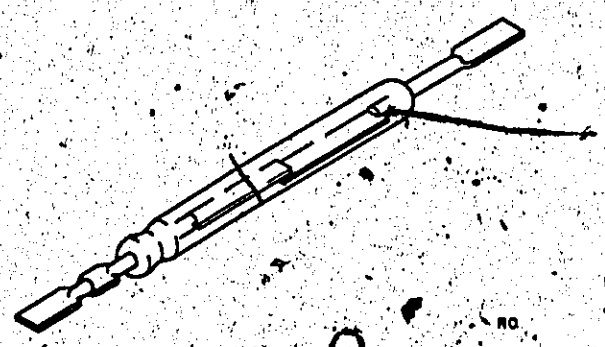


Figure 1

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nted in U.S.A.

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SERVICE NOTE

3443A-2

-hp- Model 3443A High Gain/Auto Range Unit
Serial Number 444-03425 and below

MODIFICATIONS TO ELIMINATE ZERO OFFSET AND FALSE AUTO RANGING

Zero offset problems with the Hewlett-Packard Model 3443A can be eliminated by replacing A2C11 (-hp- Part No. 0180-0269) with a 10 μf capacitor (-hp- Part No. 0180-0089). This will more effectively filter the chopper driver ripple which may appear at the anode of A2CR3, causing the offset.

To eliminate false auto ranging, which may occur at low line voltages with no input, replace (-hp- Part No. 0683-4335) with a 30 kΩ resistor (-hp- Part No. 0683-3035).

These replacements can be made directly with no other circuit modifications; however, the modifications are not necessary unless the symptoms described are being experienced.

Change the schematic diagram and Parts List in your Operating and Service Manual to reflect these modifications.

These modifications are incorporated, during manufacture, in all -hp- Model 3443A's with serial number 444-03426 and above.

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SERVICE NOTE

3443A-3

-hp- Model 3443A High Gain Auto Range Unit
(Serial Number 444-03725 and below)

MODIFICATION TO ELIMINATE COMPONENT FAILURES WHILE AUTORANGING WITH HIGH INPUT VOLTAGES

When the 3443A is used to measure very large and very small voltages in the autorange mode, transients may occur which weaken and eventually destroy A2Q2 and A2Q3. This effect is particularly troublesome when the instrument is used with a scanner, which alternately applies voltages near zero and voltages near 1000 volts.

To guard against the effects described above, make the following modifications:

1. Replace A2Q2 with -hp- Part No. 1854-0087.
2. Add CR24 (-hp- Part No. 1902-3002), between the emitter of A2Q2 (signal common) and instrument common. Mount CR24 directly on the circuit side of the A2 board as shown in Figure 1.

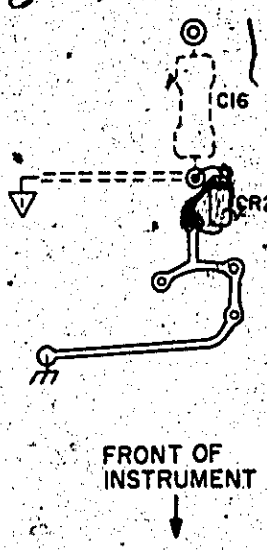

Figure 1. Section of Circuit Side of A2 Board.

3. Recalibrate the instrument.

The new diode (CR27) will eliminate high voltage spikes between signal common and instrument common, while the replacement for A2Q2 has higher breakdown voltage ratings.

This modification should be made only if the problems described above occur. Change your Operating and Service Manual schematic diagram and parts list to reflect these changes

March 1968-9

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