Model IT-1121 Semiconductor Curve Tracer

HEATH COMPANY • BENTON HARBOR, MICHIGAN

MODEL IT-1121 Semiconductor Curve Tracer

HEATHKIT®

ASSEMBLY MANUAL

HEATHKIT

Price $2.00

595-1565-03

HEATH COMPANY PHONE DIRECTORY

The following telephone numbers are direct lines to the departments listed:

Kit orders and delivery information .... (616) 982-3411
Credit .... (616) 982-3561
Replacement Parts .... (616) 982-3571
Technical Assistance:
R/C, Audio, and Electronic Organs .... (616) 982-3310
Amateur Radio .... (616) 982-3296
Test Equipment, Strobe Lights, Calculators,
Clocks, Weather Instruments .... (616) 982-3315
Television .... (616) 982-3307
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YOUR HEATHKIT 90-DAY FULL WARRANTY

During your first ninety (90) days of ownership, Heath Company will replace or repair free of charge — as soon as practical — any parts which are defective, either in materials or workmanship. You can obtain parts directly from Heath Company by writing us or telephoning us at (616) 982-3571. And we'll pay shipping charges to get those parts to you — anywhere in the world.

We warrant that, during the first ninety (90) days of ownership, our products, when correctly assembled, calibrated, adjusted, and used in accordance with our printed instructions, will meet published specifications.

If a defective part or error in design has caused your Heathkit product to malfunction during the warranty period, through no fault of yours, we will service it free upon delivery at your expense to the Heath factory, Benton Harbor, Michigan, or to any Heathkit Electronic Center (units of Schlumberger Products Corporation), or through any of our authorized overseas distributors.

You will receive free consultation on any problem you might encounter in the assembly or use of your Heathkit product. Just drop us a line or give us a call. Sorry, we cannot accept collect calls.

Our warranty, both express and implied, does not cover damage caused by use of corrosive solder, defective tools, incorrect assembly, misuse, fire, customer-made modifications, flood or acts of God, nor does it include re-imbursement for customer assembly or set-up time. The warranty covers only Heath products and is not extended to non-Heath allied equipment or components used in conjunction with our products or uses of our products for purposes other than as advertised.

And if you are dissatisfied with our service — warranty or otherwise — or our products, write directly to our Director of Customer Services, Heath Company, Benton Harbor, Michigan, 49022. Telephone (616) 982-3524. He'll make certain your problems receive immediate, personal attention.

HEATH COMPANY
BENTON HARBOR, MI. 49022

Prices and specifications subject to change without notice.

Assembly

and

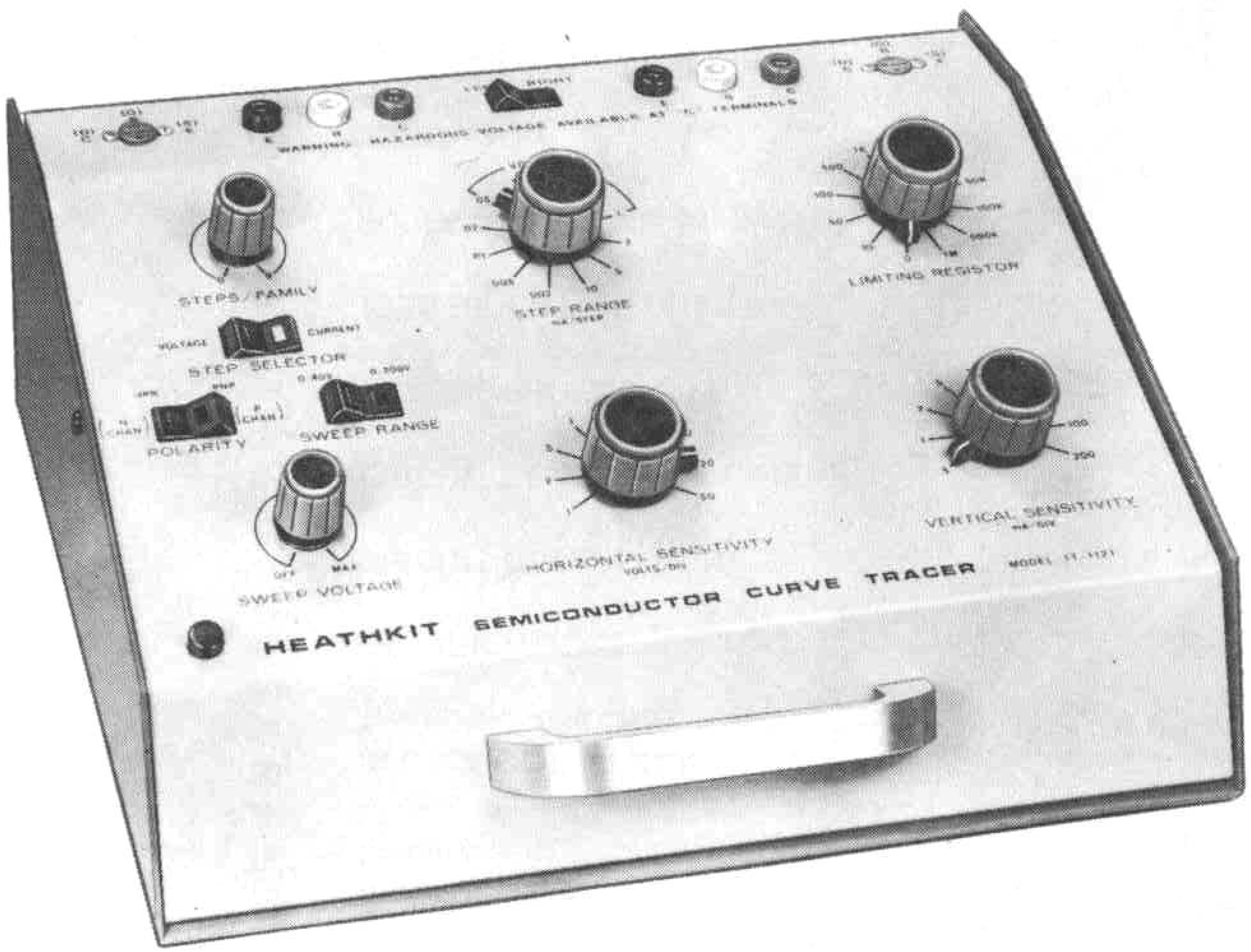
Operation

of the

HEATHKIT

SEMICONDUCTOR CURVE TRACER

MODEL IT-1121



HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

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INTRODUCTION

The Model IT-1121 Heathkit Semiconductor Curve Tracer is a versatile and sophisticated instrument. It accurately measures the operating parameters of virtually all types of discrete semiconductors – gain (beta), leakage, breakdown voltage, saturation, forward conduction voltage, output admittance, linearity, capacitance effects, temperature effects, etc. The Curve Tracer also can be used to select devices for specific design applications; for sorting, inspecting, and testing semiconductors; and for troubleshooting.

Any oscilloscope with horizontal sensitivity of .5 volt/division and vertical sensitivity of 1 volt/division can be used with the Curve Tracer. Connecting the Curve Tracer to the oscilloscope is easy with the plug-in cables supplied, and a calibration switch permits fast and accurate oscilloscope calibration.

The following features make the Curve Tracer very versatile:

- Accurate current steps from 2 μA/step to 10 mA/step in a 1, 2, 5 sequence – the steps are variable from 0 to 9.
- Accurate voltage steps from .05 volt/step to 1 volt/step in a 1, 2, 5 sequence – the steps are variable from 0 to 9.
- Two-range sweep supply – 0 to 40 volts at currents up to 1 ampere, and 0 to 200 volts at currents up to 200 milliamperes.
- Monitored sweep voltage can be displayed from .1 volt/division to 50 volts/division in a 1, 2, 5 sequence.
- Monitored sweep current – from .5 mA/division to 200 mA/division in a 1, 2, 5 sequence.
- Switch selectable NPN (N channel) or PNP (P channel) testing.
- Eleven current limiting resistors from 10 Ω to 1 MΩ to protect the device being tested.
- Many internal protection devices to protect the Curve Tracer and components being tested from improper operation.

Low profile styling and the sloped front panel permit the Curve Tracer to set in front of most oscilloscopes without blocking the CRT. A convenient handle provides portability, and extra leads (included) allow you to test large devices or make in-circuit tests. The versatility, accuracy, and reliability of this test instrument make it a valuable addition to your work bench for years to come.

Refer to the "Kit Builders Guide" for complete information on unpacking, parts identification, tools, wiring, soldering, and step-by-step assembly procedures.

PARTS LIST

Check each part against the following list. Make a check (✓) in the space provided as each part is identified. Any part that is packed in an individual envelope with the part number on it should be placed back in the envelope after you identify it until it is called for in a step. Do not throw away any packing materials until all parts are accounted for.

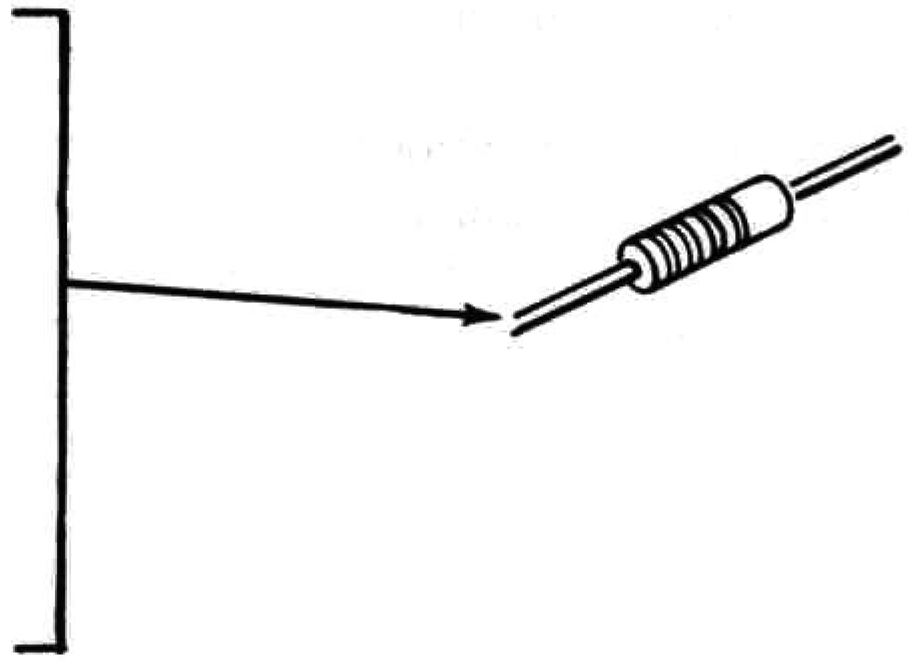
To order a replacement part, use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to "Replacement Parts" inside the rear cover of the Manual. For pricing information, refer to the separate "Heath Parts Price List."

	PARTS Per Kit	DESCRIPTION	PART No.	CIRCUIT Component No.

RESISTORS, 1/2-Watt 10%

NOTE: 10% resistors have a fourth color band of silver.

( )	2	2700 Ω (red-violet-red)	1-13	R43, 44
( )	8	10 kΩ (brown-black-orange)	1-20	R4, 39, 41, 42, 57, 71, 62, 66
( )	9	27 kΩ (red-violet-orange)	1-23	R58, 59, 63, 64, 67, 68, 72, 73, 95
( )	7	100 kΩ (brown-black-yellow)	1-26	R2, 3, 22, 23, 28, 45, 105
( )	2	1 MΩ (brown-black-green)	1-35	R24, 25

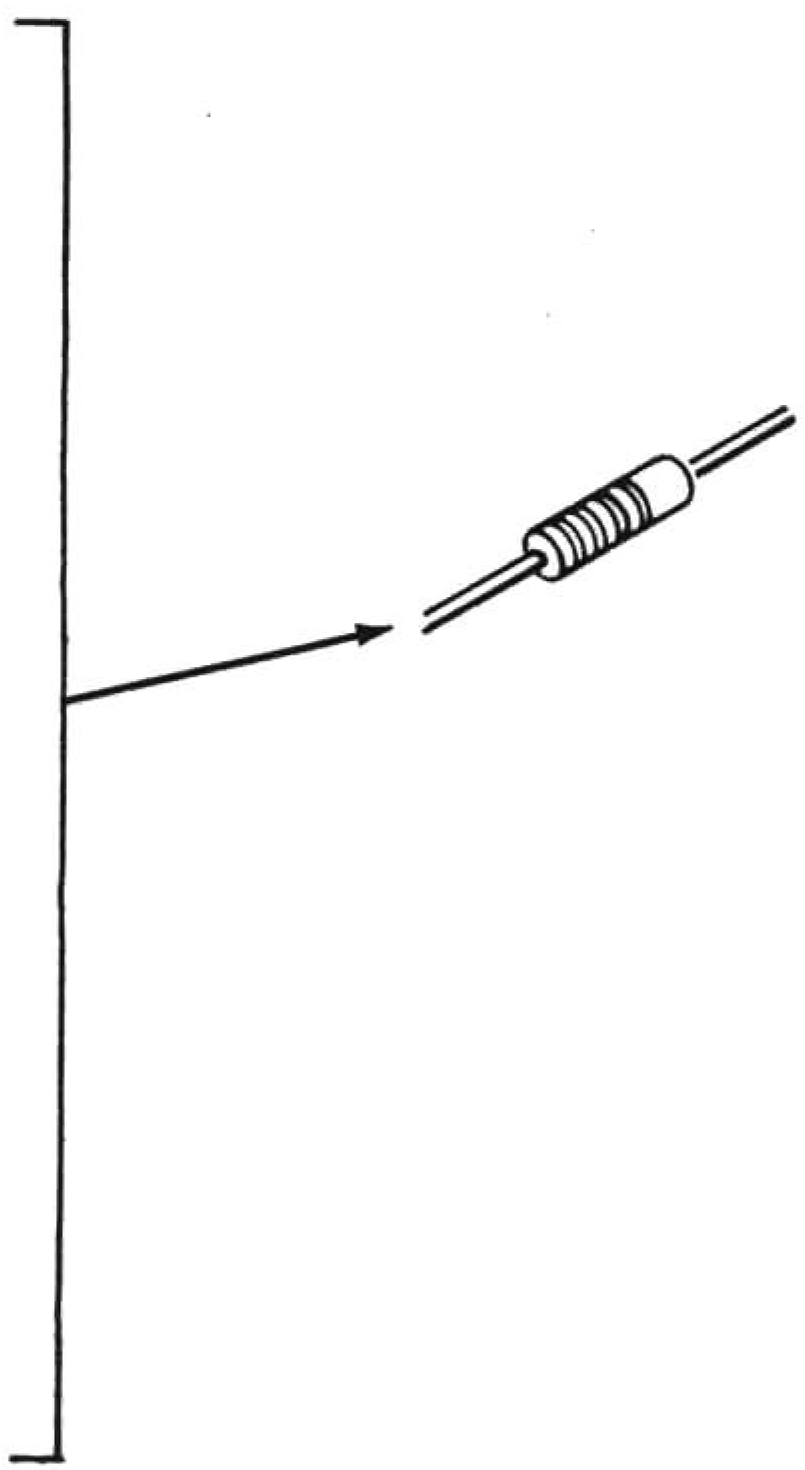


PARTS Per Kit	DESCRIPTION	PART No.	CIRCUIT Component No.

5%

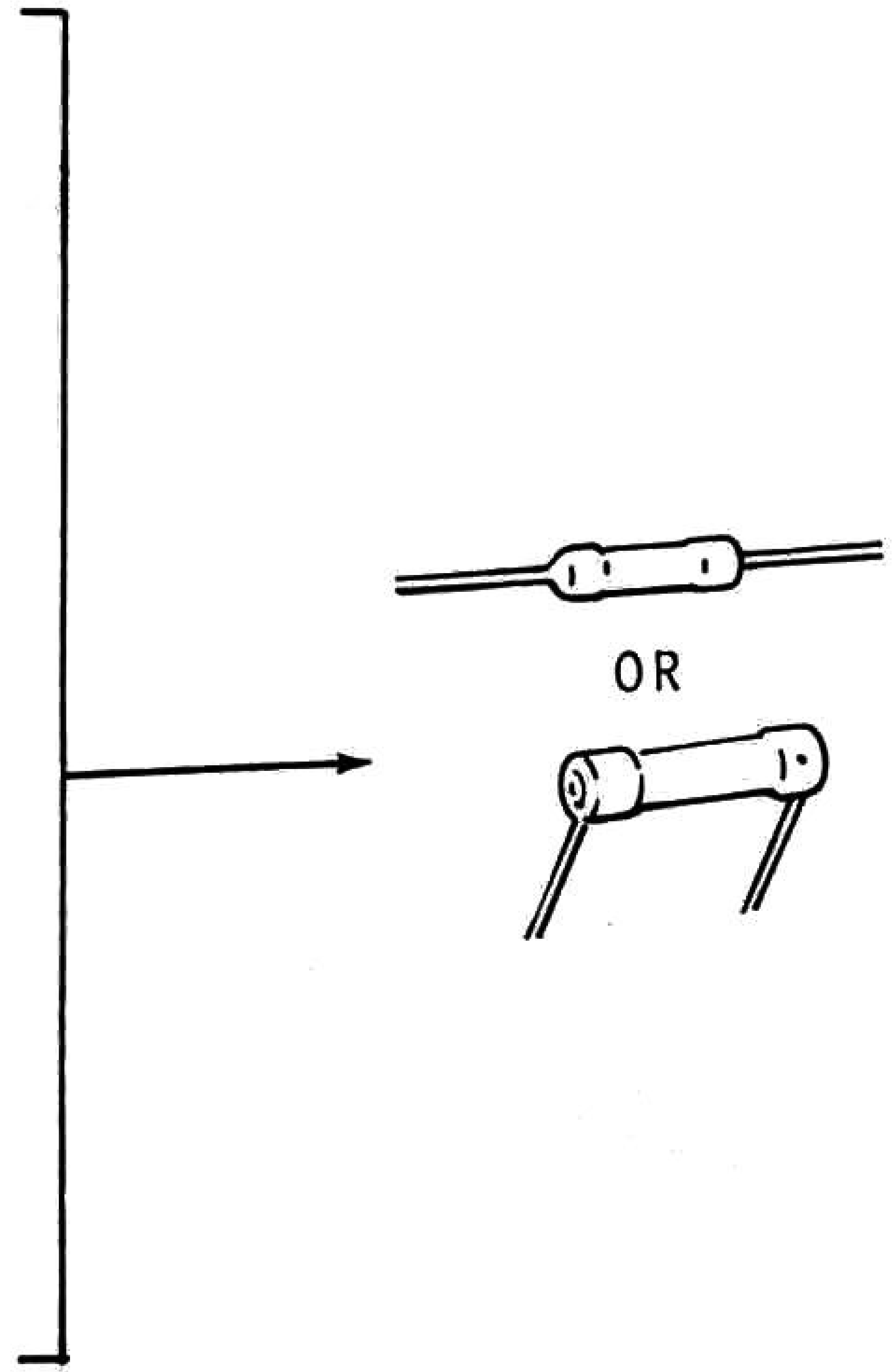
NOTE: 5% resistors have a fourth color band of gold.

	PARTS Per Kit	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	56 Ω (green-blue-black)	1-83	R38
( )	2	180 Ω (brown-gray-brown)	1-112	R11, 74
( )	3	360 Ω (orange-blue-brown)	1-5	R36, 37, 69
( )	2	750 Ω (violet-green-brown)	1-96	R65, 85
( )	1	1500 Ω (brown-green-red)	1-81	R61
( )	3	62 kΩ (blue-red-orange)	1-128	R1, 7, 30
( )	1	82 kΩ (gray-red-orange)	1-159	R32
( )	1	1.2 MΩ (brown-red-green)	1-184	R48
( )	2	2.4 MΩ (red-yellow-green)	1-183	R46, 49
( )	1	5.1 MΩ (green-brown-green)	1-182	R51
)	1	10 MΩ (brown-black-blue)	1-166	R52



1%

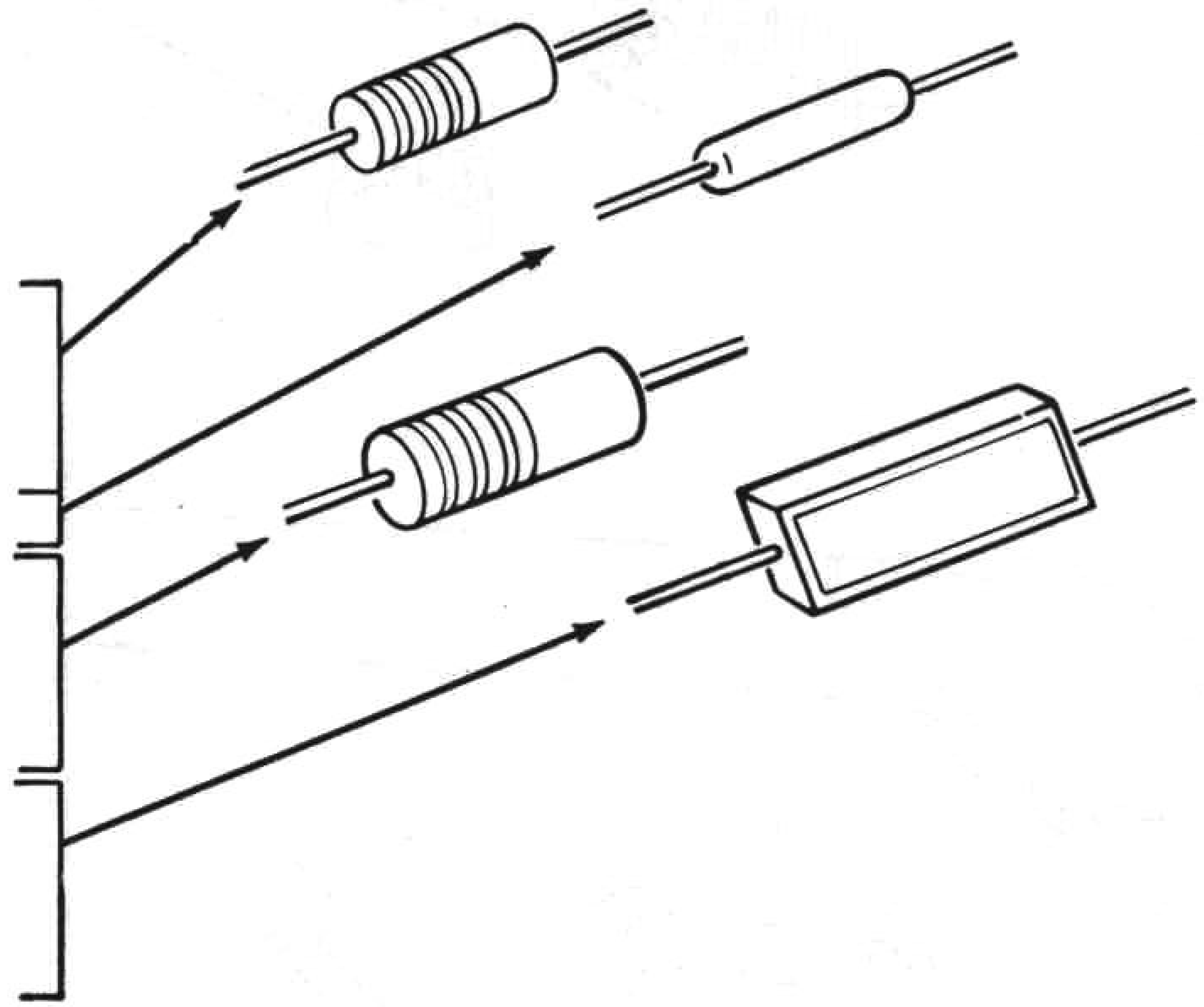
	PARTS Per Kit	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	2	10 Ω	2-131	R99, 101
( )	3	100 Ω	2-159	R94, 97, 98
( )	1	200 Ω	2-83	R93
( )	1	250 Ω	2-140	R76
( )	2	500 Ω	2-292	R77, 92
( )	2	1000 Ω (1 k)	2-58	R78, 91
( )	1	2500 Ω (2.5 k)	2-249	R79
( )	1	5000 Ω (5 k)	2-247	R75
( )	1	10 kΩ	2-50	R56
( )	6	20 kΩ	2-38	R33, 55, 81, 82, 83, 96
( )	1	30 kΩ	2-201	R31
( )	1	40 kΩ	2-202	R54
( )	2	50 kΩ	2-99	R29, 89
( )	1	80 kΩ	2-124	R53
( )	3	100 kΩ	2-11	R35, 88, 104
( )	1	200 kΩ	2-54	R87
( )	1	400 kΩ	2-138	R34
( )	1	500 kΩ	2-76	R86
( )	1	900 kΩ	2-51	R26
( )	1	1 MΩ	2-14	R106
( )	1	9 MΩ	2-52	R27



PARTS Per Kit		DESCRIPTION	PART No.	CIRCUIT Component No.

Other

( )	1	.51 Ω, 1-watt (green-brown-silver)	3-6-2	R8
( )	1	2.2 Ω, 1-watt (red-red-gold)	3-5-2	R9
( )	2	1 Ω, 1-watt, .5%	2-46-1	R102, 103
( )	2	10 kΩ, 2-watt (brown-black-orange)	1-3-2	R19, 21
( )	1	15 kΩ, 2-watt (brown-green-orange)	1-4-2	R13
( )	1	10 Ω, 5-watt	3-33-5	R14
( )	1	680 Ω, 5-watt	3-34-5	R12
( )	2	100 Ω, 7-watt	3-9-7	R15, 16
( )	2	500 Ω, 10-watt	3-12-10	R17, R18



CAPACITORS

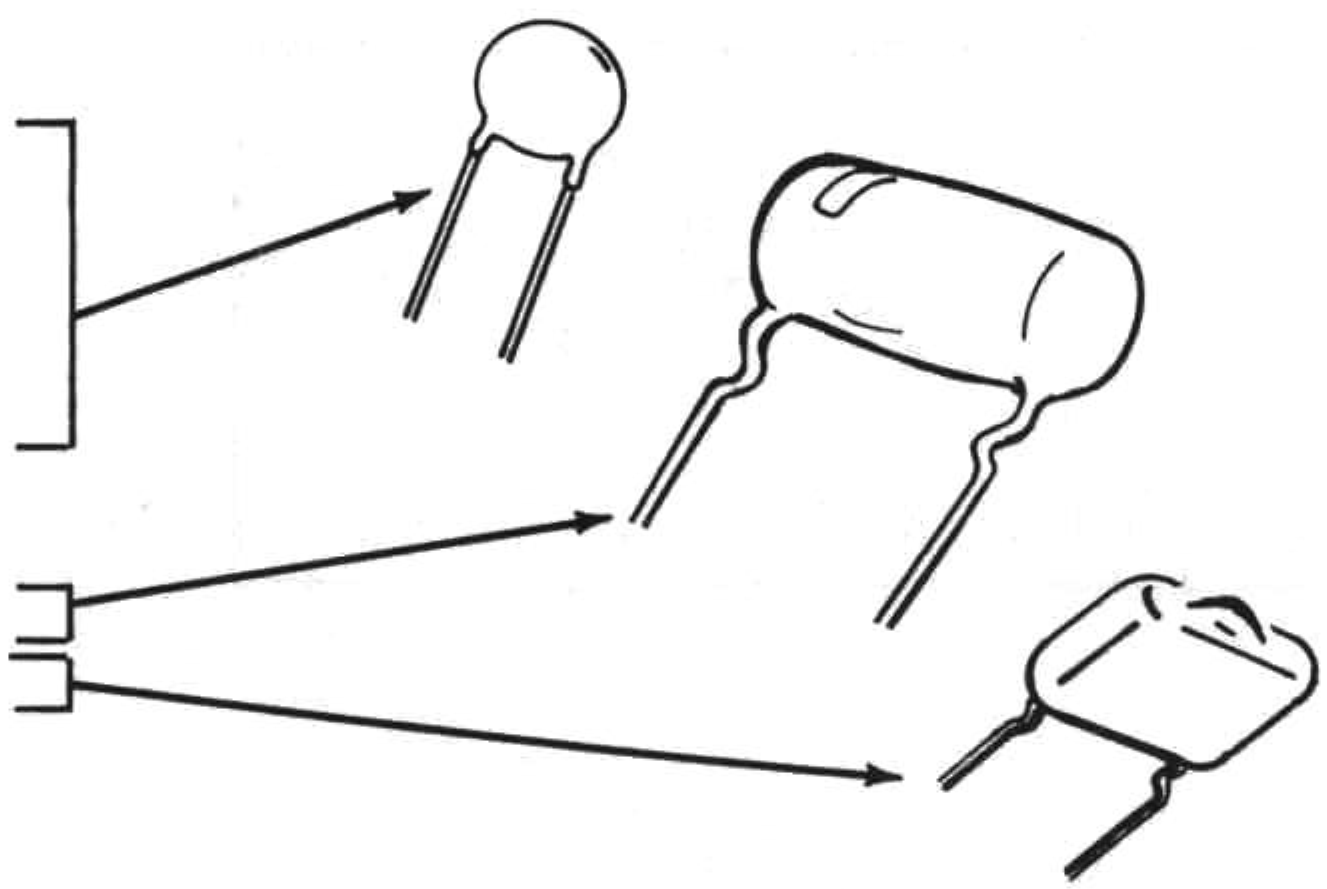
Disc

( )	1	20 pF disc	21-5	C15
( )	1	.001 μF disc	21-140	C17
( )	1	.0033 μF disc	21-141	C1
( )	1	.01 μF disc	21-47	C4
( )	1	.05 μF disc	21-48	C16

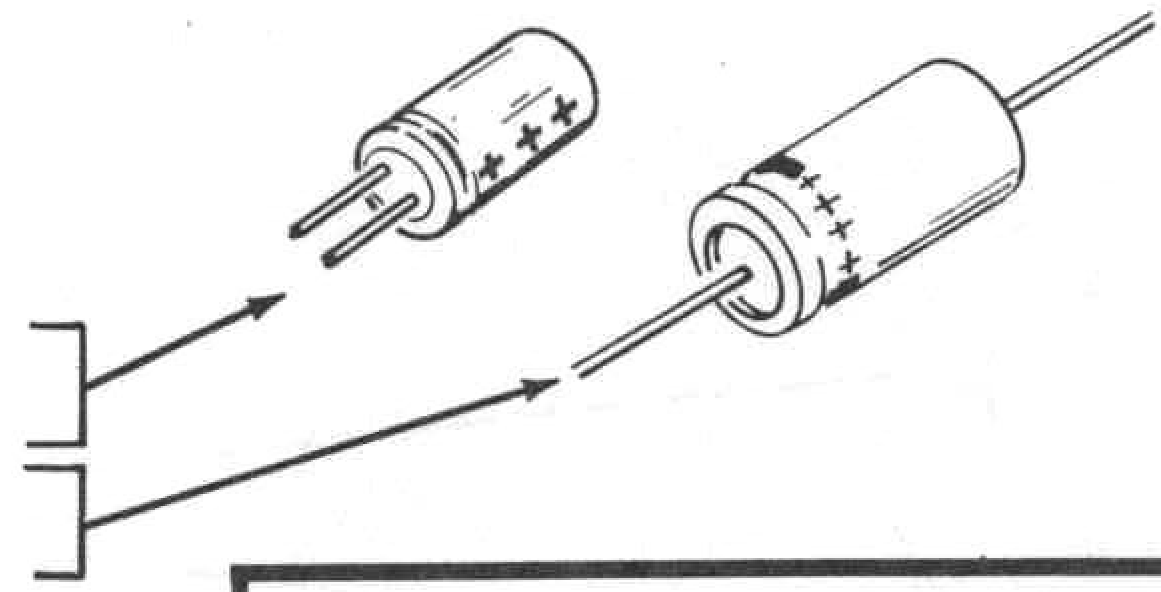
Mylar*

( )	1	.22 μF	27-114	C3
( )	1	.47 μF	27-61	C2

*DuPont registered trademark.

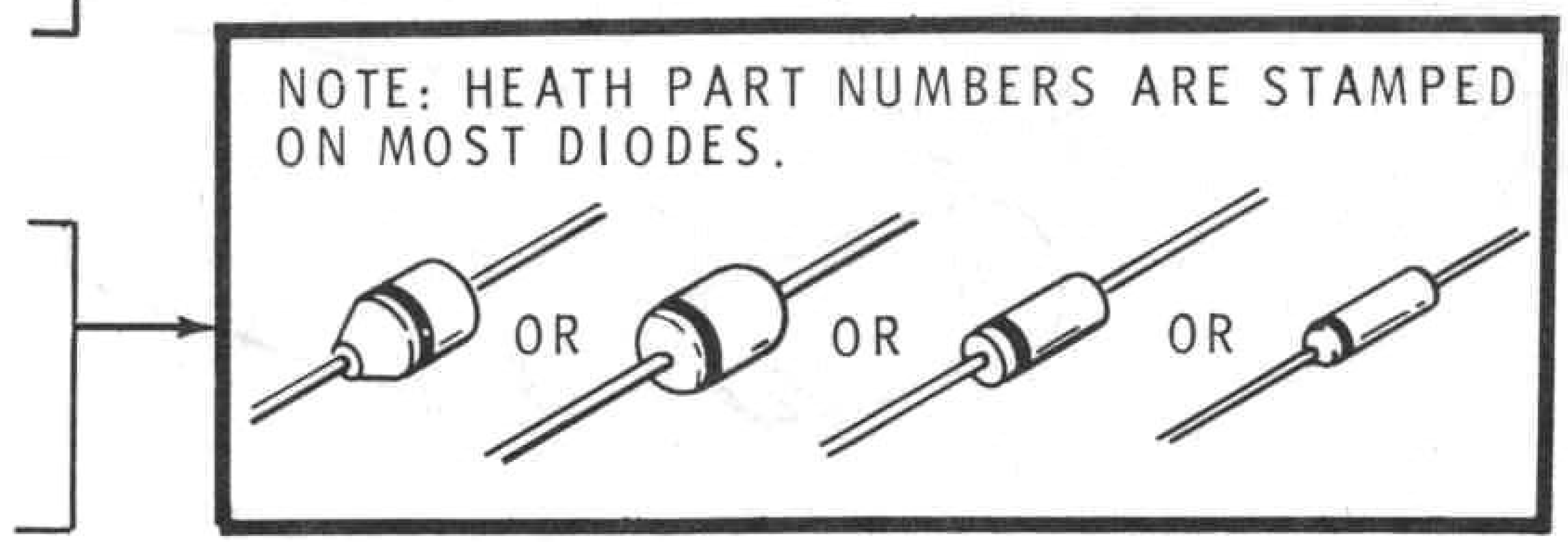


	PARTS Per Kit	DESCRIPTION	PART No.	CIRCUIT Component No.
Electrolytic				
( )	4	10 μF electrolytic	25-257	C11, 12, 13, 14
( )	1	100 μF electrolytic	25-117	C7
( )	2	50 μF electrolytic	25-250	C6, 9
( )	2	200 μF electrolytic	25-104	C5, 8



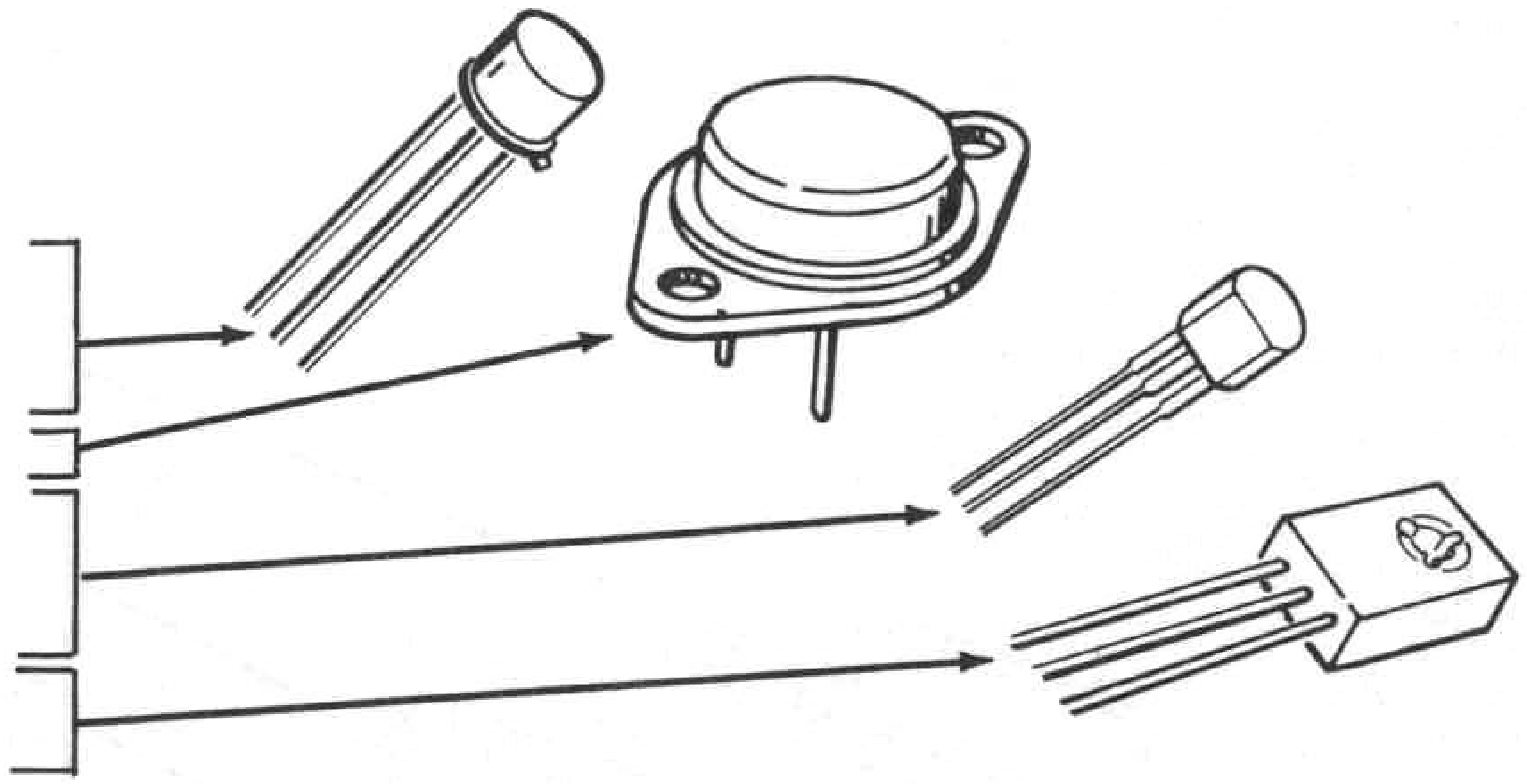
DIODES

( )	2	VR-16.1G zener diode	56-36	D17, 18
( )	6	1N2071 diode	57-27	D1, 2, 3, 4, 15, 16
( )	10	1N4002 diode	57-65	D5, 6, 7, 8, 9, 10, 11, 12, 13, 14



TRANSISTORS

( )	1	FT123	417-232	Q2
( )	1	SGC5282	417-269	Q11
( )	1	SGC5283	417-270	Q12
( )	1	TA7420	417-239	Q1
( )	2	MPSA42	417-294	Q3, 4
( )	11	MPSA20	417-801	Q5, 6, 7, 8, 9, 10, 15, 16, 17, 18
( )	1	MJE181	417-818	Q13
( )	1	MJE171	417-819	Q14

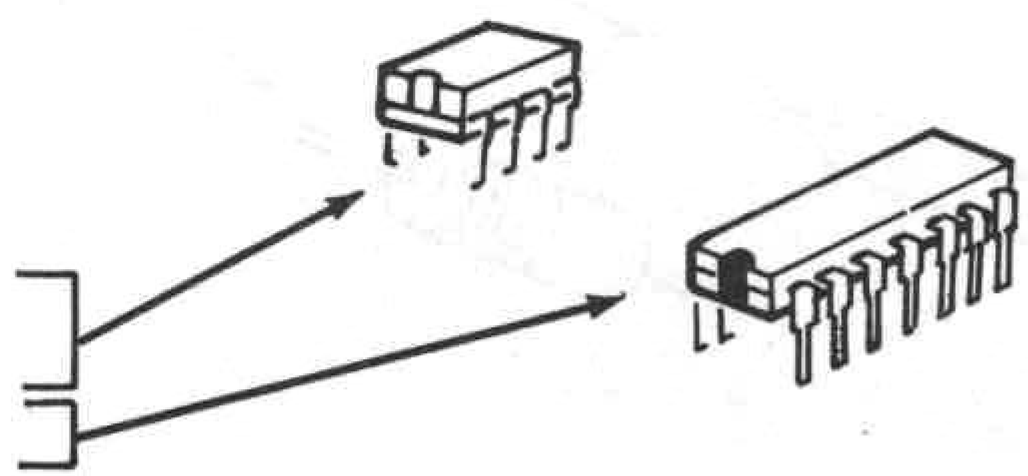


INTEGRATED CIRCUITS

The "Description" number may have additional letters and numbers other than those given in this list.

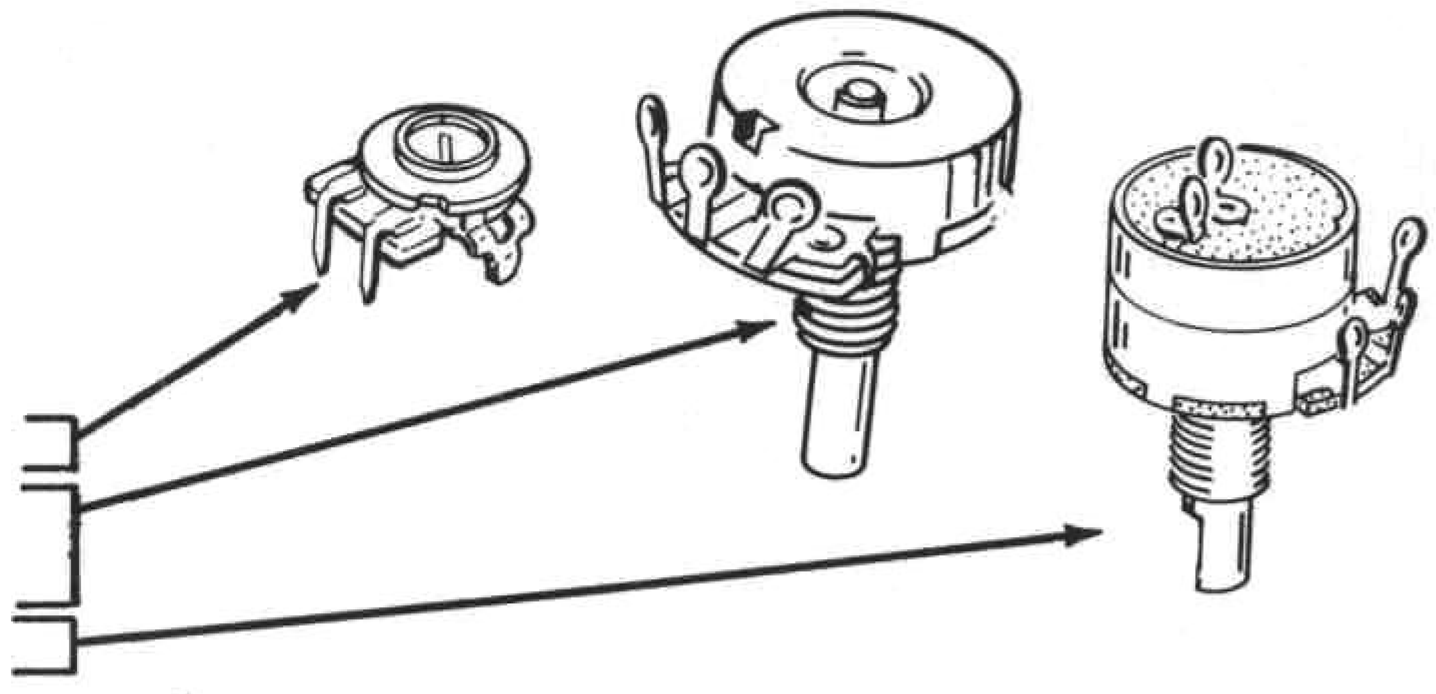
Example: SN(7490)N or MC(7490)P.

( )	4	741	442-22	IC1, 2, 3, 5
( )	1	301	442-39	IC4
( )	1	7490	443-7	IC6



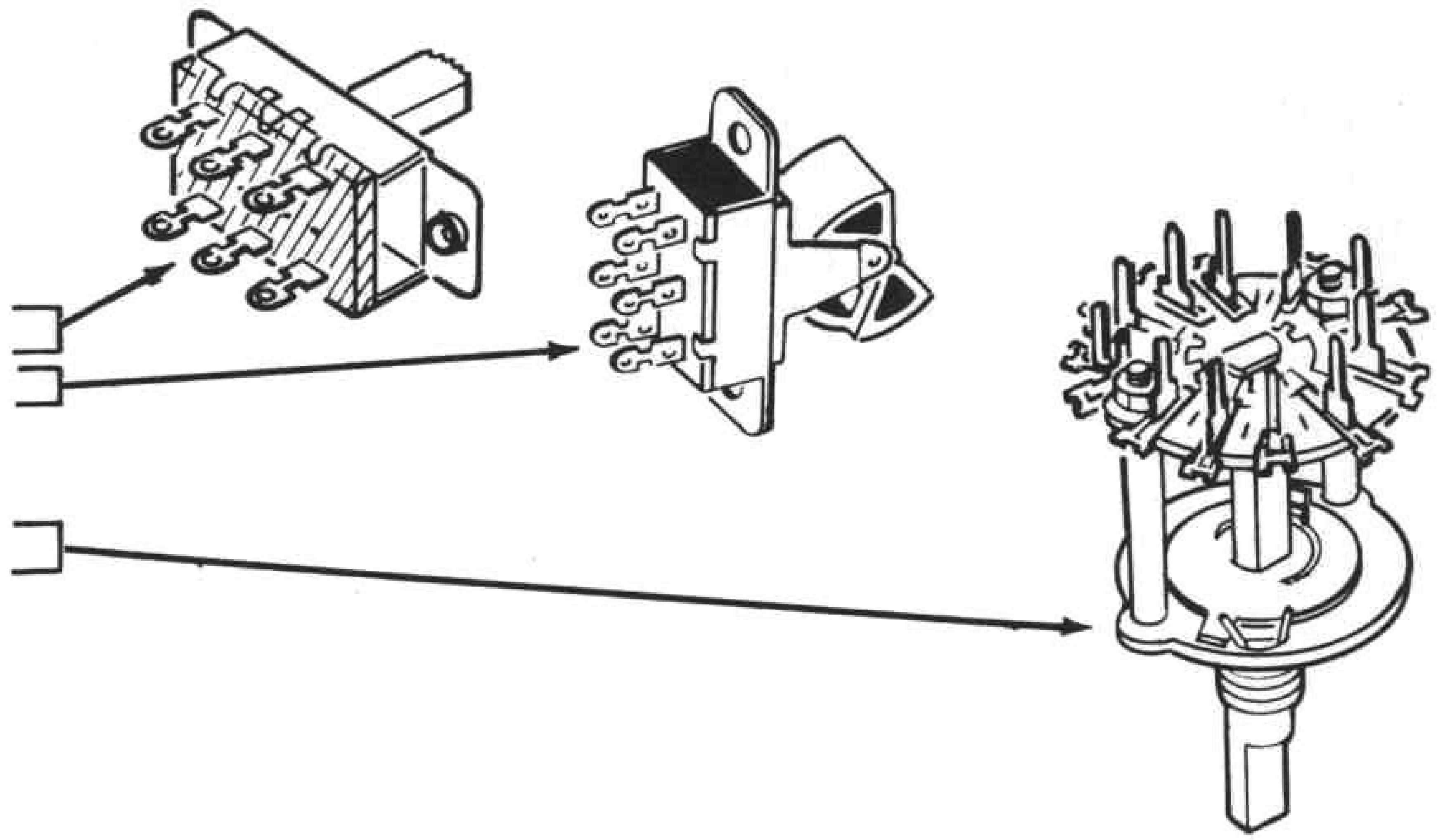
CONTROLS

	PARTS Per Kit	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	10 kΩ	10-383	R84
( )	1	5 MΩ	10-980	R5
( )	1	7.5 MΩ	10-976	R47
( )	1	200 kΩ with switch	19-192	R6



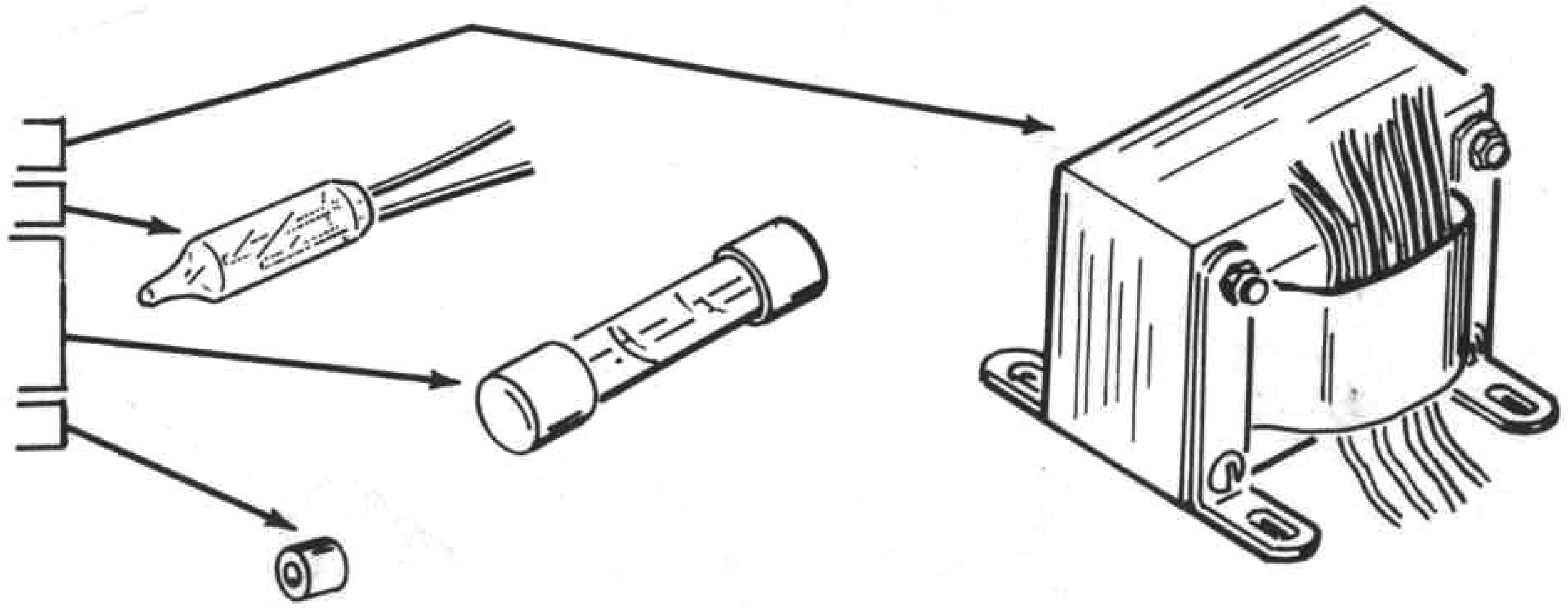
SWITCHES

	PARTS Per Kit	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	6-lug slide	60-2	SW10
( )	1	6-lug rocker	60-25	SW5
( )	1	9-lug rocker	60-34	SW2
( )	2	12-lug rocker	60-37	SW3, 9
( )	1	Rotary	63-684	SW4
( )	1	Rotary	63-685	SW6
( )	1	Rotary	63-686	SW7
( )	1	Rotary	63-687	SW8



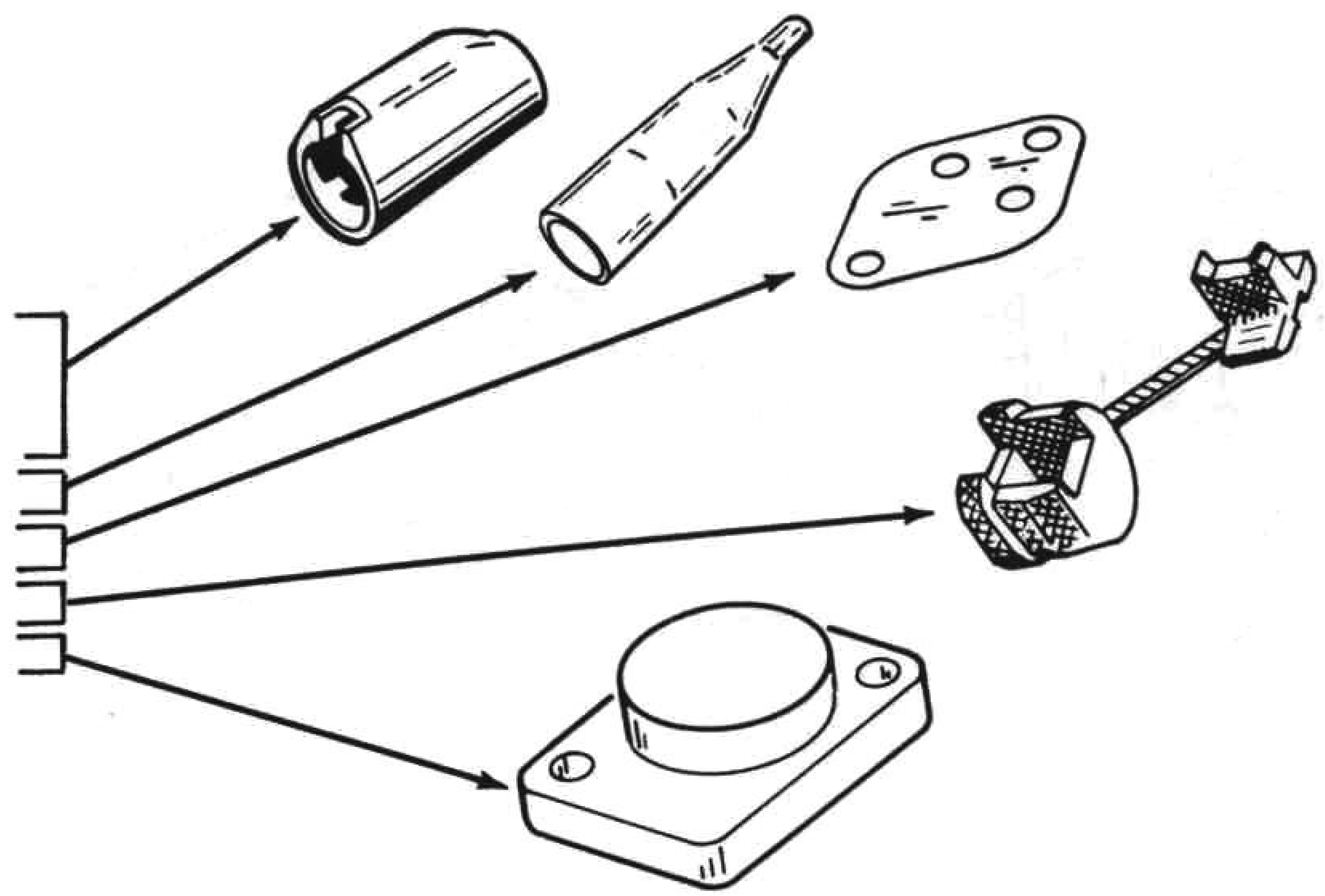
OTHER ELECTRONIC PARTS

	PARTS Per Kit	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	Power transformer	54-839	T1
( )	1	Lamp	412-15	PL1
( )	1	1/16-ampere fuse	421-50	F1
( )	1	1/2-ampere, slow-blow fuse	421-20	F2
( )	8	Ferrite bead	475-15	



PARTS Per Kit	DESCRIPTION	PART No.	CIRCUIT Component No.

INSULATORS



( )	3	Black sleeve	70-10
( )	5	Red sleeve	70-11
( )	1	White sleeve	70-13
( )	3	Clip insulator	73-34
( )	1	Mica insulator	75-60
( )	1	Strain relief	75-71
( )	1	Transistor cover	75-142

WIRE-SLEEVING

( )	1	Wiring harness	134-874
( )	1	Bare wire (For soldering iron tip.)	340-11

NOTE: The following test leads are made of stranded wire which is covered by a shiny insulation.

( )	1	Black test lead	341-1
( )	1	Red test lead	341-2
( )	1	White test lead	341-5

( ) Lay the three test leads aside until specifically called for in a step.

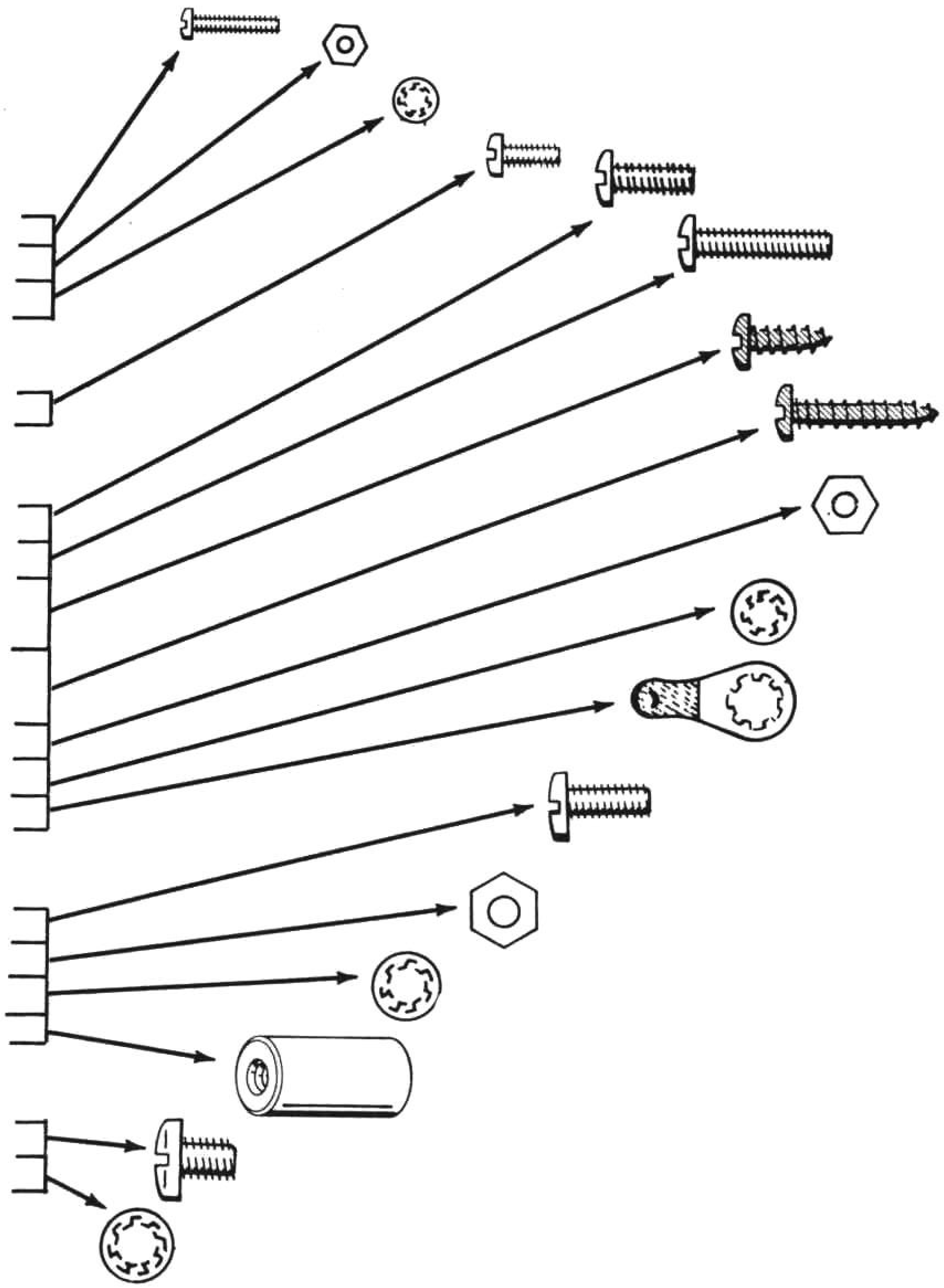
( )	1	Large red wire	344-3
( )	1	Red wire	344-52
( )	1	Black wire	344-50
( )	1	White wire	344-59
( )	1	Sleeving	346-1

PARTS Per Kit	DESCRIPTION	PART No.	CIRCUIT Component No.

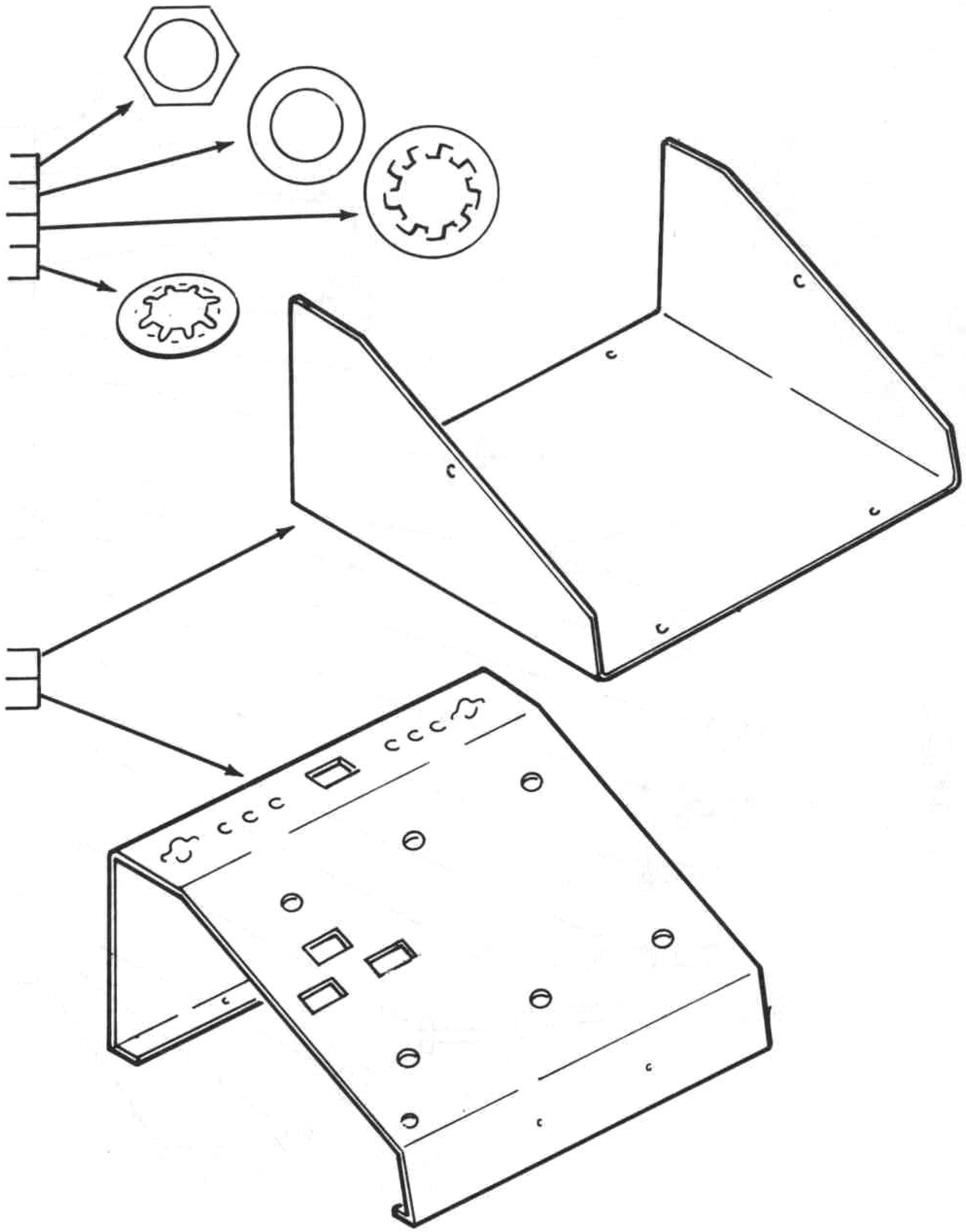
HARDWARE

NOTE: The hardware is shown full size. A part can be identified by placing it on its drawing.

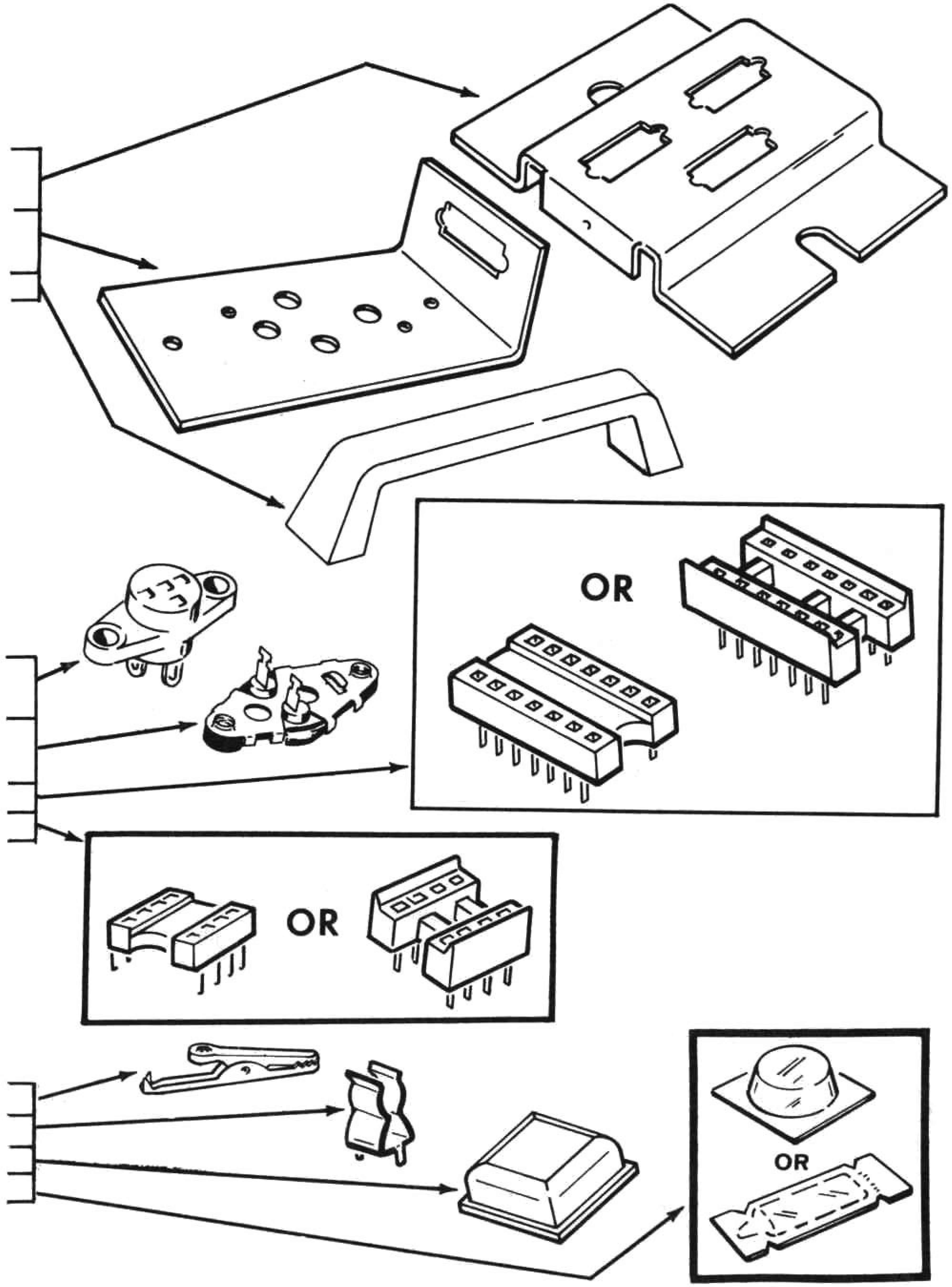
#2 Hardware				
( )	4	2-56 x 3/8" screw	250-175	
( )	4	2-56 nut	252-51	
( )	4	#2 lockwasher	254-7	
#4 Hardware				
( )	4	4-40 x 1/4" screw	250-285	
#6 Hardware				
( )	11	6-32 x 3/8" screw	250-89	
( )	2	6-32 x 5/8" screw	250-26	
( )	7	#6 x 3/8" sheet metal screw	250-155	
( )	2	#6 x 5/8" sheet metal screw	250-548	
( )	5	6-32 nut	252-3	
( )	8	#6 lockwasher	254-1	
( )	2	#6 solder lug	259-1	
#8 Hardware				
( )	6	8-32 x 3/8" screw	250-137	
( )	4	8-32 nut	252-4	
( )	6	#8 lockwasher	254-2	
( )	2	3/4" spacer	255-47	
#10 Hardware				
( )	2	10-24 x 1/4" screw	250-107	
( )	2	#10 lockwasher	254-3	



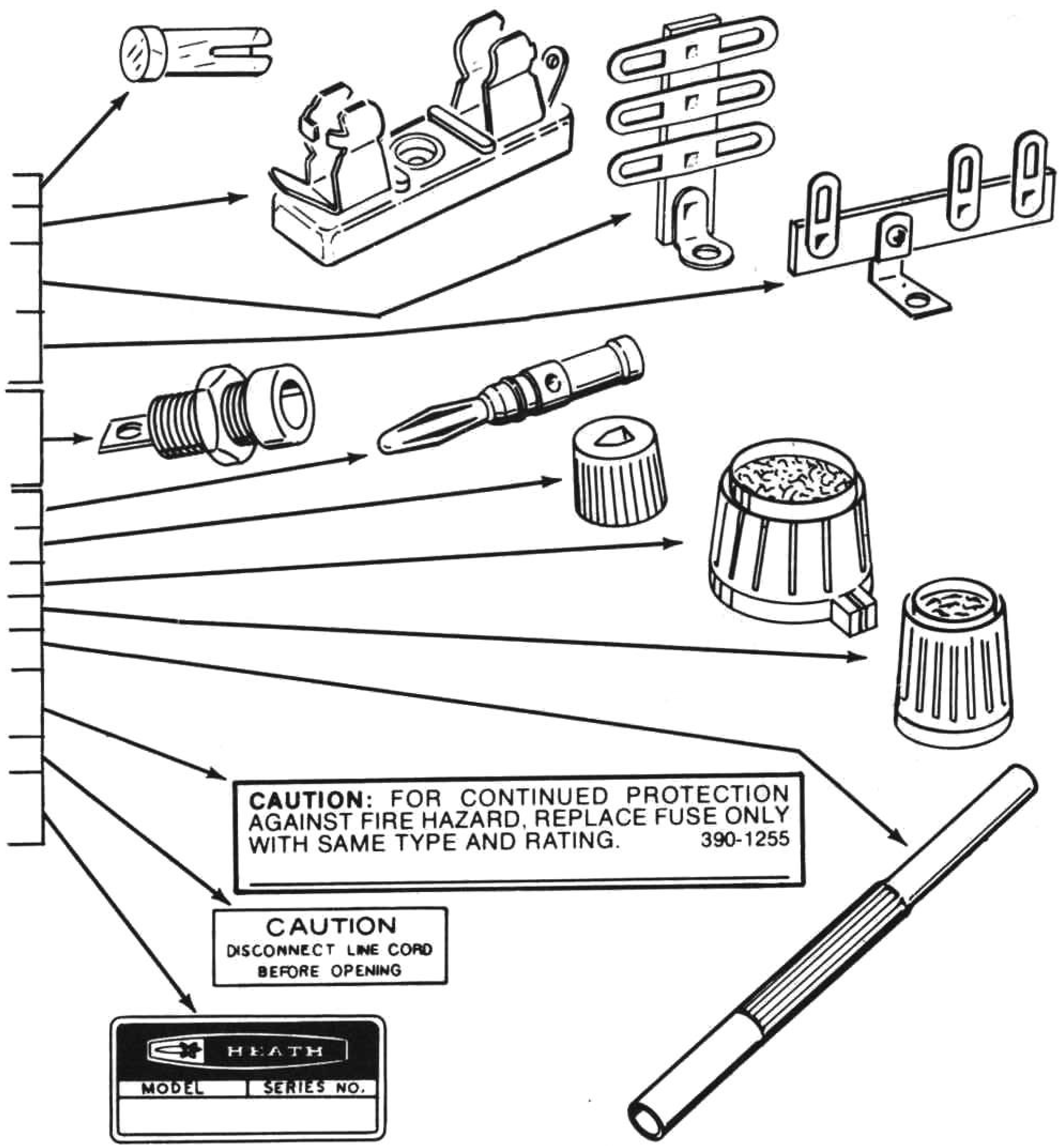
PARTS Per Kit		DESCRIPTION	PART No.	CIRCUIT Component No.
Control Hardware				
( )	7	Control nut	252-7	
( )	7	Control flat washer	253-10	
( )	7	Control lockwasher	254-4	
( )	1	Push-on nut	252-73	
METAL PARTS				
( )	1	Cabinet shell	90-601-1	
( )	1	Top panel	203-1531-1	



	PARTS Per Kit	DESCRIPTION	PART No.	CIRCUIT Component No.
Metal Parts (cont'd.)				
( )	1	Large switch bracket	204-1925	
( )	1	Small switch bracket	204-1926	
( )	1	Handle	211-14	
SOCKETS				
( )	2	Small transistor socket	434-116	
( )	1	Large transistor socket	434-117	
( )	1	14-pin IC socket	434-298	
( )	5	8-pin IC socket	434-230	
MISCELLANEOUS				
( )	1	Circuit board	85-1365-1	
( )	1	Line cord	89-23	
( )	3	Alligator clip	260-16	
( )	2	Fuse clip	260-65	
( )	4	Plastic foot	261-29	
( )	1	Silicone grease	352-13	



PARTS Per Kit		DESCRIPTION	PART No.
		Miscellaneous (cont'd.)	
( )	1	Lamp lens	413-10
( )	1	Fuseholder	422-1
( )	1	Vertical terminal strip	431-4
( )	1	Horizontal terminal strip	431-43
( )	4	Red banana jack with nut	436-11
( )	3	Black banana jack with nut	436-22
( )	2	White banana jack with nut	436-24
( )	9	Banana plug	438-47
( )	6	Knob insert	455-50
( )	4	Large knob	462-245
( )	2	Small knob	462-250
( )	1	Nut starter	490-5
( )	1	Fuse replacement label	390-1255
( )	1	Line cord label	390-926
( )	1	Blue and white label	391-34
( )	1	Parts Order Form	597-260
( )	1	Kit Builders Guide	597-308
( )	1	Manual (See front cover for part number.)	
( )		Solder (Additional 3' rolls of solder, #331-6, can be ordered for 25 cents each.)	



STEP-BY-STEP ASSEMBLY

Before starting to assemble this kit, be sure you have read the wiring, soldering, and step-by-step assembly information in the "Kit Builders Guide."

Due to the small foil area around circuit board holes at integrated circuits, and the small areas between foils, it will be necessary to use the utmost care to prevent solder bridges between these adjacent foil areas. Use only a minimum amount of solder, and do not heat components excessively with the soldering iron. Diodes, transistors, etc., can be damaged if subjected to excessive amounts of heat. Apply the soldering iron only long enough to make a good solder connection.

NOTE: For soldering integrated circuits you need a small wattage, small-tip soldering iron. If one of these is not available, proceed as follows: Be sure your soldering iron is cool. Then wrap the large bare wire, supplied with this kit, tightly around the soldering iron tip as shown in Figure 1. Allow approximately 1/4" of wire to extend beyond the end of the soldering iron. Cut the wire end to a chisel shape as shown. After the iron is hot, apply solder to the wire windings.

Resistors will be called out by their resistance value in Ω, kΩ, or MΩ, and color code.

Capacitors will be called out by their capacitance value (in pF or μF) and type (disc, Mylar, or electrolytic).

SAFETY WARNING: Avoid eye injury when you clip off excess leads. We suggest that you wear glasses, or at least clip the leads so the ends will not fly toward your eyes.

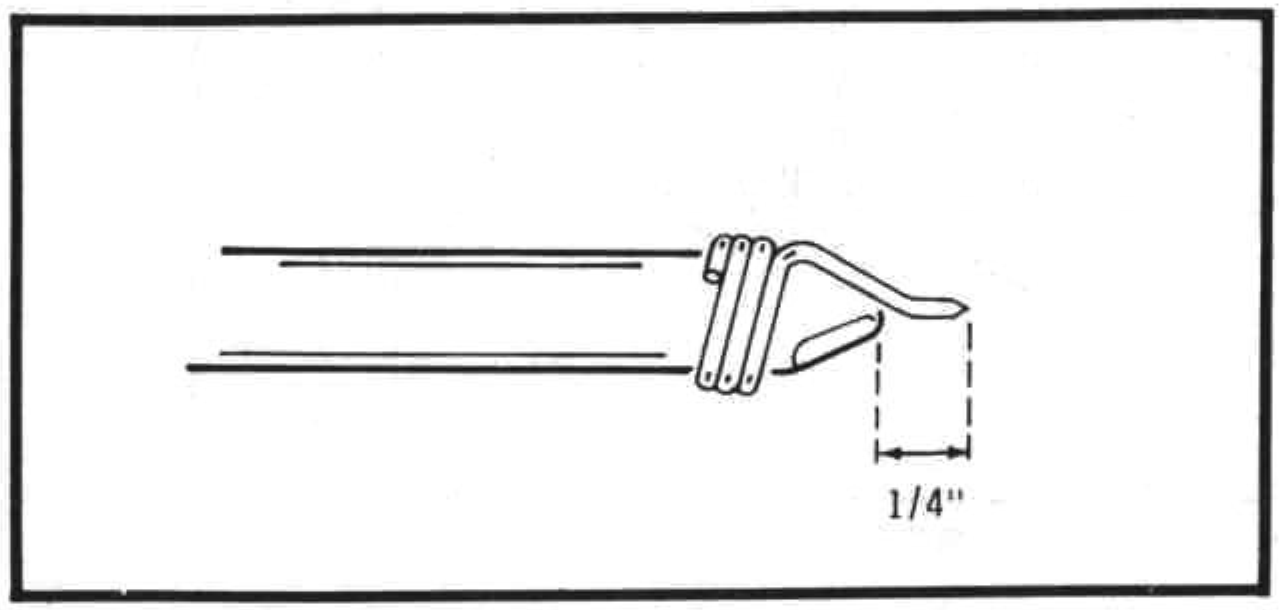


Figure 1

CIRCUIT BOARD

START

Position the circuit board lettered-side-up as shown. Then perform the steps on each page.

NOTE: When you install a diode, always match the band on the diode with the band mark on the circuit board.

( ) D18: VR-16.1 diode (#56-36).

( ) D17: VR-16.1 diode (#56-36).

NOTE: To prepare a wire, cut a white solid wire to the length specified; then remove 1/4" of insulation from each end. When bare wire is called for, remove all the insulation.

( ) 1" bare wire.

( ) 3/4" bare wire.

( ) 3/4" bare wire.

( ) 1" bare wire.

( ) 1" bare wire.

( ) 1-3/4" wire. Do not remove all the insulation.

( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) R52: 10 MΩ (brown-black-blue).

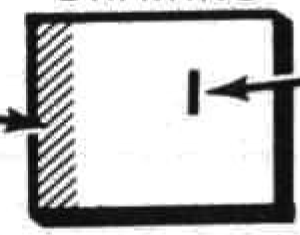
( ) R48: 1.2 MΩ (brown-red-green).

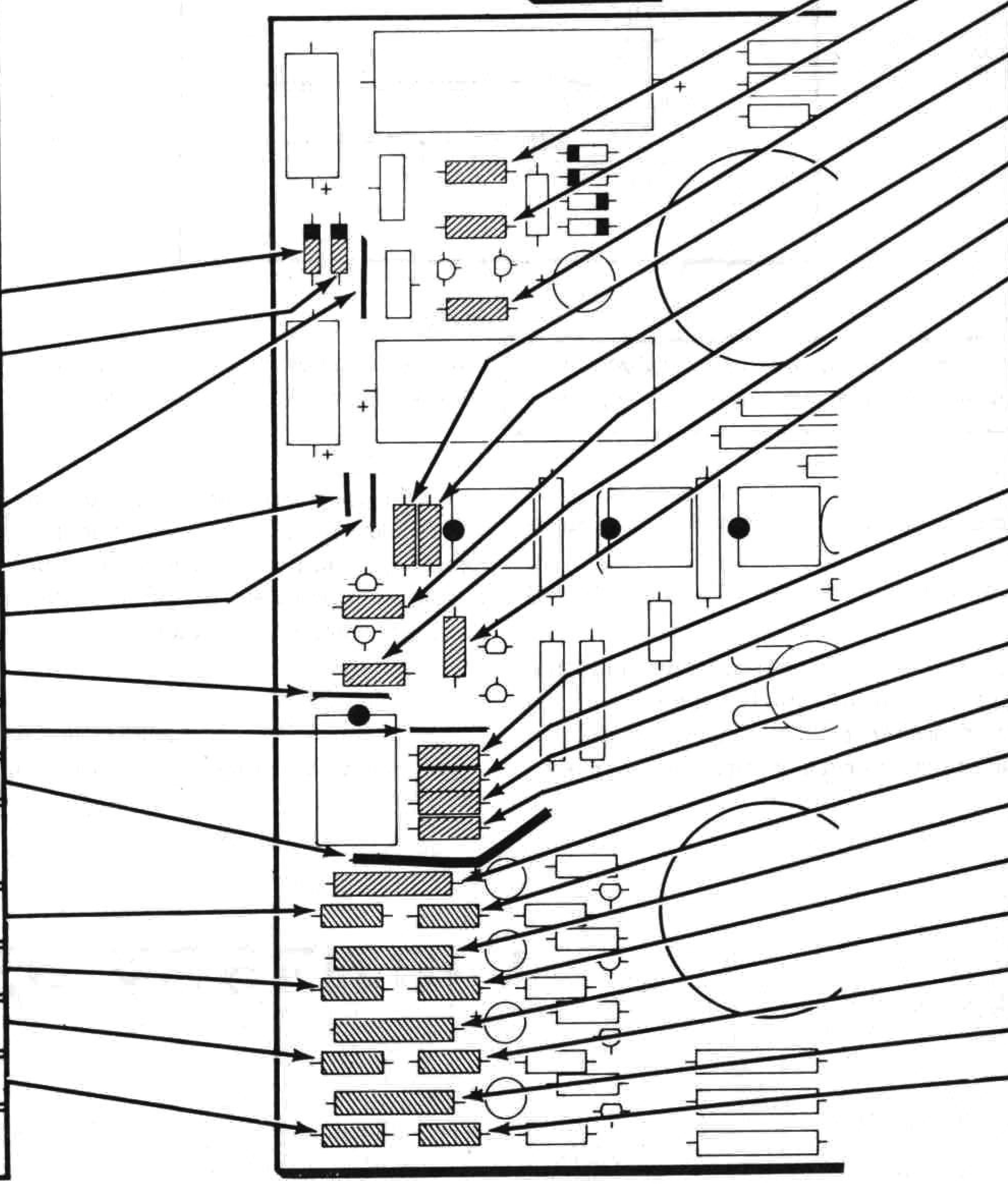
( ) R51: 5.1 MΩ (green-brown-green).

( ) R49: 2.4 MΩ (red-yellow-green).

( ) Solder the leads to the foil and cut off the excess lead lengths.

The steps performed in this Pictorial are in this area of the circuit board.





CONTINUE

( ) R36: 360 Ω (orange-blue-brown).

( ) R38: 56 Ω (green-blue-black).

( ) R39: 10 kΩ (brown-black-orange).

( ) R42: 10 kΩ (brown-black-orange).

( ) R41: 10 kΩ (brown-black-orange).

( ) R45: 100 kΩ (brown-black-yellow).

( ) R44: 2700 Ω (red-violet-red).

( ) R43: 2700 Ω (red-violet-red).

( ) Solder the leads to the foil and cut off the excess lead lengths.

Install four 10 kΩ (brown-black-orange) resistors in the following locations.

( ) R57.

( ) R71.

( ) R62.

( ) R66.

( ) R53: 80 kΩ, 1%.

( ) R61: 1500 Ω (brown-green-red).

( ) R56: 10 kΩ, 1%.

( ) R74: 180 Ω (brown-gray-brown).

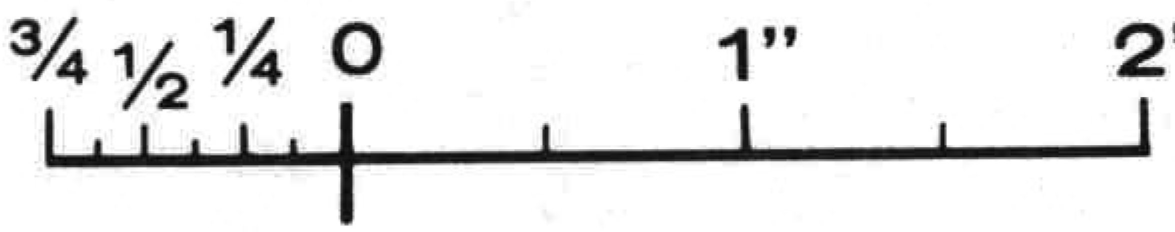
( ) R54: 40 kΩ, 1%.

( ) R65: 750 Ω (violet-green-brown).

( ) R55: 20 kΩ, 1%.

( ) R69: 360 Ω (orange-blue-brown).

( ) Solder the leads to the foil and cut off the excess lead lengths.



PICTORIAL 1-1

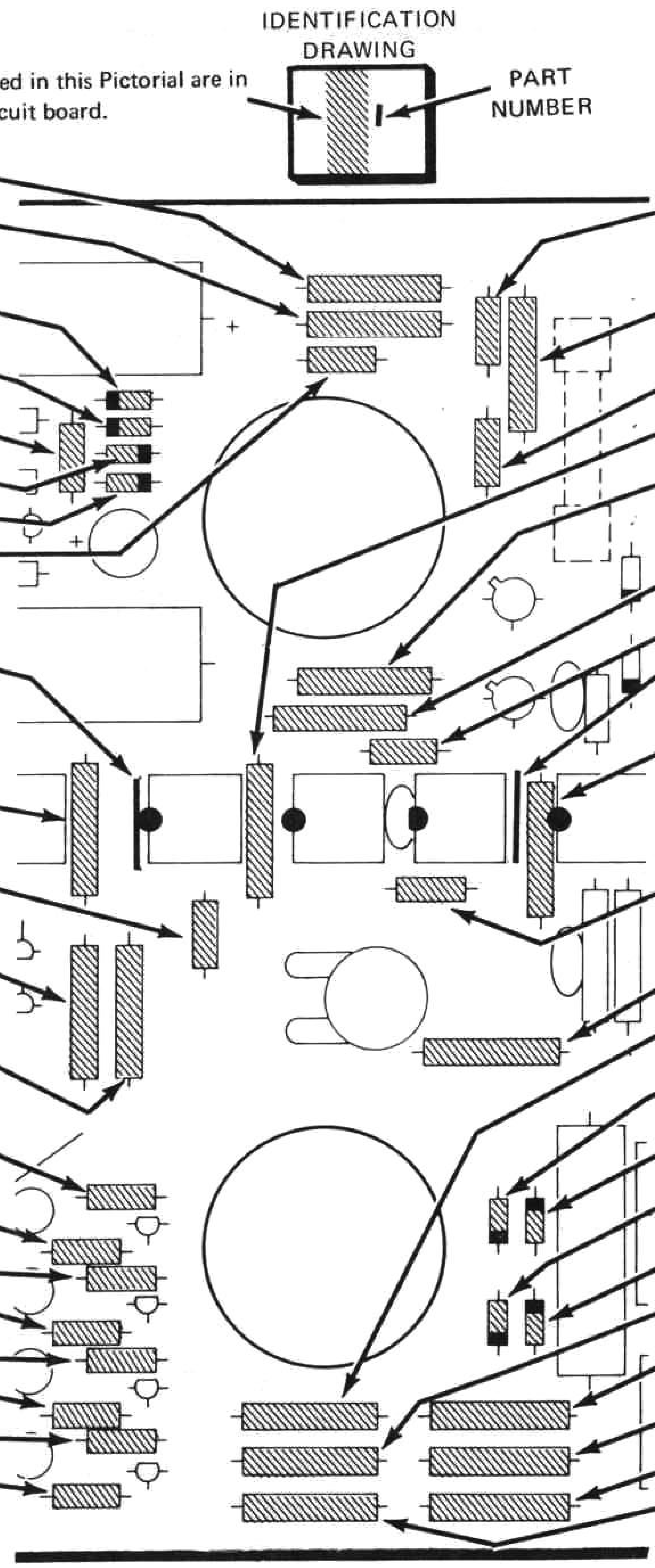
START

- ( ) R33: 20 kΩ, 1%.
- ( ) R31: 30 kΩ, 1%.
- ( ) D5: 1N4002 diode (#57-65).
- ( ) D6: 1N4002 diode (#57-65).
- ( ) R37: 360 Ω (orange-blue-brown).
- ( ) D7: 1N4002 diode (#57-65).
- ( ) D8: 1N4002 diode (#57-65).
- ( ) R32: 82 kΩ (gray-red-orange).
- ( ) 1" bare wire.
- ( ) Solder the leads to the foil and cut off the excess lead lengths.
- ( ) R34: 400 kΩ, 1%.
- ( ) R105: 100 kΩ (brown-black-yellow).
- ( ) R35: 100 kΩ, 1%.
- ( ) R104: 100 kΩ, 1%.

Install eight 27 kΩ resistors (red-violet-orange) as follows:

- ( ) R58.
- ( ) R59.
- ( ) R73.
- ( ) R72.
- ( ) R64.
- ( ) R63.
- ( ) R68.
- ( ) R67.
- ( ) Solder each lead to the foil and cut off the excess lead lengths.

The steps performed in this Pictorial are in this area of the circuit board.

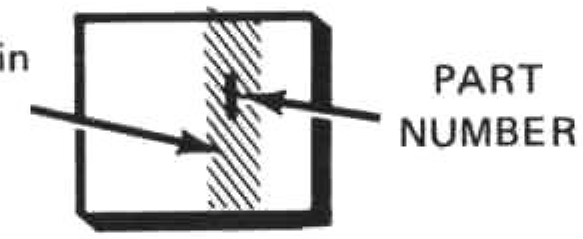


CONTINUE

- ( ) R30: 62 kΩ (blue-red-orange).
- ( ) R29: 50 kΩ, 1%.
- ( ) R28: 100 kΩ (brown-black-yellow).
- ( ) R106: 1 MΩ, 1%.
- ( ) R26: 900 kΩ, 1%.
- ( ) R27: 9 MΩ, 1%.
- ( ) R46: 2.4 MΩ (red-yellow-green).
- ( ) 1" bare wire.
- ( ) R96: 20 kΩ, 1%.
- ( ) Solder each lead to the foil and cut off the excess lead lengths.
- ( ) R95: 27 kΩ (red-violet-orange).
- ( ) R82: 20 kΩ, 1%.
- ( ) R102: 1 Ω, .5%, 1-watt.
- ( ) D11: 1N4002 diode (#57-65).
- ( ) D9: 1N4002 diode (#57-65).
- ( ) D12: 1N4002 diode (#57-65).
- ( ) D10: 1N4002 diode (#57-65).
- ( ) R103: 1 Ω, .5%, 1-watt.
- ( ) R98: 100 Ω, 1%.
- ( ) R97: 100 Ω, 1%.
- ( ) R99: 10 Ω, 1%.
- ( ) R101: 10 Ω, 1%.
- ( ) Solder each lead to the foil and cut off the excess lead lengths.

PICTORIAL 1-2

IDENTIFICATION DRAWING



The steps performed in this Pictorial are in this area of the circuit board.

START

( ) R91: 1000 Ω (1 k), 1%.

( ) D13: 1N4002 diode (#57-65).

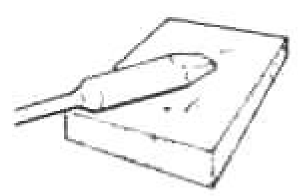
( ) D14: 1N4002 diode (#57-65).

( ) R85: 750 Ω (violet-green-brown).

( ) 1" bare wire.

FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN...

WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.

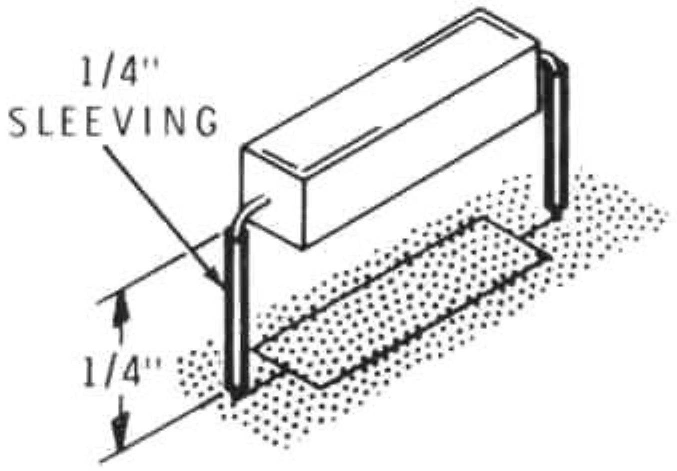


( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) R81: 20 kΩ, 1%.

( ) R83: 20 kΩ, 1%.

( ) R14: 10 Ω, 5-watt. Place a 1/4" length of sleeving on each lead. Then install the resistor.



( ) R15: 100 Ω, 7-watt. Use 1/4" of sleeving on each lead.

( ) R19: 10 kΩ, 2-watt (brown-black-orange).

( ) Solder the leads to the foil and cut off the excess lead lengths.

CONTINUE

( ) R93: 200 Ω, 1%.

( ) R92: 500 Ω, 1%.

( ) R4: 10 kΩ (brown-black-orange).

Install six 1N2071 diodes (#57-27) as follows:

( ) D16.

( ) D15.

( ) D1.

( ) D2.

( ) D3.

( ) D4.

( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) R24: 1 MΩ (brown-black-green).

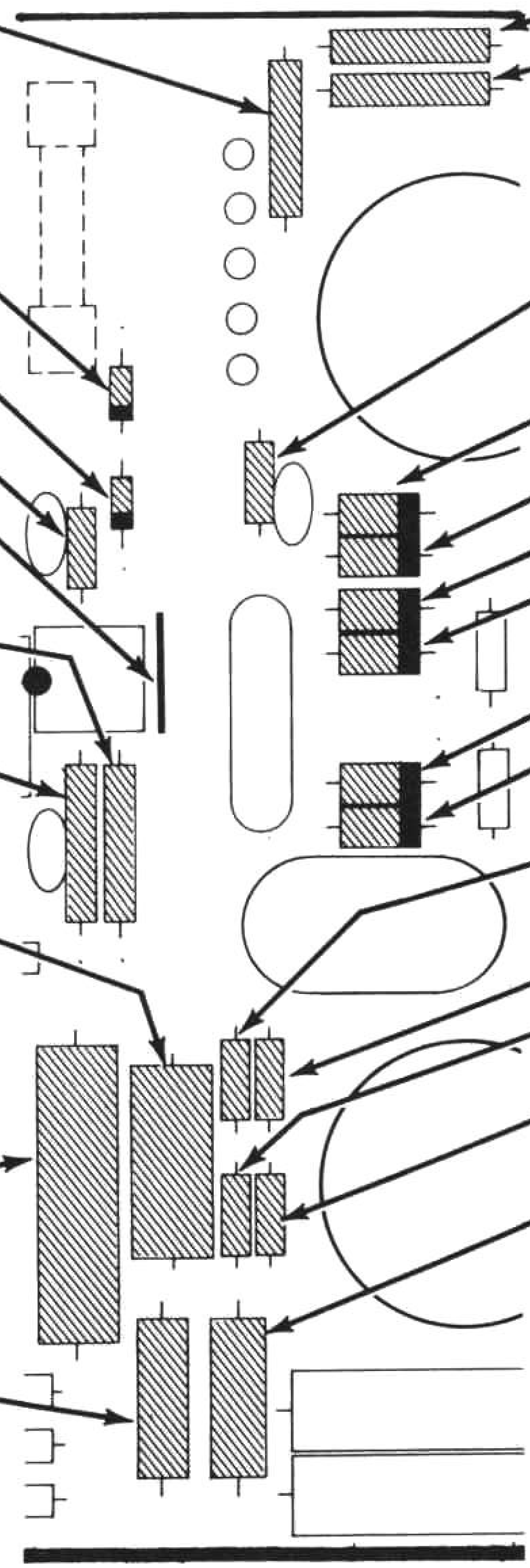
( ) R25: 1 MΩ (brown-black-green).

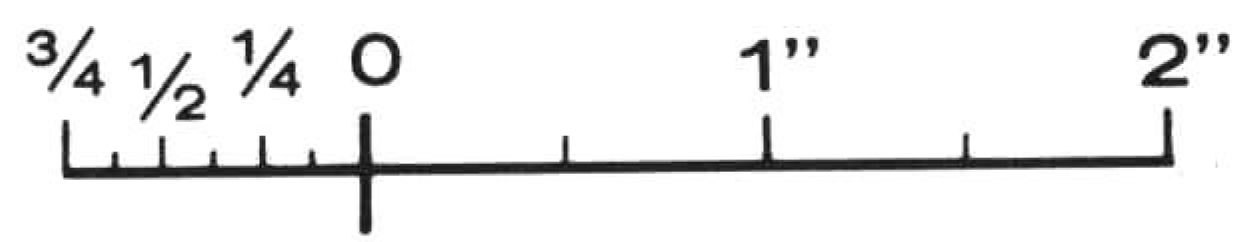
( ) R23: 100 kΩ (brown-black-yellow).

( ) R22: 100 kΩ (brown-black-yellow).

( ) R21: 10 kΩ, 2-watt (brown-black-orange).

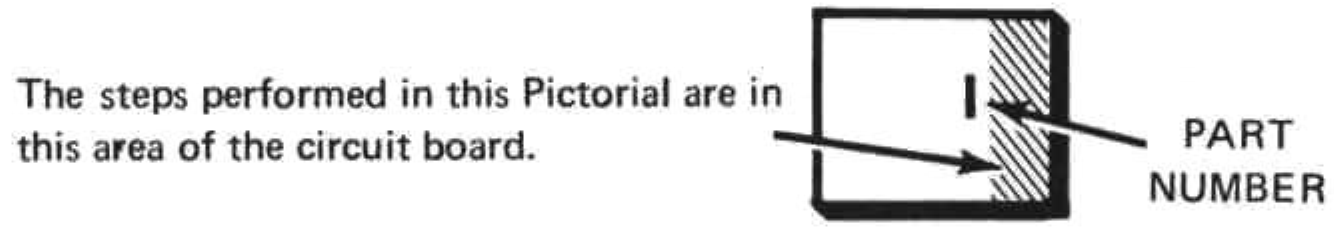
( ) Solder the leads to the foil and cut off the excess lead lengths.

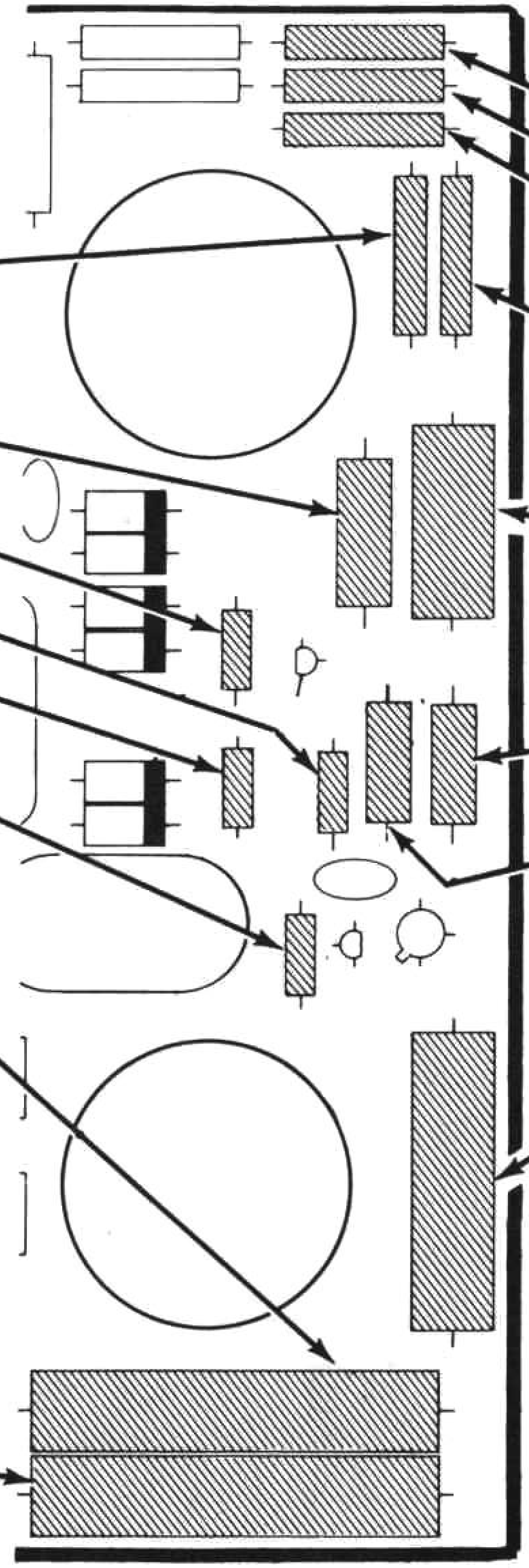




PICTORIAL 1-3

IDENTIFICATION DRAWING





START

- ( ) R88: 100 kΩ, 1%.
- ( ) R13: 15 kΩ, 2-watt (brown-green-orange).
- ( ) R3: 100 kΩ (brown-black-yellow).
- ( ) R11: 180 Ω (brown-gray-brown).
- ( ) R2: 100 kΩ (brown-black-yellow).
- ( ) R7: 62 kΩ (blue-red-orange).
- ( ) R18: 500 Ω, 10-watt. Place a 1/4" length of sleeving on each lead.
- ( ) R17: 500 Ω, 10-watt. Place a 1/4" length of sleeving on each lead.
- ( ) Solder the leads to the foil and cut off the excess lead lengths.

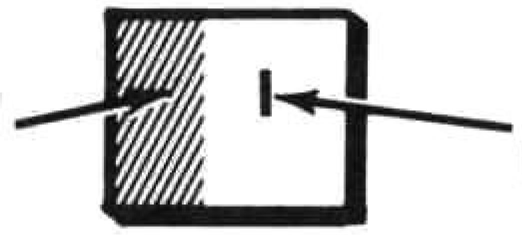
CONTINUE

- ( ) R94: 100 Ω, 1%.
- ( ) R86: 500 kΩ, 1%.
- ( ) R87: 200 kΩ, 1%.
- ( ) R89: 50 kΩ, 1%.
- ( ) R12: 680 Ω, 5-watt. Place a 1/4" length of sleeving on each lead.
- ( ) R9: 2.2 Ω, 1-watt (red-red-gold).
- ( ) R8: .51 Ω, 1-watt (green-brown-silver).
- ( ) R16: 100 Ω, 7-watt. Place a 1/4" length of sleeving on each lead.
- ( ) Solder each lead to the foil and cut off the excess lead lengths.

PICTORIAL 1-4

IDENTIFICATION DRAWING

The steps performed in this Pictorial are in this area of the circuit board.

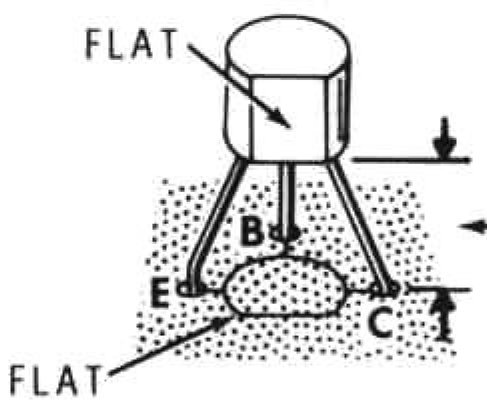


PART NUMBER

START

In the following steps, solder each part to the foil as it is installed; then cut off the excess lead lengths.

NOTE: In each of the following steps where a transistor is installed, line up the flat on the transistor with the flat on the circuit board. Then insert the transistor leads into the corresponding E, B, and C holes in the circuit board.



POSITION THE TRANSISTOR 1/8" ABOVE THE CIRCUIT BOARD.

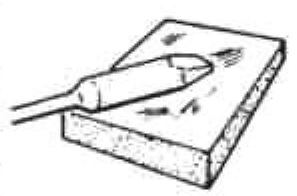
( ) Q15: MPSA20 transistor (#417-801).

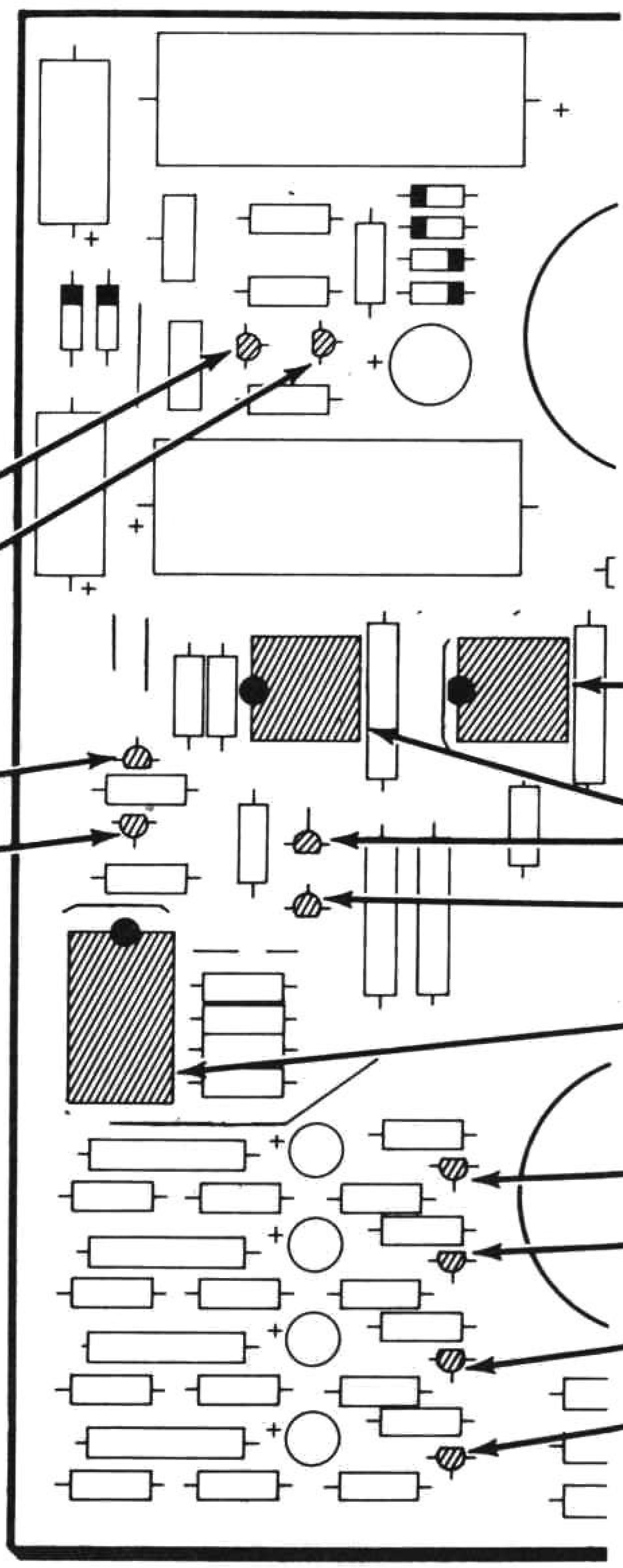
( ) Q16: MPSA20 transistor (#417-801).

( ) Q17: MPSA20 transistor (#417-801).

( ) Q18: MPSA20 transistor (#417-801).

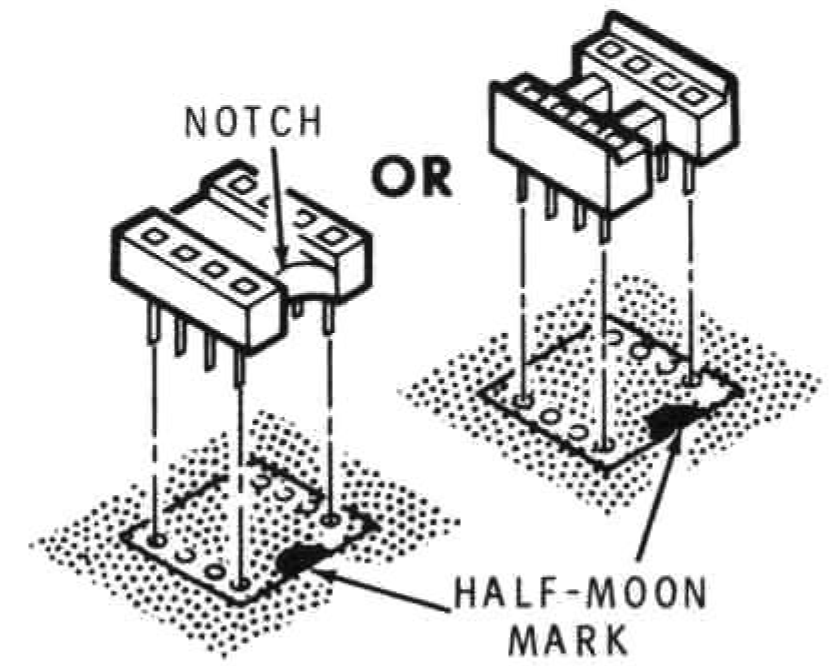
FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN...
WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.





CONTINUE

NOTE: To install an IC (integrated circuit) socket, insert the socket pins into the holes. The half-moon mark on the circuit board should still be visible after it is installed. Solder the pins to the foil.



( ) IC2: 8-pin IC socket.

( ) IC1: 8-pin IC socket.

( ) Q5: MPSA20 transistor (#417-801).

( ) Q6: MPSA20 transistor (#417-801).

( ) IC6: 14-pin IC socket.

Install four MPSA20 transistors (#417-801) at the following locations.

( ) Q7.

( ) Q8.

( ) Q9.

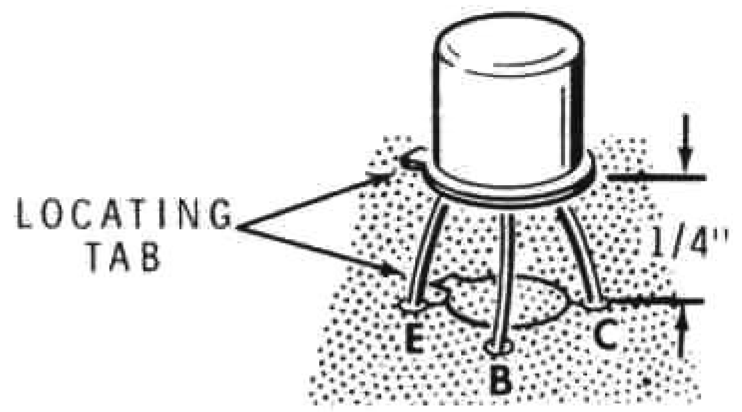
( ) Q10.

PICTORIAL 1-5

START

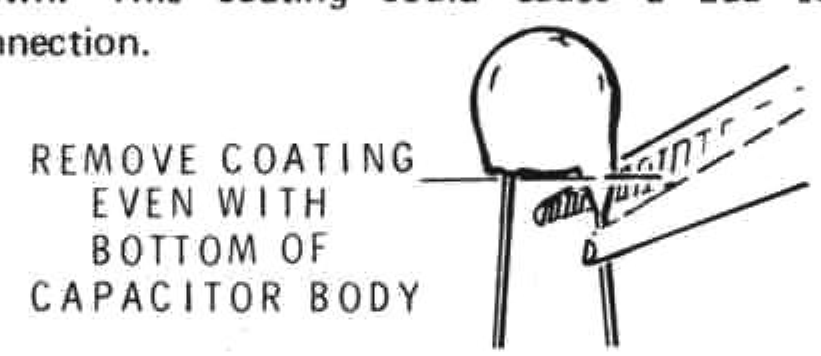
Solder each part to the foil as it is installed and cut off the excess lead lengths.

( ) Q11: SGC5282 transistor (#417-269). Align the locating tab on the transistor with the locating tab on the circuit board. Then insert the transistor leads into the corresponding E, B, and C holes on the circuit board and solder the leads to the foil.



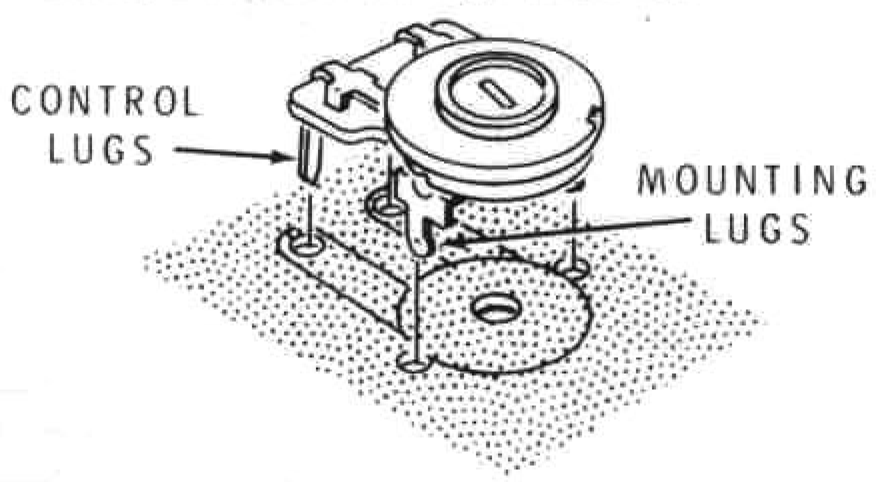
( ) IC3: 8-pin IC socket.

NOTE: Check the leads of each capacitor as you install it. Remove the coating from each capacitor as shown. This coating could cause a bad solder connection.



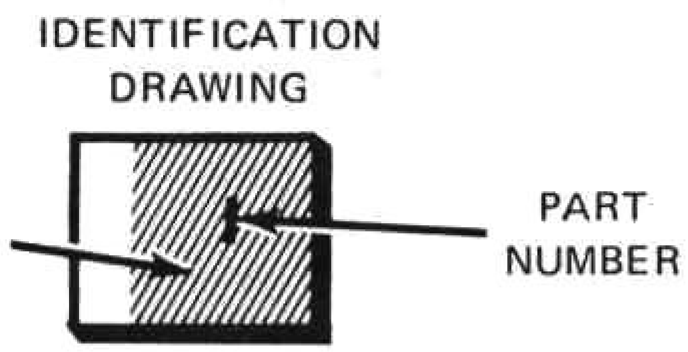
( ) C17: .001 μF disc.

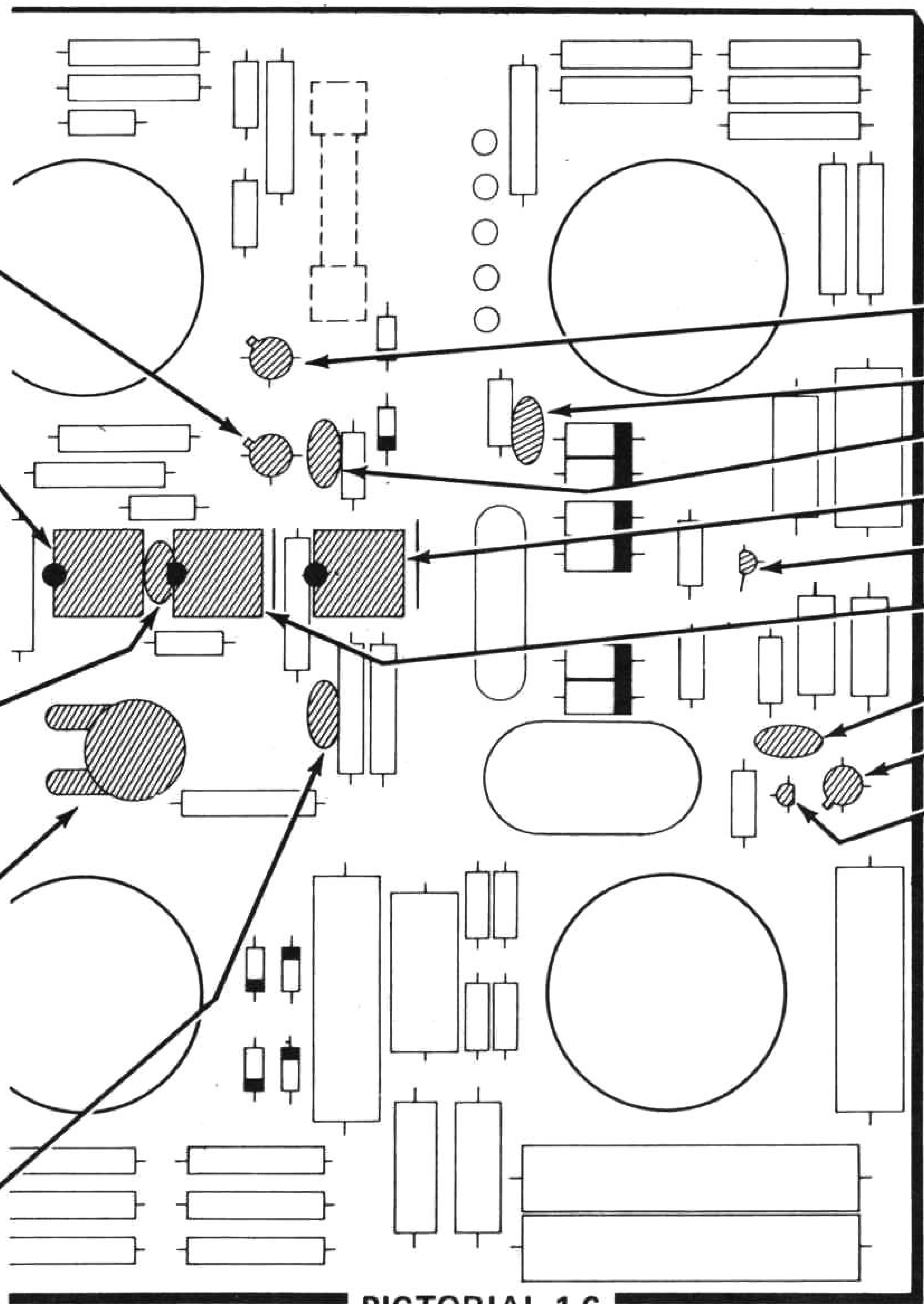
( ) R84: Install the 10 kΩ control (#10-383) as follows: First insert the control lugs; then insert the mounting lugs through the circuit board. Seat the control firmly against the circuit board, and solder the lugs to the foil.



( ) C15: 20 pF disc.

The steps performed in this Pictorial are in this area of the circuit board.





PICTORIAL 1-6

CONTINUE

( ) Q12: SGC5283 transistor (#417-270).

( ) C1: .0033 μF disc.

( ) C16: .05 μF disc.

( ) IC5: 8-pin IC socket.

( ) Q4: MPSA42 transistor (#417-294).

( ) IC4: 8-pin IC socket.

( ) C4: .01 μF disc.

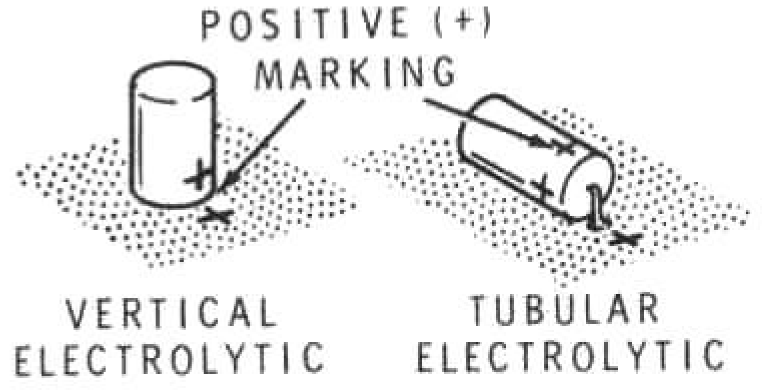
( ) Q2: FT123 transistor (#417-232).

( ) Q3: MPSA42 transistor (#417-294).

START

Solder each part to the foil as it is installed; then cut off the excess lead lengths.

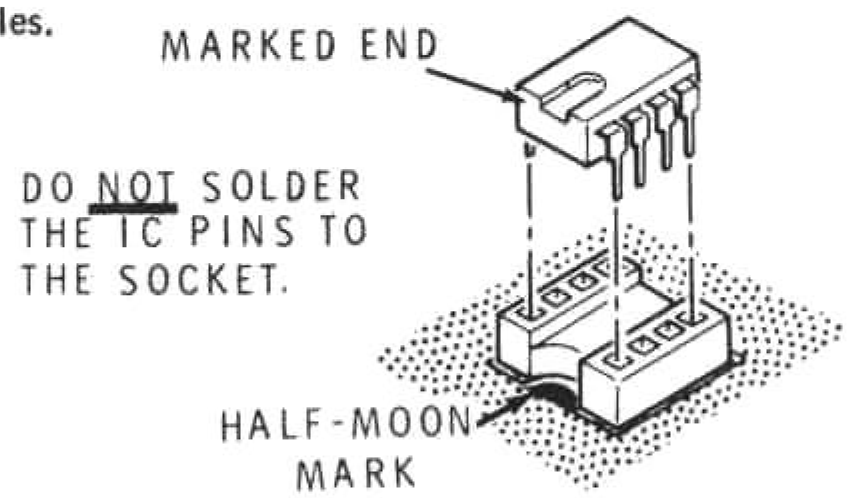
NOTE: When you install electrolytic capacitors, always match the positive (+) mark on the capacitor with the positive (+) mark on the circuit board.



( ) C6: 50 µF electrolytic.

( ) C9: 50 µF electrolytic.

NOTE: When you install integrated circuits into their sockets, always position the marked end of the integrated circuit toward the half-moon mark on the circuit board. Then carefully install the integrated circuit. Make sure the pins are in their respective holes.

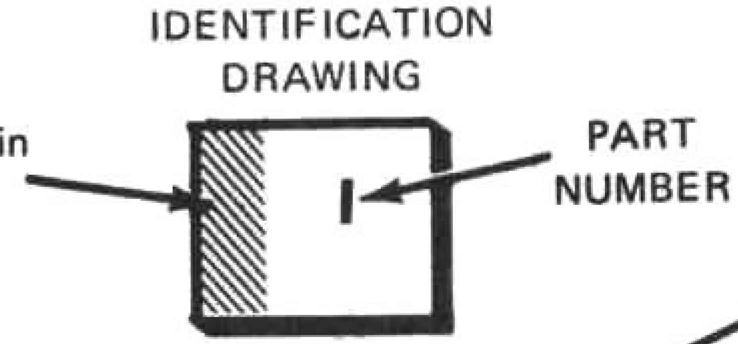


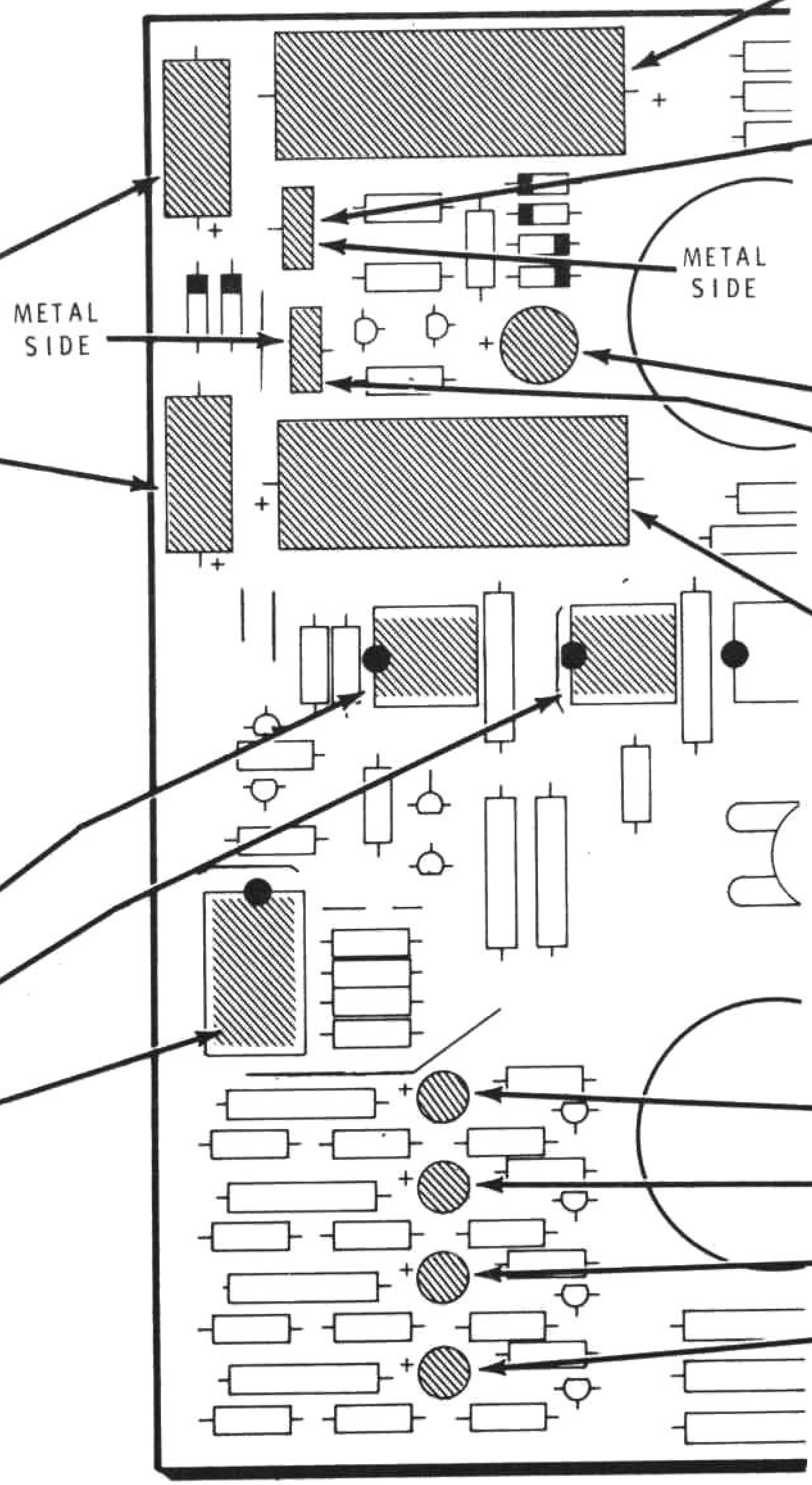
( ) IC1: 741 integrated circuit (#442-22).

( ) IC2: 741 integrated circuit (#442-22).

( ) IC6: 7490 integrated circuit (#443-7).

The steps performed in this Pictorial are in this area of the circuit board.





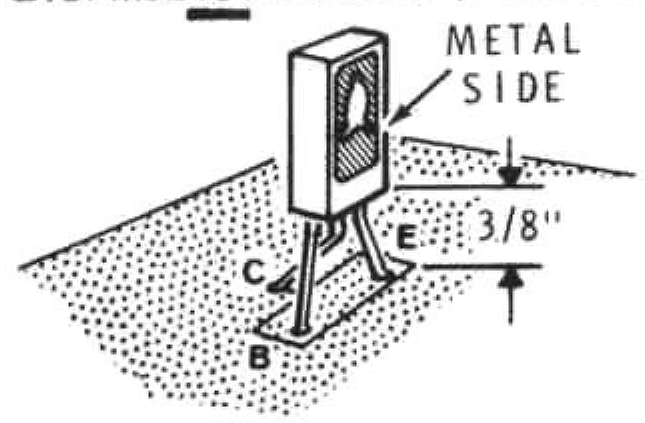
PICTORIAL 1-7

CONTINUE

( ) C5: 200 µF electrolytic.

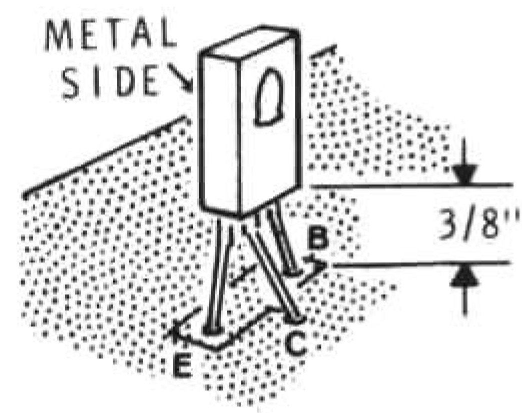
CAUTION: In the following step, make sure the transistor is correctly identified as MJE181. Also make sure the metal side is positioned properly when you install the transistor.

( ) Q13: MJE181 transistor (#417-818).



( ) C7: 100 µF electrolytic.

( ) Q14: MJE171 transistor (#417-819).



( ) C8: 200 µF electrolytic.

Install four 10 µF electrolytic capacitors as follows. Make sure the (+) mark on each capacitor matches the (+) mark on the circuit board.

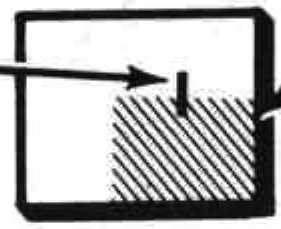
( ) C11.

( ) C14.

( ) C12.

( ) C13.

IDENTIFICATION DRAWING

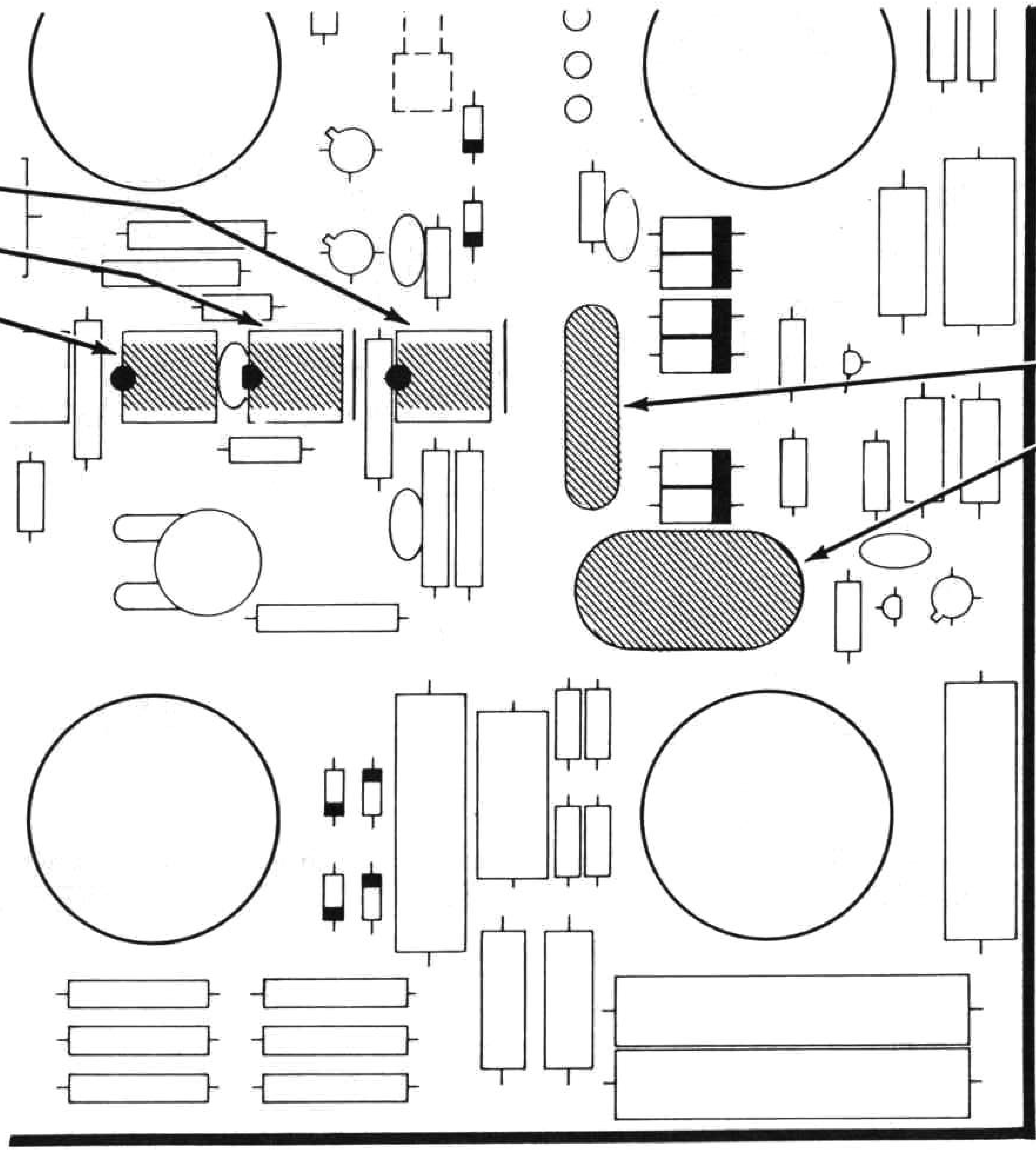


START

( ) IC5: 741 integrated circuit (#442-22).

( ) IC4: 301 integrated circuit (#442-39).

( ) IC3: 741 integrated circuit (#442-22).



CONTINUE

( ) C2: .47 μF Mylar.

( ) C3: .22 μF Mylar.

( ) Solder the capacitor leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-8

Refer to Pictorial 1-9 for the following steps.

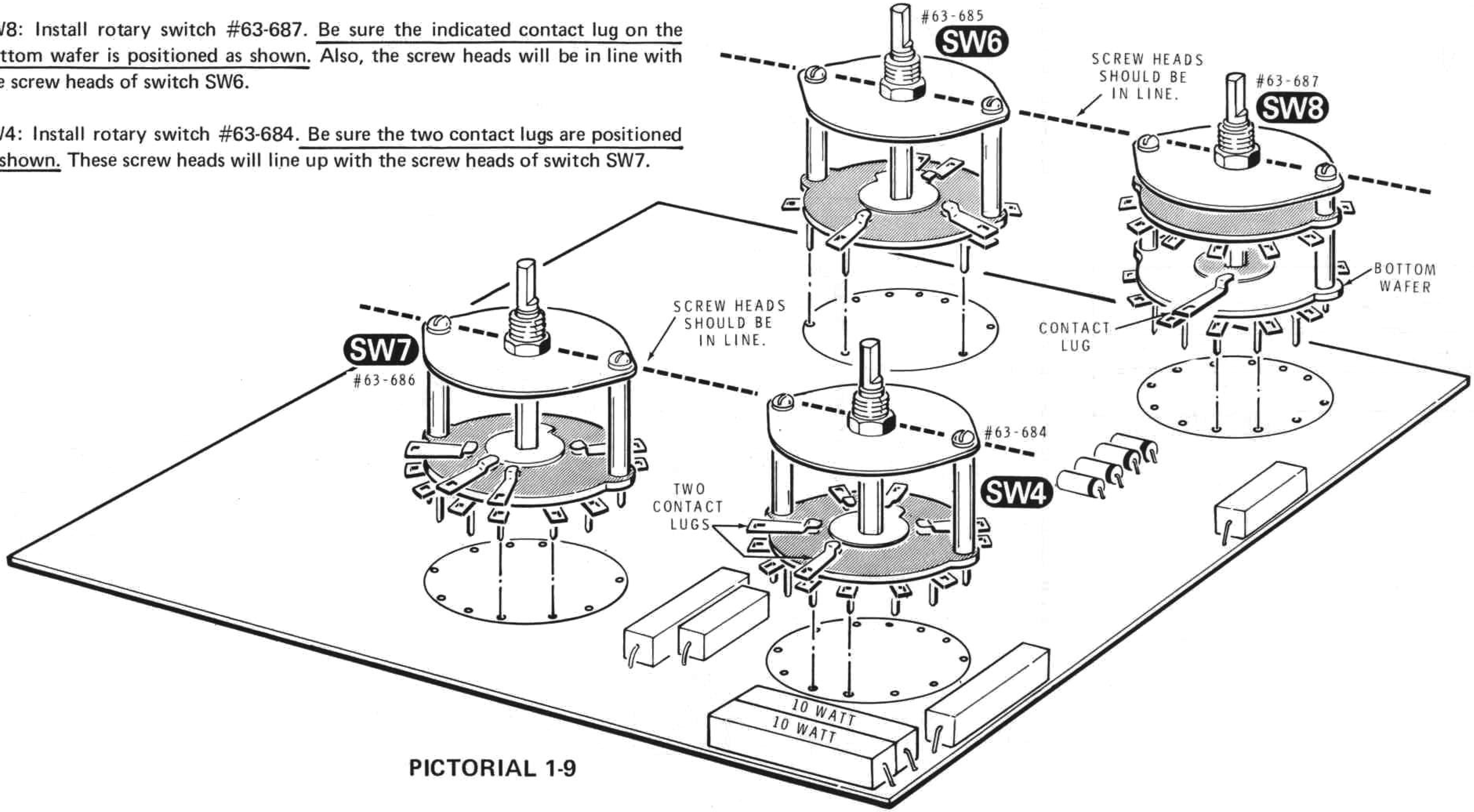
NOTE: In the following steps, you will mount the rotary switches to the circuit board. DO NOT solder any lugs until you are instructed to do so. Be sure the lugs are all the way into the circuit board.

( ) SW6: Install rotary switch #63-685.

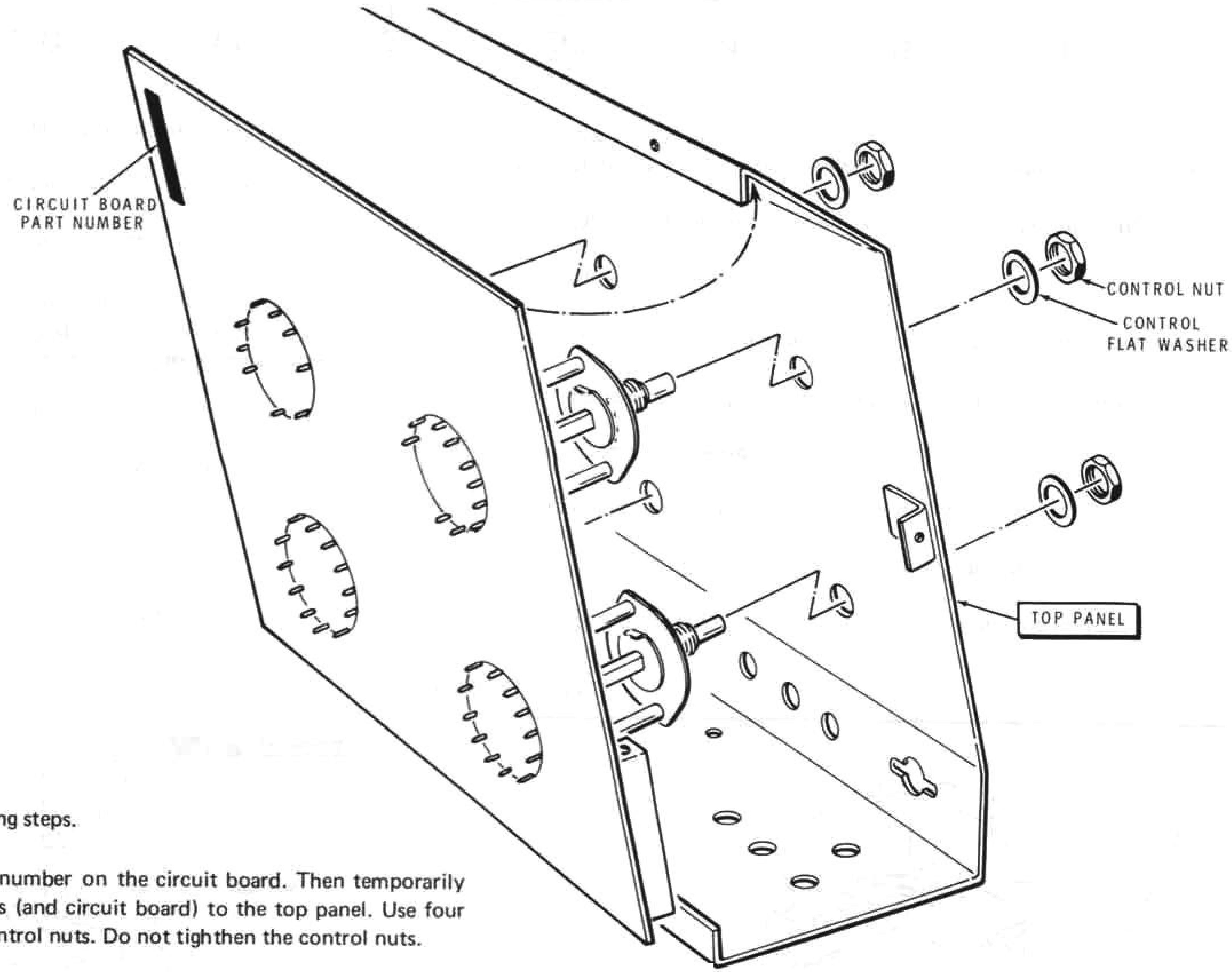
( ) SW7: Install rotary switch #63-686.

( ) SW8: Install rotary switch #63-687. Be sure the indicated contact lug on the bottom wafer is positioned as shown. Also, the screw heads will be in line with the screw heads of switch SW6.

( ) SW4: Install rotary switch #63-684. Be sure the two contact lugs are positioned as shown. These screw heads will line up with the screw heads of switch SW7.



PICTORIAL 1-9



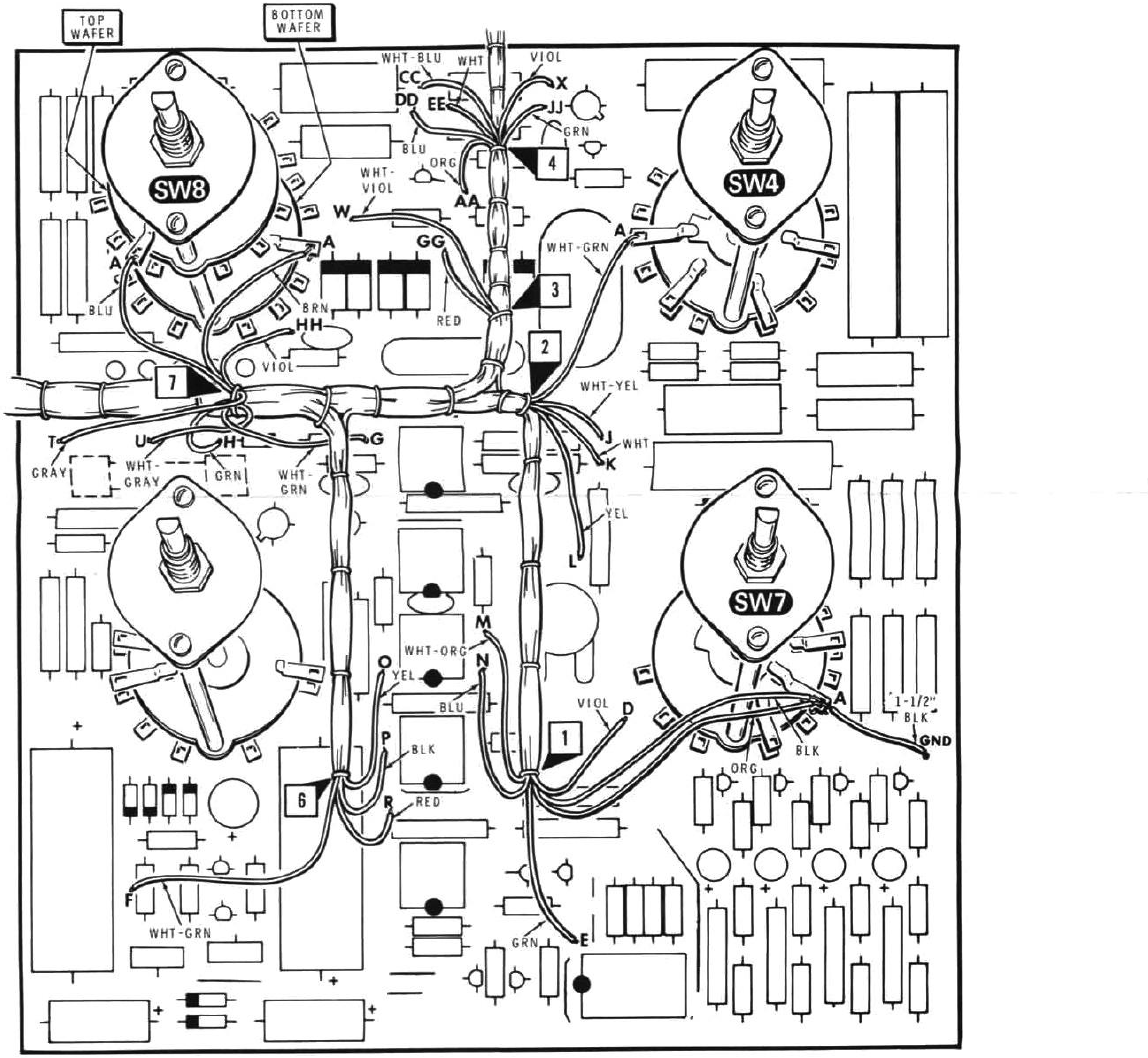
Refer to Pictorial 1-10 for the following steps.

( ) Note the position of the part number on the circuit board. Then temporarily mount the four rotary switches (and circuit board) to the top panel. Use four control flat washers and four control nuts. Do not tighthen the control nuts.

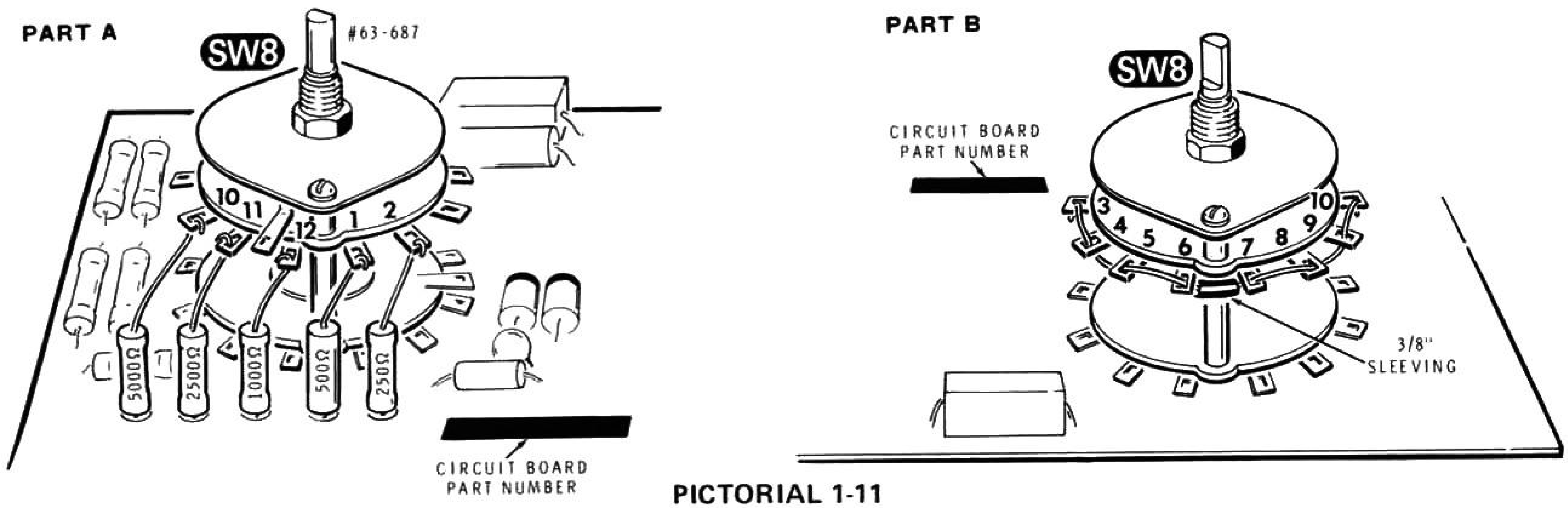
( ) Be sure the circuit is properly positioned on the lugs of the switches. Then solder the switch lugs to the foil of the circuit board.

( ) Remove the circuit board assembly from the top panel and set the top panel aside.

PICTORIAL 1-10



PICTORIAL 1-13



PICTORIAL 1-11

Refer to Part A of Pictorial 1-11 for the following steps.

NOTES:

1. To install a stand-up resistor in one of the following steps, insert one lead through the appropriate hole in the circuit board. Then solder the lead and cut off the excess lead length. Connect the top resistor lead to switch SW8 as directed in each step and cut off the excess lead length if it is soldered.

2. In the following steps, (NS) means not to solder because other wires will be added later. "S–" with a number, such as (S-3), means to solder the connection. The number following the "S" tells how many wires are at the connection.

( ) R76: 250 Ω, 1% resistor. Connect the top lead to lug 2 (S-1).

( ) R77: 500 Ω, 1% resistor. Connect the top lead to lug 1 (S-1).

( ) R78: 1000 Ω (1 k), 1% resistor. Connect the top lead to lug 12 (S-1).

( ) R79: 2500 Ω (2.5 k), 1% resistor. Connect the top lead to lug 11 (S-1).

( ) R75: 5000 Ω (5 k), 1% resistor. Connect the top lead to lug 10 (NS).

Refer to Part B of Pictorial 1-11 for the following steps.

( ) Cut a 3-5/8" length of small red wire and remove all the insulation.

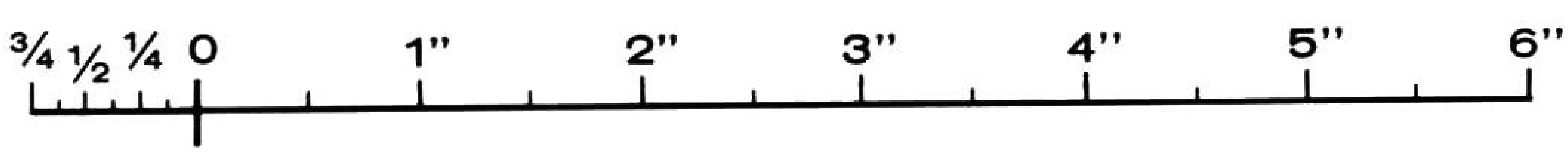
( ) Connect one end of the bare wire to lug 10 of switch SW8 (S-2).

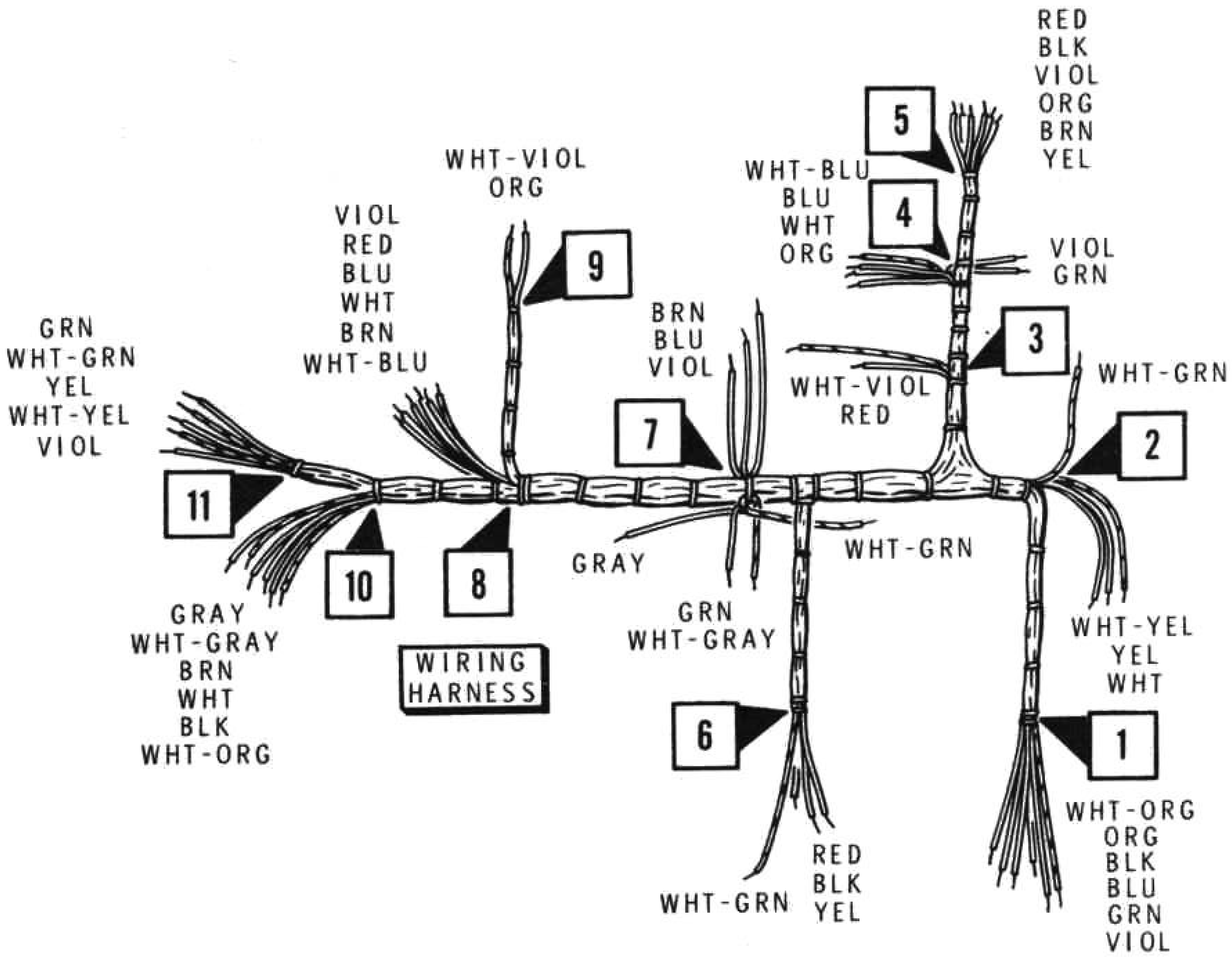
( ) Route the wire down through lug 9, up through lug 8, and down through lug 7.

( ) Solder the wire to lug 7, 8, and 9.

( ) Place a 3/8" length of sleeving over the free end of the wire.

( ) Route the wire through lugs 6, 5, 4, and 3 as shown; solder the wire to the lugs; and cut off the excess wire length.





PICTORIAL 1-12

( ) Refer to Pictorial 1-12 and form the wiring harness as shown.

( ) Refer to Pictorial 1-13 (fold-out from Page 26) and connect the wires coming from the indicated breakouts (BO) to the points indicated in the following steps.

BO#7

( ) Blue to lug A of the top wafer of switch SW8 (S-1).

( ) Brown to lug A of the bottom wafer of switch SW8 (S-1).

( ) Violet to hole HH (S-1).

( ) Gray to hole T (S-1).

( ) White-gray to hole U (S-1).

( ) Green to hole H (S-1).

( ) White-green to hole G (S-1).

BO#3

( ) Red to hole GG (S-1).

( ) White-violet to hole W (S-1).

BO#4

( ) White-blue to hole CC (S-1).

( ) White to hole EE (S-1).

( ) Blue to hole DD (S-1).

( ) Green to hole JJ (S-1).

( ) Violet to hole X (S-1).

( ) Orange to hole AA (S-1).

BO#6

( ) Yellow to hole O (S-1).

( ) Black to hole P (S-1).

( ) Red to hole R (S-1).

( ) White-green to hole F (S-1).

BO#2

( ) White-green to lug A of switch SW4 (S-1).

( ) White-yellow to hole J (S-1).

( ) White to hole K (S-1).

( ) Yellow to hole L (S-1).

BO#1

( ) White-orange to hole M (S-1).

( ) Blue to hole N (S-1).

( ) Violet to hole D (S-1).

( ) Orange and black wires to lug A of switch SW7 (NS).

( ) Green to hole E (S-1).

( ) Connect a 1-1/2" black wire from lug A of switch SW7 (S-3) to GND (S-1).

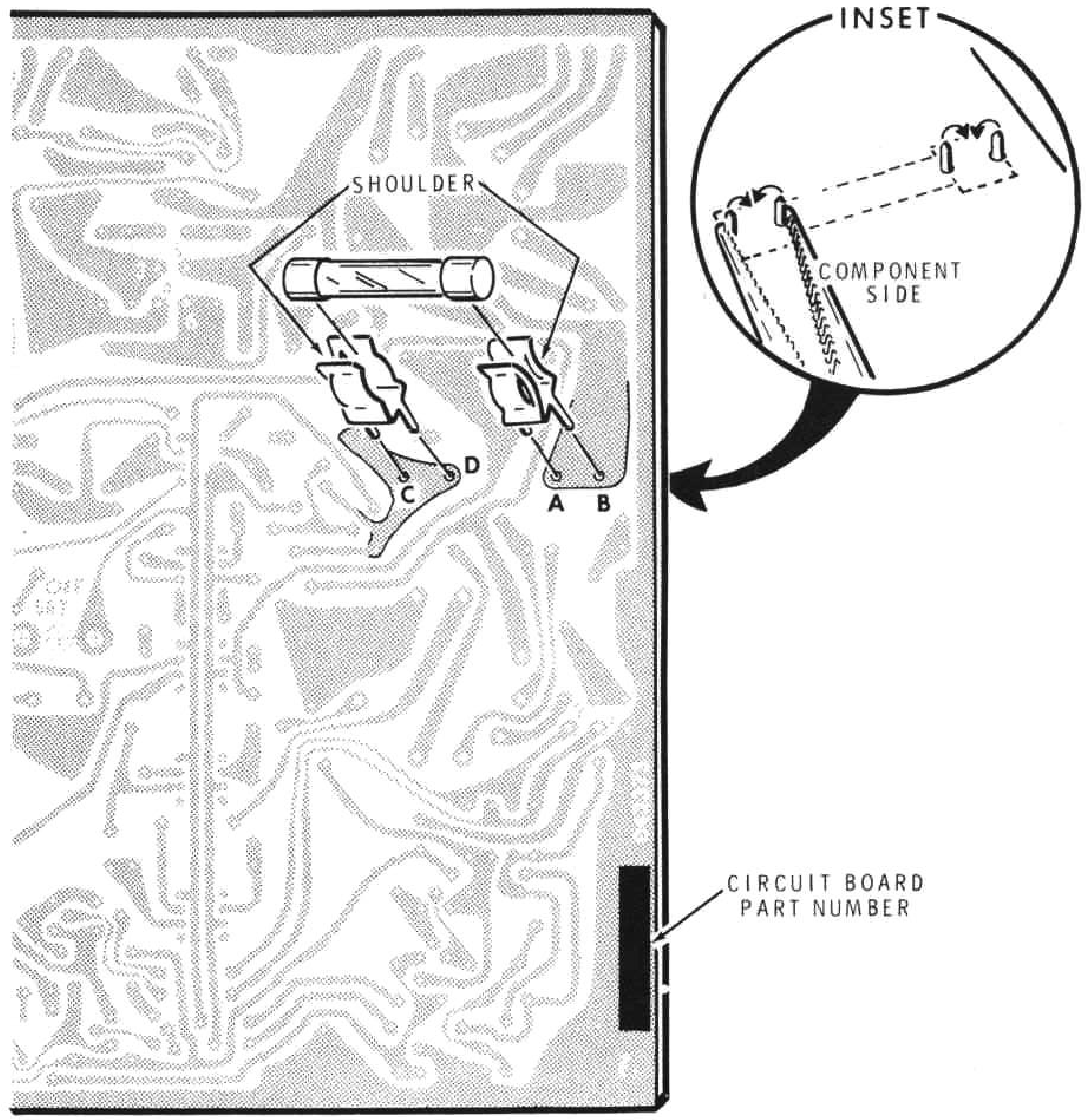
Refer to Pictorial 1-14 for the following steps.

( ) Turn the circuit board foil-side-up and locate holes C and D. Install a fuse clip in these holes. Be sure the shoulder is positioned as shown, but do not solder it yet.

( ) Install another fuse clip at holes A and B. Be sure the shoulder is positioned as shown.

( ) F1: Install the 1/16-ampere fuse in the fuse clips.

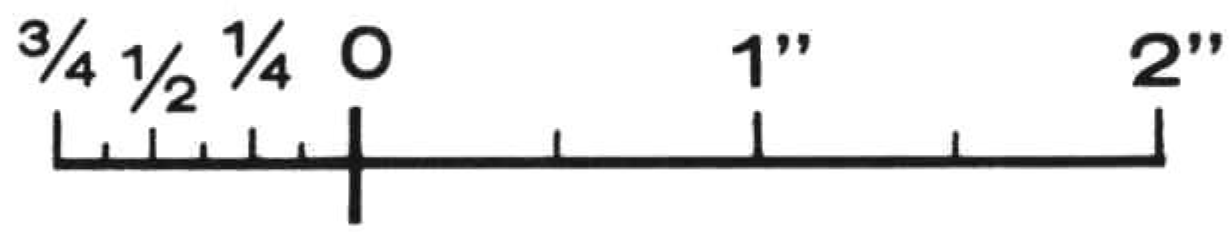
( ) Turn the circuit board over and bend the ends of the fuse clips; use pliers. See the inset drawing.

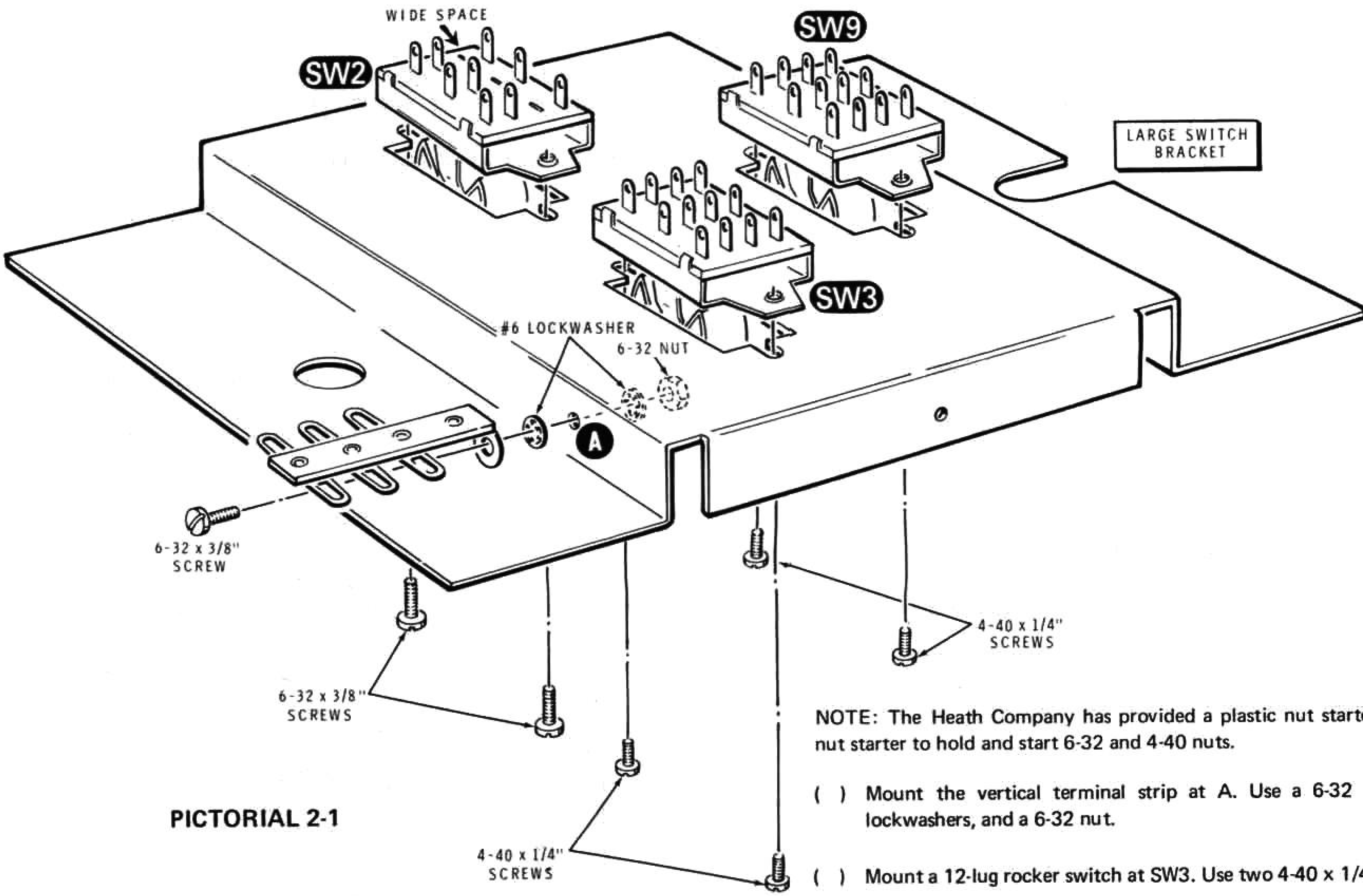


PICTORIAL 1-14

( ) Solder the fuse clips to the foil side of the circuit board.

( ) Set the circuit board aside temporarily.





PICTORIAL 2-1

NOTE: The Heath Company has provided a plastic nut starter with this kit. Use the nut starter to hold and start 6-32 and 4-40 nuts.

( ) Mount the vertical terminal strip at A. Use a 6-32 x 3/8" screw, two #6 lockwashers, and a 6-32 nut.

( ) Mount a 12-lug rocker switch at SW3. Use two 4-40 x 1/4" screws.

( ) Mount the 9-lug rocker switch at SW2. Use two 6-32 x 3/8" screws. Make sure the switch lugs are positioned so the wide space is as shown in the pictorial.

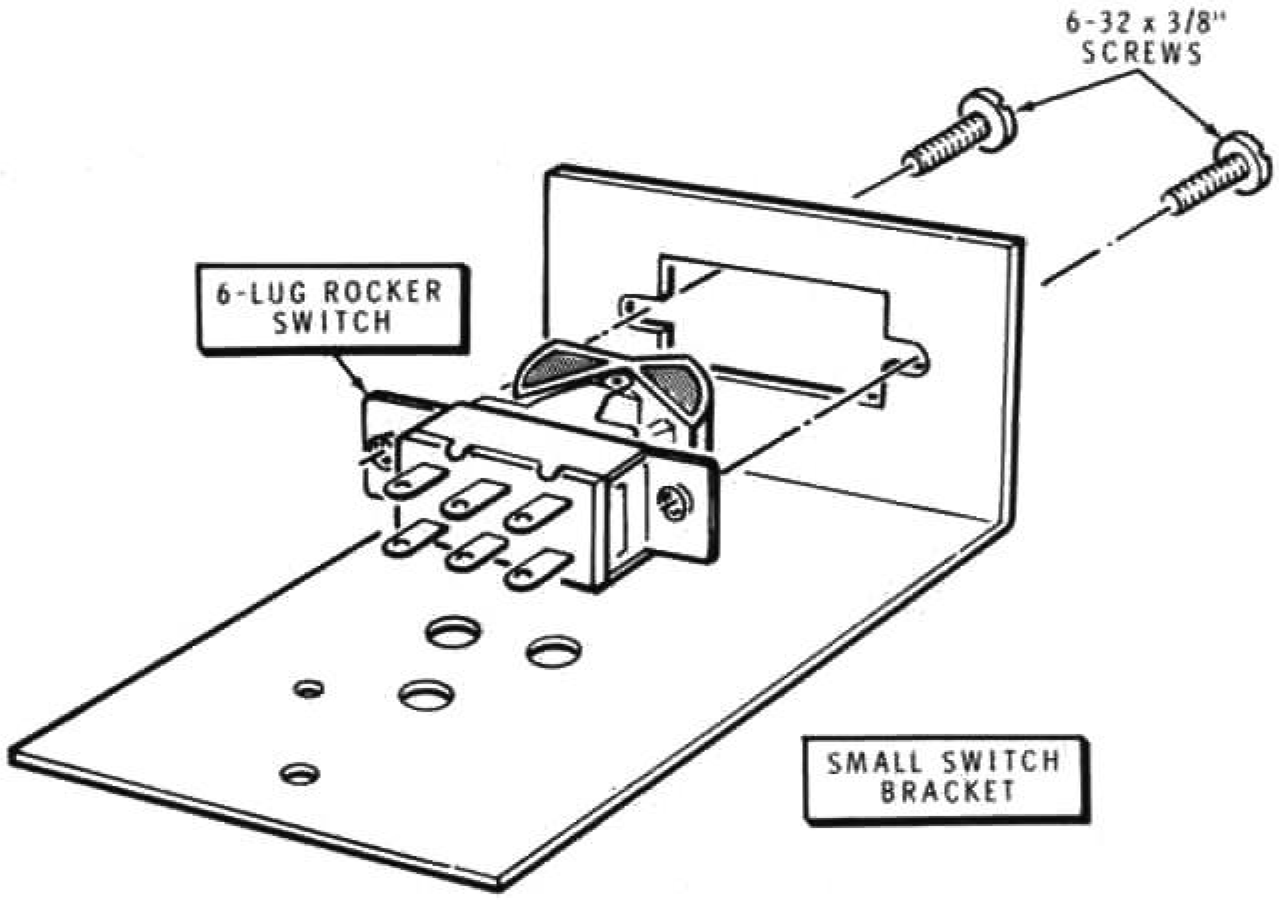
( ) Mount a 12-lug rocker switch at SW9. Use two 4-40 x 1/4" screws.

Lay the large switch bracket aside temporarily.

SUBASSEMBLY PARTS MOUNTING

Refer to Pictorial 2-1 for the following steps.

( ) Locate the large switch bracket and position it as shown in the pictorial.



PICTORIAL 2-2

Refer to Pictorial 2-2 for the following steps.

( ) Locate the small switch bracket and position it as shown.

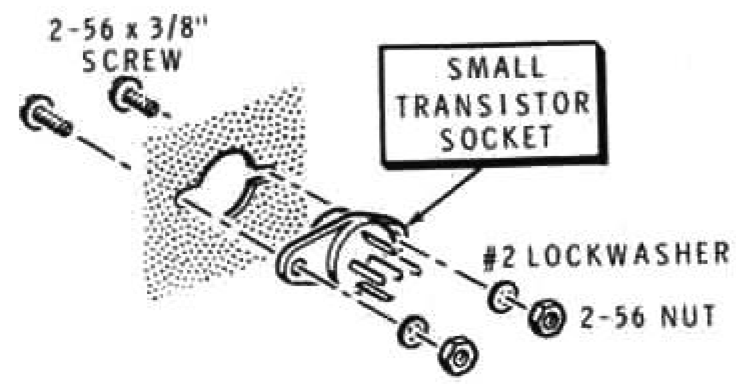
( ) Mount the 6-lug rocker switch to the bracket. Use two 6-32 x 3/8" screws.

( ) Set the bracket aside temporarily.

CHASSIS ASSEMBLY

Refer to Pictorial 2-3 (fold-out from this page) for the following steps.

NOTE: You will install small transistor sockets in the following steps. Small numbers are molded in the base of these sockets. Be sure lug 1 is positioned as shown in the Pictorial.



Detail 2-3A

Detail 2-3B

( ) Refer to Detail 2-3A and mount a small transistor socket at B on the front panel. Use two 2-56 x 3/8" screws, two #2 lockwashers, and two 2-56 nuts. Be sure lug 1 is positioned as shown.

( ) In a similar manner, mount a small transistor socket at J.

( ) Refer to Detail 2-3B and mount a black banana jack at C. Use the nut supplied with the jack.

In a similar manner, mount banana jacks at the following locations.

( ) White banana jack at D.

( ) Red banana jack at E.

( ) Black banana jack at F.

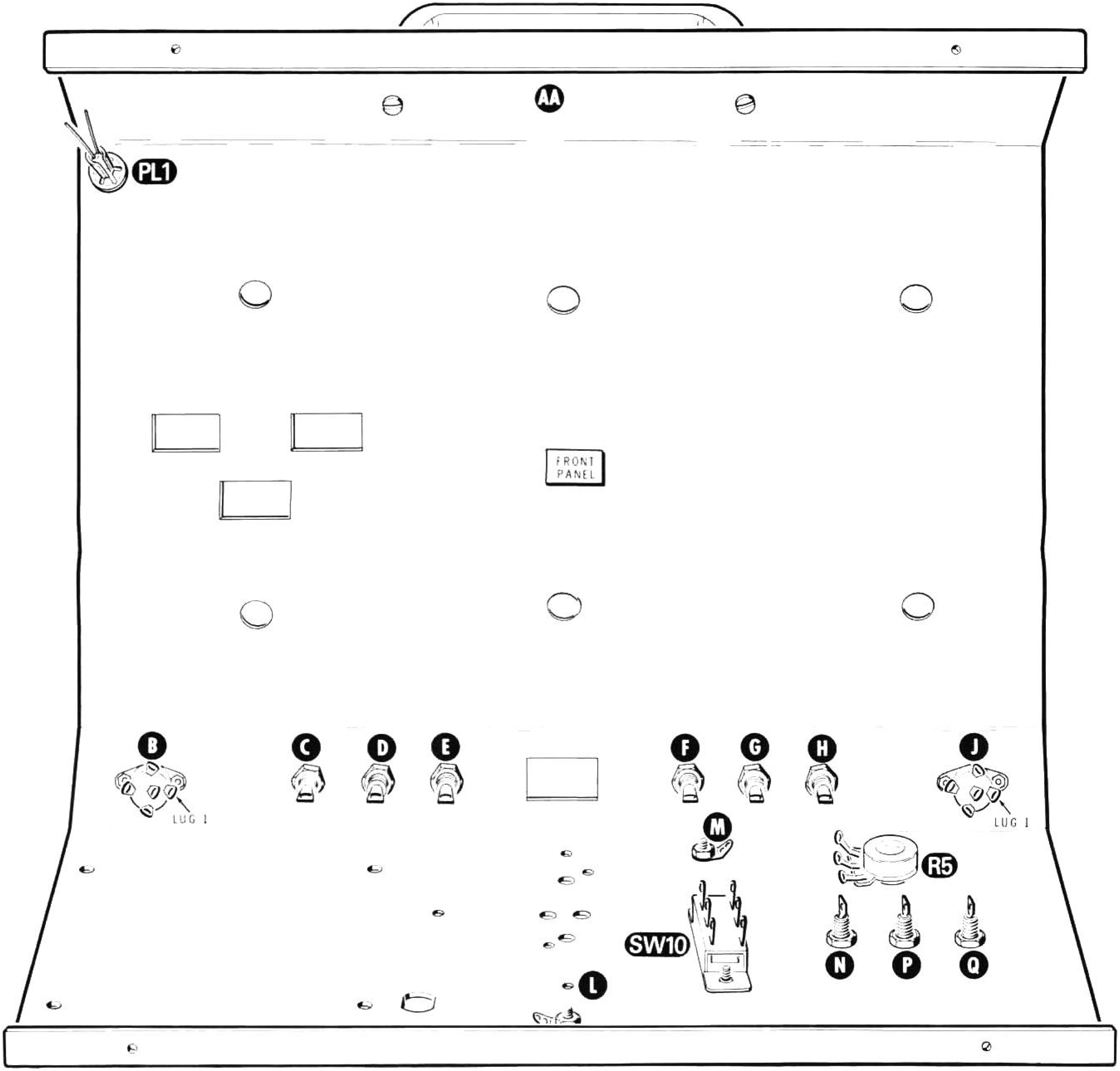
( ) White banana jack at G.

( ) Red banana jack at H.

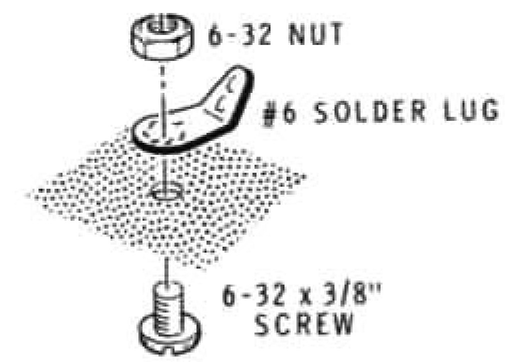
( ) Red banana jack at N.

( ) Black banana jack at P.

( ) Red banana jack at Q.



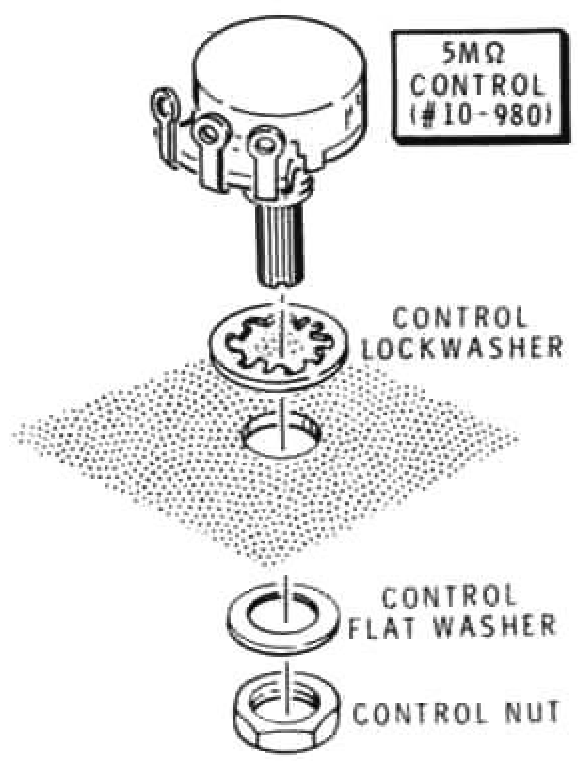
PICTORIAL 2-3



Detail 2-3C

( ) Scrape any paint from around hole M. Then mount a #6 solder lug as shown in Detail 2-3C. Use a 6-32 x 3/8" screw and a 6-32 nut.

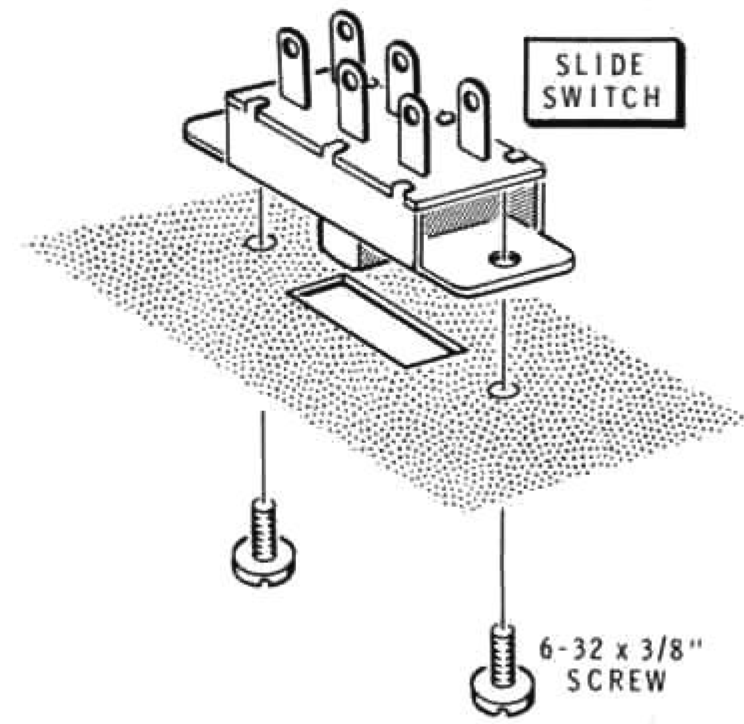
( ) In a similar manner, mount a #6 solder lug at L.



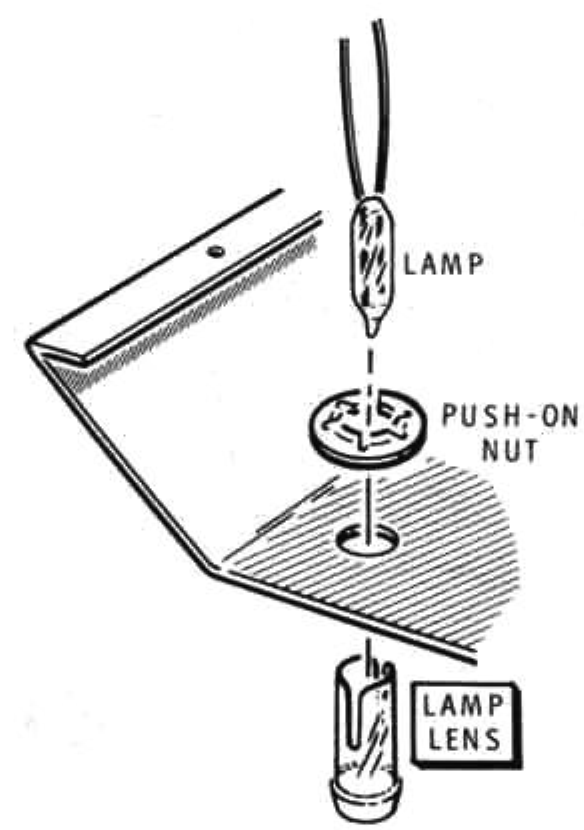
Detail 2-3D

( ) Refer to Detail 2-3D and install a 5 MΩ control (#10-980) at R5 as shown. Use a control lockwasher, control flat washer, and control nut.

( ) Refer to Detail 2-3E and mount the slide switch at SW10. Use two 6-32 x 3/8" screws.



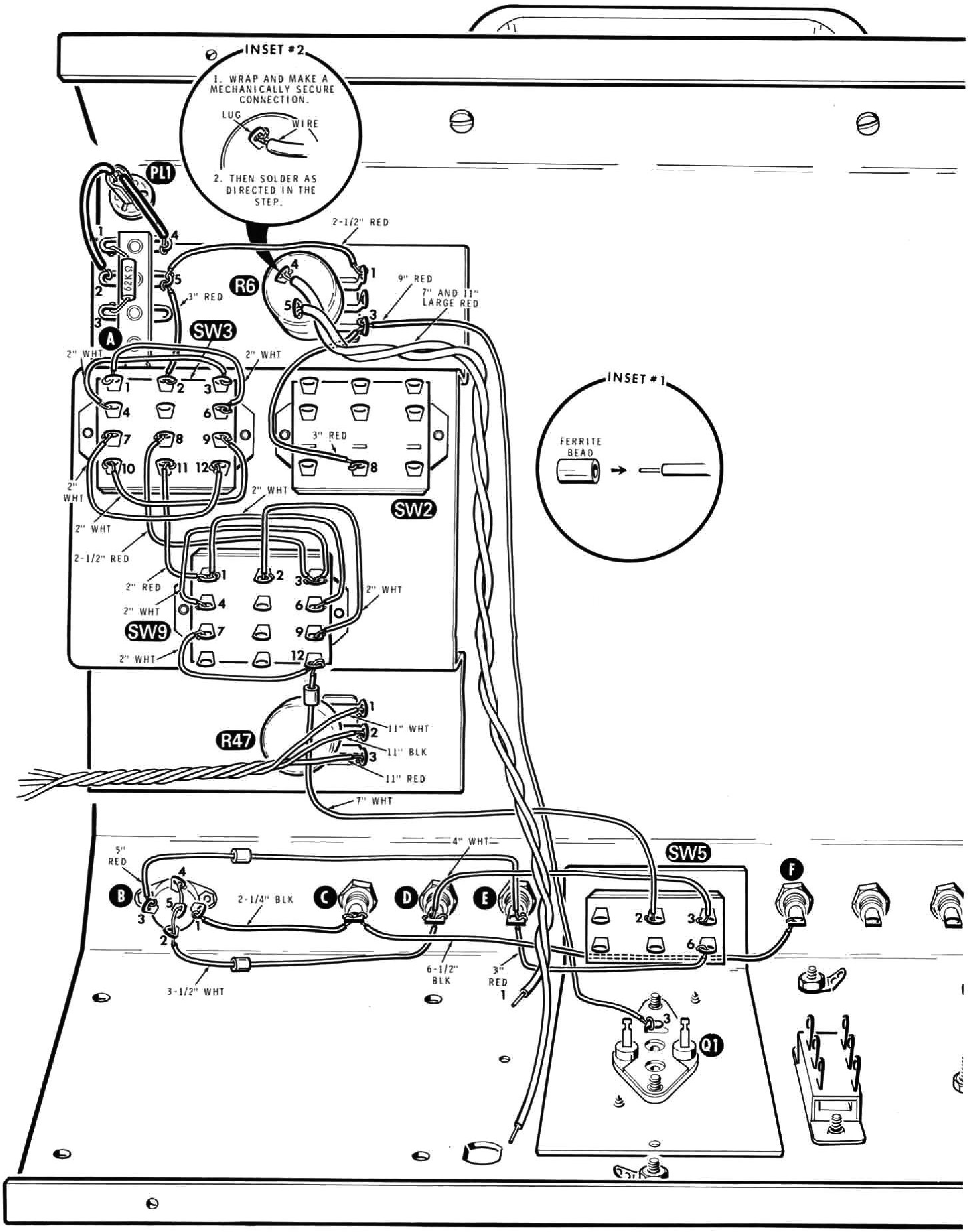
Detail 2-3E



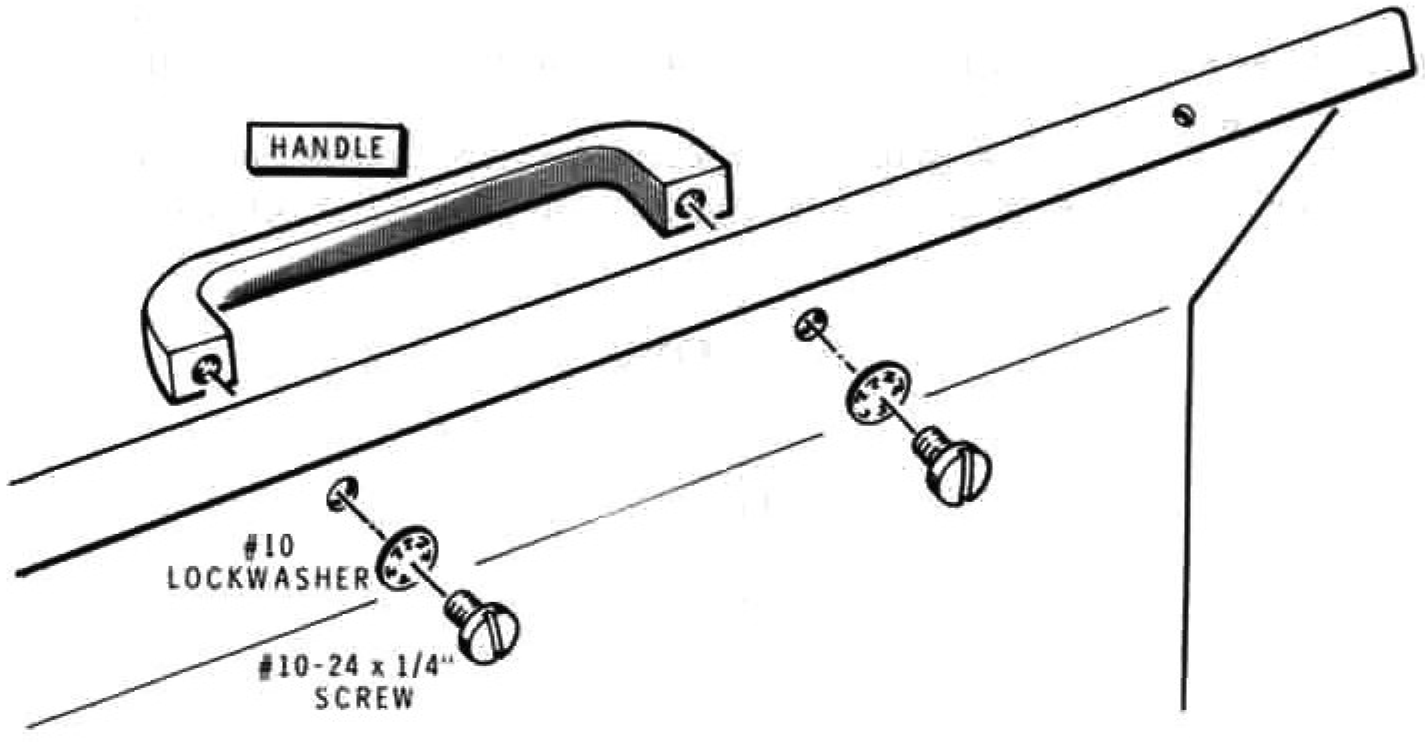
Detail 2-3F

( ) Refer to Detail 2-3F and install the lamp lens at PL1. Use the push-on nut.

( ) Push the lamp into the lamp lens.

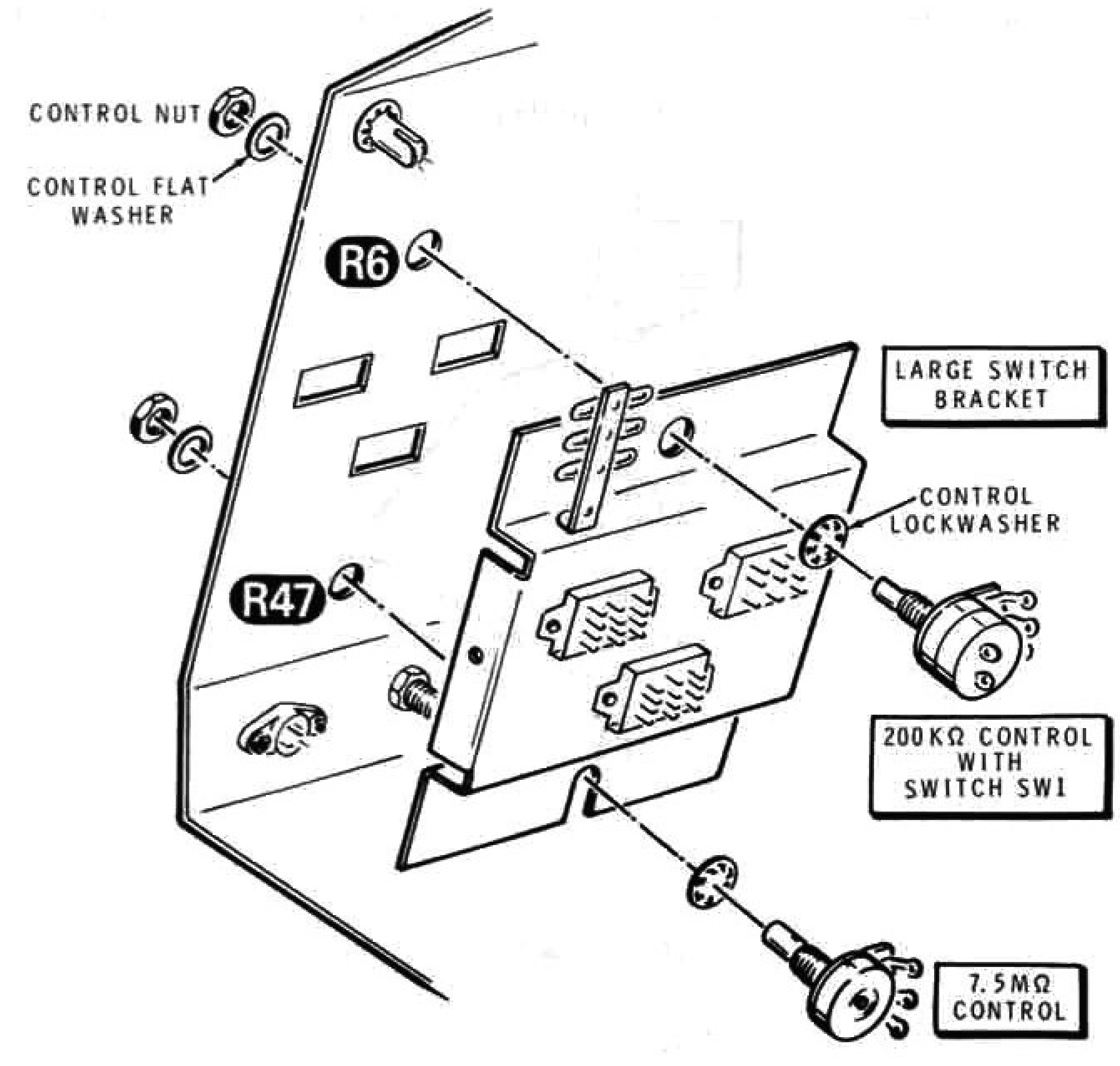


PICTORIAL 3-1



Detail 2-3G

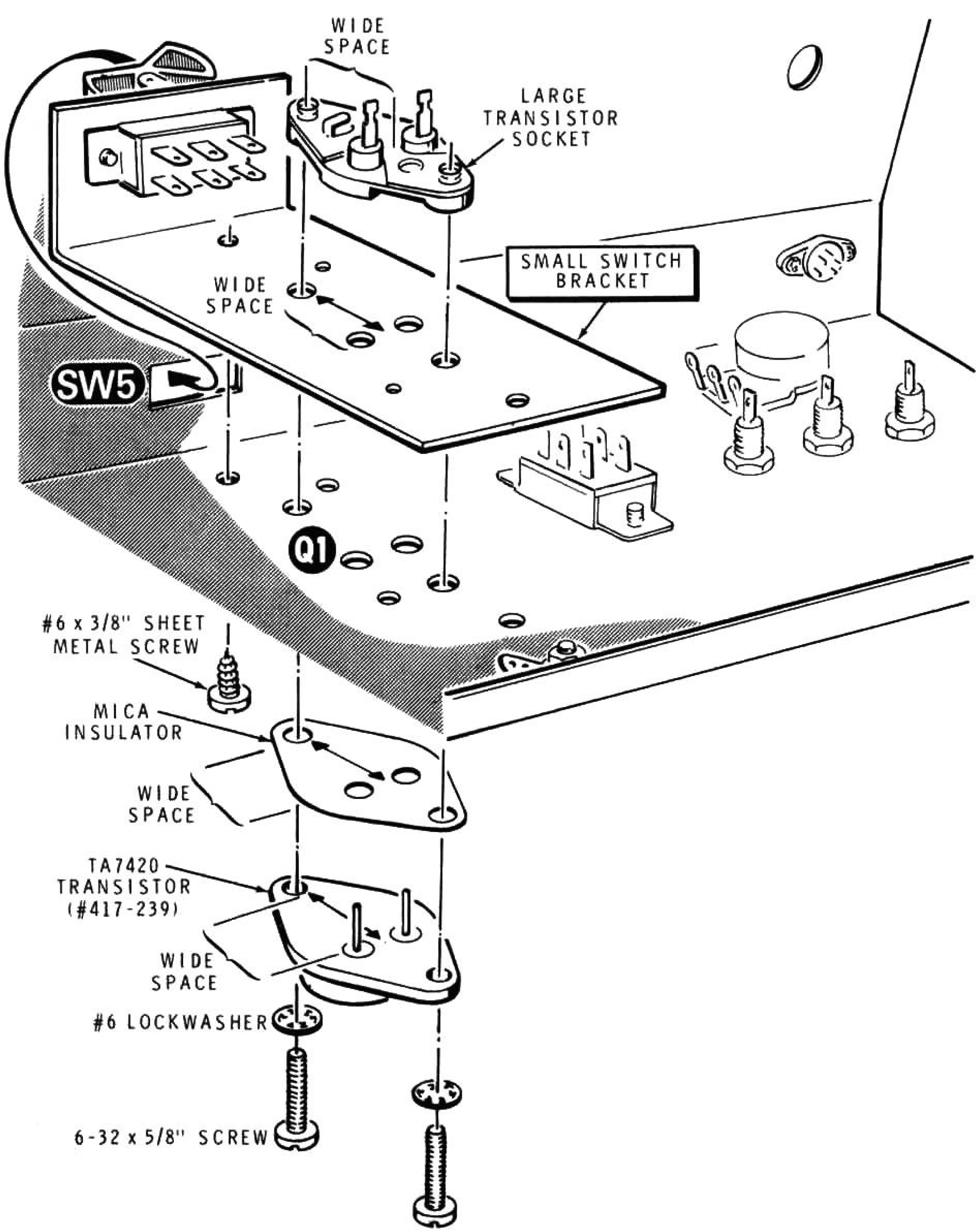
( ) Refer to Detail 2-3G and mount the handle at AA. Use two 10-24 x 1/4" screws and two #10 lockwashers.



PICTORIAL 2-4

Refer to Pictorial 2-4 for the following steps.

( ) Mount the large switch bracket as shown. Install the 200 kΩ control with switch (#19-192), control lockwasher, control flat washer, and control nut at R6. Similarly, install the 7.5 MΩ control (#10-976) at R47. Be sure the rocker switches operate freely before you tighten the control nuts. (NOTE: If the switches do not operate freely, loosen the screws and reposition the switches slightly.)



PICTORIAL 2-5

Refer to Pictorial 2-5 for the following steps.

( ) Position the small switch bracket with the rocker of the rocker switch through the opening at SW5 as shown. Secure the bracket with a #6 x 3/8" sheet metal screw. Be sure the holes in the bracket and panel line up properly, and the switch operates freely.

( ) Position the large transistor socket on the switch bracket. Be sure the ridges on the socket seat into the holes and be sure to observe the wide space between the holes.

( ) Apply a layer of silicone grease to both sides of the mica insulator.

( ) Lay the mica insulator on the TA7420 transistor (#417-239) as shown.

( ) Then install the TA7420 transistor (#417-239) at Q1 with two 6-32 x 5/8" screws and two #6 lockwashers.

NOTE: You should have an MPSA20 transistor (#417-801) left. It will be used later.

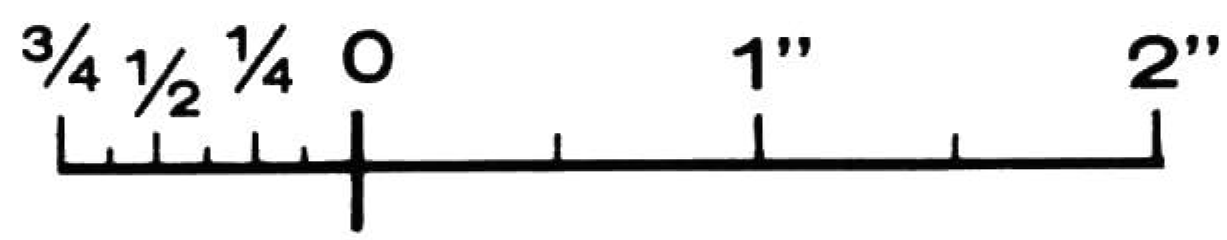
CHASSIS WIRING

Refer to Pictorial 3-1 (fold-out from Page 32) for the following steps.

( ) Place a 1/2" length of sleeving over either lead of the lamp at PL1. Connect this lead to lug 4 of terminal strip A (S-1).

( ) Place a 1" length of sleeving over the other lamp lead. Connect this lead to lug 2 of terminal strip A (NS). Be sure the lamp leads do not cross each other.

( ) R1: Connect a 62 kΩ resistor (blue-red-orange) from lug 1 (S-1) to lug 3 (S-1) of terminal strip A.



( ) Prepare the following red wires. (NOTE: Do not use the large red wire or red test leads until called for in a step.)

2-1/2" 5"
3" 3"
2-1/2"
2"
3"
9"

Connect the red wires as follows:

( ) 2-1/2" wire from lug 1 of R6 (NS) to lug 5 of terminal strip A (NS).

( ) 3" wire from lug 5 of terminal strip A (S-2) to lug 2 of switch SW3 (S-1).

( ) 2-1/2" wire from lug 8 of switch SW3 (S-1) to lug 3 of switch SW9 (NS).

( ) 2" wire from lug 11 of switch SW3 (S-1) to lug 1 of switch SW9 (NS).

( ) 3" wire from lug 3 of R6 (NS) to lug 8 of switch SW2 (NS).

( ) 9" wire from lug 3 of R6 (S-2) to lug 3 of Q1 (S-1).

( ) 5" wire to lug 3 of socket B (S-1). Then slide a ferrite bead over the free end of the wire (see inset drawing #1) and connect the wire to banana jack E (NS).

( ) 3" wire from banana jack E (S-2) to lug 6 of switch SW5 (S-1).

( ) Prepare the following white wires:

QUANTITY	LENGTH
8	2"

Connect the wires as follows:

( ) 2" wire from lug 4 (S-1) to lug 3 (NS) of switch SW3.

( ) 2" wire from lug 1 (NS) to lug 6 (S-1) of switch SW3.

( ) 2" wire from lug 7 (S-1) to lug 12 (NS) of switch SW3.

( ) 2" wire from lug 10 (NS) to lug 9 (S-1) of switch SW3.

( ) 2" wire from lug 4 (S-1) to lug 3 (S-2) of switch SW9.

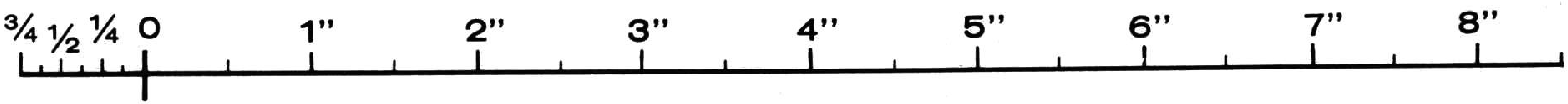
( ) 2" wire from lug 1 (S-2) to lug 6 (S-1) of switch SW9.

( ) 2" wire from lug 2 (S-1) to lug 9 (NS) of switch SW9.

( ) 2" wire from lug 7 (NS) to lug 12 (NS) of switch SW9.

( ) Prepare the following white wires:

7"
3-1/2"
4"



Connect the wires as follows:

( ) 7" wire. Slide a ferrite bead over one end and connect this end to lug 12 of switch SW9 (S-2). Connect the other end to lug 2 of switch SW5 (S-1).

( ) 3-1/2" wire. Remove an additional 1/4" of insulation from one end. Then route this end through lugs 2, 5, and 4 of socket B and solder the connections.

( ) Slide a ferrite bead over the free end of the wire and connect the end to banana jack D (NS).

( ) 4" wire from banana jack D (S-2) to lug 3 of switch SW5 (S-1).

( ) Prepare the following lengths of black wire:

2-1/4"
6-1/2"

Connect the black wires as follows:

( ) 2-1/4" wire from lug 1 of socket B (S-1) to banana jack C (NS).

( ) 6-1/2" wire from banana jack C (S-2) to banana jack F (NS).

( ) Prepare the following large red wires. (Not the test lead wire.)

9"
11"

( ) Connect the wires to control R6 as follows:

( ) Either wire to lug 4 (S-1). Make a mechanically secure connection; see inset drawing #2.

( ) Other wire to lug 5 (S-1). Make a mechanically secure connection.

( ) Twist the two wires together as shown.

( ) Prepare the following wires:

11" white
11" black
11" red

Connect one end of each of these wires to control R47 as follows. The free ends will be connected later.

( ) Red wire to lug 3 (S-1).

( ) Black wire to lug 2 (S-1).

( ) White wire to lug 1 (S-1).

( ) Twist the three wires together as shown.

Refer to Pictorial 3-2 for the following steps.

( ) Prepare the following red wires:

4-1/2"
2-1/2"
3"
4"

Connect the prepared wires as follows:

( ) 4-1/2" wire from lug 4 of switch SW5 (S-1) to banana jack H (NS).

( ) 2-1/2" wire to banana jack H (S-2). Slide a ferrite bead on the wire and connect the wire to lug 3 of socket J (S-1).

( ) 3" wire to lug 2 of switch SW10 (S-1). Slide a ferrite bead on the wire and connect the wire to banana jack N (S-1).

( ) 4" wire to lug 5 of switch SW10 (S-1). Slide a ferrite bead on the wire and connect the wire to banana jack Q (S-1).

( ) Prepare the following white wires:

4-1/2"
3-1/4"

Connect the prepared wires as follows:

( ) 4-1/2" wire to lug 1 of switch SW5 (S-1). Slide a ferrite bead on the wire as shown and connect the wire to banana jack G (NS).

( ) 3-1/4" wire to banana jack G (S-2). Remove an additional 1/4" of insulation from the free end and connect this end to lugs 2, 5, and 4 of socket J. Solder the connections.

( ) Prepare the following black wires:

5"
1-1/2"
1-1/2"
1-1/2"

Connect the prepared wires as follows:

( ) 5" wire from banana jack F (NS) to lug 1 of socket J (S-1).

( ) 1-1/2" wire from banana jack F (S-3) to solder lug M (NS). Use the indicated hole in the solder lug.

( ) 1-1/2" wire from solder lug M (S-2) to lug 3 of control R5 (NS). Do not fill the remaining hole in the solder lug with solder.

( ) 1-1/2" wire from lug 3 of control R5 (S-2) to banana jack P (S-1).

( ) Bend down lug 1 of control R5 so it is not near banana jack H.

( ) Prepare the following wires:

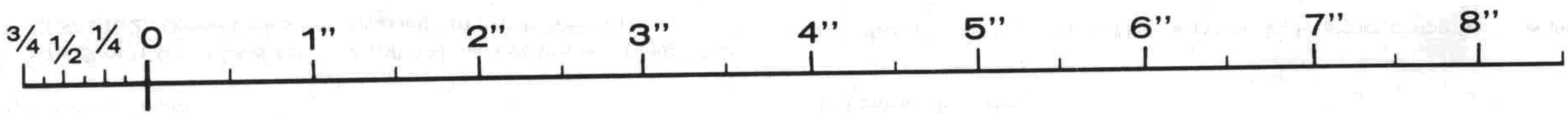
6-1/2" red
5-1/2" black

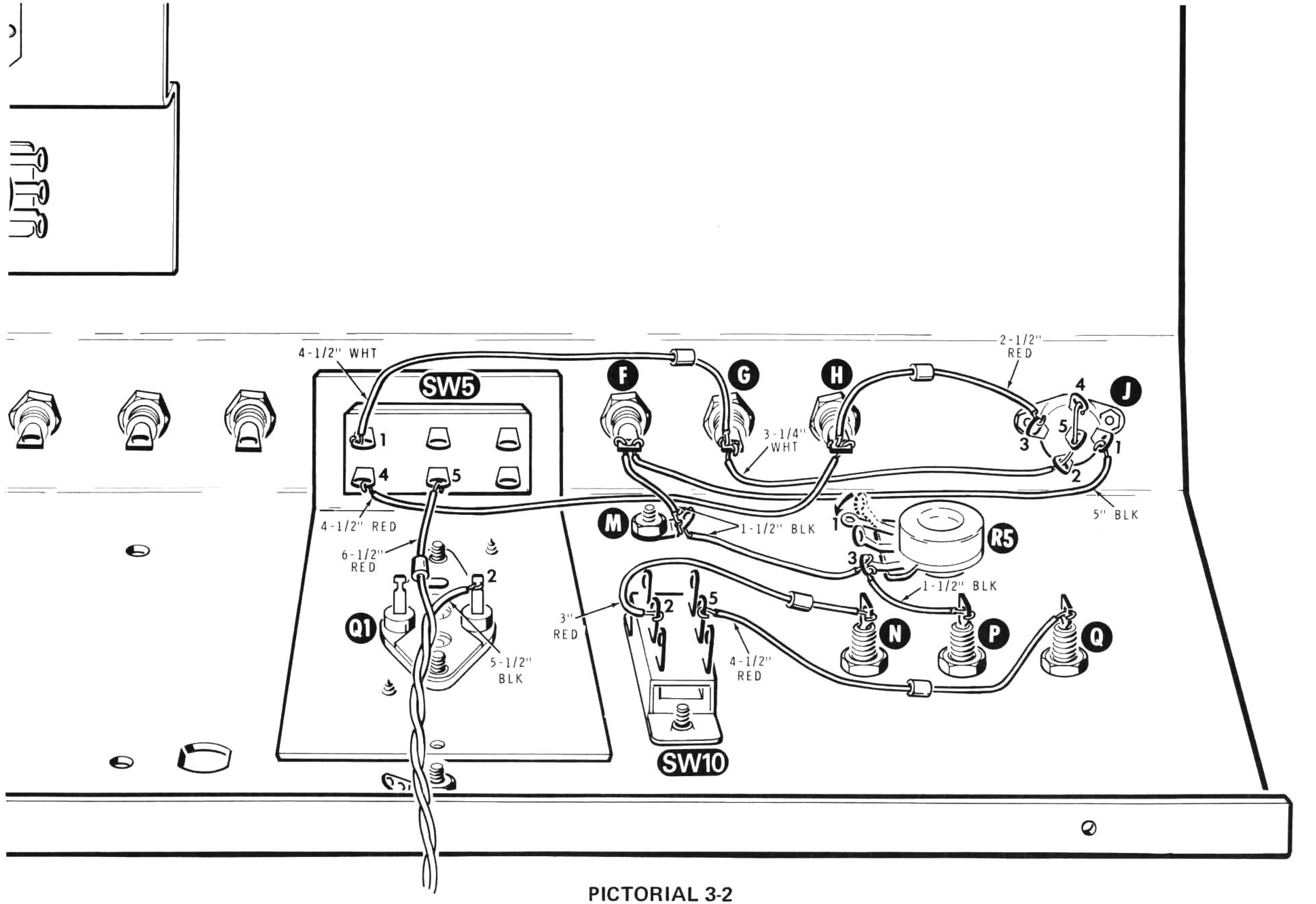
Connect one end of the prepared wires as follows. The free ends will be connected later.

( ) Red wire to lug 5 of switch SW5 (S-1).

( ) Black wire to lug 2 of socket Q1 (S-1).

( ) Slide a ferrite bead on the red wire and twist the wires together as shown.





PICTORIAL 3-2

Refer to Pictorial 3-3 for the following steps.

( ) Position the circuit board near the top panel. Then connect the wiring harness wires as follows:

BO#10 to switch SW9:

( ) Gray to lug 10 (S-1).

( ) White to lug 11 (S-1).

( ) Brown to lug 7 (S-2).

( ) White-orange to lug 8 (S-1).

( ) Black to lug 9 (S-2).

( ) White-gray to lug 5 (S-1).

BO#11 to switch SW3:

( ) Yellow to lug 10 (S-2).

( ) White-yellow to lug 12 (S-2).

( ) Green to lug 5 (S-1).

( ) White-green to lug 1 (S-2).

( ) Violet to lug 3 (S-2).

BO#8 to switch SW2:

( ) Violet to lug 8 (S-2).

( ) Red to lug 9 (S-1).

( ) Brown to lug 5 (NS).

( ) Blue through lug 5 to lug 2. Solder the connections.

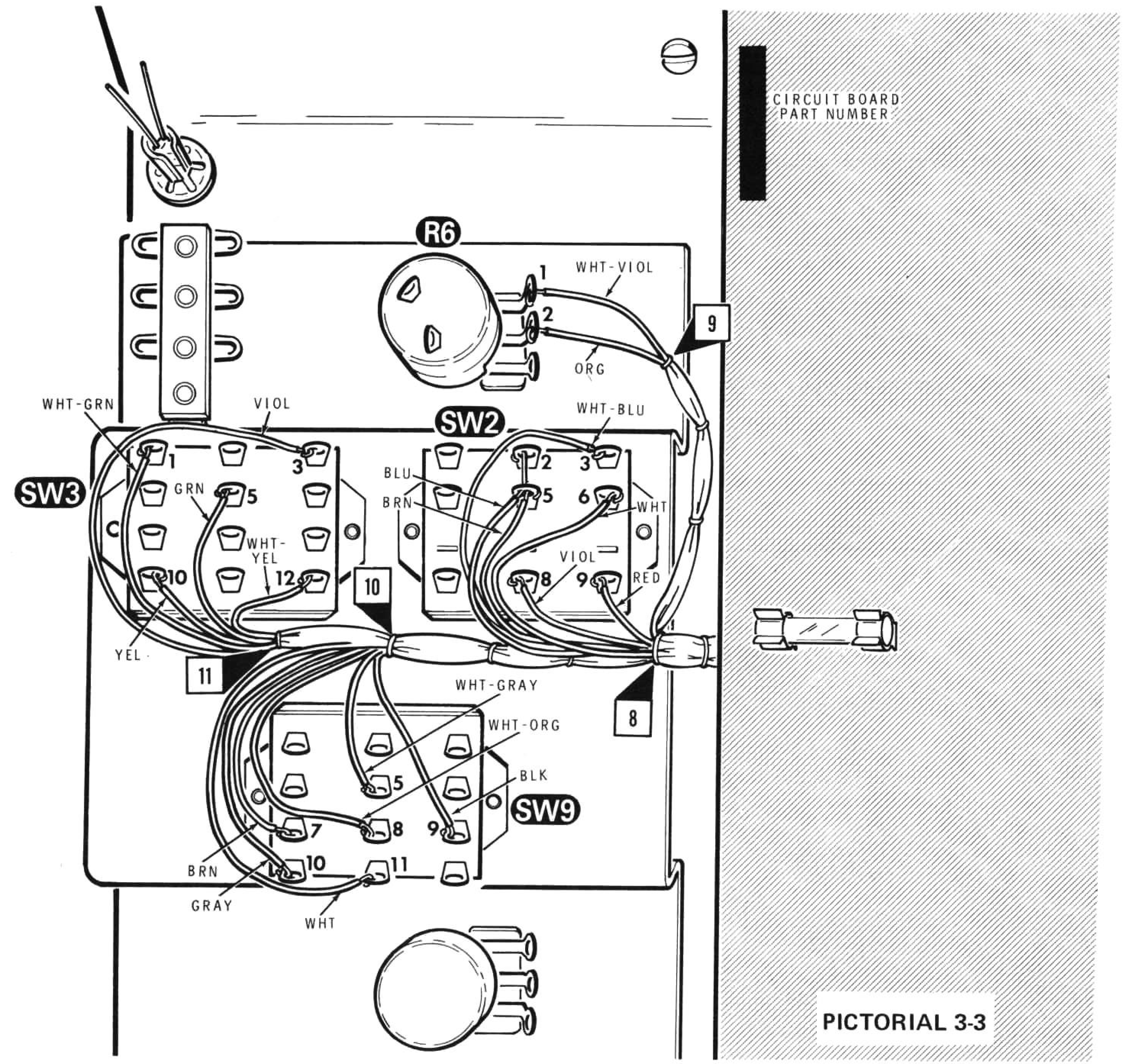
( ) White to lug 6 (S-1).

( ) White-blue to lug 3 (S-1).

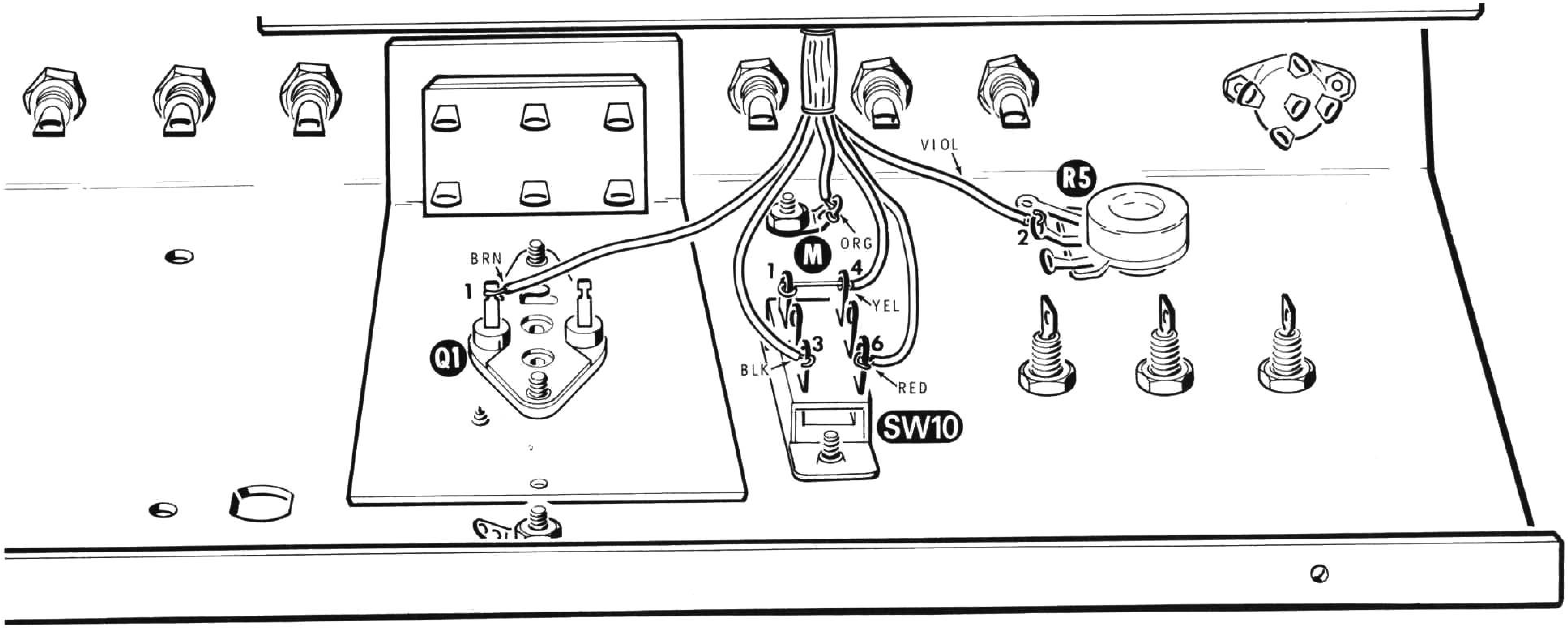
BO#9 to control R6:

( ) Orange to lug 2 (S-1).

( ) White-violet to lug 1 (S-2).



PICTORIAL 3-3



PICTORIAL 3-4

Refer to Pictorial 3-4 for the following steps.

Connect the remaining wiring harness wires as follows:

( ) Orange to top hole of solder lug M (S-1).

( ) Violet to lug 2 of control R5 (S-1).

( ) Yellow through lug 4 (S-2) to lug 1 (S-1) of switch SW10. Remove an additional 1/4" of insulation from the wire.

( ) Black to lug 3 of switch SW10 (S-1).

( ) Red to lug 6 of switch SW10 (S-1).

( ) Brown to lug 1 of socket Q1 (S-1).

Refer to Pictorial 3-5 for the following steps.

Connect the two twisted wires to the circuit board as follows:

( ) Black to hole Y (S-1).

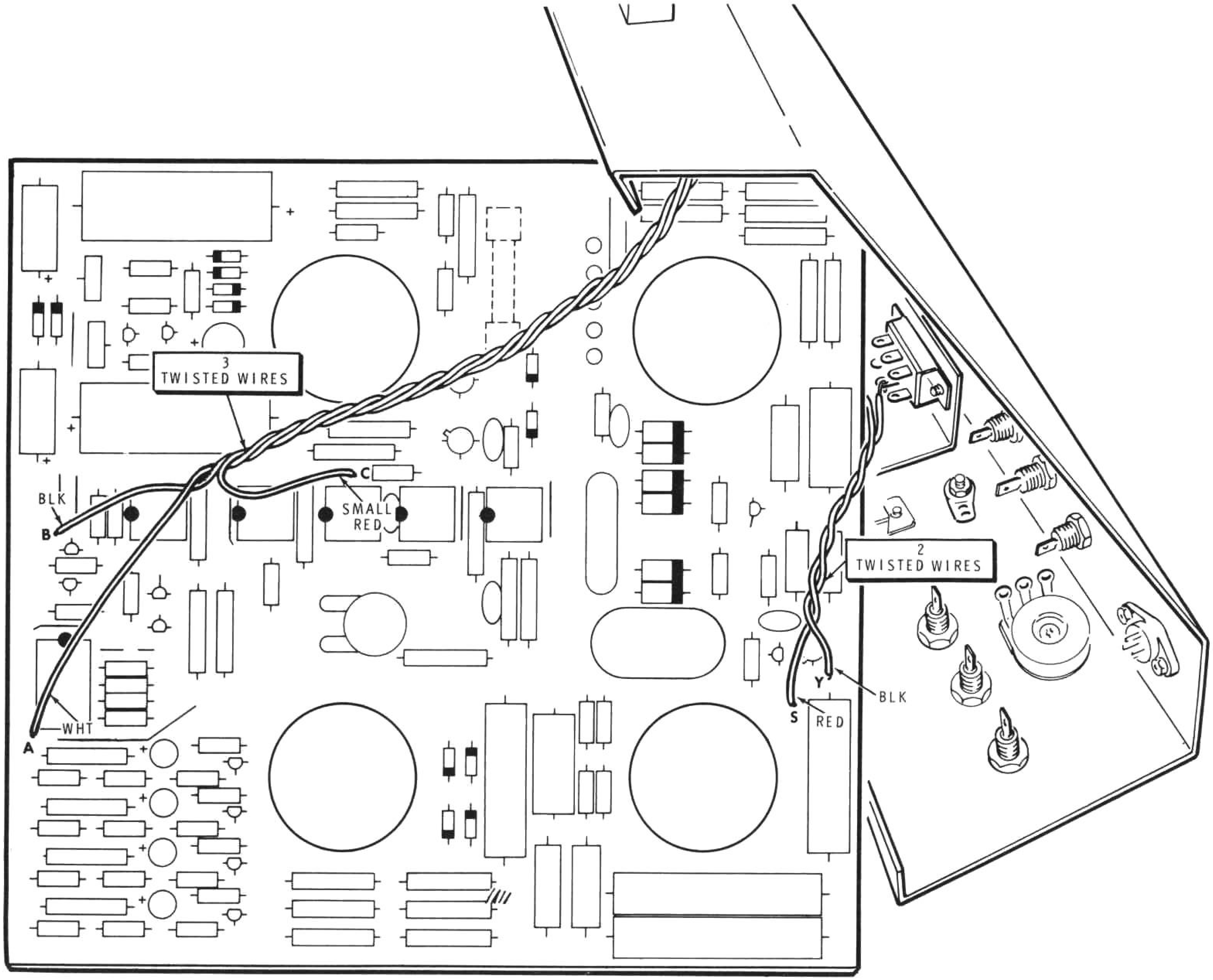
( ) Red to hole S (S-1).

Connect the three twisted wires to the circuit board as follows:

( ) Red to hole C (S-1).

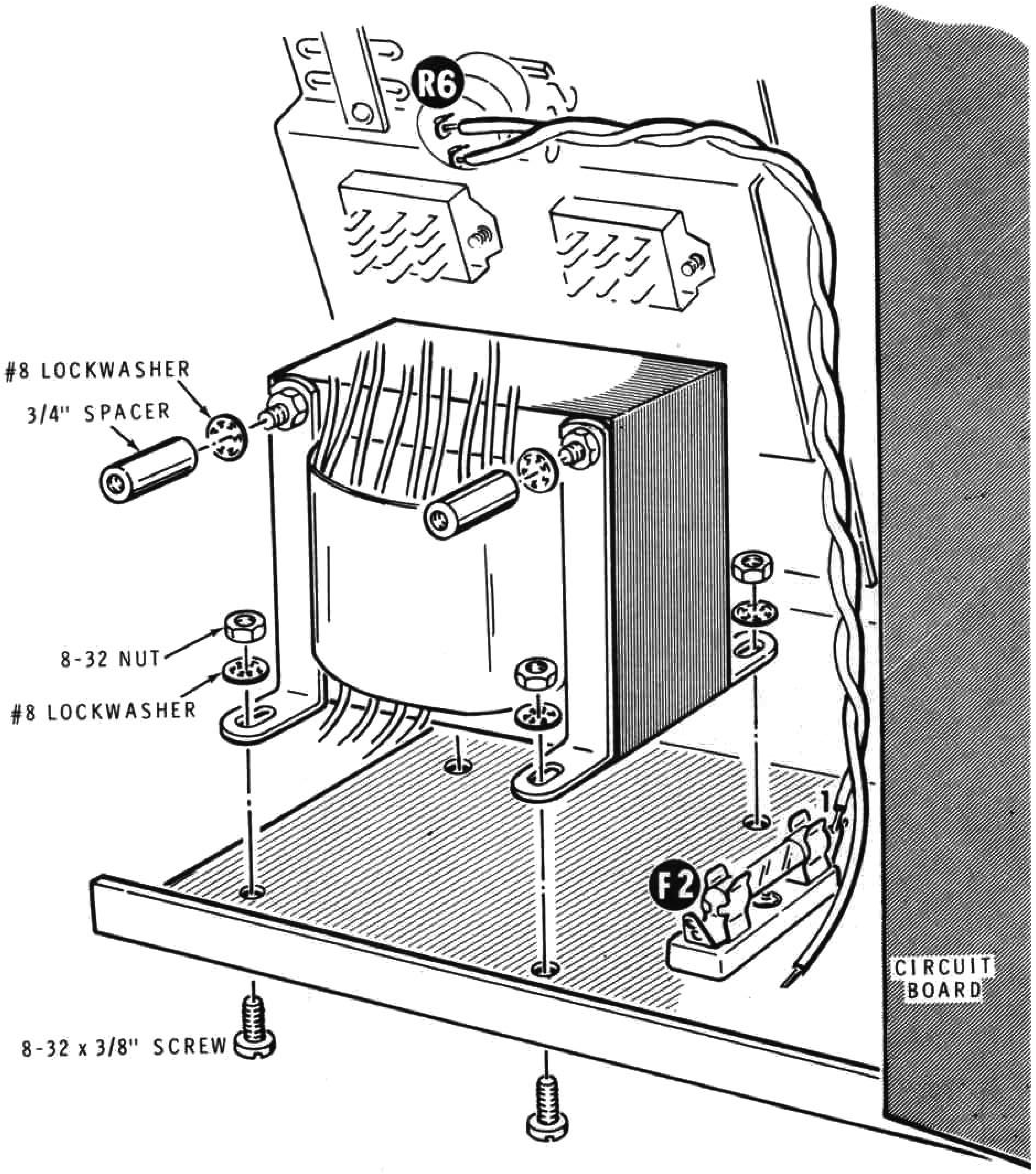
( ) Black to hole B (S-1).

( ) White to hole A (S-1).

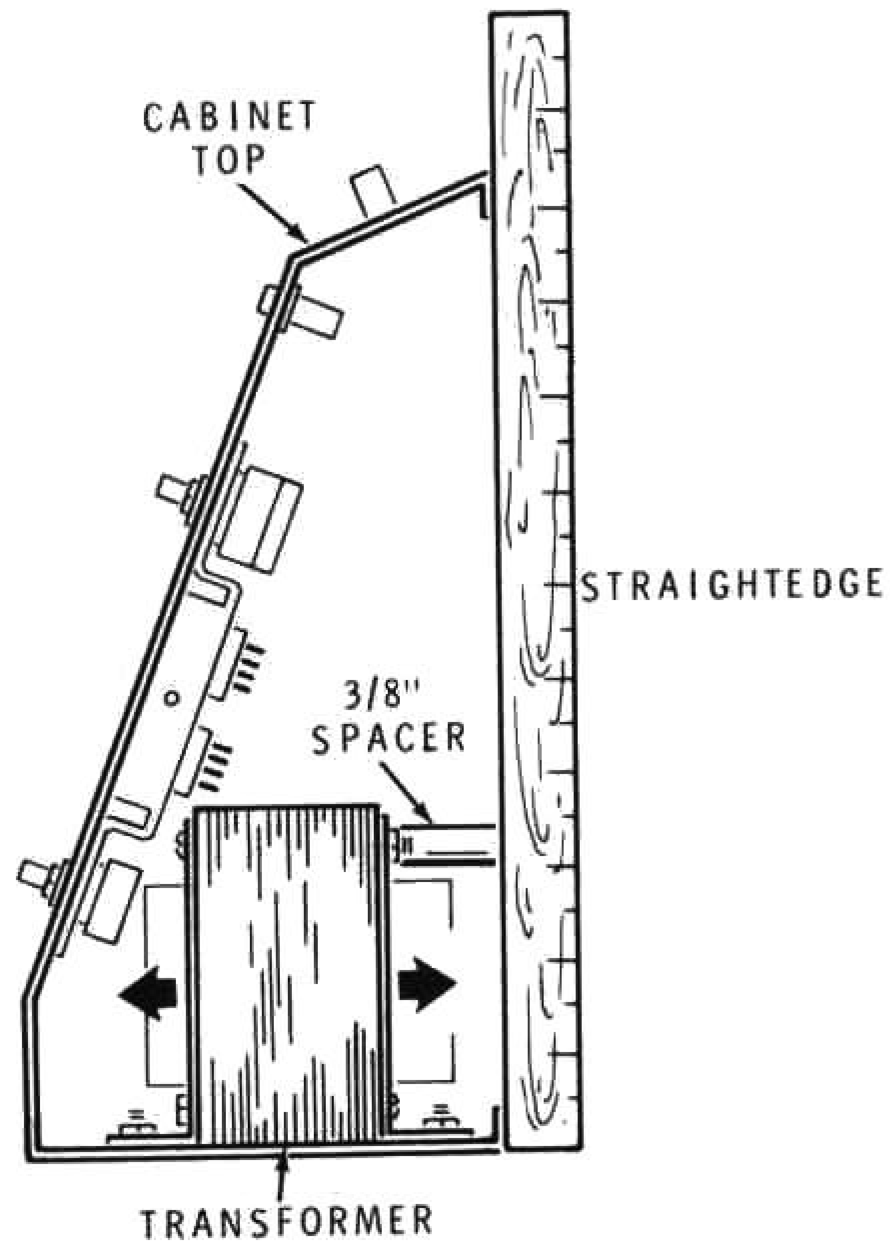


PICTORIAL 3-5

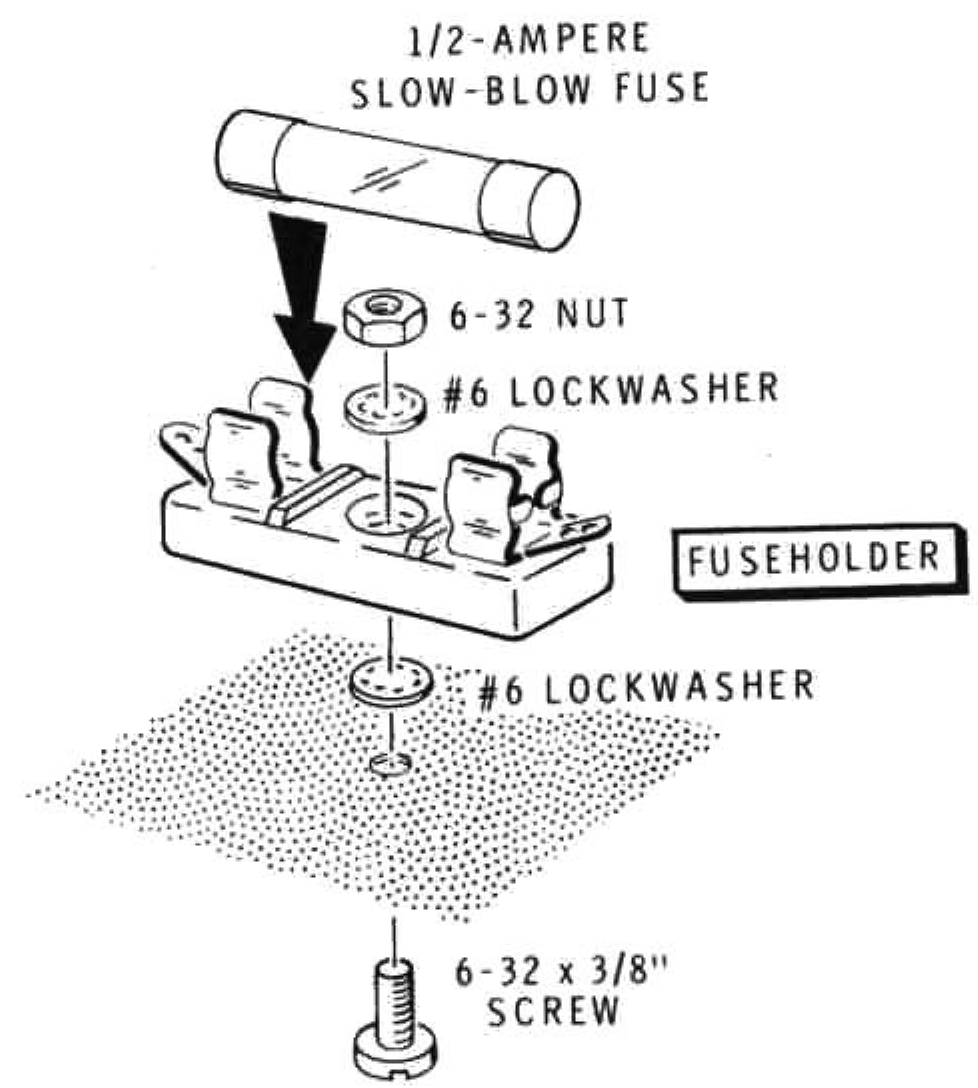
HEATHKIT



PICTORIAL 3-6



Detail 3-6A



Detail 3-6B

( ) Refer to Pictorial 3-6 and install the power transformer as shown. Use four 8-32 x 3/8" screws, four #8 lockwashers, and four 8-32 nuts. Do not tighten the hardware at this time. (NOTE: Position the circuit board out of the way.)

( ) Install two 3/4" spacers on the transformer. Use two #8 lockwashers.

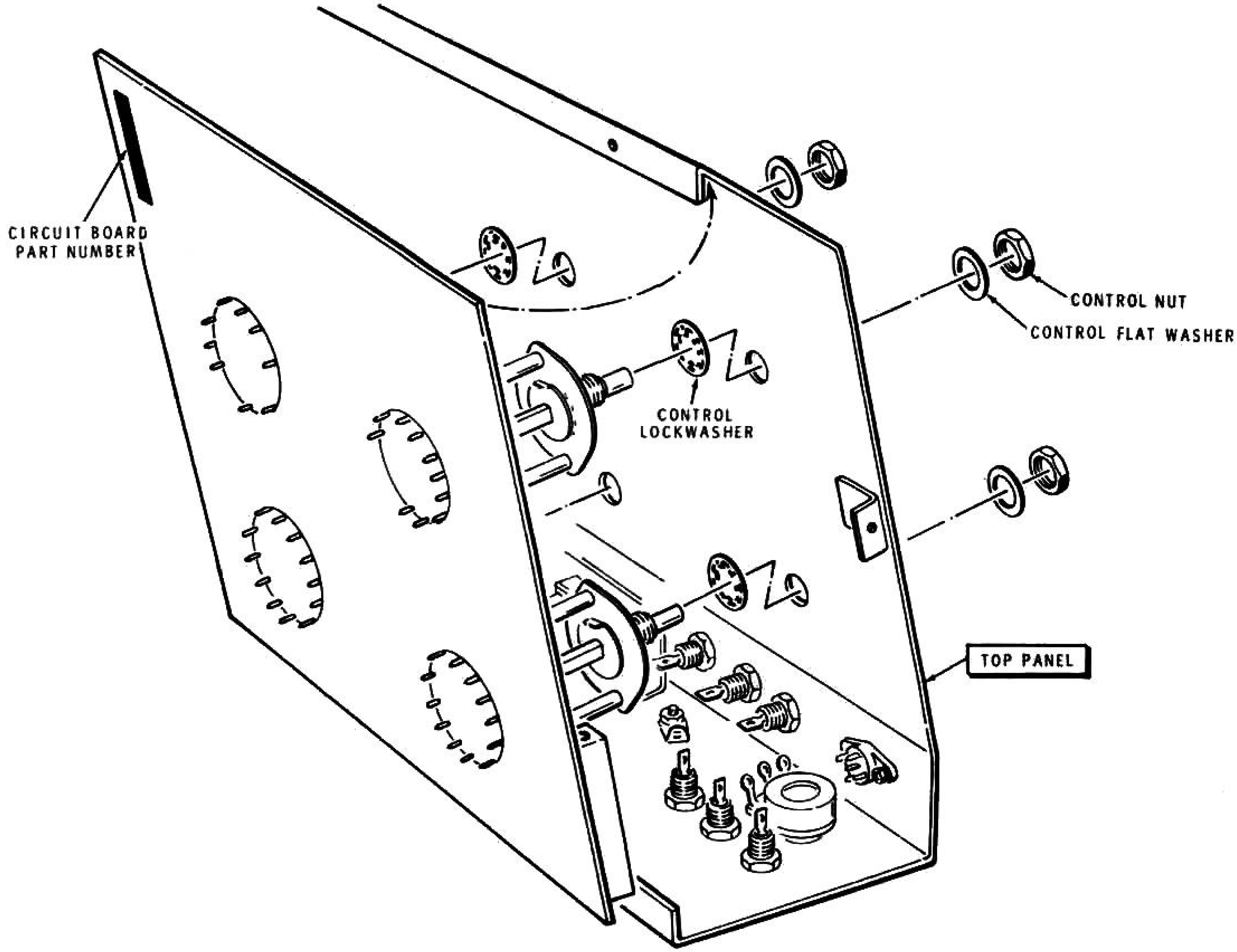
( ) Refer to Detail 3-6A and hold a straightedge against the edges of the chassis top as shown. Then move the transformer over until the spacers touch the straightedge. Tighten the screws that hold the transformer.

( ) Refer to Detail 3-6B and mount the fuseholder at F2. Use a 6-32 x 3/8" screw, two #6 lockwashers, and a 6-32 nut (Do not install the fuse yet.)

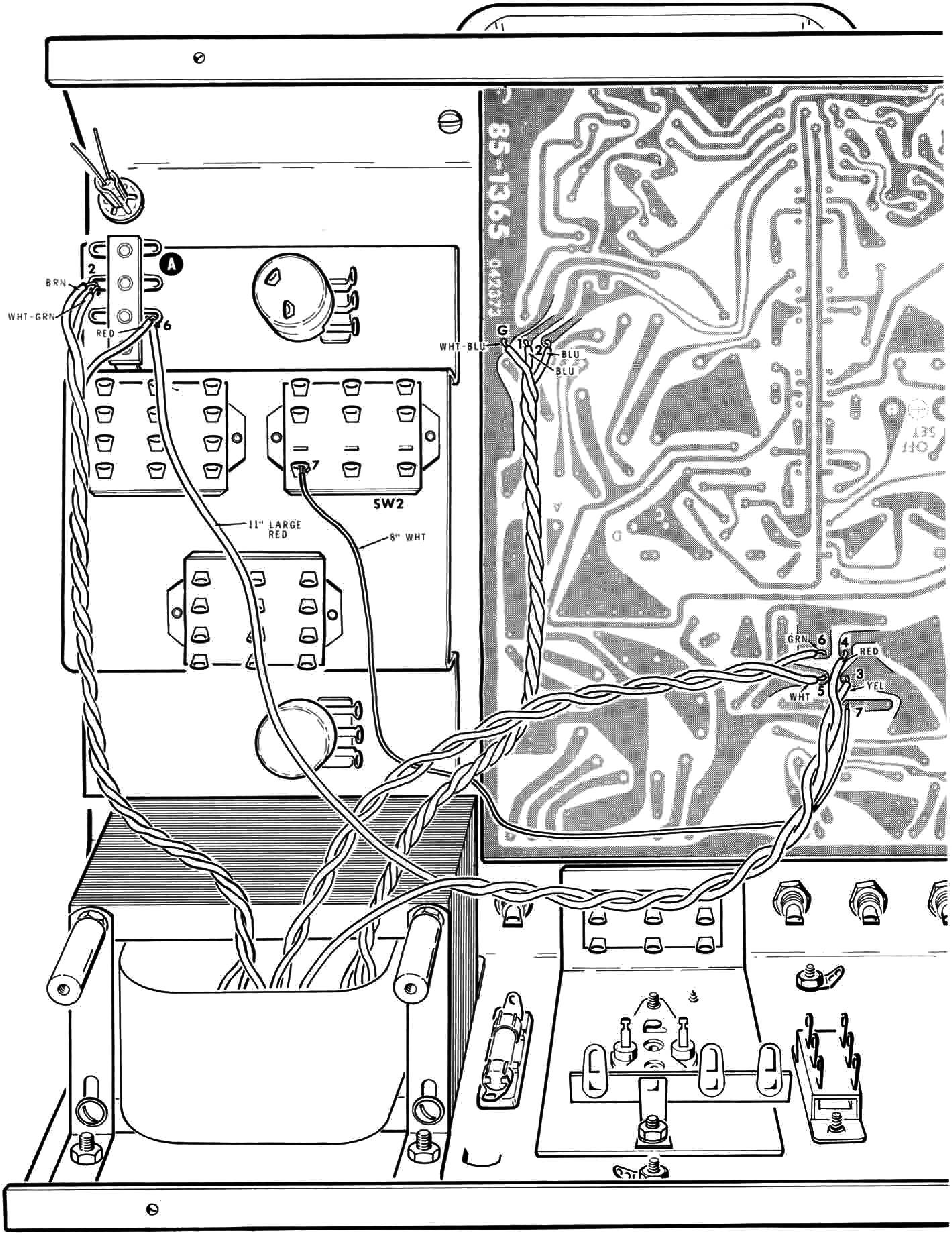
( ) Connect the free end of the shorter large red wire (one of the two twisted wires coming from control R6) to lug 1 of fuseholder F2 (S-1). Make a mechanically secure connection.

( ) Push the 1/2-ampere, slow-blow fuse into the fuseholder. (NOTE: Install a 1/4-ampere slow-blow fuse, not supplied, if you wired your unit for 240 VAC.)

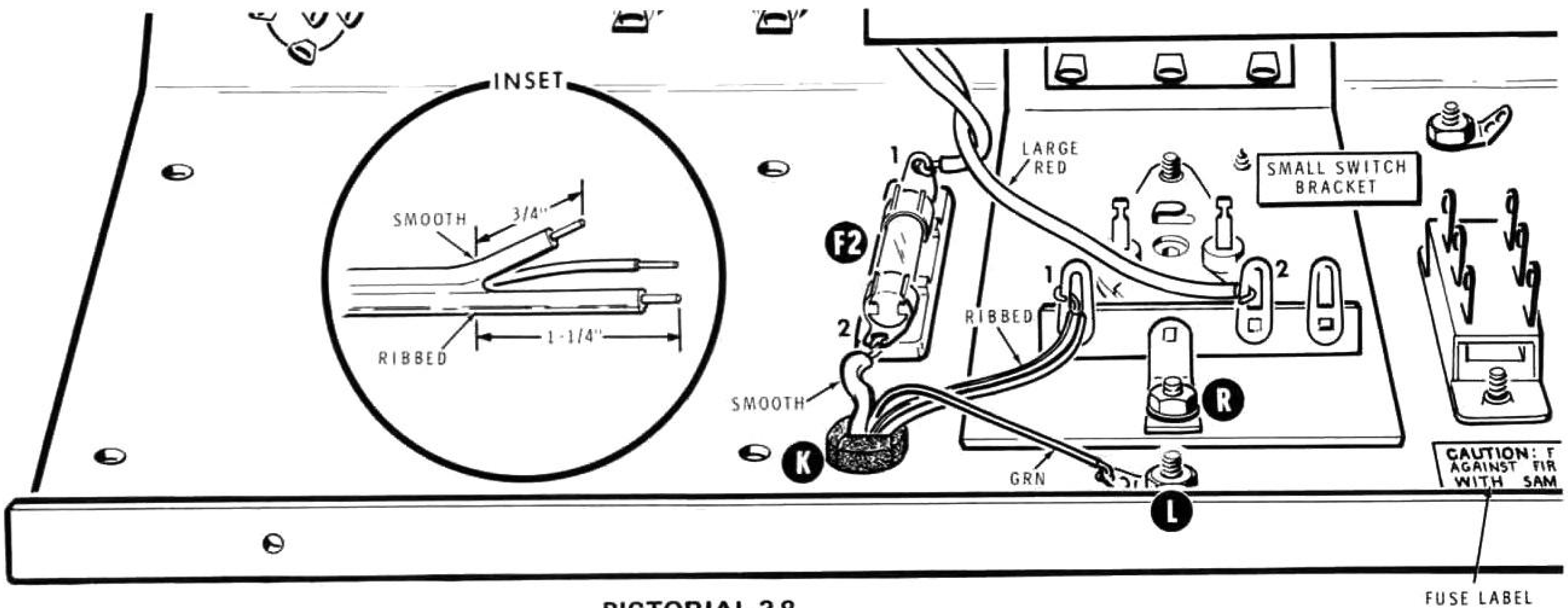
( ) Refer to Pictorial 3-7 and mount the four rotary circuit board switches to the top panel. Use four control lockwashers, four control flat washers, and four control nuts.



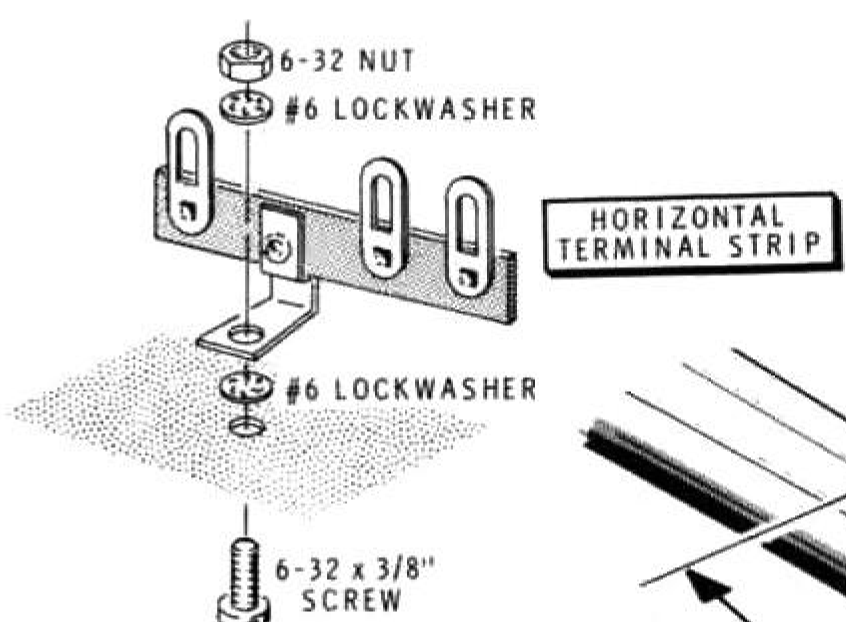
PICTORIAL 3-7



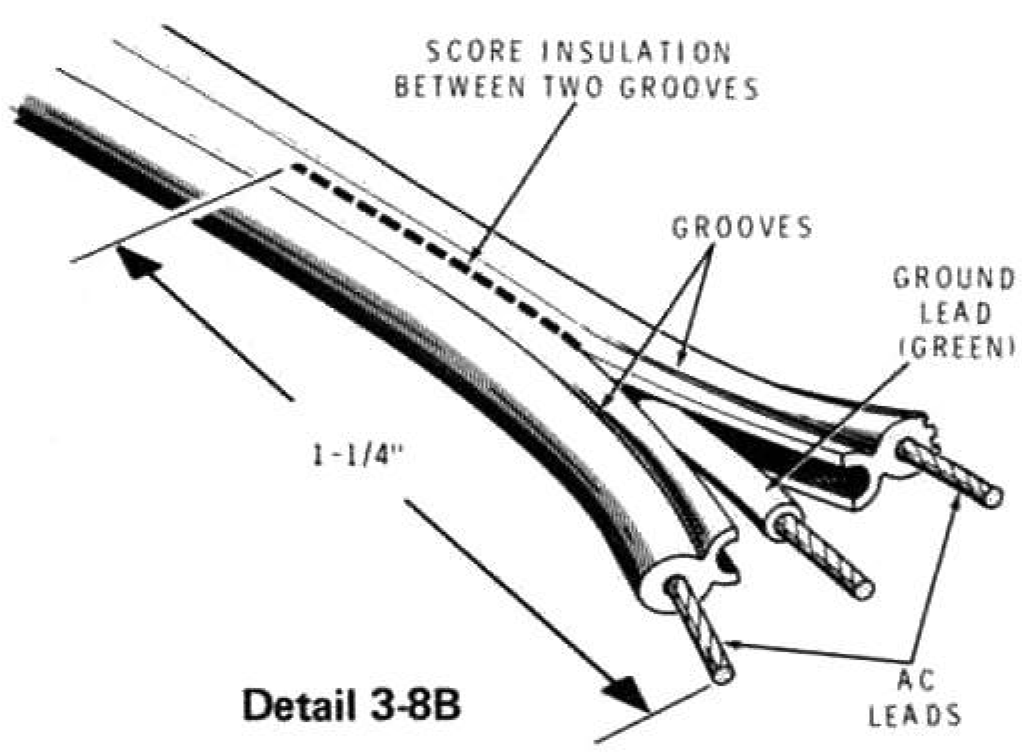
PICTORIAL 3-9



PICTORIAL 3-8



Detail 3-8A



Detail 3-8B

Refer to Pictorial 3-8 for the following steps.

( ) Write the fuse rating and type onto the fuse replacement label (1/2A, SLOW-BLOW). Then remove the protective backing and press the label in place inside the cabinet top as shown in the Pictorial. (NOTE: Write "1/4A, SLOW-BLOW" on the label if you wired your unit for 240 VAC.)

( ) Refer to Detail 3-8A and mount the horizontal terminal strip at R. Use a 6-32 x 3/8" screw, two #6 lockwashers, and a 6-32 nut. NOTE: Loosen the screws and readjust the small switch bracket if necessary.

( ) Refer to the inset drawing on the Pictorial and prepare the end of the line cord as shown. Then twist the bare wire ends and apply a small amount of solder to hold the small wire strands together.

( ) Insert 2" of the line cord through hole K as shown.

( ) Refer to Detail 3-8B and split the outer insulation of the line cord for 1-1/4 inches, as follows, so you do not cut into the protective insulation for the AC leads.

240 VAC Wiring

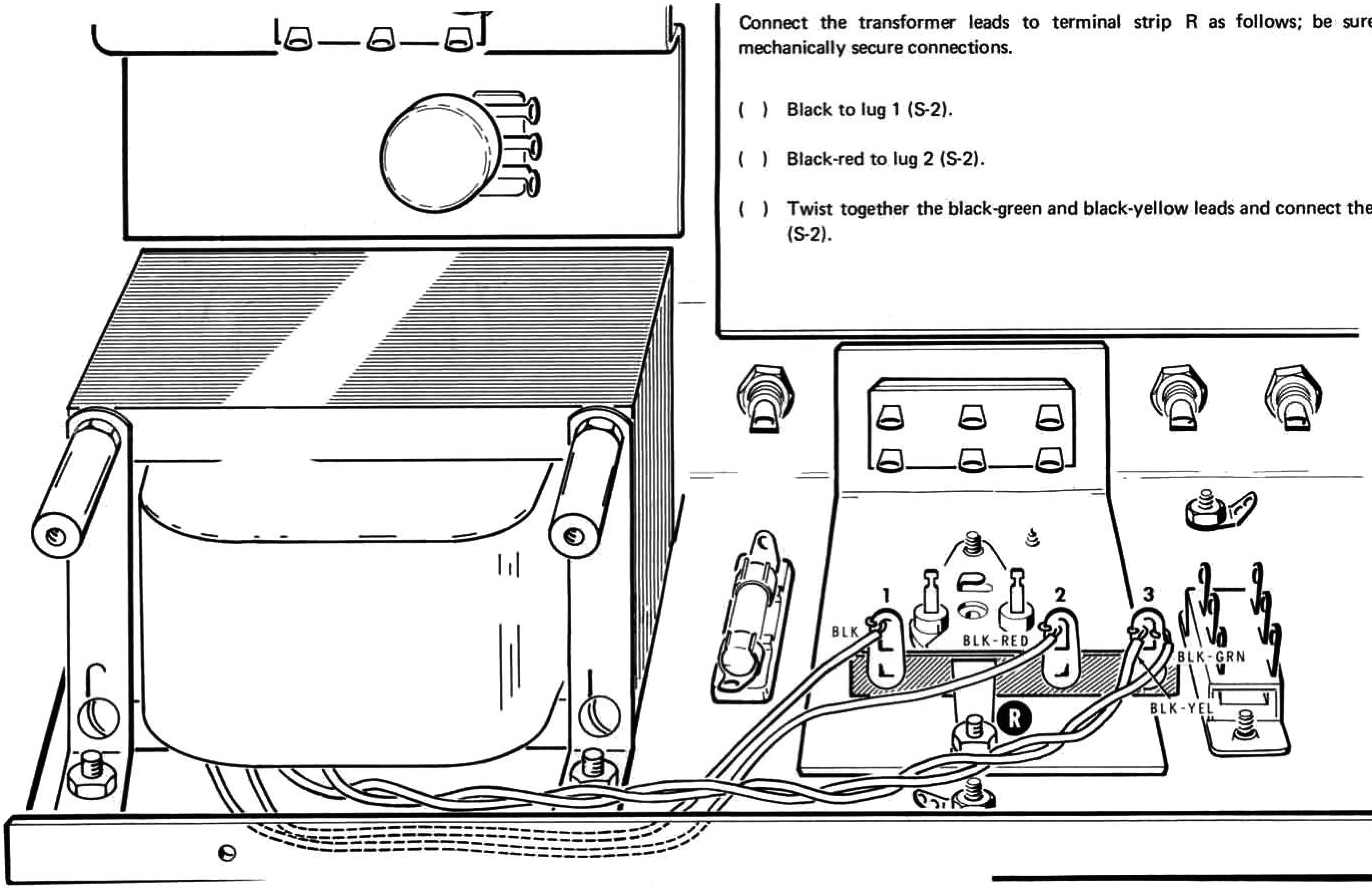
Refer to Detail 3-9B for the following steps.

Connect the transformer leads to terminal strip R as follows; be sure to make mechanically secure connections.

( ) Black to lug 1 (S-2).

( ) Black-red to lug 2 (S-2).

( ) Twist together the black-green and black-yellow leads and connect them to lug 3 (S-2).



Detail 3-9B

1. Use a knife point to score a 1-1/4" line, BETWEEN the two grooves.

2. Turn the cord over and repeat step 1.

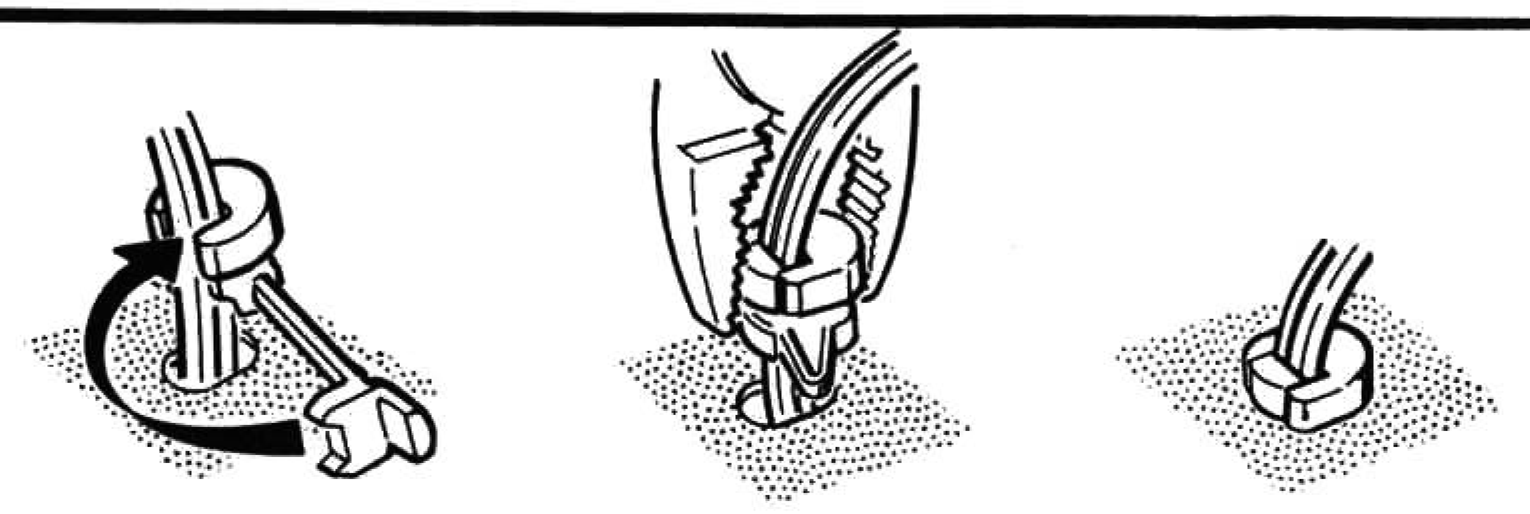
3. Grasp the lead ends by the insulation and pull the leads apart. The line cord will separate on the scored lines.

Connect the line cord as follows; be sure to make mechanically secure connections.

( ) Smooth lead to lug 2 of fuseholder F2 (S-1).

( ) Ribbed lead to lug 1 of terminal strip R (NS).

( ) Green lead to solder lug L (S-1).



Detail 3-8C

( ) Refer to Detail 3-8C and install the strain relief in hole K.

( ) Connect the free end of the <u>large</u> red wire (one of the two twisted wires coming from control R6) to lug 2 of terminal strip R (NS). Make a mechanically secure connection.

Refer to Pictorial 3-9 (fold-out from Page 44) for the following steps.

( ) Connect an 8" white wire from lug 7 of switch SW2 (S-1) to hole 7 in the circuit board (S-1). Tug lightly on the wire to be sure it is soldered.

Connect the power transformer leads as follows:

( ) Twist together the red, brown, and white-green leads.

Connect these leads to terminal strip A as follows:

( ) Brown and white-green leads to lug 2 (S-3).

( ) Red to lug 6 (NS).

( ) Twist together the two blue leads and the white-blue lead.

Connect the leads to the circuit board as follows. Be sure these bare wire ends are no longer than 1/4".

( ) White-blue to hole G (S-1).

( ) Either blue to hole 1 (S-1).

( ) Other blue to hole 2 (S-1).

( ) Tug lightly on the wires to be sure they are soldered.

( ) Twist together the green and white leads.

Connect the leads as follows:

( ) Green to hole 6 (S-1).

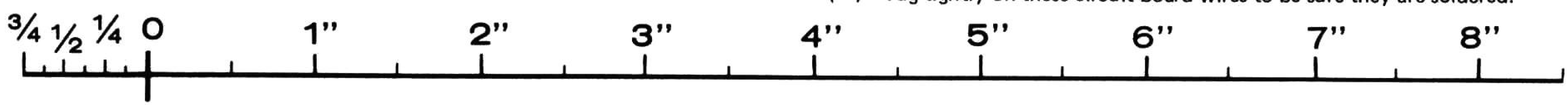
( ) White to hole 5 (S-1).

( ) Connect the yellow transformer lead to hole 3 (S-1).

( ) Prepare an 11" large red wire. Twist the small wire strands together and melt a small amount of solder on the bare ends.

( ) Connect one end of the 11" large red wire to lug 6 of terminal strip A (S-2). Then wrap this wire around the yellow transformer lead as shown and connect the free end to hole 4 in the circuit board (S-1).

( ) Tug tightly on these circuit board wires to be sure they are soldered.



ALTERNATE LINE VOLTAGE WIRING

NOTE: Two sets of line voltage wiring instructions are given, one for 120 VAC line voltage and the other for 240 VAC line voltage. In the U.S.A. 120 VAC is most often used, while in foreign countries 240 VAC is more common. USE ONLY THE INSTRUCTIONS THAT AGREE WITH THE LINE VOLTAGE IN YOUR AREA.

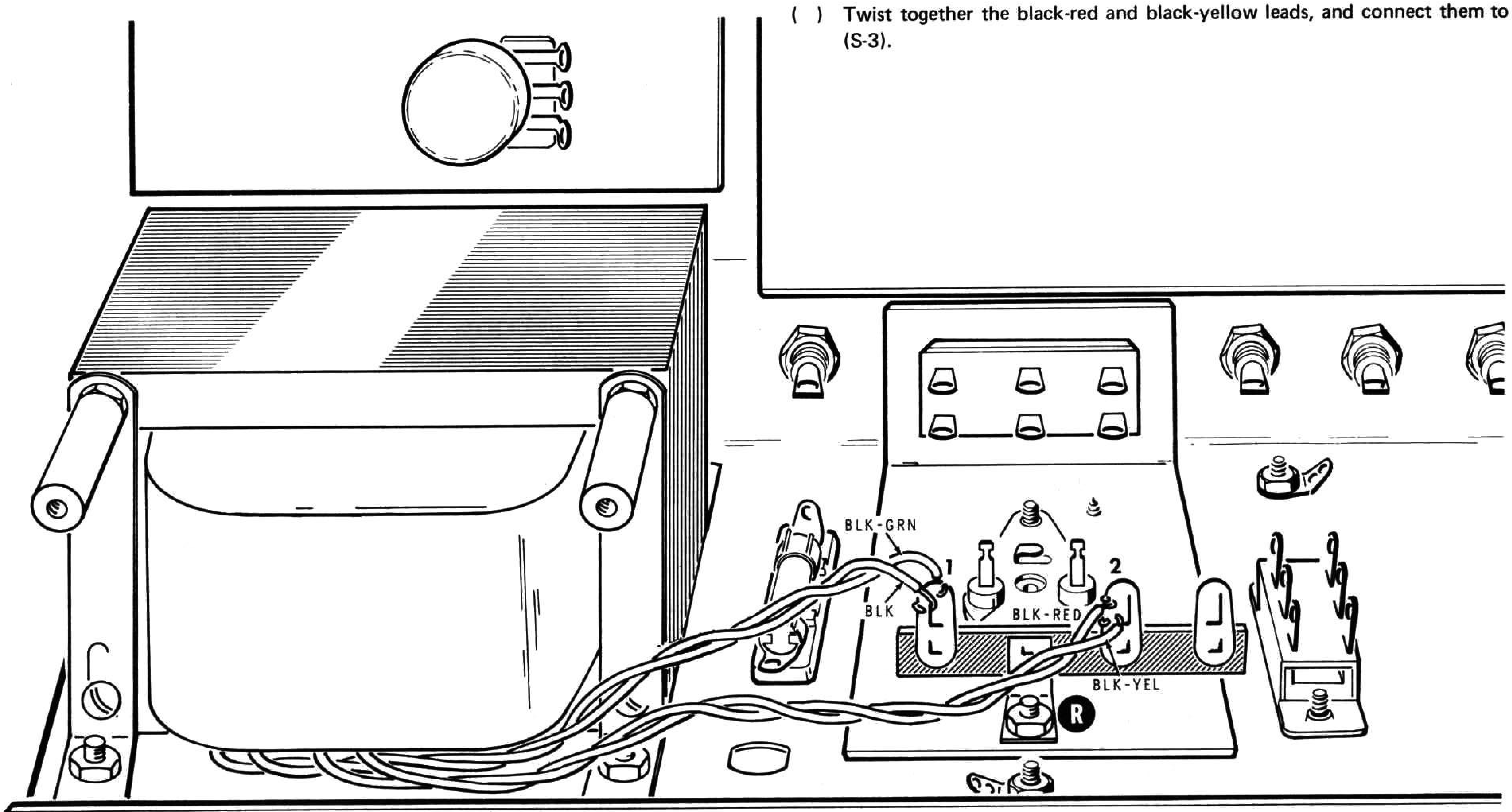
120 VAC Wiring

Refer to Detail 3-9A for the following steps.

Connect the transformer leads to terminal strip R as follows; be sure to make mechanically secure connections.

( ) Twist together the black and black-green leads, and connect them to lug 1 (S-3).

( ) Twist together the black-red and black-yellow leads, and connect them to lug 2 (S-3).



Detail 3-9A

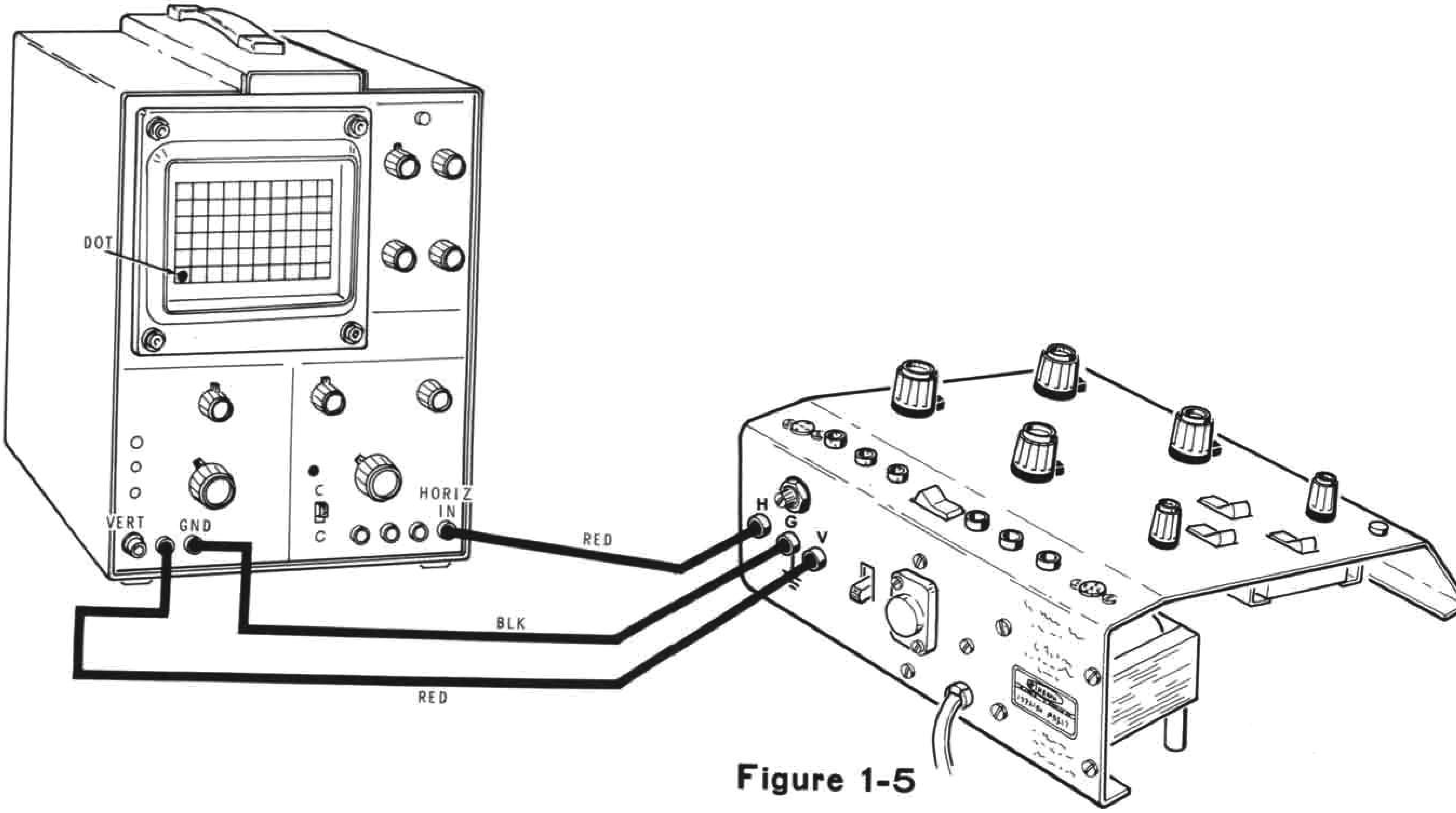


Figure 1-5

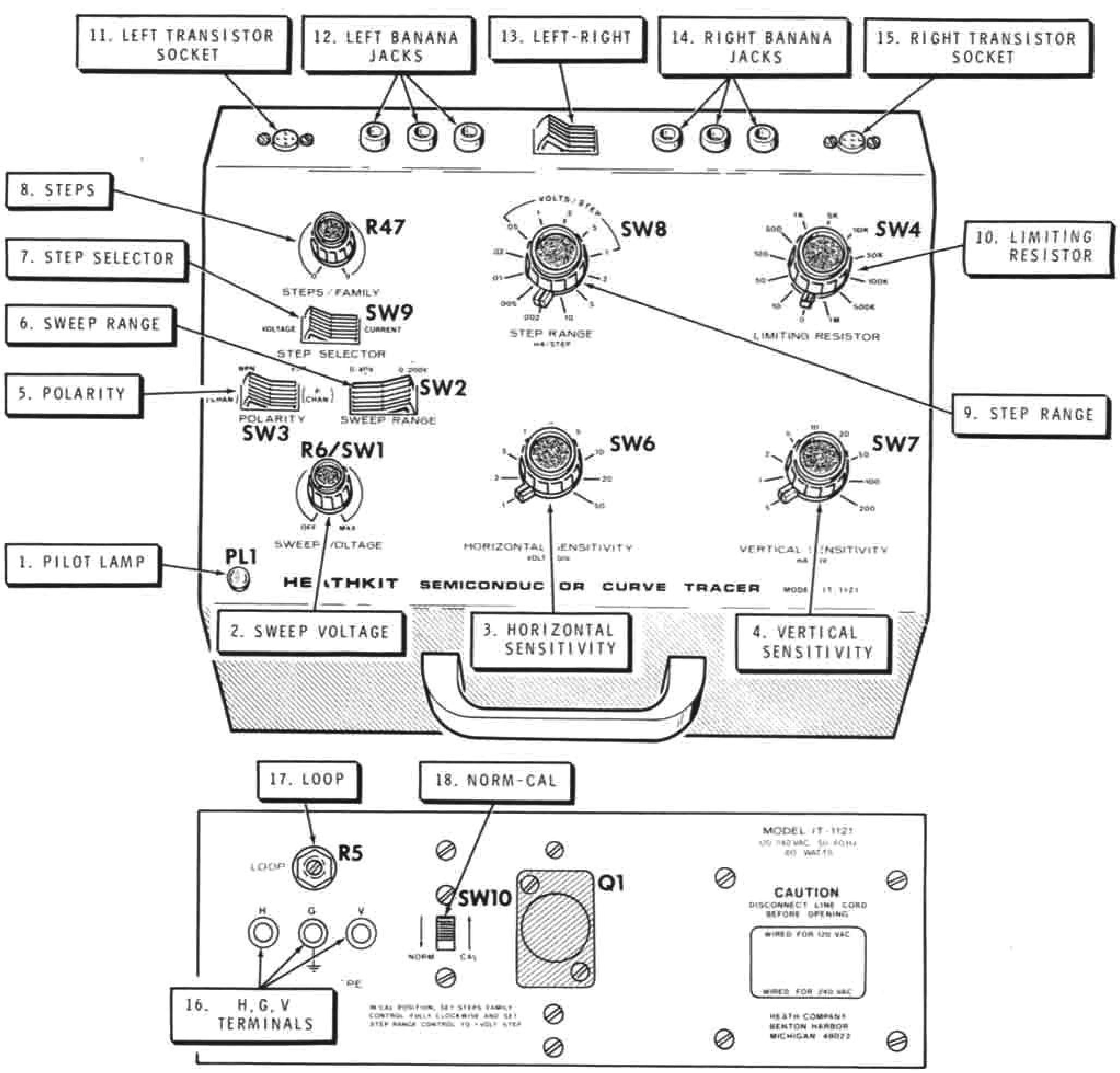
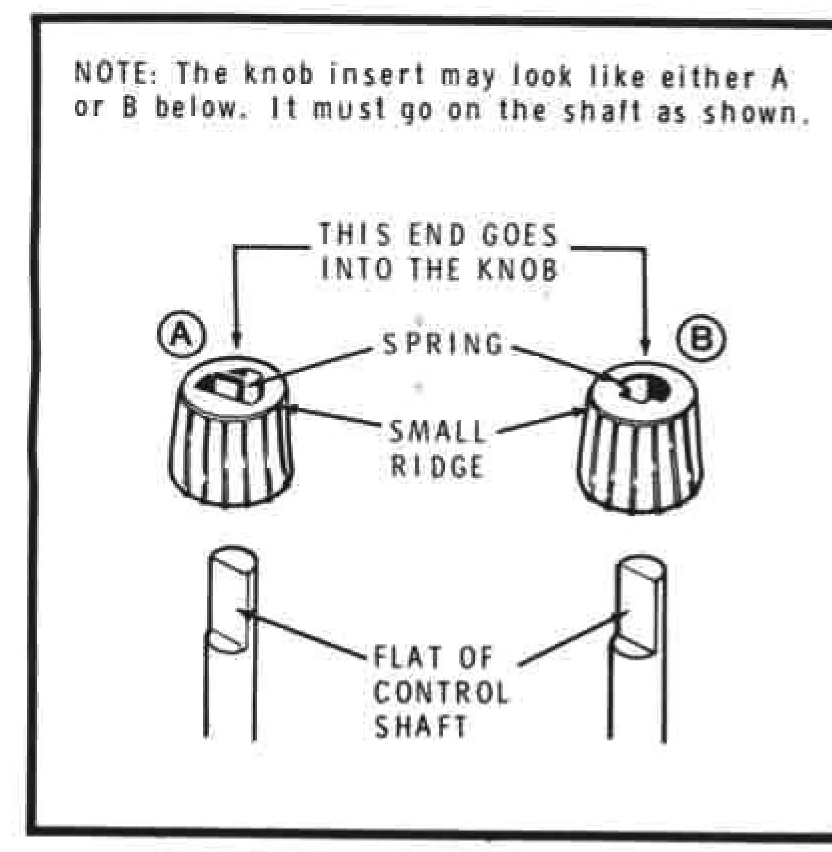
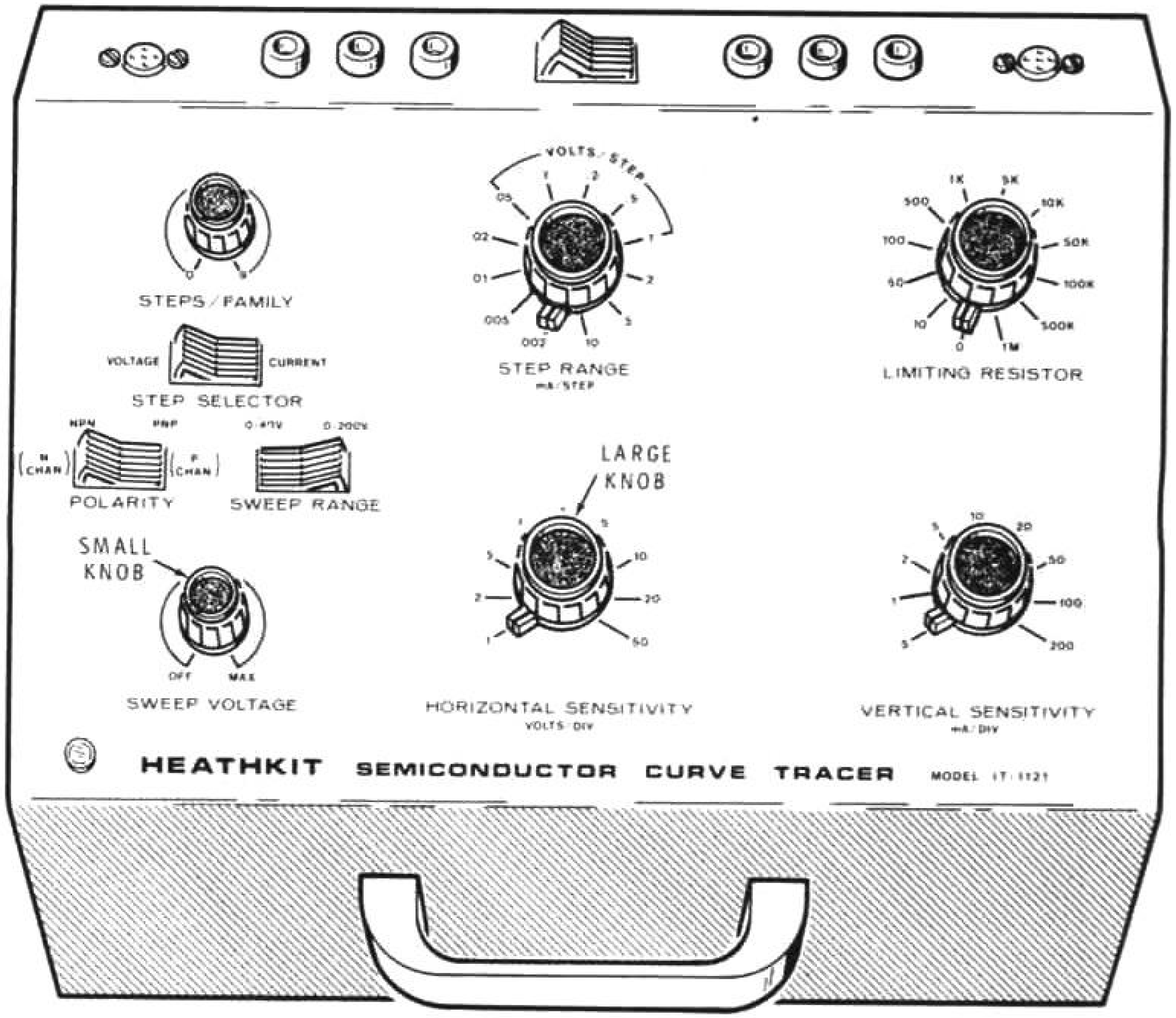


Figure 2-1



Detail 3-10A



PICTORIAL 3-10

KNOB INSTALLATION

Refer to Pictorial 3-10 for the following steps.

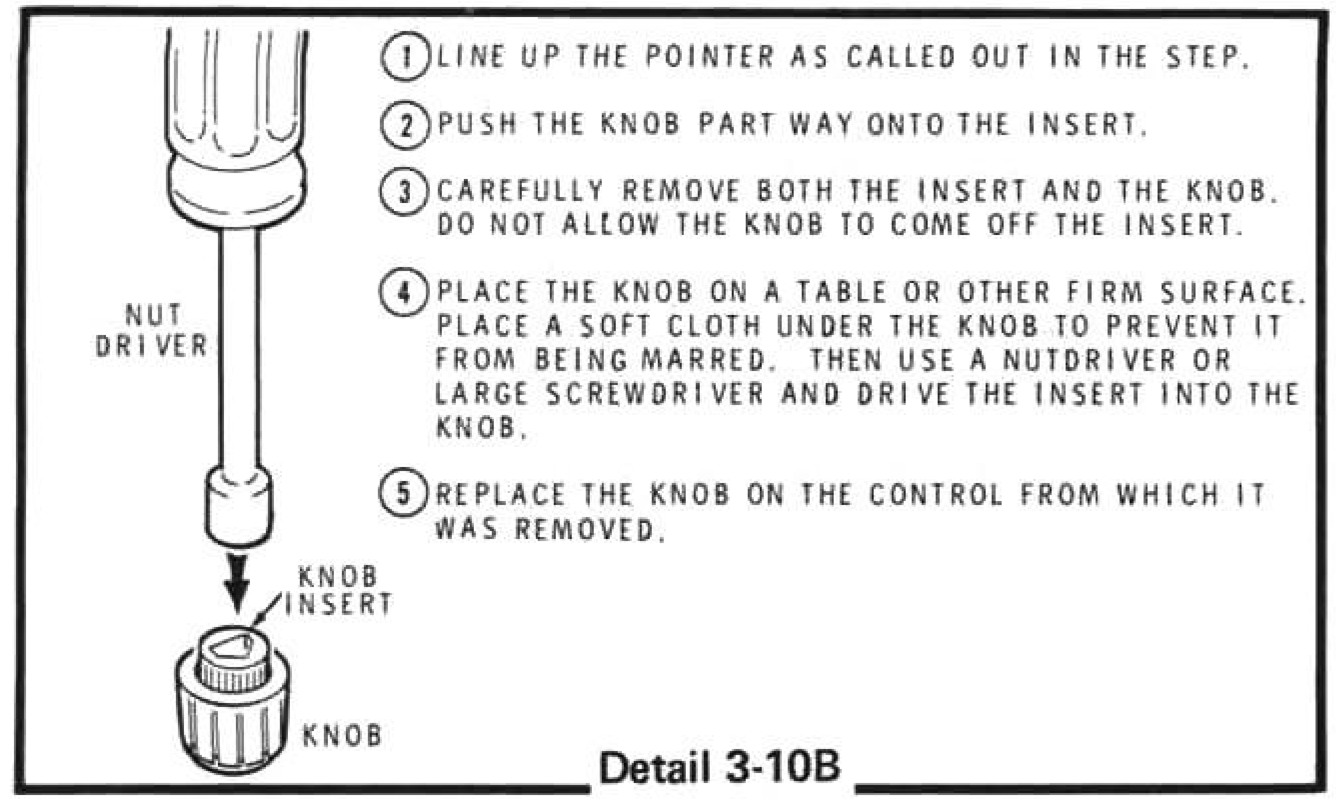
( ) Refer to Detail 3-10A and push knob inserts onto the six control and switch shafts.

Turn the six shafts fully counterclockwise.

( ) Refer to Detail 3-10B and install a small knob on the knob insert on the SWEEP VOLTAGE control. Be sure the knob pointer is toward OFF.

( ) Install a small knob on the STEPS/FAMILY control. Position the pointer toward 0.

( ) Install large knobs on the remaining four switch shafts. Be sure the pointers are at the fully counterclockwise positions as shown in the Pictorial.

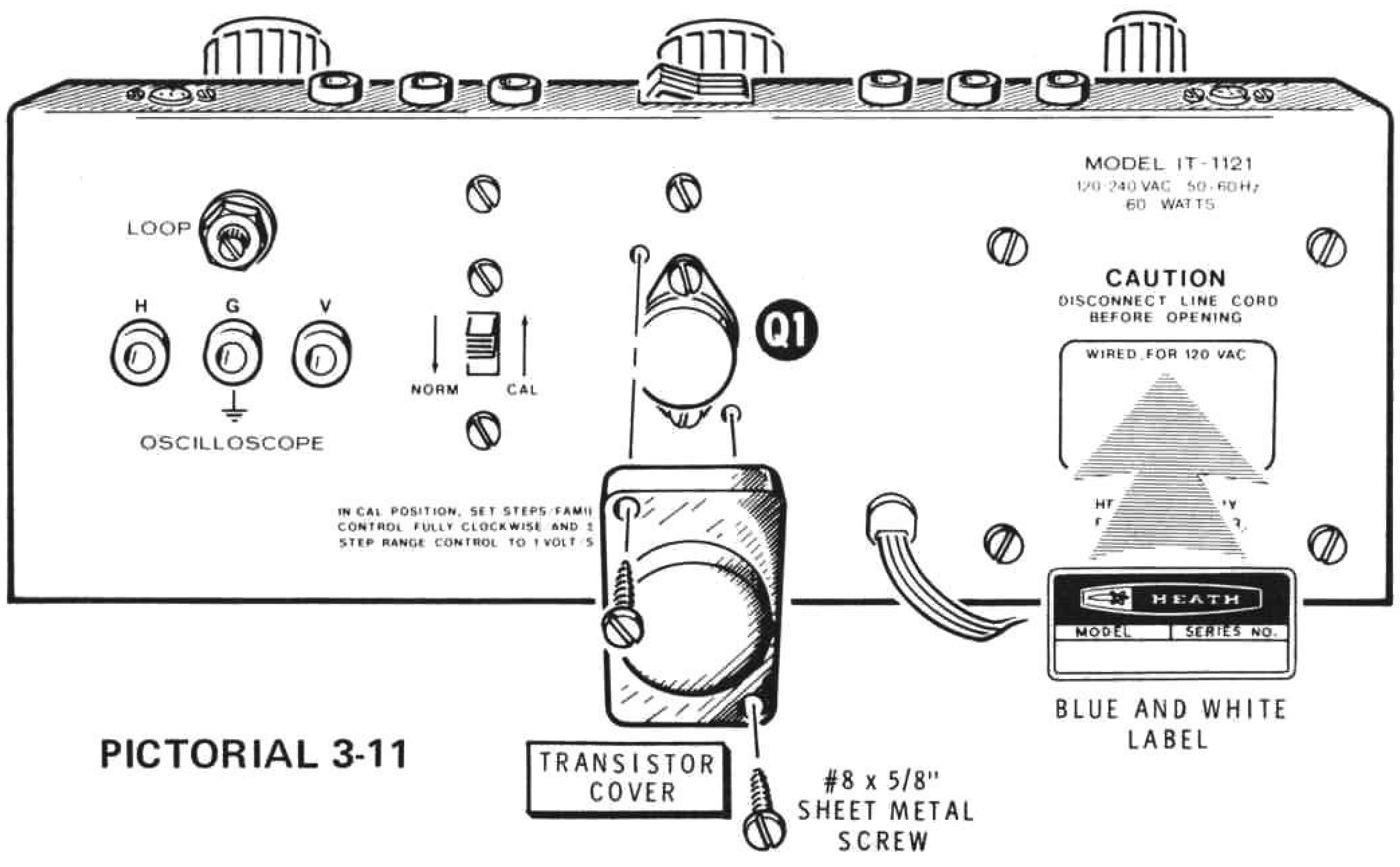


Detail 3-10B

Refer to Pictorial 3-11 for the following steps.

( ) Install the transistor cover at Q1. Use two #8 x 5/8" sheet metal screws.

( ) Remove the protective backing from the blue and white label and apply it to the area shown. If your unit is "wired for 120 VAC" leave those words exposed. If it is "wired for 240 VAC," leave those words exposed. Be sure to refer to the numbers on the blue and white label in any communications you have with the Heath Company about this kit.



PICTORIAL 3-11

TEST LEADS

Refer to Pictorial 3-12 for the following steps.

( ) Locate the test leads that were set aside earlier.

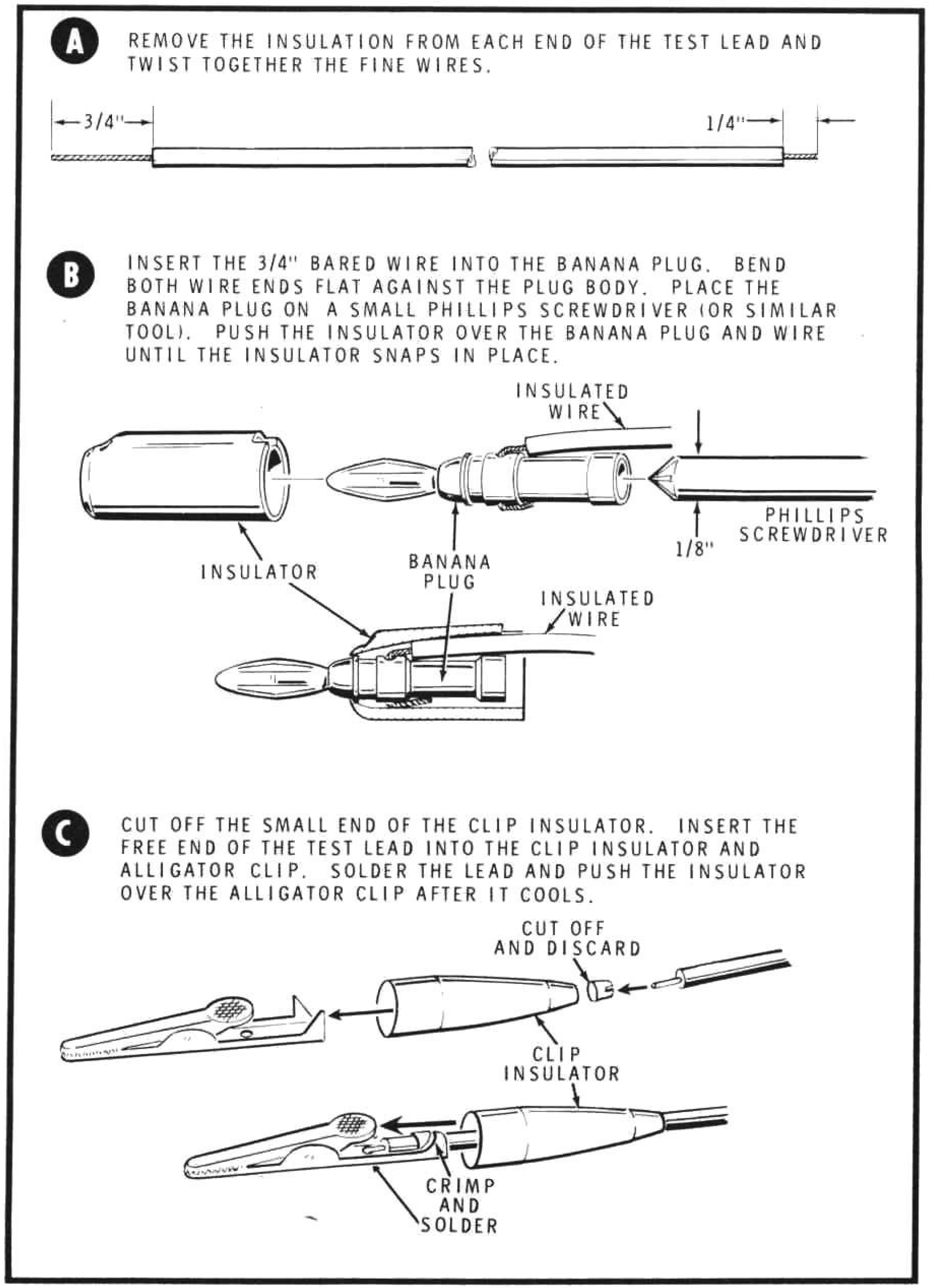
( ) Prepare a 30" red test lead as shown in part A of the Pictorial. Then install a banana plug with a red insulator on one end and a rubber insulator and alligator clip on the other end of the test lead as shown in parts B and C of the Pictorial.

( ) In a similar manner, prepare a 30" black test lead. Use a black banana plug insulator.

( ) In a similar manner, prepare a 30" white test lead. Use a white banana plug insulator.

( ) Prepare two 18" red test leads and one 18" black test lead. Remove 3/4" of insulation from both ends of the leads. Install banana plugs on both ends of the leads. Use red insulators on the red leads and black insulators on the black lead.

This completes the "Step-by-Step Assembly" of your kit. Proceed to "Tests and Adjustments."



PICTORIAL 3-12

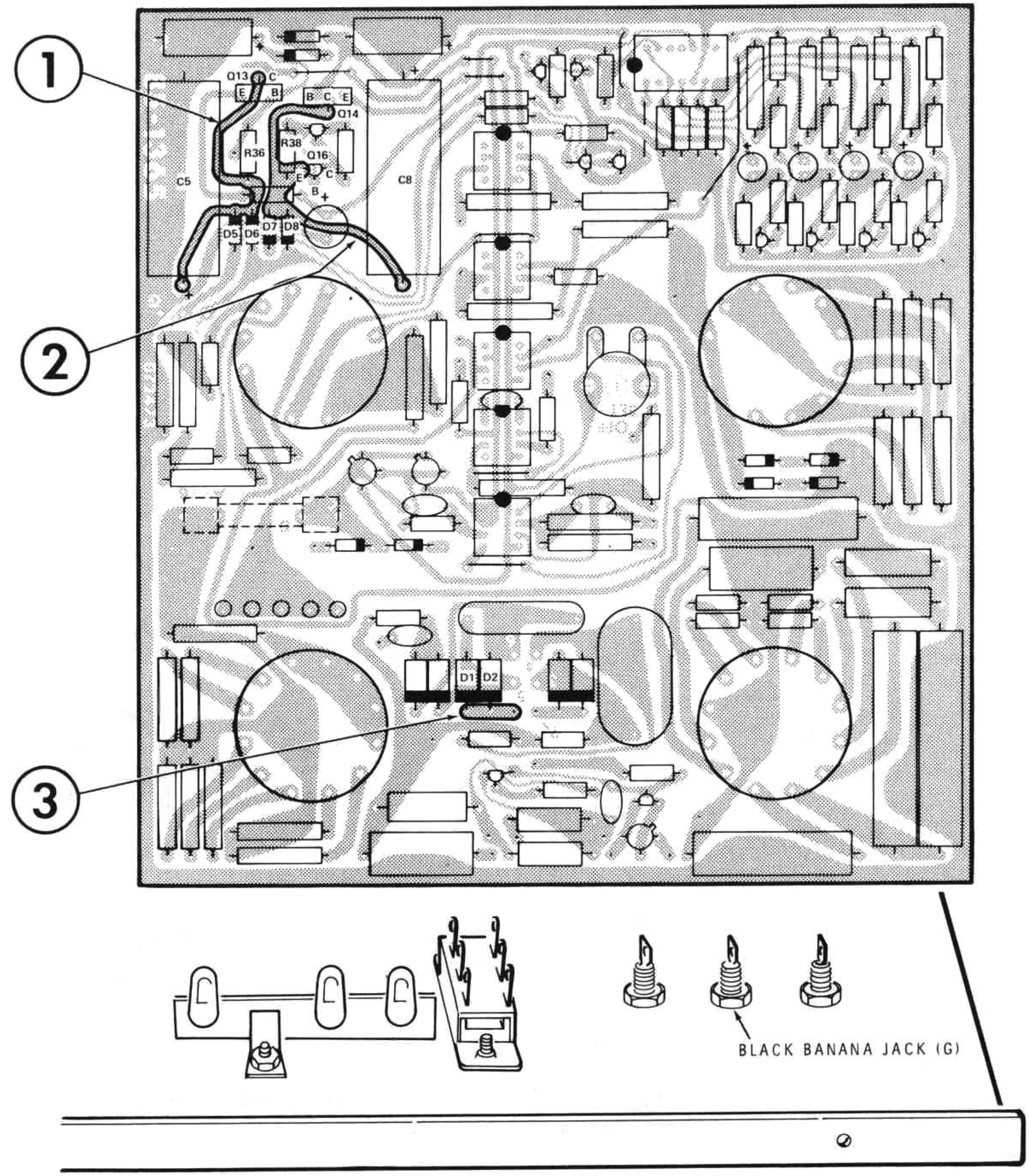

1
2
3
Q13
C
E
B
B
C
E
Q14
R36
R38
Q16
C5
C8
D5
D6
D7
D8
D1
D2
BLACK BANANA JACK (G)

Figure A

TESTS AND ADJUSTMENTS

INITIAL CHECKS

The purpose of this section of the Manual is to make sure your Curve Tracer operates properly and will not be damaged as the result of a wiring error. A transistor or integrated circuit, for example, could be destroyed instantly by a short circuit that causes excessive current.

( ) Inspect the Curve Tracer for improperly soldered connections, or connections that may have been missed and not soldered. Also check for solder bridged across two or more circuit board foils, which would cause a short circuit.

( ) Examine the chassis-mounted parts to make sure they are properly mounted and connected.

( ) Be sure no bare wires are touching any components or the chassis.

NOTE: If a VTVM is available, make the following "Resistance Checks." If a meter is not available, proceed to "Oscilloscopes."

RESISTANCE CHECKS

These resistance checks are to make sure there are no short circuits in any of the three power supply branches. DO NOT plug in the line cord until you are instructed to do so.

( ) Set your ohmmeter on the RX100 scale.

( ) Connect the common lead of your ohmmeter to the black banana jack (G) shown in Figure A.

NOTE: The resistances in the following steps are the minimum desired. If the resistance readings are significantly less, the reason (such as a short circuit caused by a solder bridge between foils) must be determined and corrected before you proceed. As some ohmmeters use the "common" lead as the positive lead, try reversing your ohmmeter leads if you do not get the designated resistance readings.

( ) Refer to Figure A and touch the ohmmeter probe to the foil at point (1). The meter reading should be 10 kΩ or more.

( ) Touch the ohmmeter probe to the foil at point (3). The meter reading should be 100 kΩ or more.

( ) Touch the ohmmeter probe to the black banana jack (G) and the ohmmeter common lead to point (2). The meter reading should be 10 kΩ or more.

( ) Disconnect the meter.

CAUTION: High voltage are exposed in the Curve Tracer when the line cord is plugged into an AC outlet. Refer to the "Chassis Photographs" on Page 100 for the location of these high voltage areas.

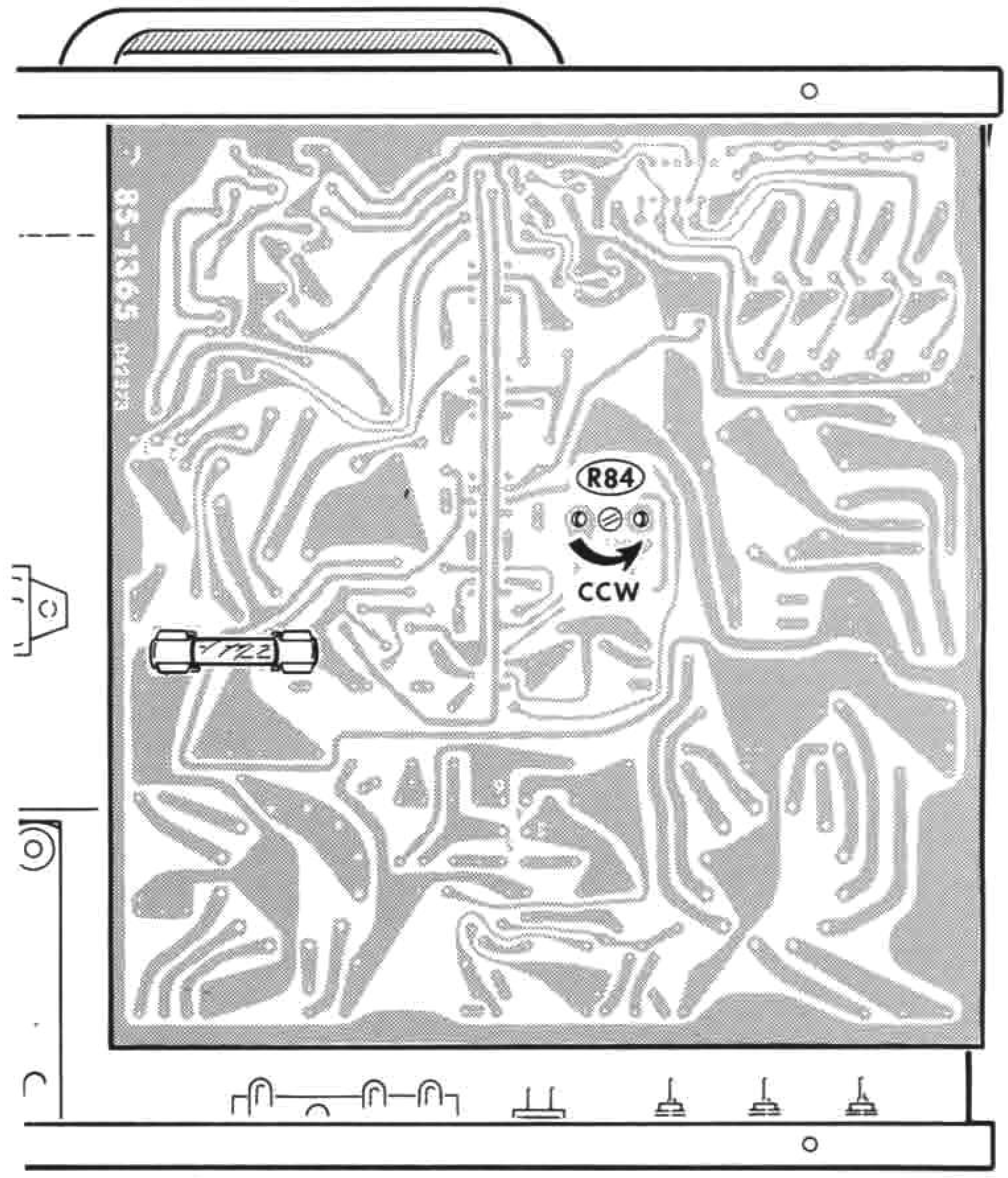


Figure 1-7

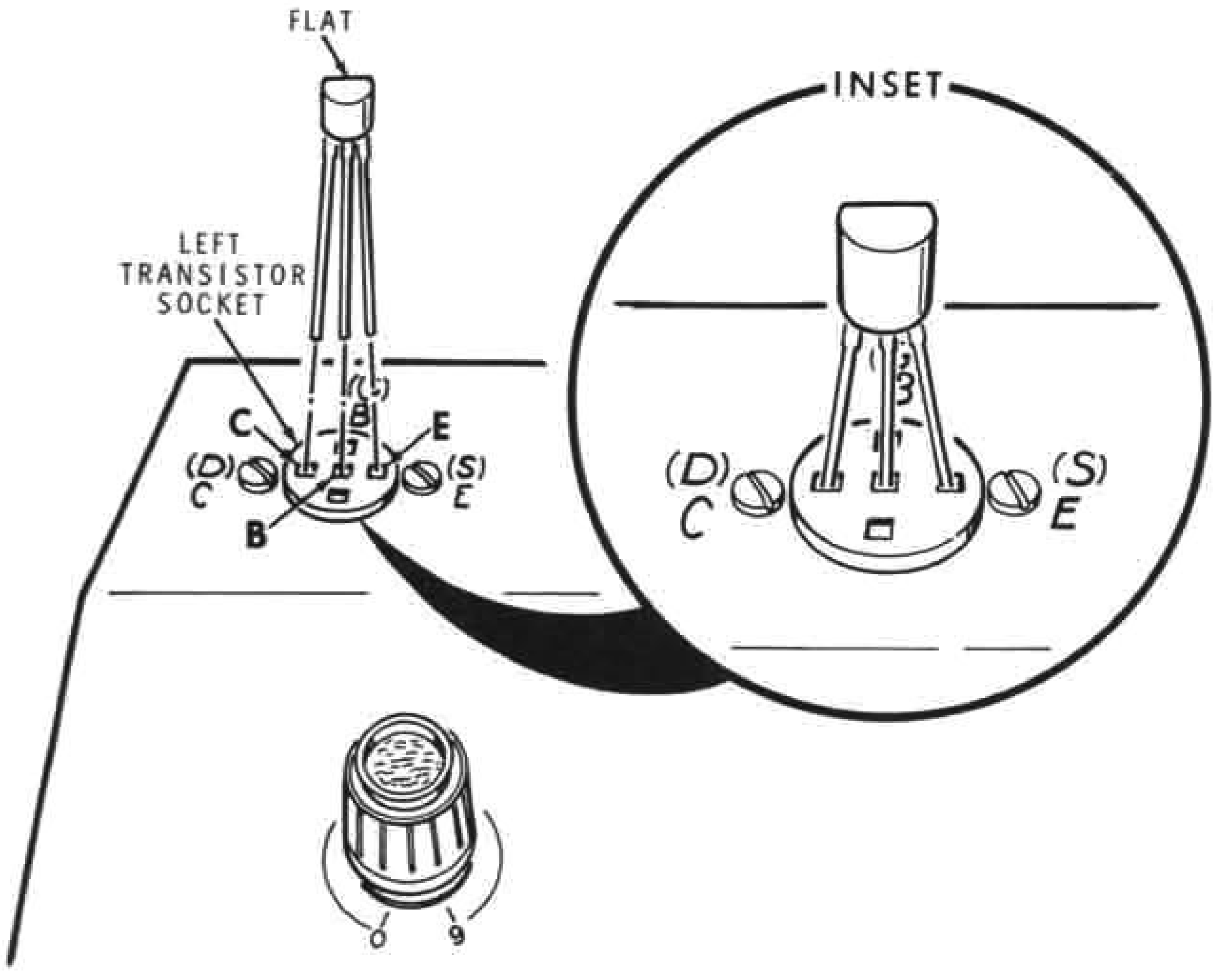


Figure 1-8

OSCILLOSCOPES

This section of the Manual contains special considerations for "Heath Oscilloscopes" and all kinds of "AC-coupled oscilloscopes." Therefore, if you intend to use a DC oscilloscope other than a Heath one with your Curve Tracer, you may proceed to "Oscilloscope Calibration."

HEATH OSCILLOSCOPES

NOTES:

1. In the following material, X means horizontal and Y means vertical.
2. The IO-10, IO-12, IO-17, IO-18, and IO-21 will produce backward traces. That is, an NPN transistor display will be from right to left instead of from left to right, etc.

IO-10 – Use the X and Y input channels.

IO-12 – This oscilloscope is AC coupled. Read "AC-Coupled Oscilloscopes."

IO-14 – This oscilloscope may not have enough horizontal gain for proper calibration. If necessary, when you perform the "Oscilloscope Calibration," calibrate the horizontal dots on every division. Note that, in this case, all the horizontal sensitivity readings will be off by a factor of two. (Example: When the Curve Tracer is set for 1 V/division, the oscilloscope will display 2 V/division.)

IO-17 – This oscilloscope is AC coupled. Read "AC-Coupled Oscilloscopes."

IO-18 – This oscilloscope is AC coupled. Read "AC-Coupled Oscilloscopes."

IO-21 – This oscilloscope is AC coupled. Read "AC-Coupled Oscilloscopes."

IO-102 – The horizontal input of this oscilloscope is AC coupled. To obtain DC coupling for use with the Curve Tracer, place a jumper wire from the horizontal input to TP (Test Point) on the horizontal amplifier circuit board inside the IO-102. However, for normal oscilloscope operation, remove this jumper wire, as it interferes with the internal sweep. Note also that the horizontal portion of the trace should not extend over 10 cm or the input may be overloaded and produce distortion.

IO-103 – No special considerations.

IO-104 – Use the X10 position of the TIME/CM switch. If this does not provide enough gain, pull out X5 MAG knob. Do not use the X1 switch position. In some cases, you may not be able to position the dot all the way into the upper right-hand corner of the screen.

IO-105 – Use the X-Y mode.

AC-COUPLED OSCILLOSCOPES

Oscilloscopes that are AC coupled on one or both inputs (vertical and/or horizontal) are usable with the Curve Tracer but have certain limitations. Calibration of the oscilloscope will be more difficult as the dots will "smear" somewhat (see Figure 1-3 on Page 53). However, this can be reduced by using only two or three dots.

When you position the dot on the oscilloscope screen, before you apply any sweep voltage, position the dot one or two divisions toward the center of the screen. When the sweep voltage is applied, the display will expand in both directions from the dot. (That is, both ways horizontally if that input is AC coupled, and both ways vertically if that input is AC coupled.) To get better looking displays, use only 2 to 5 steps/family instead of all 9.

The following show the difference between displays of DC-coupled and AC-coupled oscilloscopes.

DC COUPLED

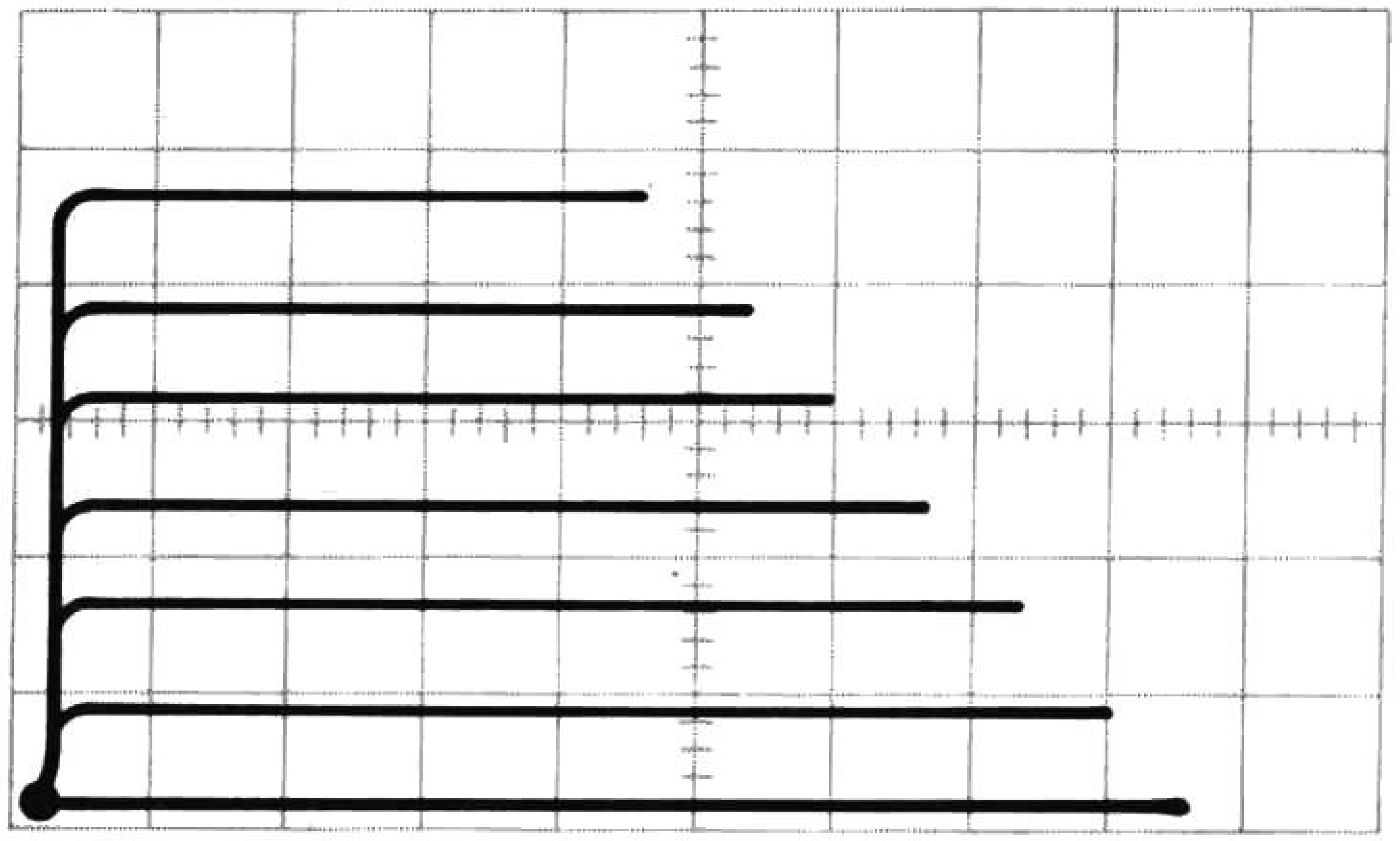


Figure 1-1

AC COUPLED

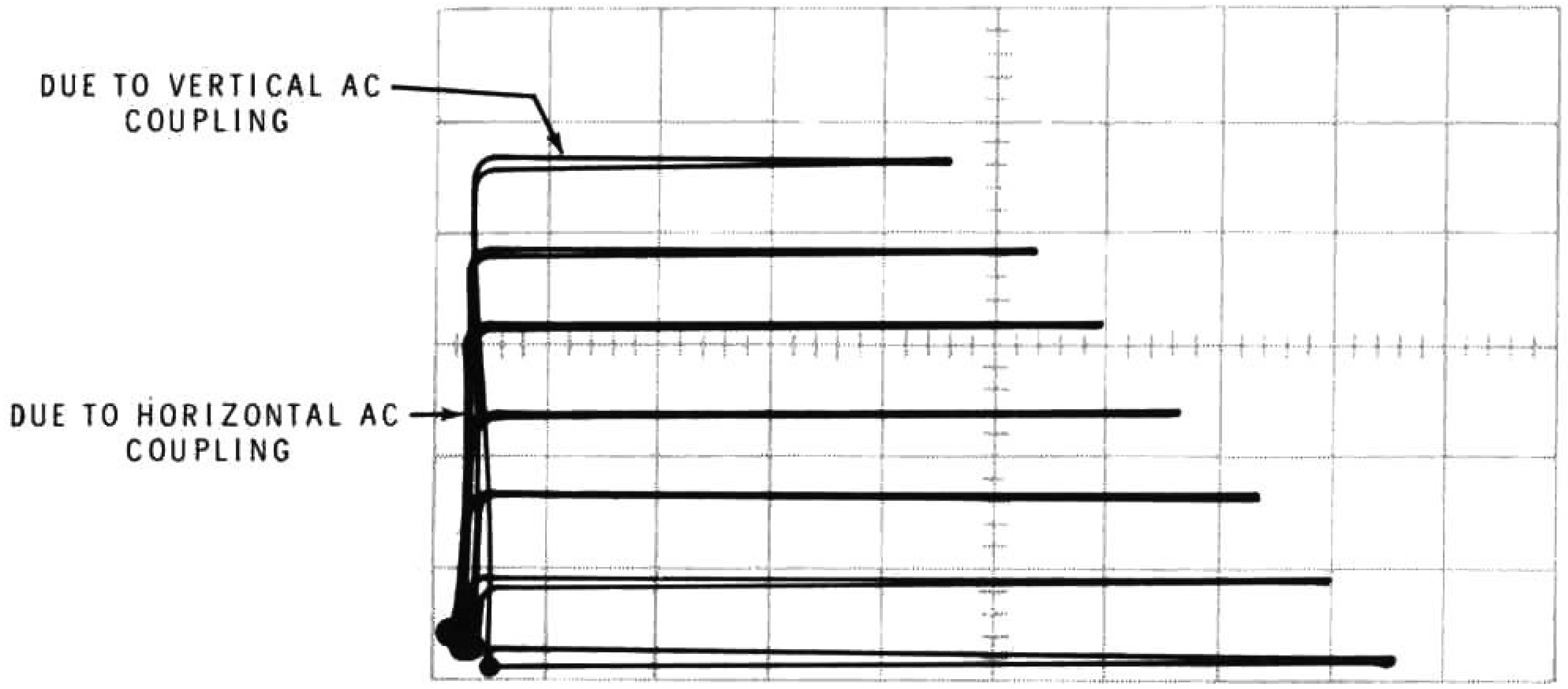


Figure 1-2

DC COUPLED

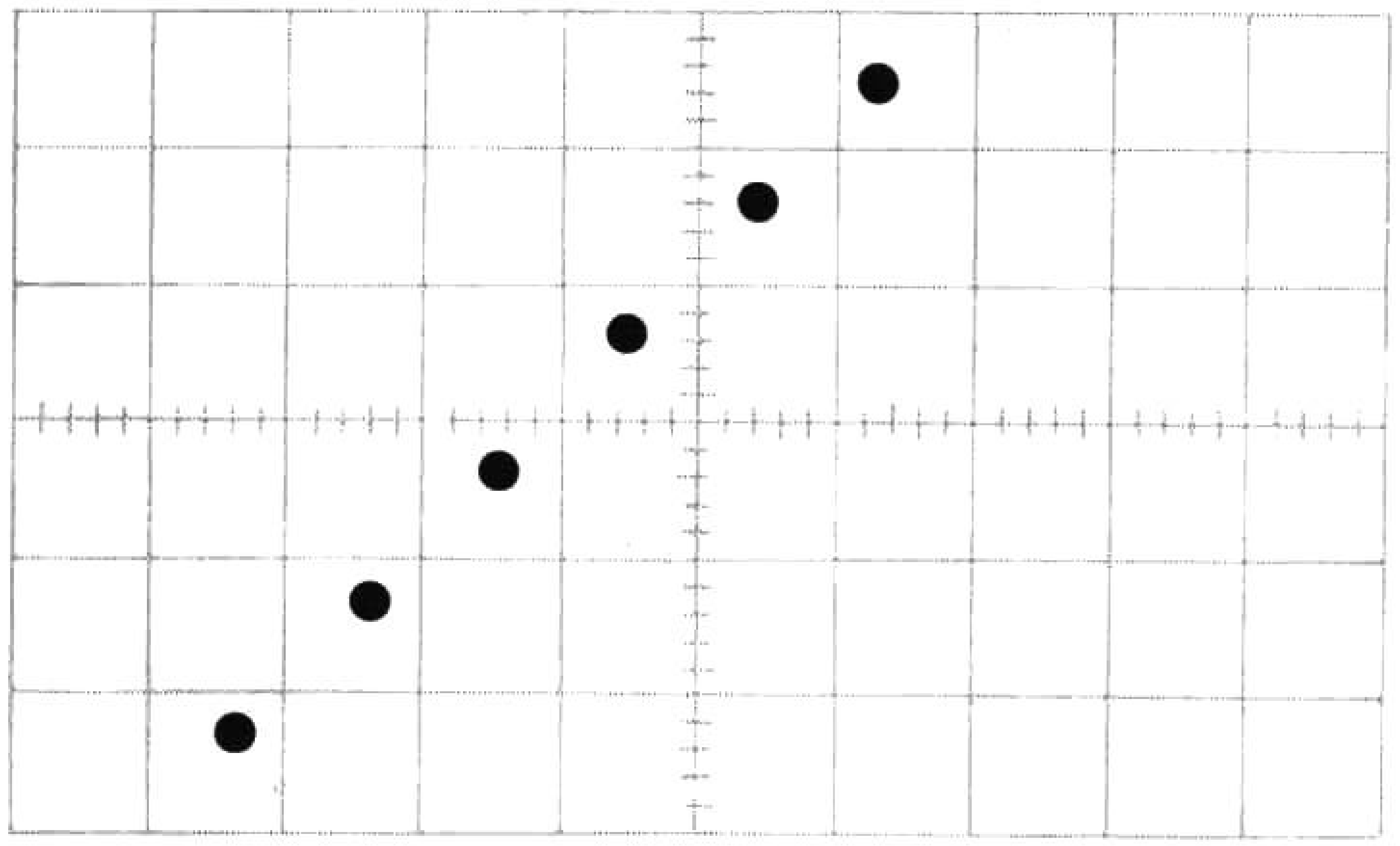


Figure 1-3

AC COUPLED

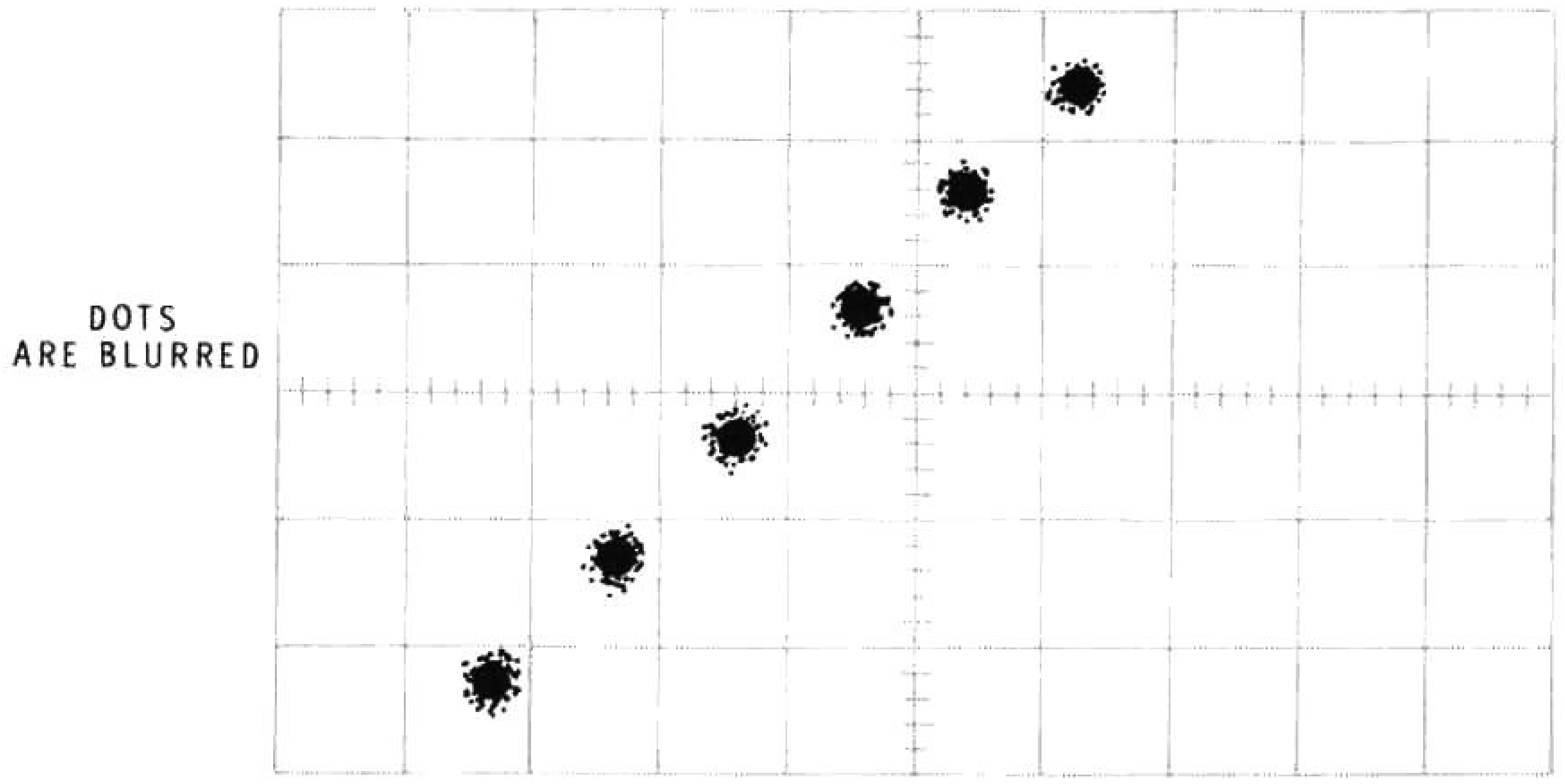


Figure 1-4

OSCILLOSCOPE CALIBRATION

Turn on your oscilloscope and set the controls as follows:

( ) Set the oscilloscope for approximately .5V/division horizontal, and 1 V/division vertical. (If you have a dual trace oscilloscope, place it in the X-Y mode.)

( ) If the vertical and horizontal inputs are switchable, place them in their DC positions.

( ) Use the vertical and horizontal position controls and move the dot to the lower left-hand area of the screen.

( ) Keep the trace intensity low to protect the screen from being burned by the dot.

Refer to Figure 2-1 (fold-out from Page 48) for the following steps.

Set the Curve Tracer controls as follows:

SWEEP VOLTAGE — Fully counterclockwise and OFF.

HORIZONTAL SENSITIVITY — 1.

VERTICAL SENSITIVITY — 10.

POLARITY — NPN.

SWEEP RANGE — 0-40V.

STEP SELECTOR — CURRENT.

STEPS/FAMILY — Fully counterclockwise.

STEP RANGE — 1.

LIMITING RESISTOR — 100.

LEFT-RIGHT — LEFT.

LOOP — Center of rotation.

NORM-CAL — CAL.

( ) Refer to Figure 1-5 (fold-out from Page 48) and connect the H, G, and V outputs of the Curve Tracer to the horizontal, ground, and vertical inputs of the oscilloscope. Use one black lead and two red leads with banana plugs on both ends as shown in the Figure.

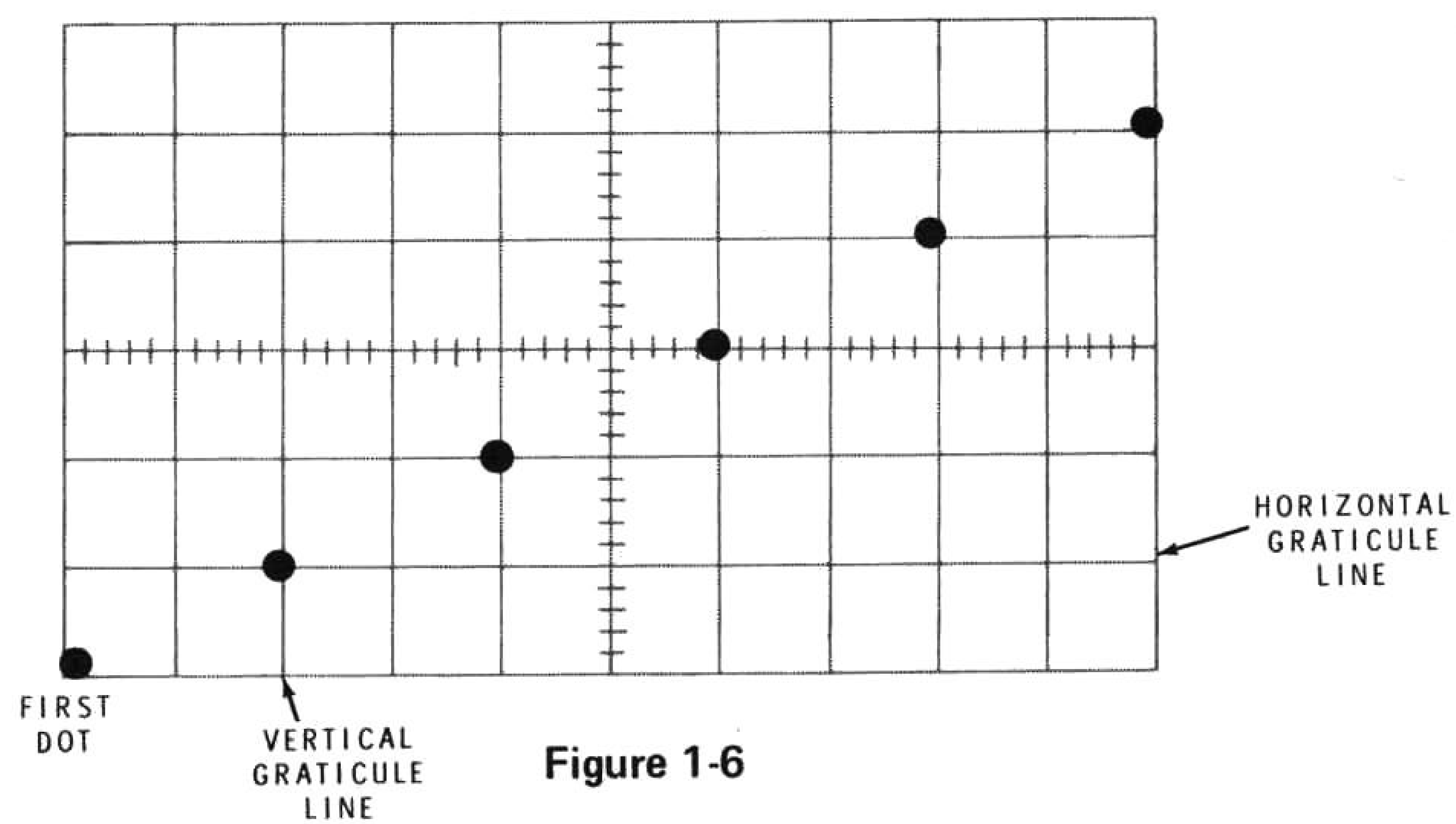


Figure 1-6

NOTE: In the following steps, if the Curve Tracer does not operate as described, immediately unplug the line cord and refer to the "In Case of Difficulty" section of the Manual on Page 88. Then correct the problem before proceeding with the "Initial Tests."

CAUTION: High voltages are exposed in the Curve Tracer when the line cord is plugged into an AC outlet. Refer to the "Chassis Photographs" on Page 100 for the location of these high voltage areas.

( ) Plug the line cord plug into an AC outlet of the proper voltage (120 or 240 VAC, depending upon the wiring of the power transformer).

( ) Turn on the Curve Tracer (until the SWEEP VOLTAGE control just clicks) and slowly turns the STEPS/FAMILY control clockwise until four to six dots appear in a diagonal row and fill the oscilloscope screen, as shown. See Figure 1-6. NOTE: Adjust the HORIZONTAL and VERTICAL SENSITIVITY controls on the oscilloscope if the dots are too widely spaced.

( ) Use the oscilloscope horizontal and vertical positioning controls to place the first dot on the line in the lower left-hand corner as shown.

( ) Adjust the vertical sensitivity and vertical position of the oscilloscope so each dot appears on the next higher horizontal graticule line as shown.

( ) Adjust the horizontal sensitivity and horizontal position so the dots appear on every other vertical graticule line as shown.

( ) Make sure the first dot is still in the position shown.

The oscilloscope is now calibrated. DO NOT readjust the oscilloscope vertical and horizontal sensitivity controls.

( ) Position the NORM-CAL switch to the NORM position. A single dot should appear within 1/2 division of the first dot of the calibration dots.

NOTE: Condensed calibration instructions are on the rear panel of the Curve Tracer for future reference.

OFFSET ADJUSTMENT

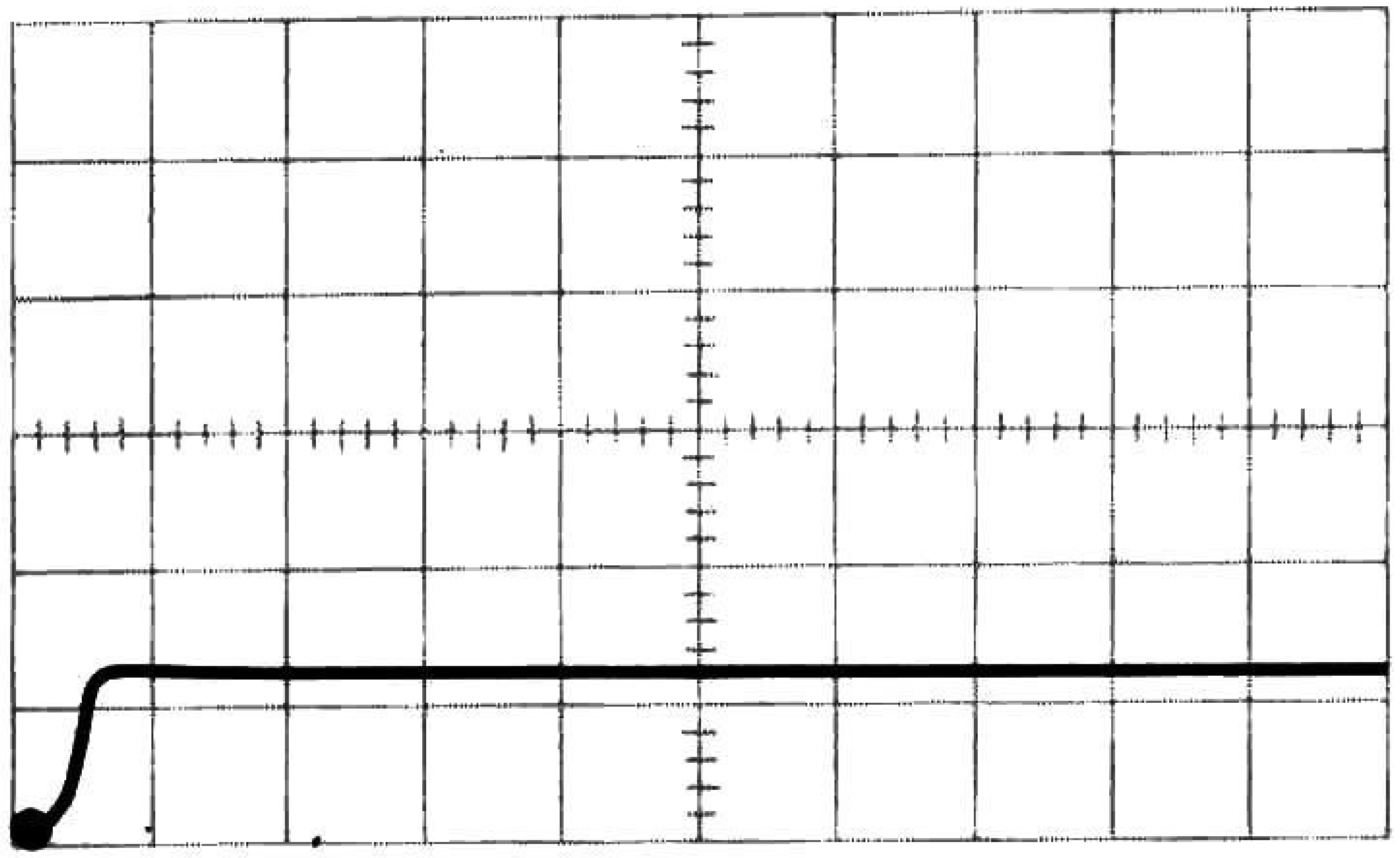


Figure 1-9

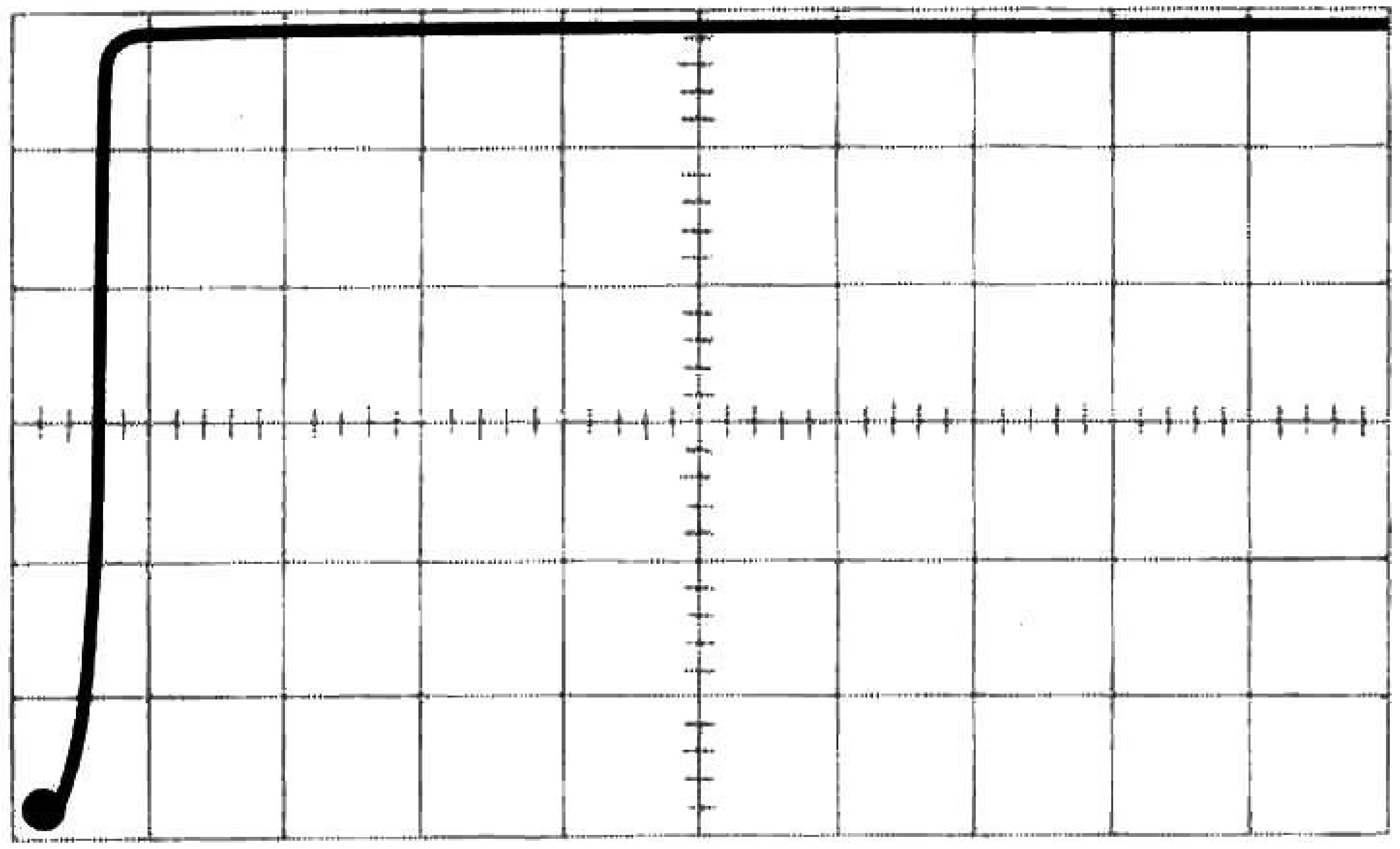


Figure 1-10

( ) Refer to Figure 1-7 (fold-out from Page 52) and turn circuit board control R84 fully counterclockwise.

( ) Refer to Figure 1-8 (fold-out from Page 52) and install the extra MPSA20 transistor in the left transistor socket as shown. Be sure the flat of the transistor is toward the rear of the cabinet.

( ) Adjust the STEPS/FAMILY control fully counterclockwise.

( ) Adjust the STEP RANGE control to .05.

( ) Adjust the SWEEP VOLTAGE control to produce a line across the bottom of the screen as shown in Figure 1-9.

( ) Turn the VERTICAL SENSITIVITY control counterclockwise until the display is near the top of the screen as shown in Figure 1-10.

( ) Adjust circuit board control R84 until the base line just becomes straight and flat. See Figure 1-11. NOTE: If you turn the control any farther than this, the base line may be distorted when you make very sensitive tests on PNP transistors and P channel FET's.

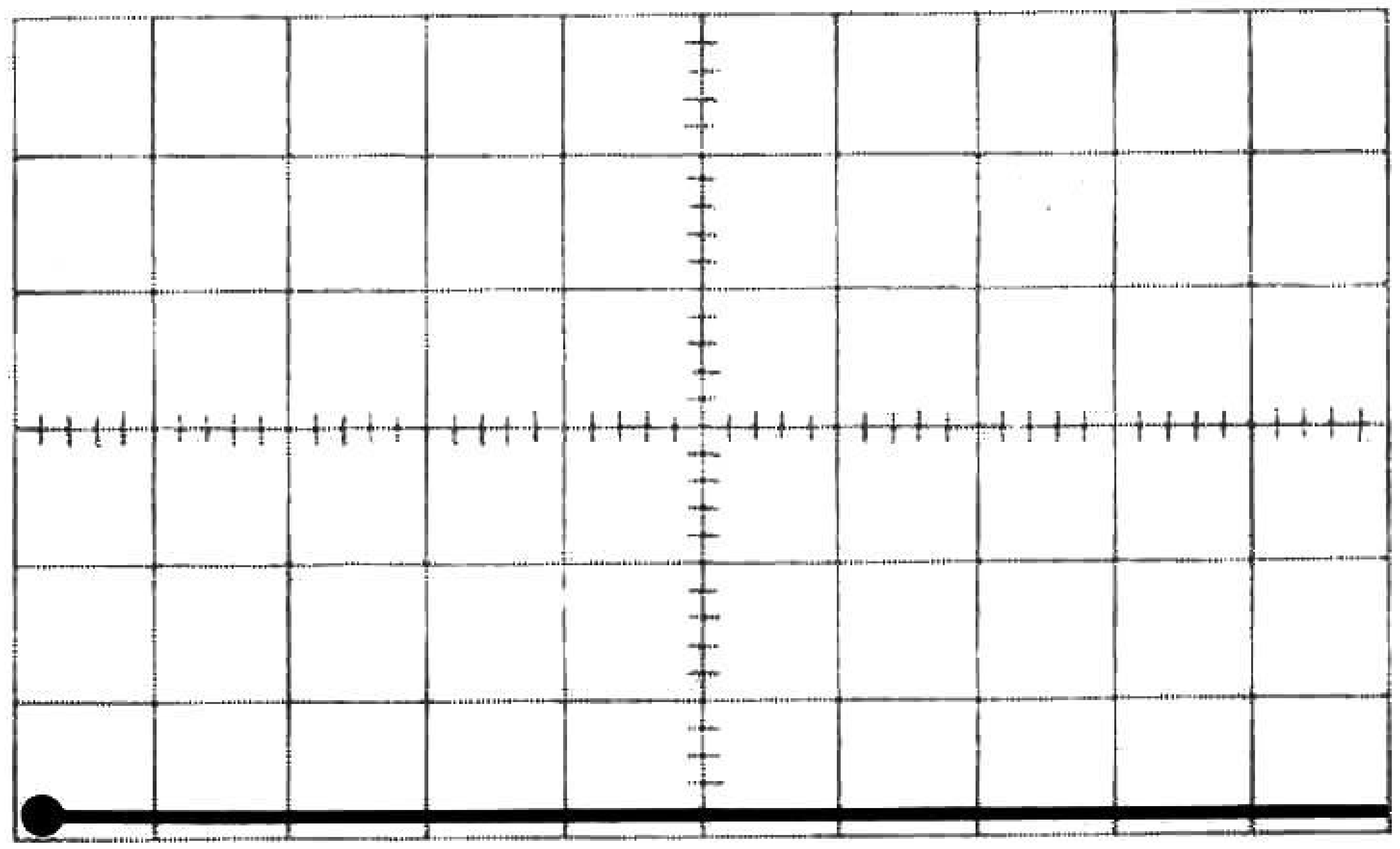


Figure 1-11

( ) Turn the VERTICAL SENSITIVITY control to .5 and make the above adjustment again.

TRANSISTOR TESTS

Again use the extra transistor (MPSA20, #417-801) that was supplied with your kit.

Set the Curve Tracer controls as follows: (See Figure 2-1 on fold-out from Page 48).

SWEEP VOLTAGE – Fully counterclockwise and OFF.

HORIZONTAL SENSITIVITY – 1.

VERTICAL SENSITIVITY – 5.

POLARITY – NPN.

SWEEP RANGE – 0-40V.

STEP SELECTOR – CURRENT.

STEPS/FAMILY – Fully counterclockwise.

STEP RANGE – .01.

LIMITING RESISTOR – 100.

LEFT-RIGHT – LEFT.

NORM-CAL – NORM.

( ) Turn the SWEEP VOLTAGE control only far enough clockwise to turn the Curve Tracer on.

NOTE: The following steps assume your oscilloscope is DC coupled. If your oscilloscope is AC coupled, you may have to make oscilloscope adjustments not listed in the steps. However, do not change the oscilloscope vertical and horizontal sensitivity controls. If necessary, again refer to "AC-Coupled Oscilloscopes" on Page 52.

( ) Position the dot in the lower left-hand corner of the graticule. See Figure 1-12.

( ) Turn the SWEEP VOLTAGE control clockwise until a line appears across the bottom of the display. Then turn the control counterclockwise until only a dot remains.

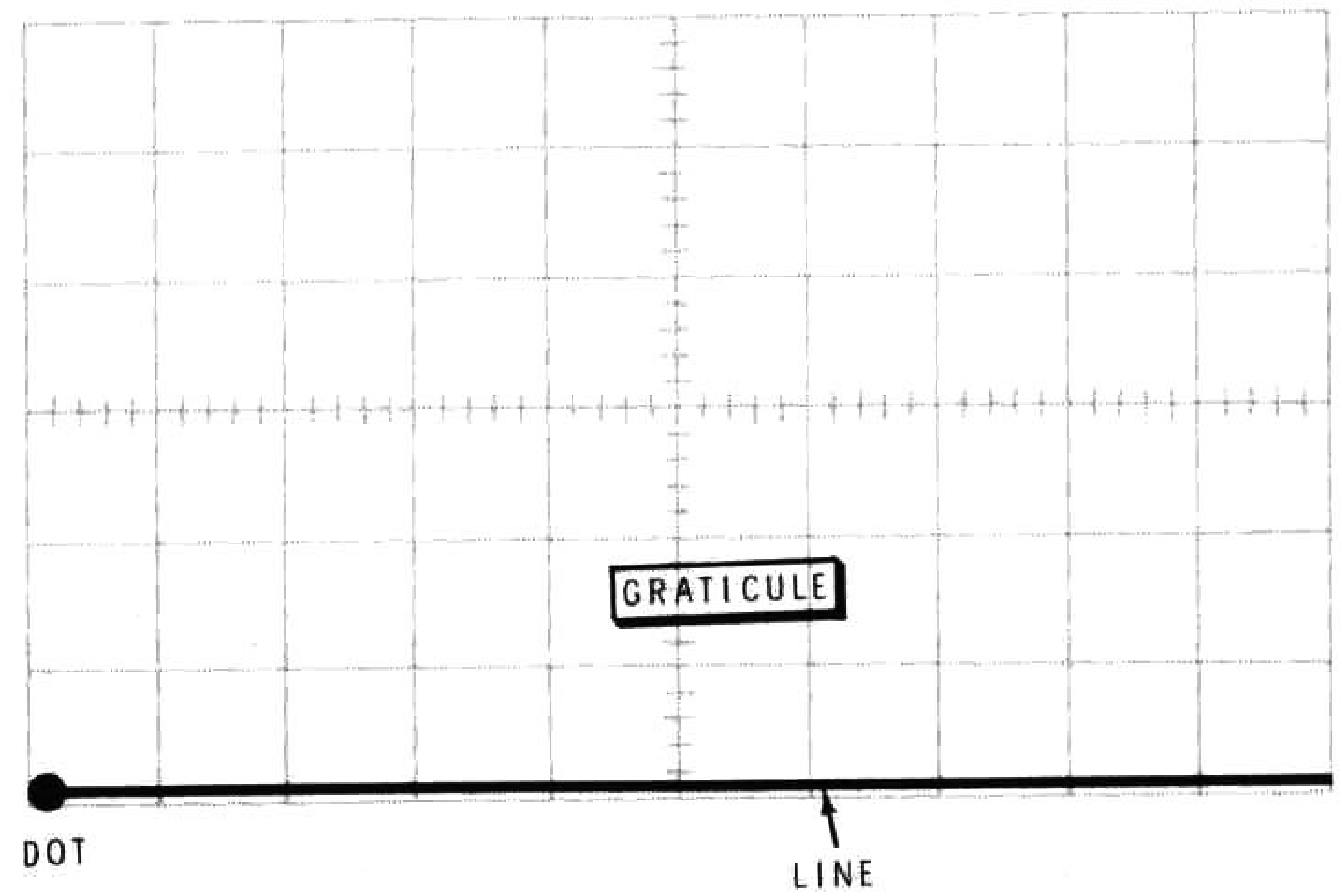


Figure 1-12

( ) Again turn the SWEEP VOLTAGE control clockwise until the bottom horizontal line is across the full length of the graticule.

( ) Turn the STEPS/FAMILY control fully clockwise. A set of nine curves plus the base line should appear. If some of the curves are off the screen, set the VERTICAL SENSITIVITY control to 10 mA/division. If they appear crowded at the bottom, set the switch to 2 mA/division.

( ) Slowly turn the STEPS/FAMILY control counterclockwise. Note that one by one, from the top down, the steps disappear until only the base line is left. Now adjust the control until three steps plus the base line appear. See Figure 1-13.

( ) If the display does not fill the screen, turn the VERTICAL SENSITIVITY switch of the Curve Tracer one step counterclockwise.

( ) Turn the LIMITING RESISTOR switch from 100 (ohms) to 50 (ohms). Note that the upper curves have increased slightly horizontally.

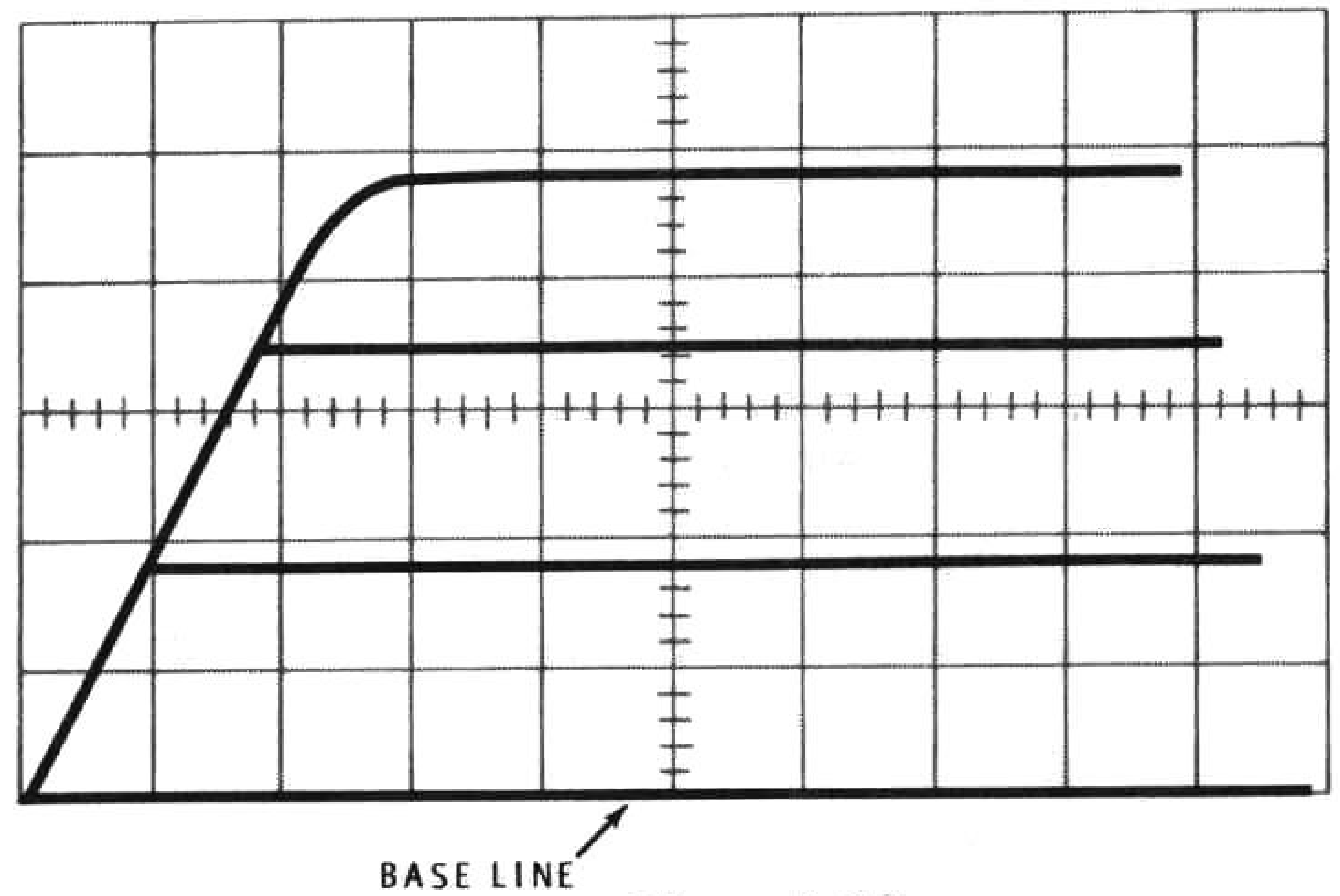


Figure 1-13

( ) Turn the same switch to 500 (ohms). Note that the upper curves have shortened. (One or two may have disappeared entirely.) Then return the switch to 100 (ohms).

( ) Turn the HORIZONTAL SENSITIVITY switch to 2 volts/division. Note that the curves have all shortened by a factor of two.

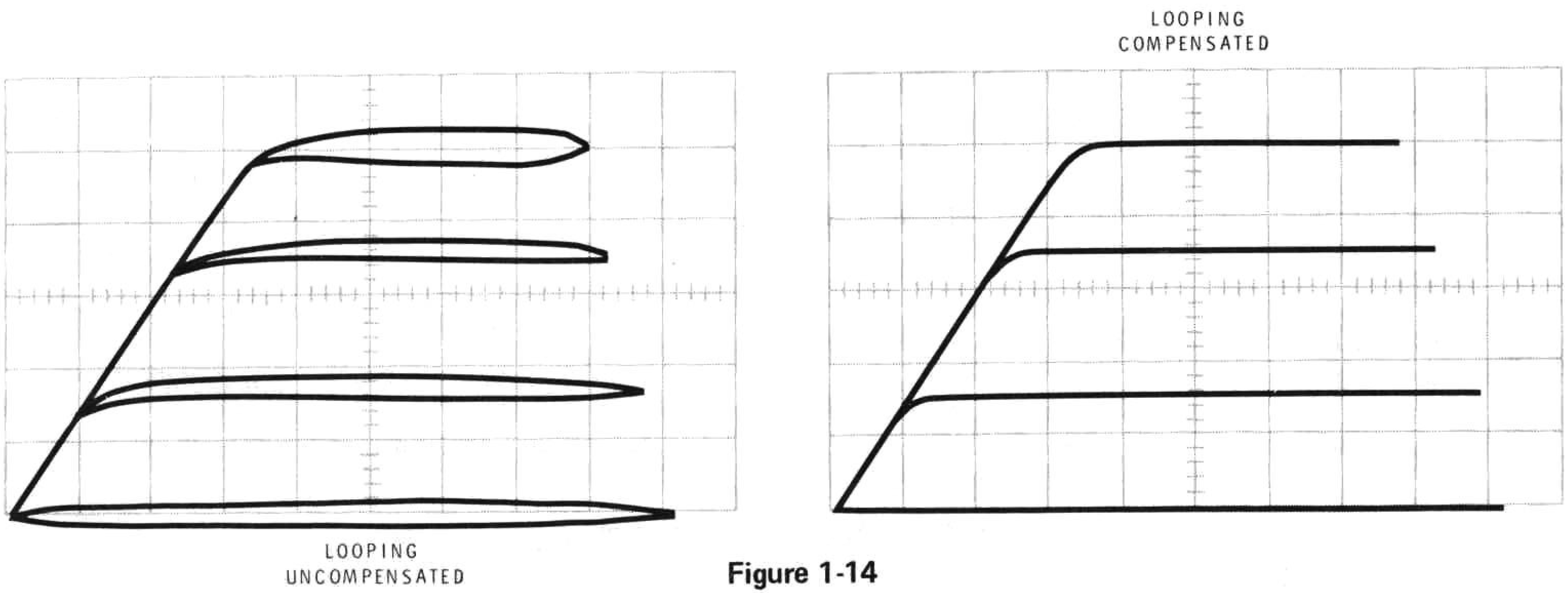


Figure 1-14

( ) Turn the HORIZONTAL SENSITIVITY switch to .5 volts/division. Note that the curves are now twice as long as they originally were and that they may extend off the CRT. Return the HORIZONTAL SENSITIVITY switch to 1.

( ) Turn the VERTICAL SENSITIVTY control to the .5 mA/division range. (Remember where the switch was set.) One or two curves may go off the screen.

( ) Adjust the LOOP control so the curves have a minimum of looping. See Figure 1-14. Then return the VERTICAL SENSITIVITY switch to its original position.

( ) Turn the STEP RANGE switch to .02 mA/division and note that the steps have doubled in value. (Some steps may go off the screen.)

( ) Turn the STEP RANGE switch to .005 mA/division and note that the steps are one half their original value. Then return the switch to .01 mA/division.

( ) Turn the SWEEP VOLTAGE control fully counterclockwise but not OFF.

( ) Switch the SWEEP RANGE switch to 0-200 V. CAUTION: On this range dangerous voltage can be available at the "C" output.

( ) Slowly turn the SWEEP VOLTAGE control clockwise until you obtain the same curves as before. (DO NOT turn the control further. The transistor is only rated to 40 volts.) Note that the curves have a less polished appearance.

( ) Turn the control back counterclockwise and set the SWEEP RANGE switch to 0-40 V.

OBSERVATION: Use the 0-200 V range only when voltages greater than 40 are required. The 40 V range provides cleaner and more precise displays, and the exposed operating voltages are safer.

( ) Position the dot in the upper right-hand corner of the screen. See Figure 1-15.

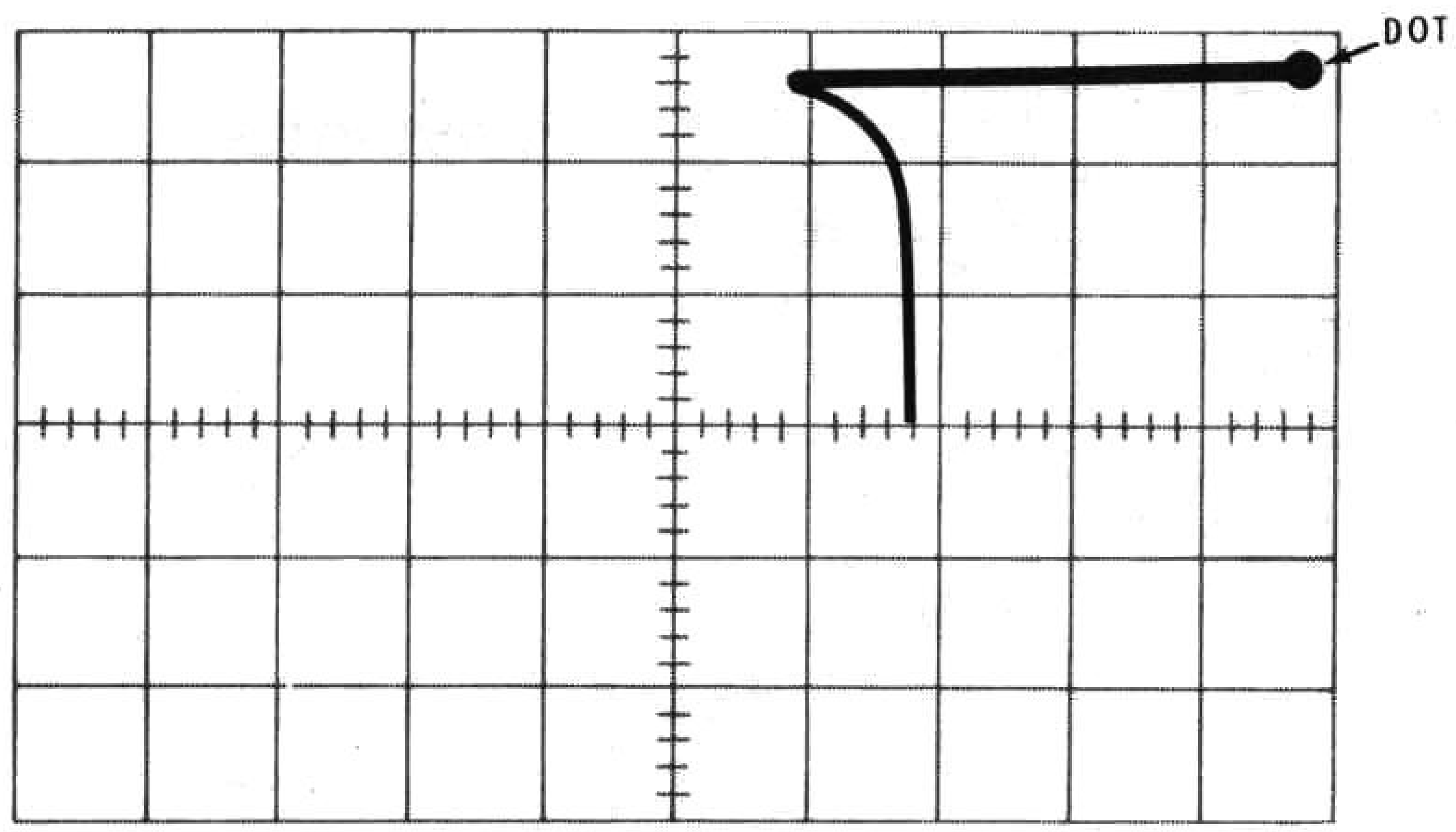


Figure 1-15

( ) Set the LIMITING RESISTOR to 1000.

( ) Set the HORIZONTAL SENSITIVITY switch to 2 volts/division.

( ) Change the POLARITY switch to PNP.

( ) Turn the STEPS/FAMILY control fully counterclockwise.

( ) Turn the SWEEP VOLTAGE control clockwise until a line appears as in Figure 1-15. This is reverse breakdown of the C to E junction.

( ) Turn the SWEEP VOLTAGE control fully counterclockwise and OFF.

This completes the "Tests and Adjustments."

FINAL ASSEMBLY

Refer to Pictorial 4-1 for the following steps.

( ) Unplug the line cord, disconnect all leads, and remove the test transistor.

( ) Carefully turn the Curve Tracer upside down. Then lower the cabinet shell into position and secure it with six #6 x 3/8" sheet metal screws and two 8-32 x 3/8" screws.

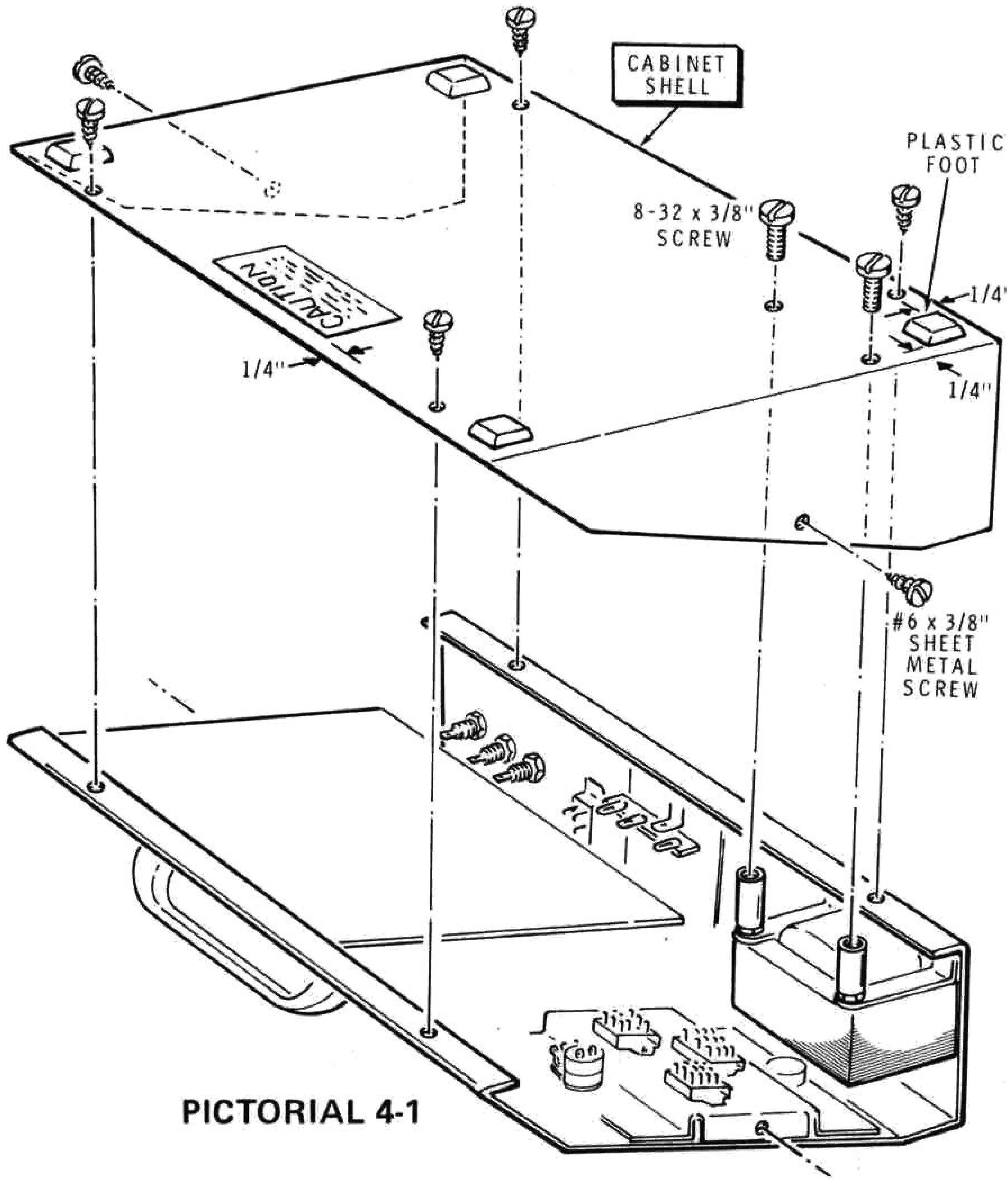
( ) Remove the protective backing from the CAUTION label and apply it to the cabinet shell as shown.

( ) Remove the protective backing from a plastic foot and press it in a corner 1/4" from the edges of the cabinet shell.

( ) In a similar manner, install plastic feet at the three remaining corners.

( ) Turn the Curve Tracer right side up.

This completes the "Final Assembly" of your kit.



PICTORIAL 4-1

OPERATION

CONTROL FUNCTIONS

Refer to Figure 2-1 (fold-out from Page 48) as you read the description of each control function.

1. PILOT LAMP (PL1) – Indicates when the Curve Tracer is plugged in and turned on.

2. SWEEP VOLTAGE (R6, SW1) – Combination ON–OFF switch and SWEEP VOLTAGE control. Turns the unit on and off, and sets the value of the sweep voltage at "C" terminals.

3. HORIZONTAL SENSITIVITY (SW6) – While the oscilloscope monitors the sweep voltage on the device under test, this switch selects one of the nine voltage ranges for a proper display.

4. VERTICAL SENSITIVITY (SW7) – Selects one of nine current ranges so the oscilloscope can monitor the current (produced by the sweep voltage) passing through the test device.

5. POLARITY (SW3) – Selects either NPN or PNP (N-channel or P-channel).

	Sweep Voltage	Current Steps	Voltage Steps
NPN	positive	positive	negative
PNP	negative	negative	positive

6. SWEEP RANGE (SW2) – Selects sweep voltage of either 0-40 V (at up to 1 ampere maximum) or 0-200 V (at up to 200 milliamperes maximum). Always use the lower range unless more voltage is needed.

7. STEP SELECTOR (SW9) – Selects either VOLTAGE or CURRENT steps, and the polarity of the signal supplied to the B output terminals.

8. STEPS/FAMILY (R47) – Adjusts the number of steps from zero to nine.

9. STEP RANGE (SW8) – Selects either current steps or voltage steps, depending on the setting of the STEP SELECTOR switch. Provides 12 values of current steps or 5 values of voltage steps.

10. LIMITING RESISTOR (SW4) – Selects one of 11 resistors plus zero ohms. These current limiting resistors protect the device under test. Use the highest value that gives a consistent display.

11. LEFT TRANSISTOR SOCKET – For testing small transistors out of circuit. Active when the LEFT-RIGHT switch is at LEFT.

12. LEFT BANANA JACKS – Use these jacks with the supplied cables to test large semiconductors in and out of circuit. Active when the LEFT-RIGHT switch is at LEFT.

13. LEFT-RIGHT (SW5) – Selects either the left or right socket and jacks.

14. RIGHT BANANA JACKS – Use with the supplied cables to test large semiconductors in or out of circuit. Active when the LEFT-RIGHT switch is at RIGHT.

15. RIGHT TRANSISTOR SOCKET – For testing small transistor out of circuit. Active when the LEFT-RIGHT switch is at RIGHT.

16. H, G, V TERMINALS – Provide output connections to an oscilloscope.

H connects to the horizontal input.
G connects to ground.
V connects to the vertical input.

17. LOOP (R5) – Compensates for circuit capacitance to minimize looping in the display.

18. NORM-CAL (SW10) – In the CAL position, dots resulting from a precision staircase waveform are applied to the oscilloscope for calibration. The NORM position provides normal operation.

CURVE TRACER CHARACTERISTICS

Because of the great versatility of this Curve Tracer, in a few instances the display may be other than ideal. These can be caused by the limitations of the device being tested, interaction between the tested device and the Curve Tracer, and, in some cases, the Curve Tracer itself.

Refer to Figure 2-2 as you read the following information.

A. A coil-like loop may occur here with sweep voltages higher than 30 volts. Higher limiting resistance will minimize this effect.

B. Looping (double line) may occur with low sweep currents (.5 mA/div) and high sweep voltages (above 30 volts). Use the LOOP control to minimize this effect.

C. This hump may occur with certain transistors. Use a higher value of limiting resistance to minimize the hump.

D. A faint line at higher sweep voltages (above 30 volts) is more noticeable with less steps and can be minimized by adding more limiting resistance.

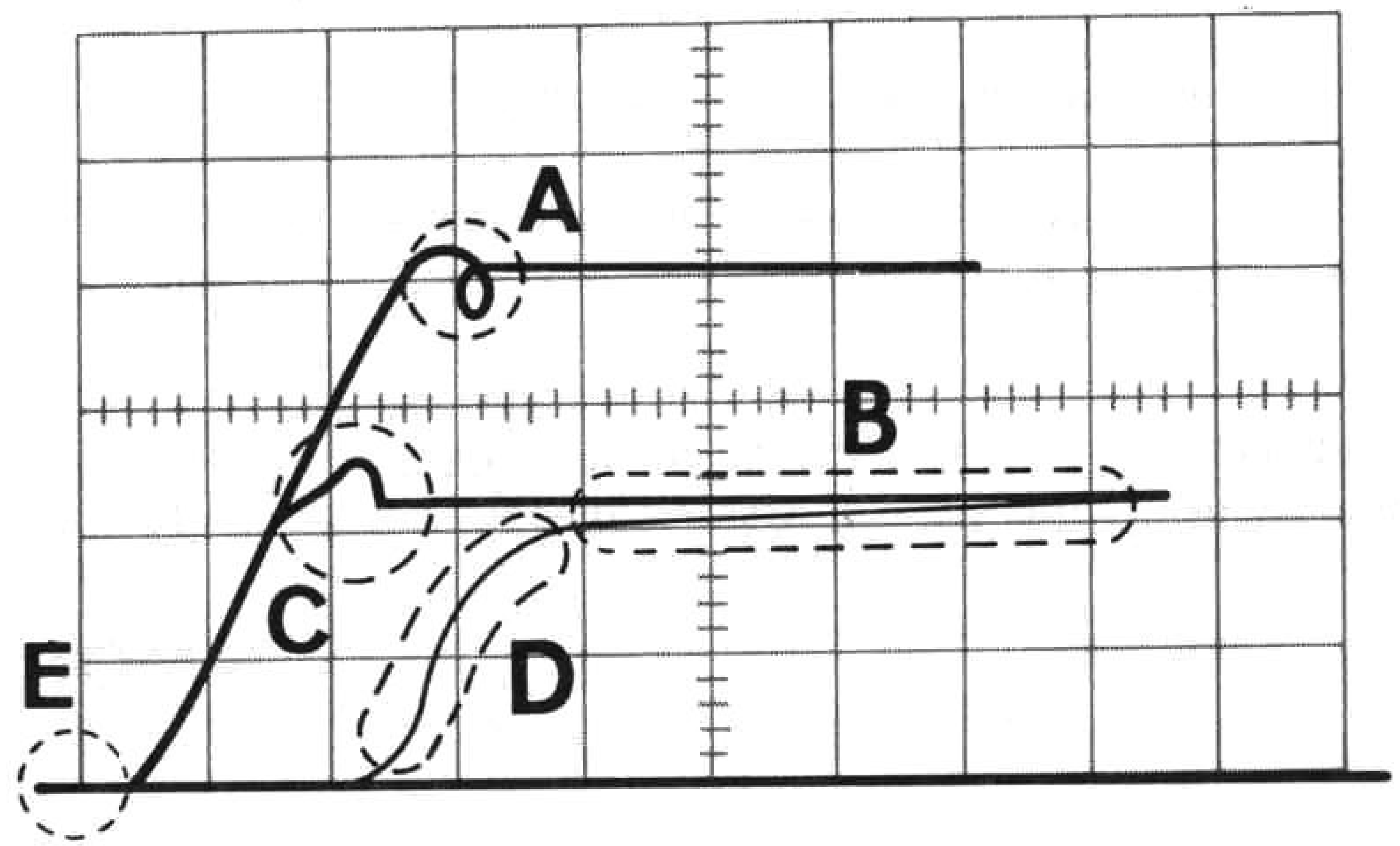


Figure 2-2

E. Some reverse voltage sweep will appear here on the .1 volts range for the low sweep range, and on the .1 volt/div through the 5 volt/div on the 200 volt sweep range.

APPLICATIONS

GENERAL INFORMATION

PRECAUTIONS

To protect the device being tested, always observe the following precautions.

- Keep the SWEEP VOLTAGE below the collector breakdown level except during the short time of a collector voltage breakdown test. Although the limiting resistors prevent destruction of the transistor, high internal temperatures from long periods of operation may cause the transistor to fail.

- Limit the testing of power transistors without heat sinks to a few seconds – just long enough to make an accurate reading. Excessive temperatures in the test device may result from longer periods of operation. Start and stop the tests by using the LEFT-RIGHT switch.

- Before you make a test, be sure the following controls are set as follows:

SWEEP VOLTAGE	Fully counterclockwise
SWEEP RANGE	0-40 V
LIMITING RESISTOR	5 k or higher
STEP RANGE	.02 mA/Step or less

Return the controls to these positions after each test. This will insure that no device will be accidentally destroyed.

- Completely remove power from the unit under test. The Curve Tracer supplies the complete test signal. Any additional signal or DC current may make the test inaccurate and could damage the unit.

TESTING BIPOLAR TRANSISTORS

The most common use of the Curve Tracer is to test NPN and PNP transistors. The family of curves of an NPN transistor is in a positive direction. That is, zero volts is at the left and zero current is at the bottom of the display. The curves sweep upward and to the right as collector voltage and current increases, and the sweep voltage is positive.

The curves of a PNP transistor, however, are in the negative direction. Zero volts is at the right and zero current is at the top of the display. The curves sweep downward and to the left as collector voltage and current increase, and the sweep voltage is negative.

Any test of an NPN transistor can be performed on a PNP and vice versa. The displays are merely inverted.

Transistors can be tested for:

- Current gain (DC and AC beta)
- Collector-to-emitter breakdown
- Collector-to-base breakdown
- Output admittance
- Saturation voltage
- Saturation resistance
- Cutoff current
- Leakage current
- Linearity and distortion
- Temperature effects
- Identifying germanium or silicon
- Matching
- Sorting and substitution

TRANSISTOR IDENTIFICATION

To test a transistor you need to know three things.

1. The basing configuration (E, B, C, or S, G, D). Figure 2-3 shows some of the more common configurations. If the transistor type number is available, the basing configuration can be found in the manufacturer's handbook. Also, a schematic may provide this information.

2. The type (NPN or PNP). This information can come from the circuit, schematic, manufacturer's handbook, or from the Curve Tracer as described on Page 66.

3. The power class. See Figure 2-3. (Signal, intermediate power, or power.)

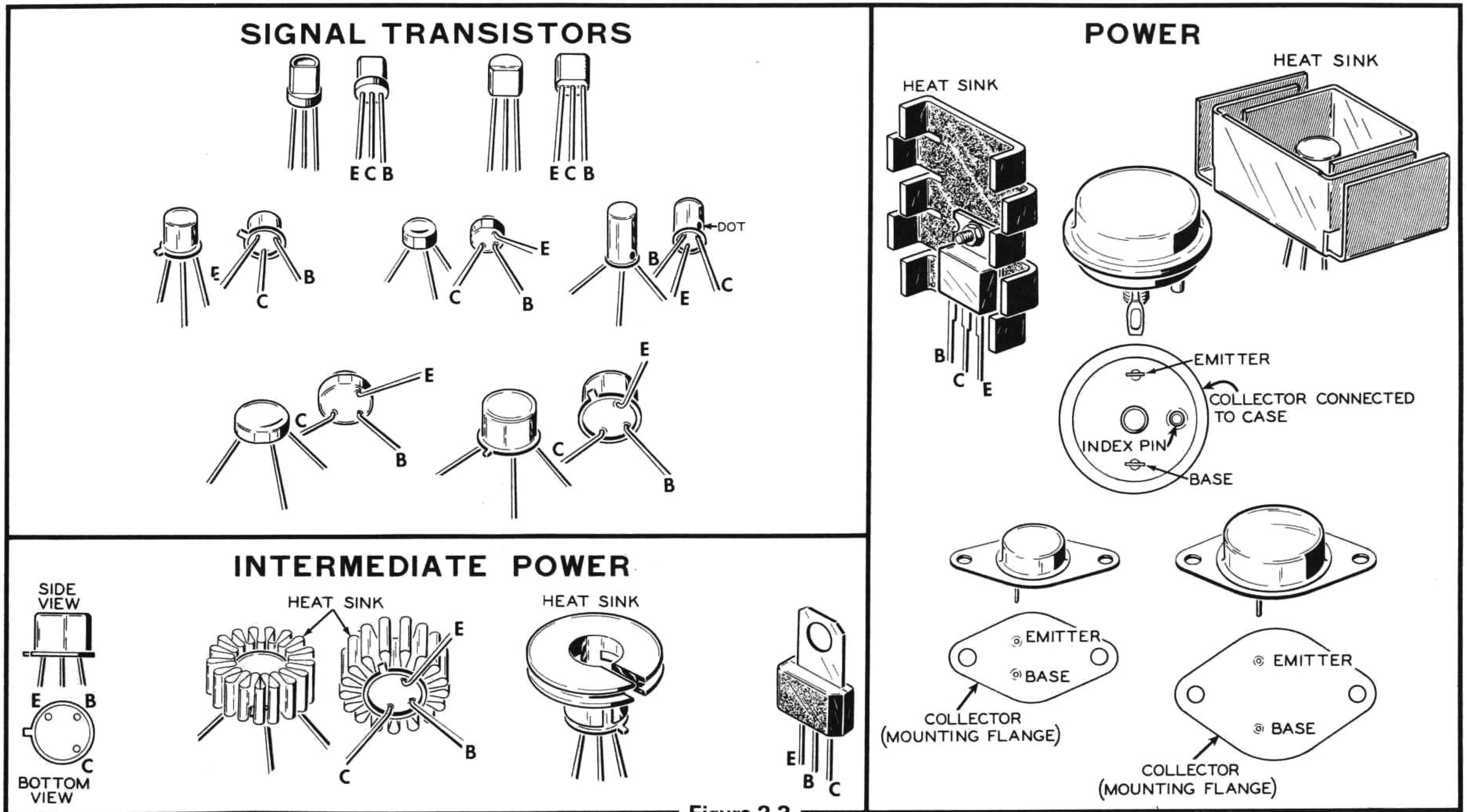


Figure 2-3

INITIAL DISPLAY

To obtain an initial display, set the Curve Tracer controls as shown below. Note that the switches marked with an asterisk are always in these positions for transistor tests. Refer to Table 1 and make other control settings according to the power rating of the transistor. Also, if the oscilloscope is not connected and calibrated, see "Oscilloscope Calibration" on Page 54.

SWEEP VOLTAGE – Fully counterclockwise and off.
HORIZONTAL SENSITIVITY – See Table 1.
VERTICAL SENSITIVITY – See Table 1.
POLARITY – Set for type of transistor.
SWEEP RANGE – 0-40 V.
STEPS/FAMILY – Fully clockwise.
*STEP SELECTOR – Current.
STEP RANGE – See Table 1.
LIMITING RESISTOR – See Table 1.
LEFT-RIGHT – Left.
LOOP – Fully clockwise.
*NORM-CAL – Norm.

	Base Step	HORIZONTAL SENSITIVITY	VERTICAL SENSITIVITY	LIMITING RESISTOR	SWEEP RANGE
SIGNAL	.002	1 V/div.	.5 mA/div.	5 k	0-40 V
INTERMEDIATE POWER	.02	1 V/div.	5 mA/div.	500	0-40 V
POWER	.2	1 V/div.	50 mA/div.	50	0-40 V

TABLE 1

( ) Turn the SWEEP VOLTAGE control clockwise only far enough to turn the unit on.

( ) Connect the transistor to be tested to the right socket, or to the E, B, C terminals with test leads.

( ) Set the LEFT-RIGHT switch to RIGHT.

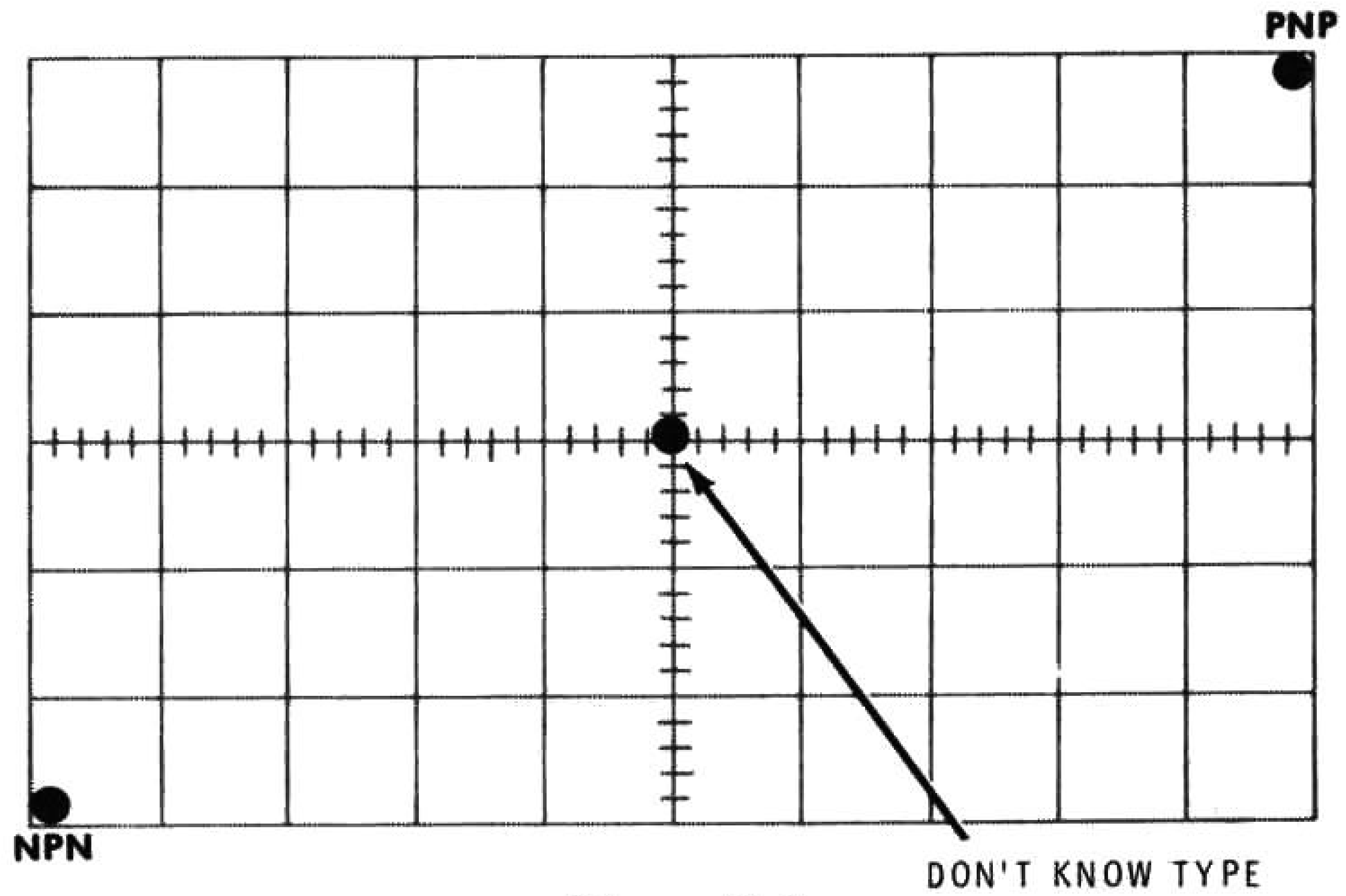


Figure 2-4

( ) If the transistor is an NPN, place the dot in the lower left-hand corner of the screen. If it is a PNP, place it in the upper right-hand corner of the screen. If you don't know if it is NPN or PNP, place the dot in the middle of the screen as shown in Figure 2-4.

NOTE: Perform the following numbered steps only if you don't know if the transistor is an NPN or PNP.

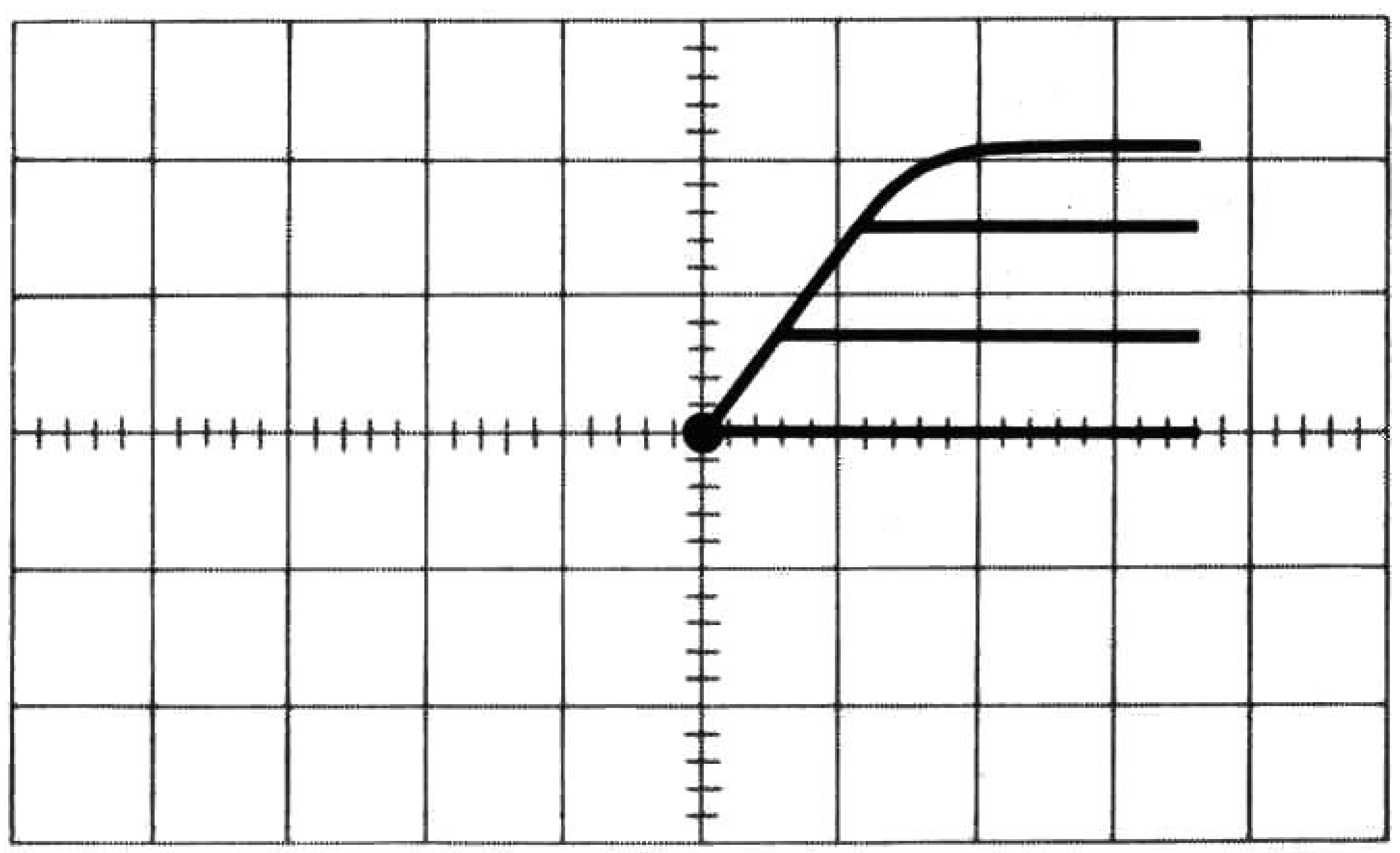


Figure 2-5

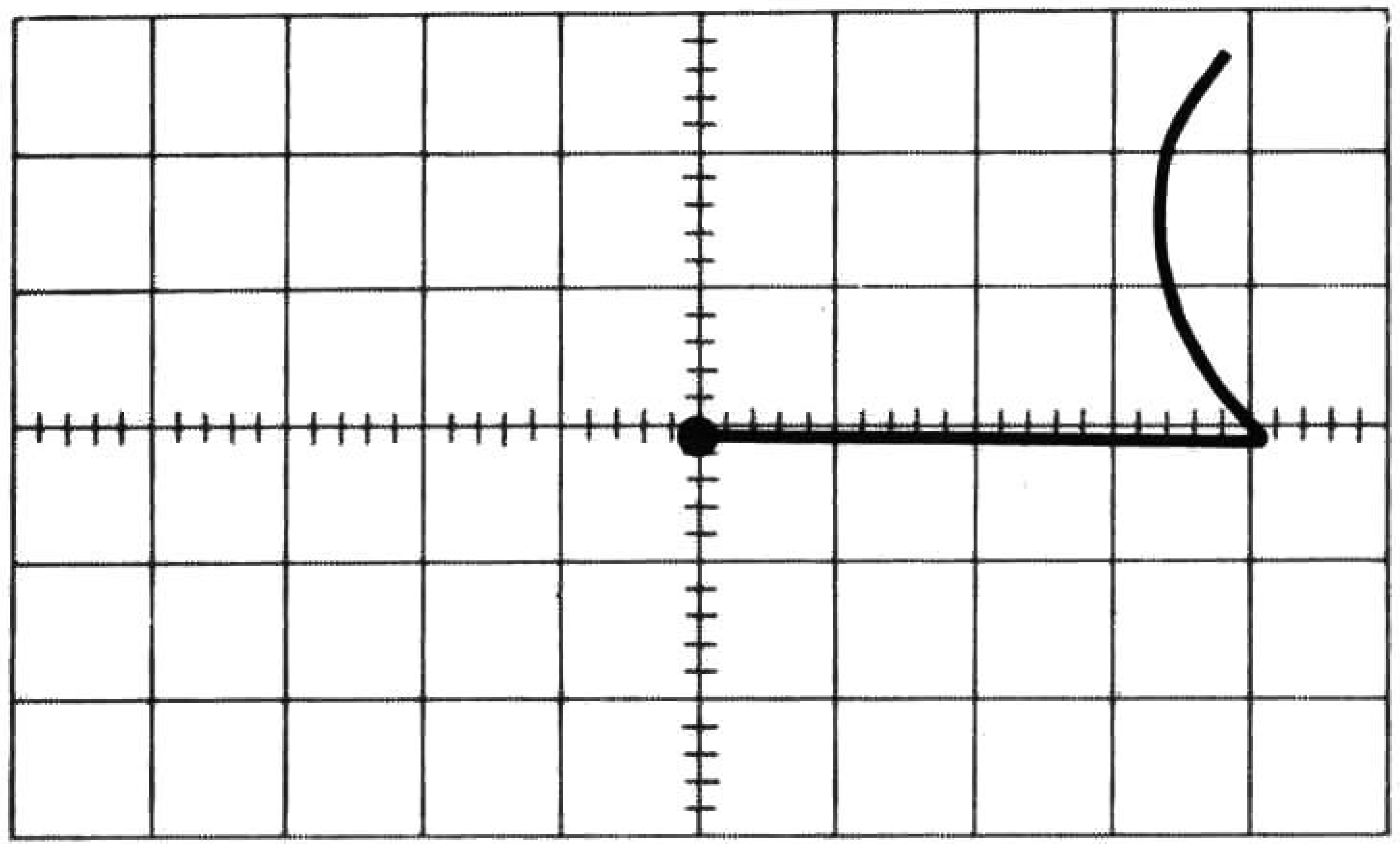


Figure 2-6

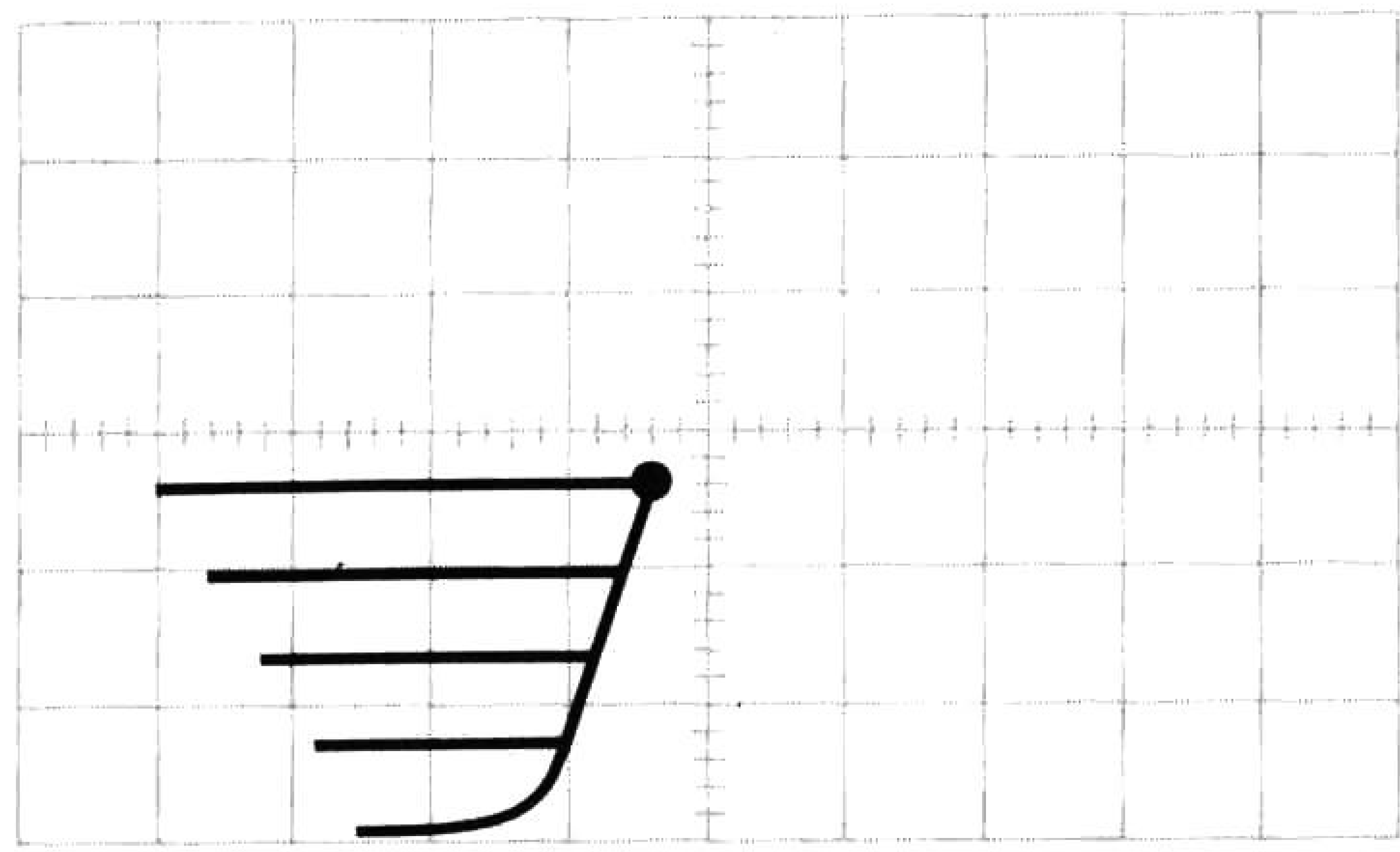


Figure 2-7

1. Slowly turn up the SWEEP VOLTAGE control. If the transistor is an NPN, curves will appear as shown in Figure 2-5. If it is a PNP, no curves will appear and breakdown, as shown in Figure 2-6, may appear. If this happens, switch the Polarity control to PNP. Then curves as shown in Figure 2-7 should appear.

2. Refer again to Figure 2-4, turn the SWEEP VOLTAGE control fully counterclockwise, and place the dot in the appropriate corner of the screen for NPN or PNP.

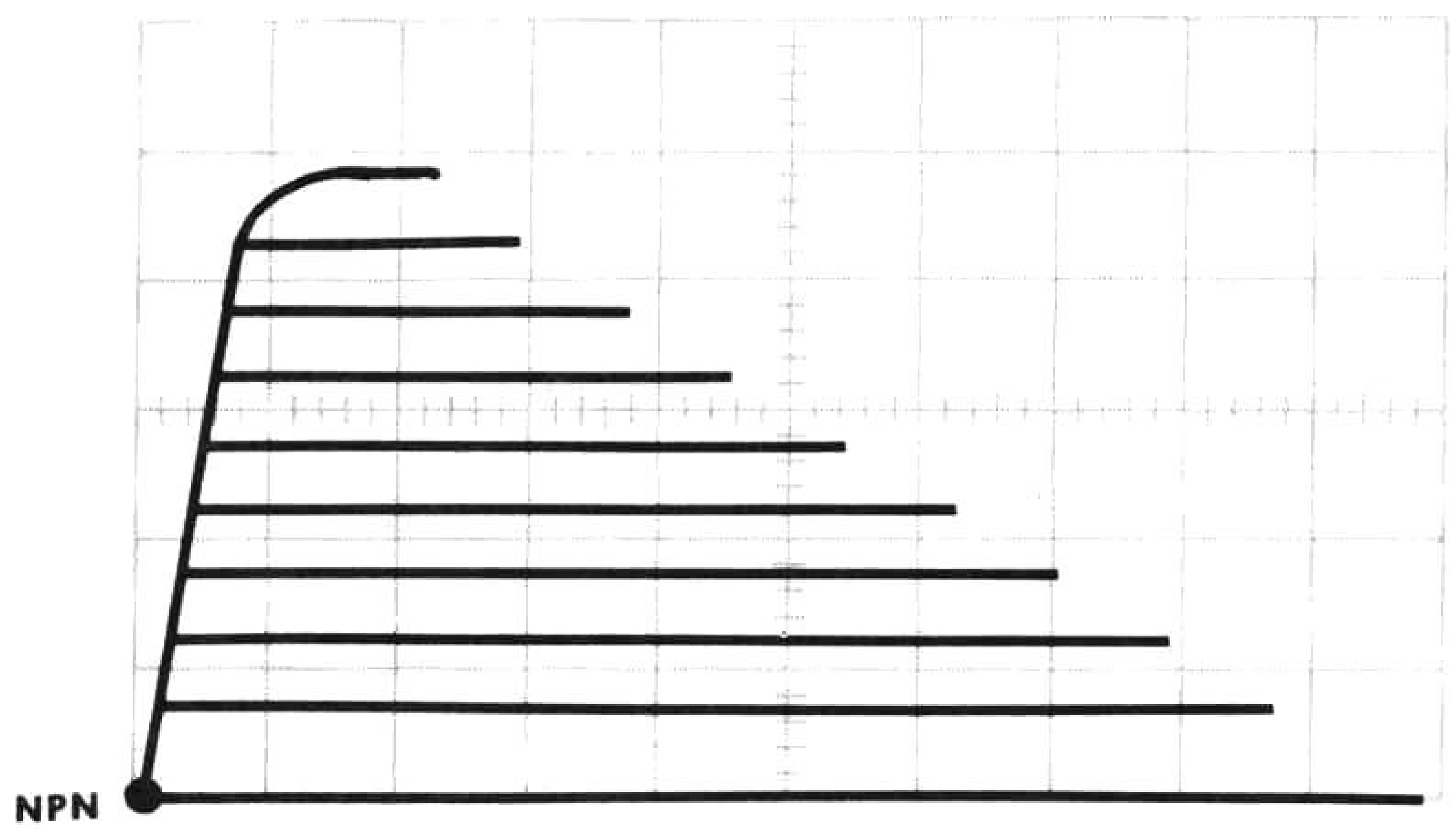


Figure 2-8

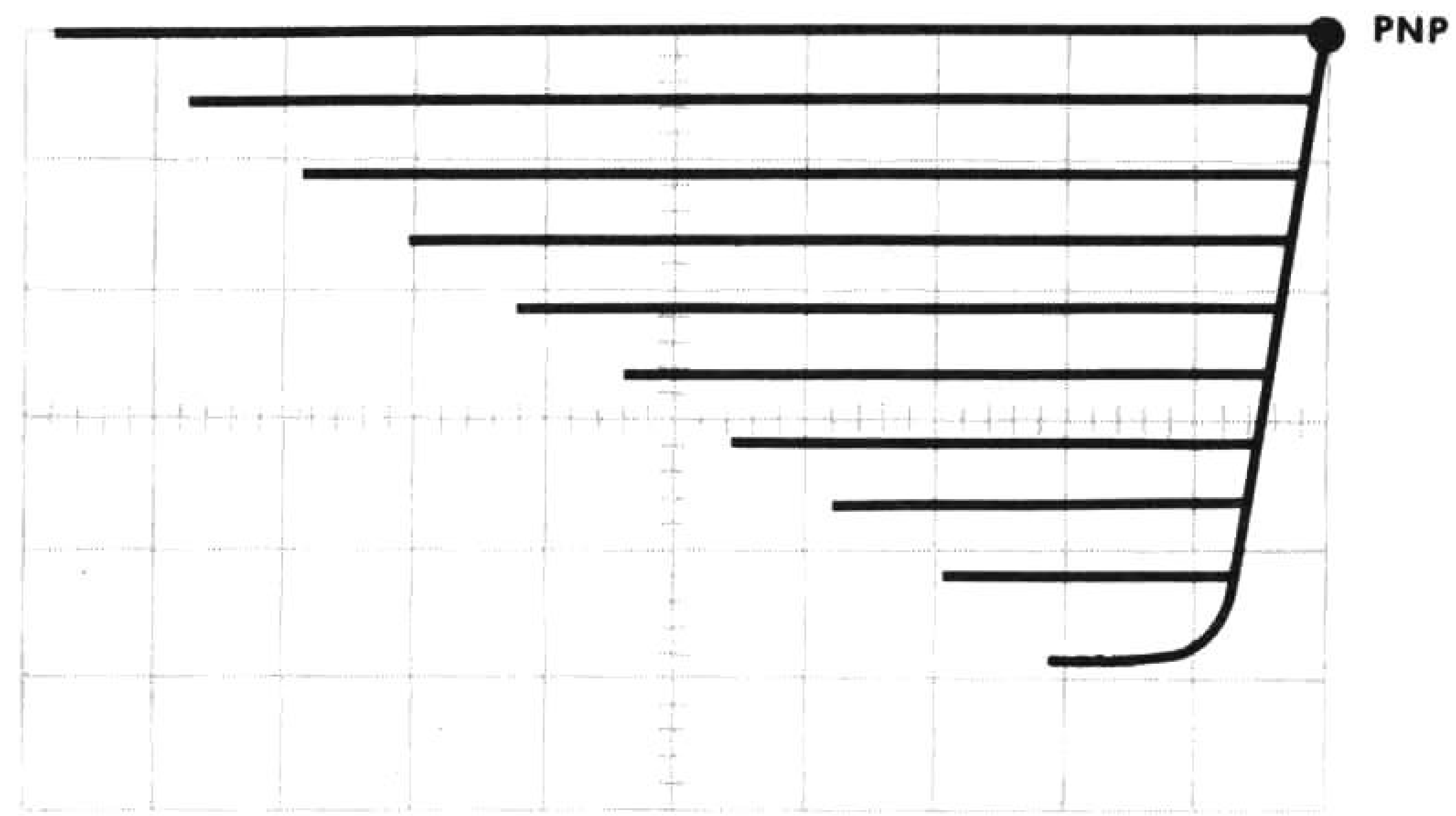


Figure 2-9

Figures 2-8 and 2-9 show typical displays of NPN and PNP transistors. They are identical – only inverted.

NOTE: If some curves go off the screen, switch the VERTICAL SENSITIVITY control to the next higher range (clockwise). Also, you may have to lower the LIMITING RESISTOR value. If the curves are to close together, select a more sensitive current range.

Table 2 gives ranges of operating parameters for transistors with different power ratings. Use Table 1 as a starting point to ensure that the device will be operated within its specifications. Always be cautious when you use ranges listed in Table 2 so that the device ratings are not exceeded.

	BASE CURRENT RANGE	COLLECTOR CURRENT RANGE	VOLTAGE RANGE
SIGNAL (Audio, RF, IF, etc.)	.002 through .1 mA/step	.5 through 5 mA/div.	STAY BELOW DEVICE BREAKDOWN
INTERMEDIATE POWER (Audio, Switching)	.02 through 1 mA/step	2 mA through 50 mA/div.	STAY BELOW DEVICE BREAKDOWN
POWER (Audio, Output, Regulator)	.2 through 10 mA/step	20 mA through 200 mA/div.	STAY BELOW DEVICE BREAKDOWN

TABLE 2

MEASUREMENTS

In-Circuit Tests – Many times these can only be made by comparing results with those known to be proper. If no curves can be obtained at all, remove the device from the circuit and then test the device.

Matching Transistors – It is often desirable to match transistors for gain, linearity, saturation, output admittance, etc. Use the LEFT-RIGHT switch to compare the curves. Matched devices have identical curves.

Sorting Transistors – To sort transistors, use the oscilloscope controls and place the CRT dot (with no input signal) in the center of the screen. Then NPN transistors will produce curves in the upper right-hand quadrant of the screen and PNP transistors will produce curves in the lower left-hand quadrant of the screen as you flip the NPN-PNP switch back and forth.

Integrated Circuits – Integrated circuits are often several transistors, diodes, etc. packaged together. These IC's may be tested if the internal devices can be identified and isolated to specific terminals of the IC. Note, however, that other circuit elements may produce loops in the curves, or other variations, of the display.

The following are examples of typical measurements and the control settings under which they were performed. Many of these use the extra MPSA20 (#417-801) transistor supplied with your kit; the control settings may vary widely for other devices.

NOTES:

1. All of these tests, unless they are described otherwise, were made with the NORM-CAL switch in the NORM position, the LOOP control adjusted for minimum looping, the LEFT-RIGHT switch in the LEFT position, and the SWEEP VOLTAGE control adjusted clockwise for a proper display.

2. If a transistor is open, only the base line will appear on the display. If the transistor is shorted, there will be a vertical line as in Figure 3-2 but there will be no base line.

Proceed to the heading of the test you are interested in.

SATURATION VOLTAGE [$V_{CE\ (sat)}$]

MPSA20:

HORIZONTAL SENSITIVITY	.1 volts/Div.
VERTICAL SENSITIVITY	2 mA/Div.
POLARITY	NPN
STEPS/FAMILY	5 steps
STEP RANGE	.01 mA/Step
LIMITING RESISTOR	0

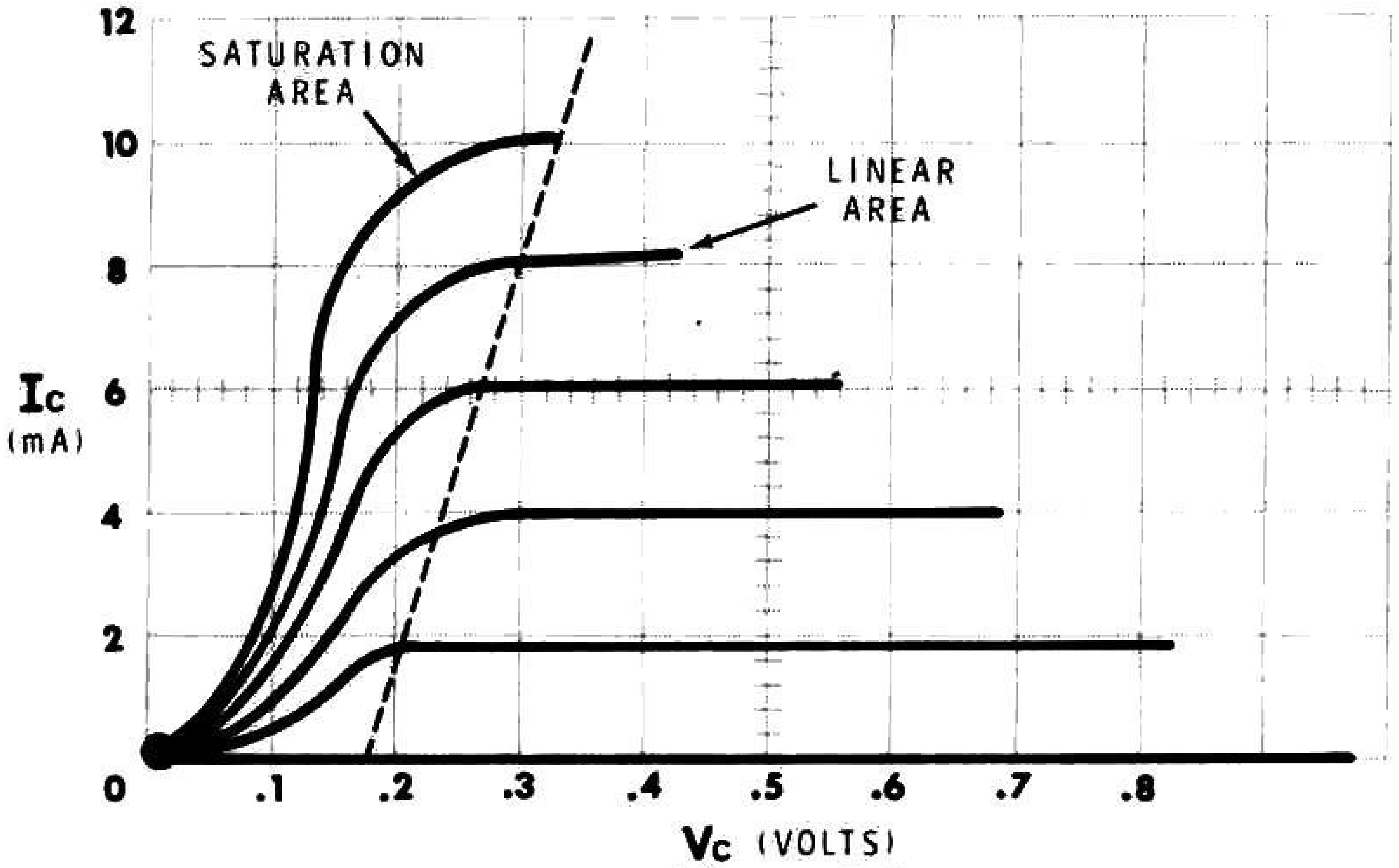


Figure 3-1

The collector saturation region of a transistor is that portion of the family of curves in the area of low collector voltage and current below the knee of each curve. The knee of each curve occurs at approximately the same collector voltage (from .18 to .32 in Figure 3-1). Collector voltage above the knee has little effect on collector current; the base current controls collector current in this area.

MPSA20: $V_{CE\ (sat)}$ = 0.25 VDC (MAX) @ I_c = 10 mA and I_B = 1 mA.

HORIZONTAL SENSITIVITY	.1 Volts/Div.
VERTICAL SENSITIVITY	2 mA/Div.
POLARITY	NPN
STEPS/FAMILY	1 Step
STEP RANGE	1 mA/Step
LIMITING RESISTOR	0

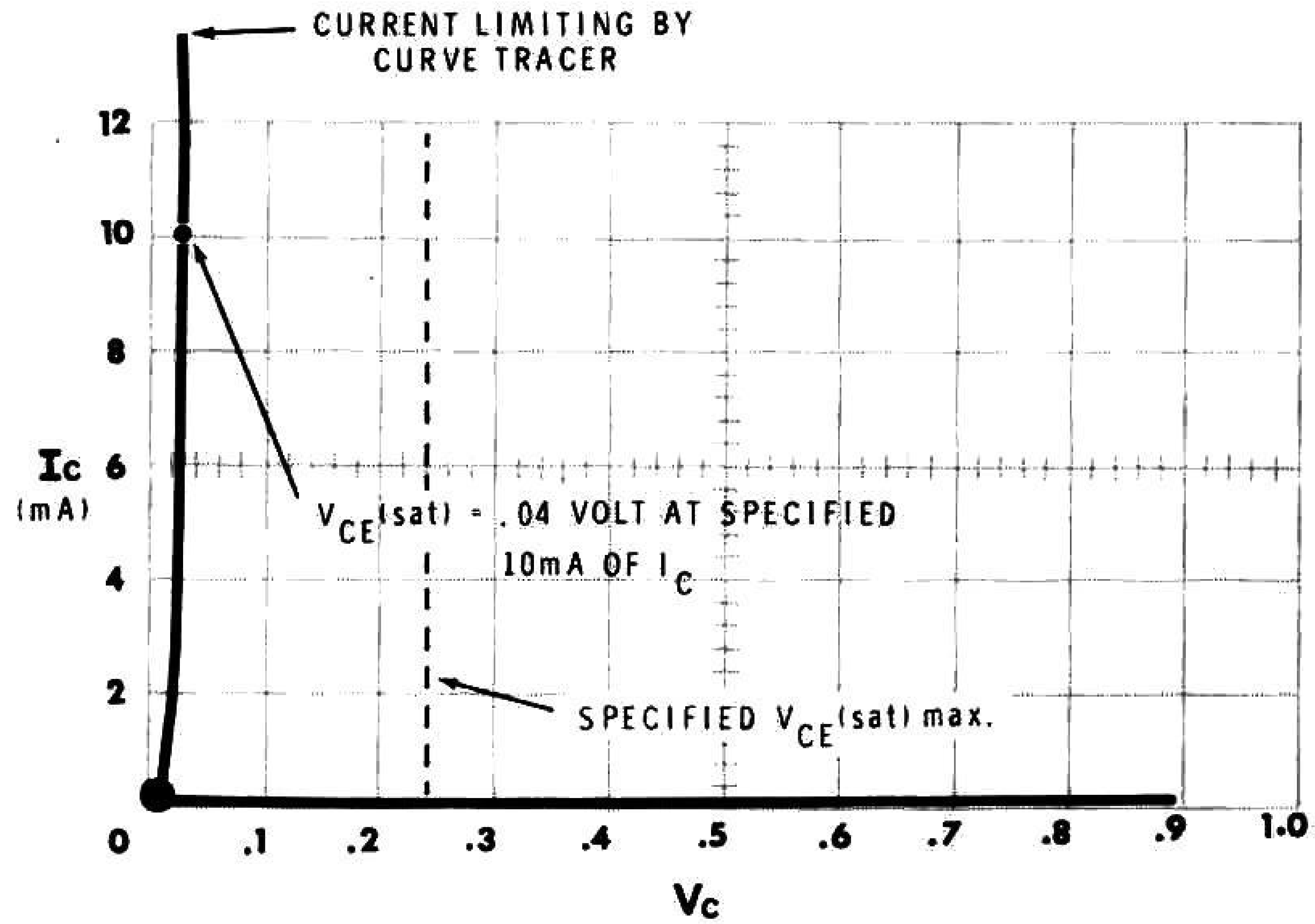


Figure 3-2

Transistor data sheets specify $V_{CE(sat)}$ as a maximum voltage at a given base current and collector current. In Figure 3-2 this value is .04 volt.

Saturation resistance, $r_{CE(sat)}$, can be calculated, if desired, by the formula $r_{CE(sat)} = \frac{V_C}{I_C}$ for a given value of base current in the saturation region. In Figure 3-2, $r_{CE(sat)} = \frac{.04\ V}{10\ mA} = \frac{40\ mV}{10\ mA} = 4\ \Omega$.

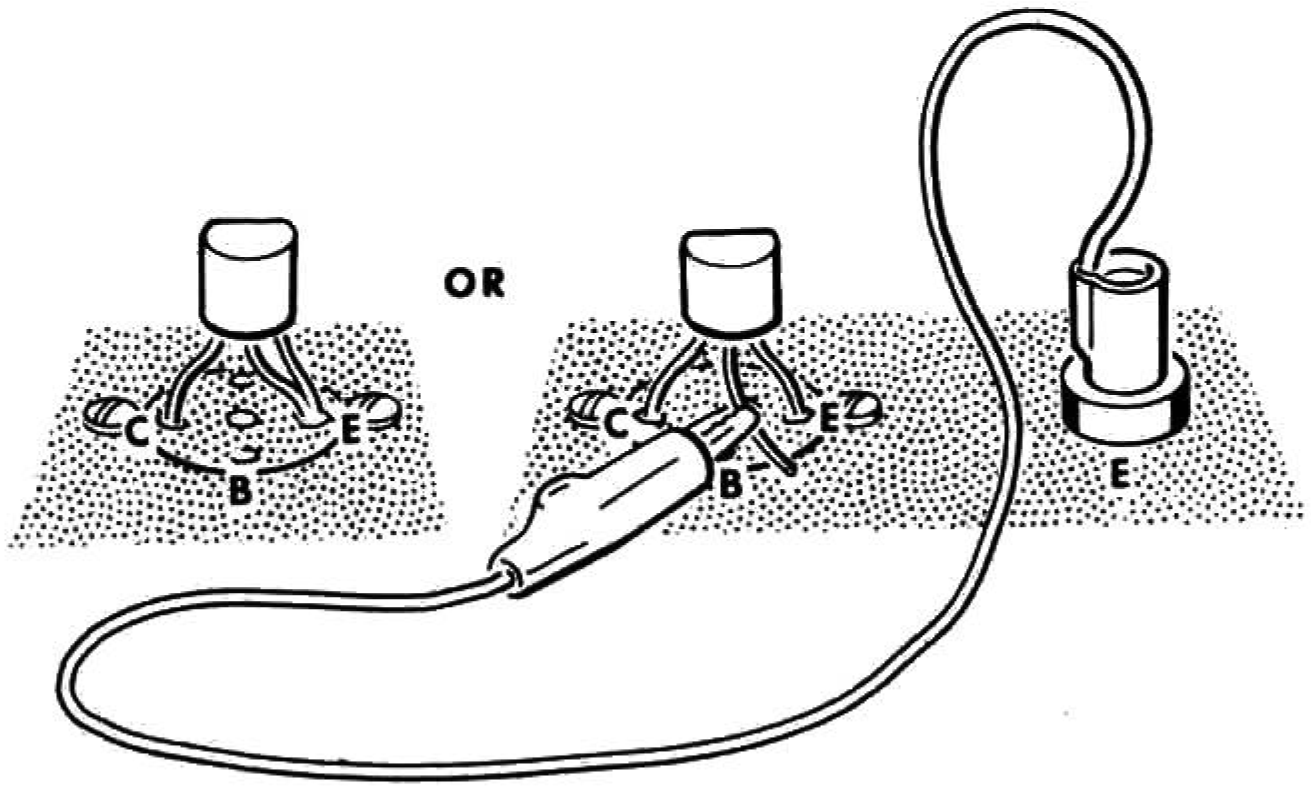
LEAKAGE CURRENT (I_{CEO}) and (I_{CES})

HORIZONTAL SENSITIVITY	5 Volts/Div.
VERTICAL SENSITIVITY	.5 mA/Div.
POLARITY	NPN
STEPS/FAMILY	0
STEP RANGE	Any position
LIMITING RESISTOR	5 k

I_{CEO} is the collector to emitter leakage current that flows when the base is open (not connected). I_{CES} is the collector to emitter leakage current that flows when the base is shorted to the emitter.

I_{CEO} – Do not connect the transistor base lead to the Curve Tracer.

I_{CES} – Connect both the transistor base lead and emitter lead to the E connector of the transistor socket. See below.



The leakage current is proportional to the collector-to-emitter voltage and becomes greatest as the breakdown voltage is approached. For a good transistor, I_{CEO} is always greater than I_{CES}.

NOTE: Silicon transistors typically have leakage currents in the nanoampere region and will not display any leakage on the Curve Tracer. Germanium transistors are much more likely to show measurable leakage.

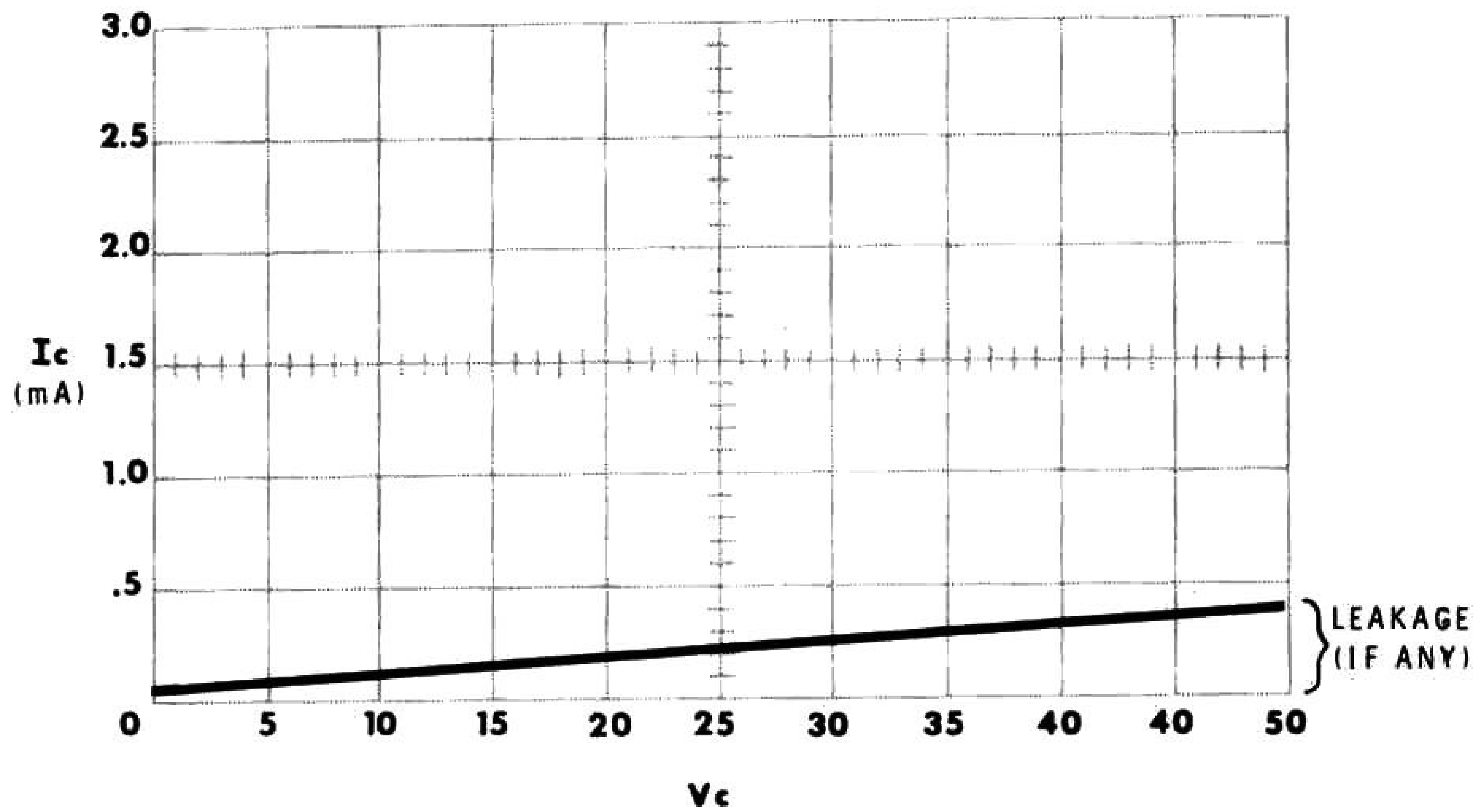


Figure 3-3

BREAKDOWN VOLTAGE

MPSA20: Minimum 40 volts at 1 mA of I_c

HORIZONTAL SENSITIVITY	5 volts/Div.
VERTICAL SENSITIVITY	2 mA/Div.
POLARITY	NPN
STEPS/FAMILY	5 Steps
STEP RANGE	.005 mA/Step
LIMITING RESISTOR	5 k

The breakdown voltage is where the collector current becomes independent of the base current and rises sharply until limited by the Curve Tracer. If it were not for this limiting, the transistor would be destroyed. Keep the test short so the transistor is not damaged by too much heat. Increase the sweep voltage until the collector breakdown point is reached.

Most transistors can be tested for breakdown because of the high voltage capability (200 volts) of the Curve Tracer.

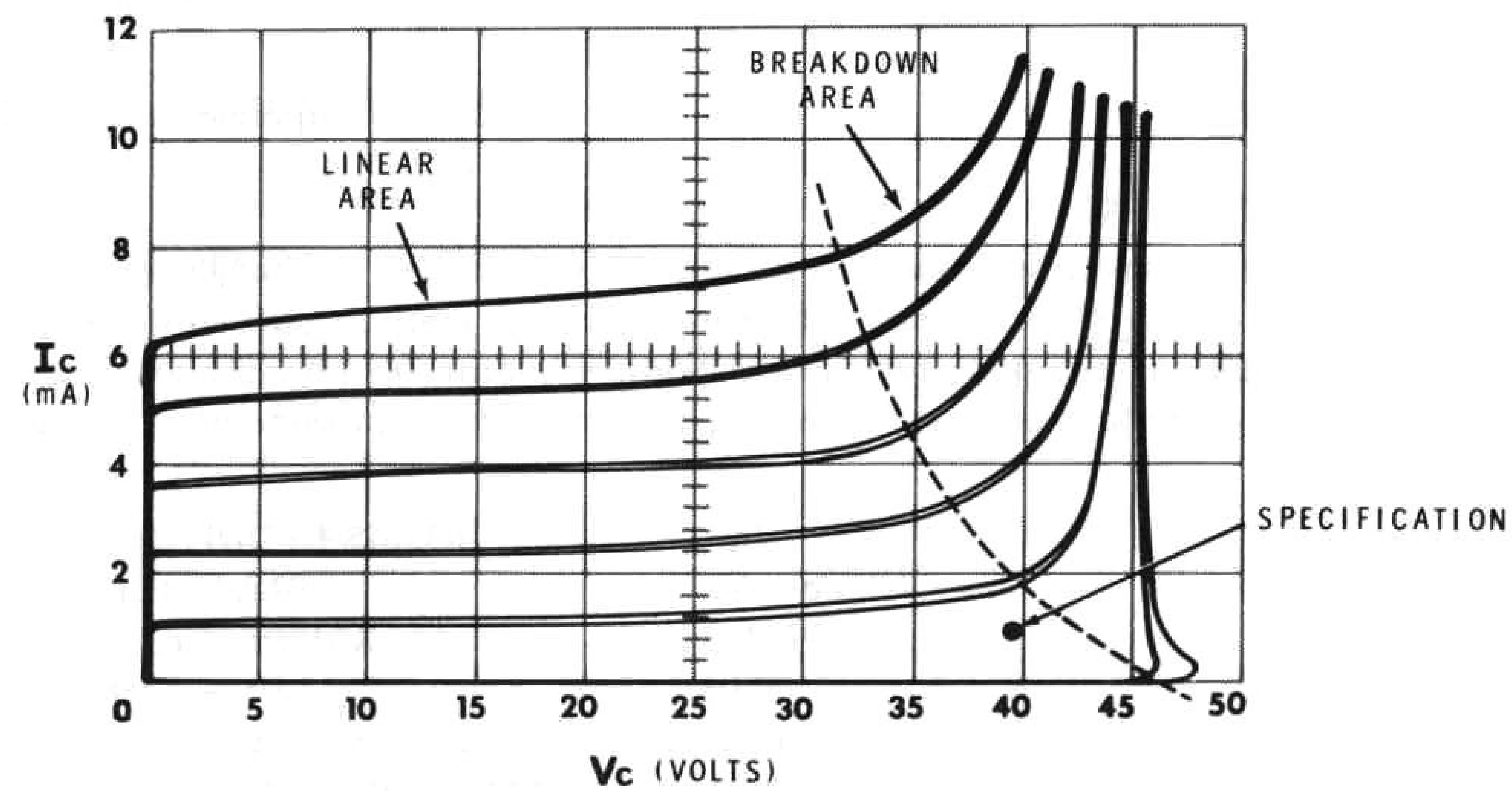


Figure 3-4

OUTPUT ADMITTANCE (h_{oe})

MPSA20:

HORIZONTAL SENSITIVITY	5 volts/Div.
VERTICAL SENSITIVITY	2 mA/Div.
POLARITY	NPN
STEPS/FAMILY	5 Steps
STEP RANGE	.005 mA/Step
LIMITING RESISTOR	5 k

The output admittance of a transistor is the change in collector current (ΔI_c) that results from a specific change in collector voltage (ΔV_c) at a constant base current. Admittance is measured in μmhos and its "h" parameter in the common emitter configuration is $h_{oe} = \frac{\Delta I_c}{\Delta V_c} = \frac{\Delta I_c}{\Delta V_c} = \frac{.8 \text{ mA}}{25 \text{ V}} = 32\ \mu\text{mhos}$.

The output impedance of the transistor (collector resistance) is the reciprocal of its output admittance and is measured in ohms. To calculate it, transpose the current and voltage values used to determine the admittance.

$$\text{Output impedance} = \frac{\Delta V_c}{\Delta I_c} = \frac{25}{.8 \text{ mA}} = 31{,}250 \text{ ohms.}$$

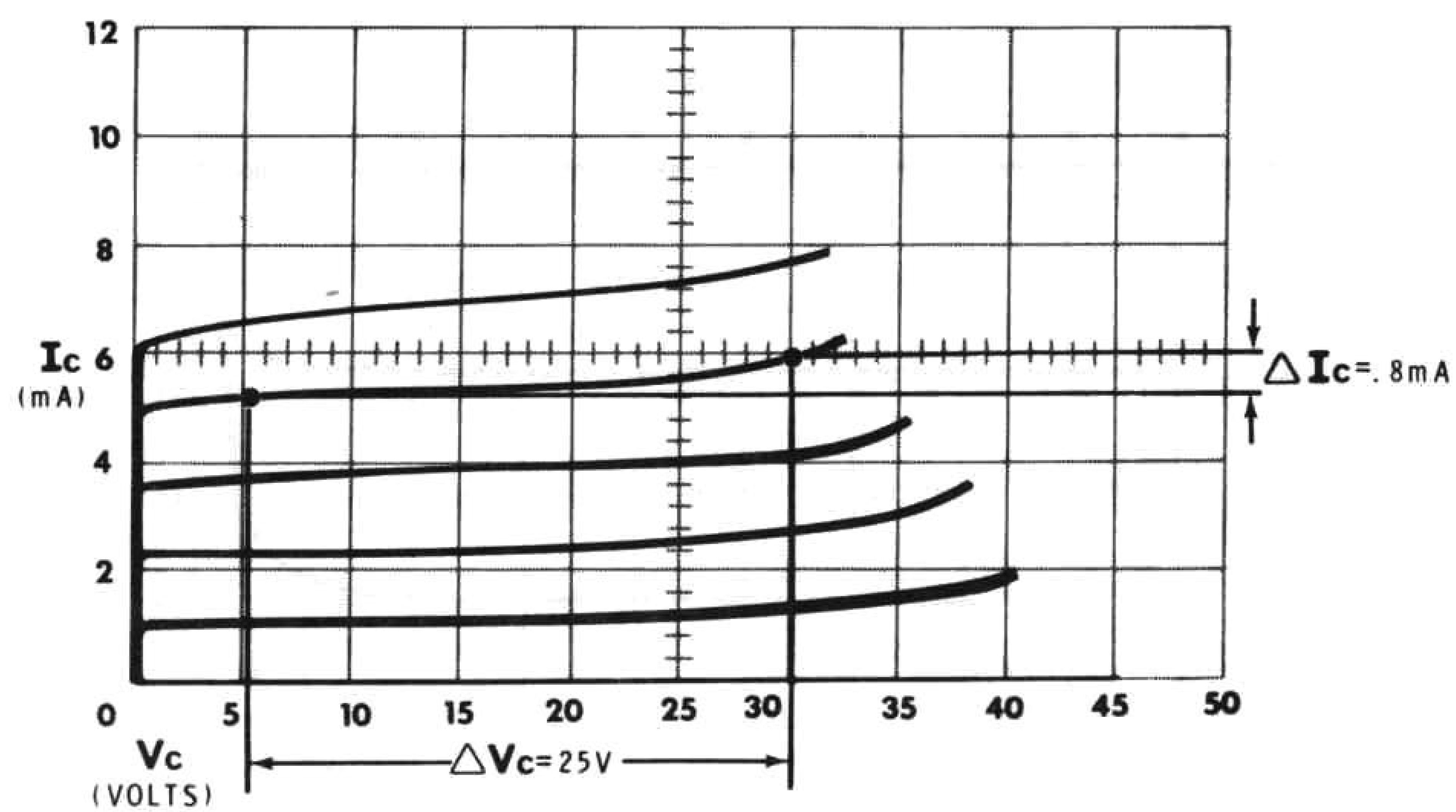


Figure 3-5

DC BETA (h_{FE})

MPSA20: 40-400, I_c = 5 mA, V_c = 10V

HORIZONTAL SENSITIVITY	1 Volt/Div.
VERTICAL SENSITIVITY	5 mA/Div.
POLARITY	NPN
STEPS/FAMILY	3 Steps
STEP RANGE	.05 mA/Step
LIMITING RESISTOR	100

Beta (β) is the ratio of collector current to base current and is equal to current gain. That is, for a given base current, a proportionally larger collector current is produced. DC beta is dependent upon what collector voltage and current points are picked. Even at specific values, DC beta can vary greatly in the same type device.

DC Beta is found by the formula:

$$\text{DC beta} = \frac{I_C}{I_B}$$

Therefore, the above example produces a beta of:

$$\beta = \frac{I_C}{I_B} \quad \beta = \frac{20\text{ mA}}{.1\text{ mA}} \quad \beta = 200$$

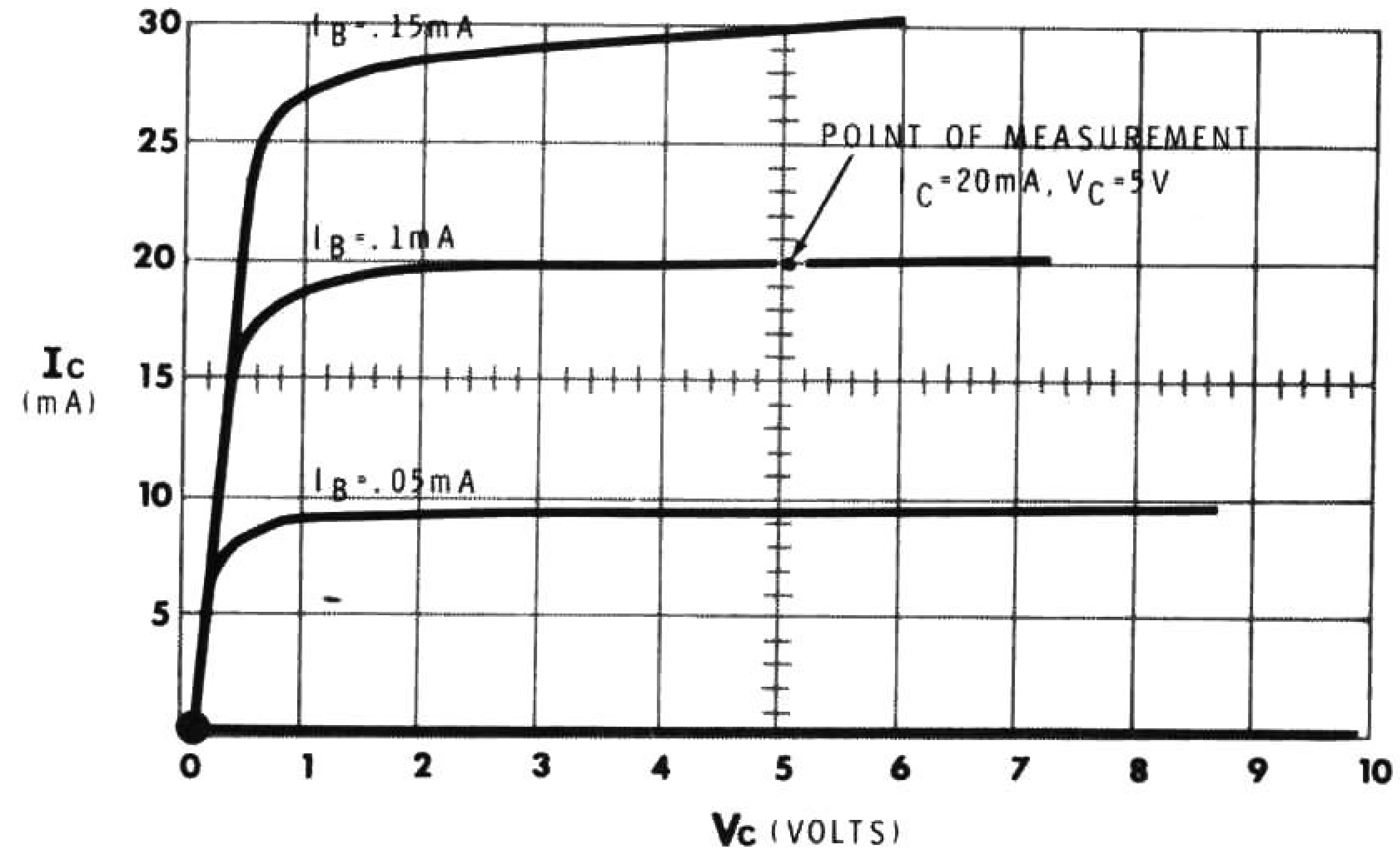


Figure 3-6

DC beta is indicated by capital FE in the term "h_{FE}," while AC beta is indicated by lower case fe in the term "h_{fe}."

AC BETA (h_{fe})

MPSA20:

HORIZONTAL SENSITIVITY	1 Volt/Div.
VERTICAL SENSITIVITY	5 mA/Div.
POLARITY	NPN
STEPS/FAMILY	3 Steps
STEP RANGE	.05 mA/Step
LIMITING RESISTOR	100

AC beta, or gain, is the ratio of change in collector current to the change in base current. This measurement is more useful because it is taken under actual operating conditions and performance can be more precisely predicted.

If the transistor data sheet is available, beta should be measured at the approximate collector current and voltage specified. If not, the STEP RANGE is usually adjusted for a display of the most evenly and widely spaced curves.

Gain is usually higher in the normal operating region of the transistor and is lower at collector currents above or below this region.

Calculate AC beta as follows:

1. Measure the difference in collector current (ΔI_c) between two curves at the same collector voltage.

2. Note the change in base current (ΔI_b) from the STEP RANGE switch. (.05 mA in this case.)

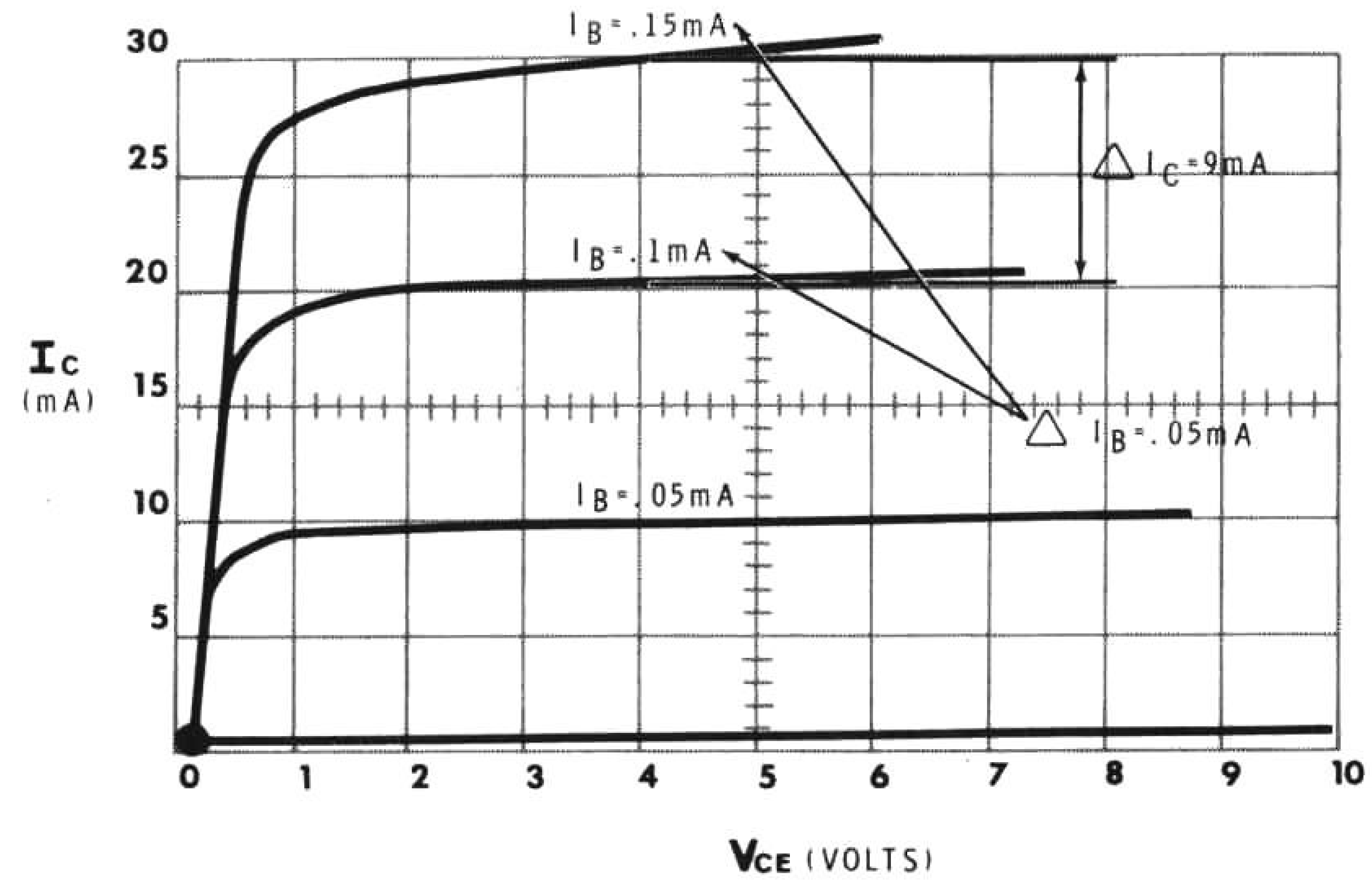


Figure 3-7

3. Then AC beta = $\frac{\Delta I_c}{\Delta I_b}$ at V_{CE} of 4 volts

$$\beta = \frac{9 \text{ mA}}{.05 \text{ mA}}$$

$$\beta = 180$$

LINEARITY AND GENERAL DISPLAY-LOW I_C

MPSA20:

HORIZONTAL SENSITIVITY	2 Volts/Div.
VERTICAL SENSITIVITY	2 mA/Div.
POLARITY	NPN
STEPS/FAMILY	9 Steps
STEP RANGE	.005 mA/Step
LIMITING RESISTOR	1 k

Linearity is a measure of the transistor's ability to amplify, in exact proportion, a signal that appears at its base.

The step generator in the Curve Tracer produces precise steps. Therefore, if the device being tested is perfect, the spacing between curves will be constant — similar to the curves in Figure 3-8. These curves can be used to check both gain and linearity. Linearity is usually better with a low collector current.

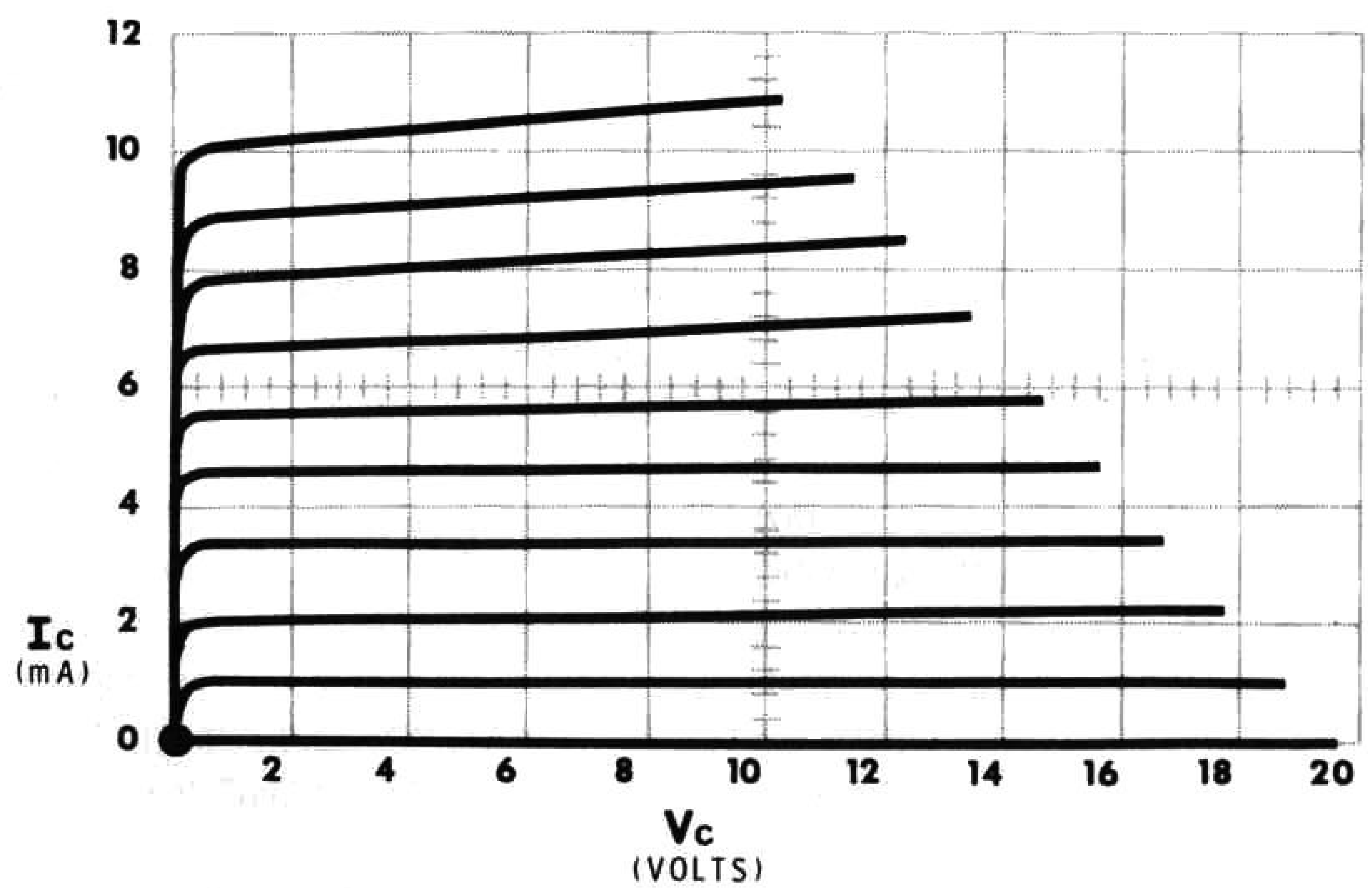


Figure 3-8

LINEARITY AND GENERAL DISPLAY—HIGH I_C

MPSA20: To maximum of 100 mA of I_c

HORIZONTAL SENSITIVITY	1 Volt/Div.
VERTICAL SENSITIVITY	20 mA/Div.
POLARITY	NPN
STEPS/FAMILY	5 Steps
STEP RANGE	.1 mA/Step
LIMITING RESISTOR	50

Nonlinearity increases with an increase in collector current. (Note the closer spacing of the upper curves.)

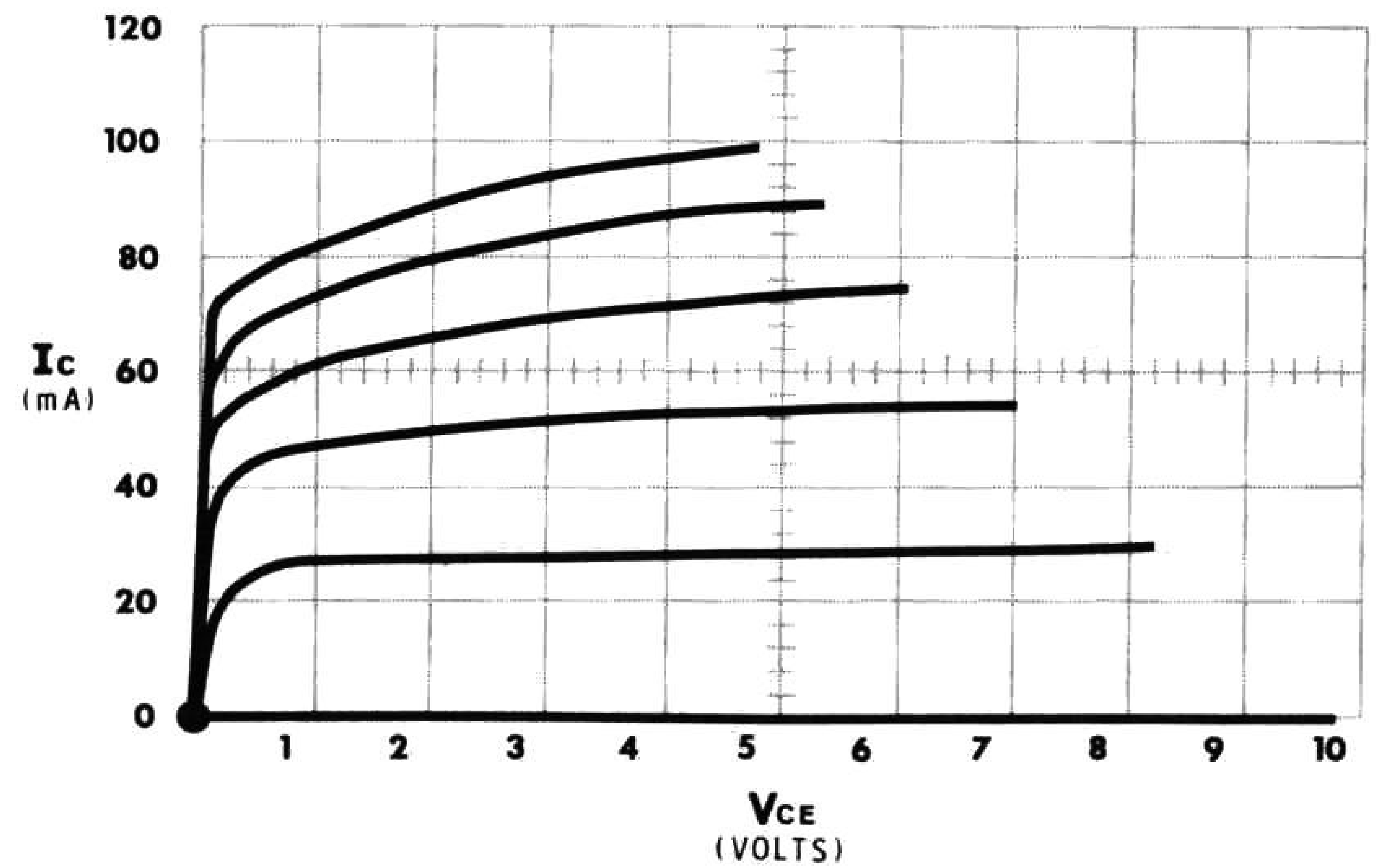


Figure 3-9

NONLINEARITY

MPSA20:

HORIZONTAL SENSITIVITY	1 Volt/Div.
VERTICAL SENSITIVITY	5 mA/Div.
POLARITY	NPN
STEPS/FAMILY	3 Steps
STEP RANGE	.05 mA/Step
LIMITING RESISTOR	100

Transistor gain is not necessarily constant, but is dependent on the point of measurement. If the transistor is operated in a nonlinear region, the gain is nonlinear and distortion is produced. This may be desirable or undesirable, depending on the application of the transistor.

To measure nonlinearity:

1. Plot an imaginary line along the ends of the curves. This is the "test load line."
2. Plot an "operating load line" in parallel with the test load line but intersecting the zero IC line at the desired operating V_{CE} for the transistor.
3. Measure and compare the changes in collector current (ΔI_c) between the curves on the operating load line. If the changes are the same, the transistor is linear at this point. If they are different,it is nonlinear at this point. In the above example there is some nonlinearity, and thus distortion at this point, because Δ 9 mA does not equal Δ 11 mA. As can be seen, an input signal of ±.05 mA will produce an output signal of +9 mA and −11 mA.

Nonlinearity should be measured along a load line rather than at a specific V_{CE} because it more nearly duplicates operating conditions. The transistor will operate with a load, not at a fixed V_{CE}. The load causes operation along the load line, since a change in collector current produces a change in collector voltage and vice versa.

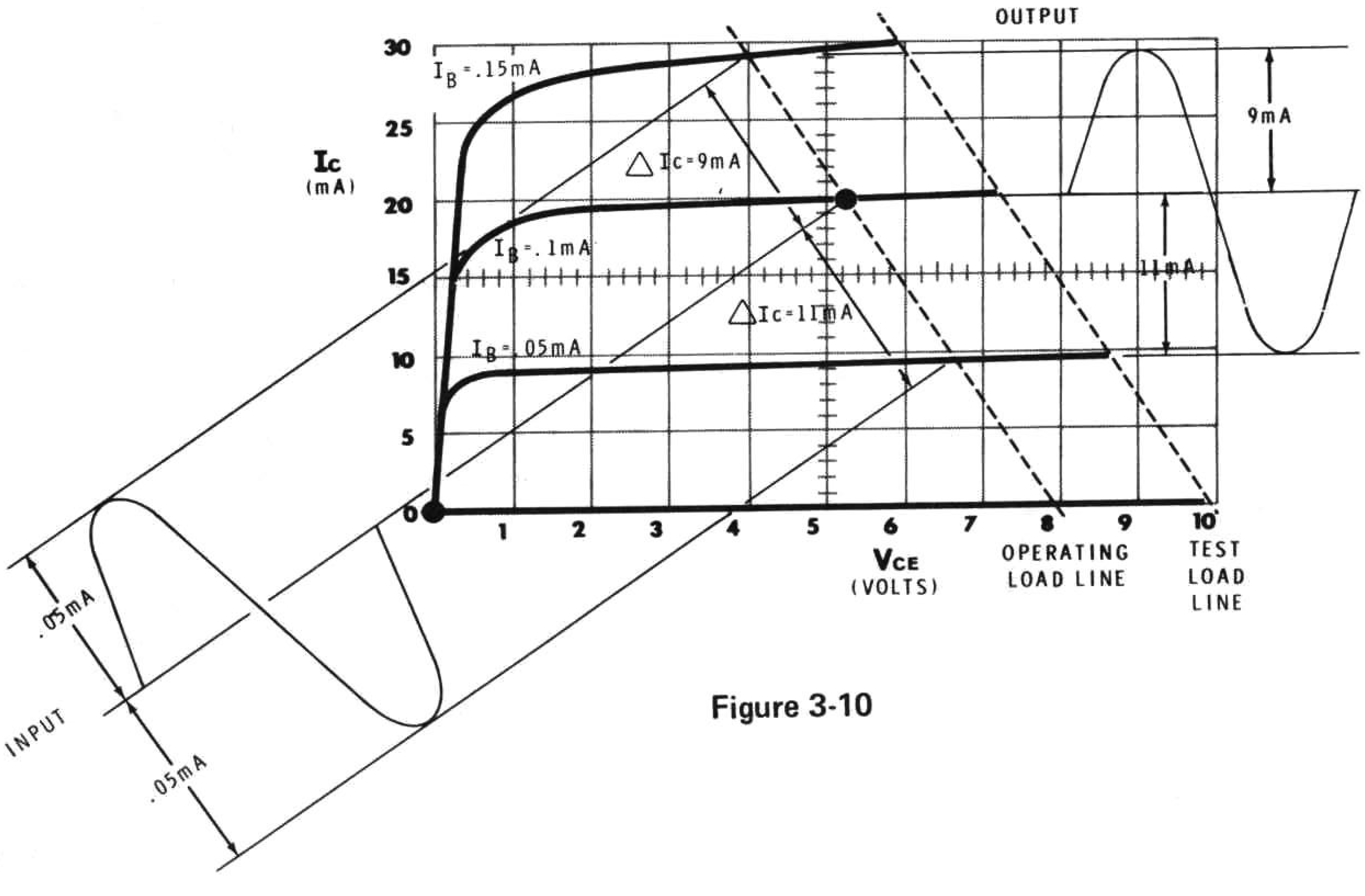


Figure 3-10

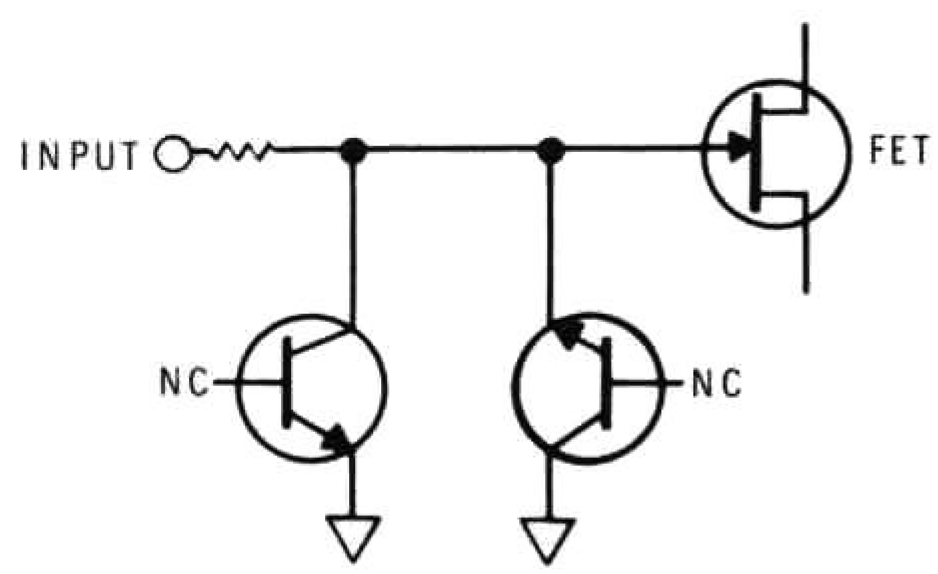
REVERSE C TO E BREAKDOWN

MPSA20:

HORIZONTAL SENSITIVITY	1 Volt/Div.
VERTICAL SENSITIVITY	2 mA/Div.
POLARITY	PNP
STEPS/FAMILY	Counterclockwise
STEP RANGE	.002 mA/Step
LIMITING RESISTOR	500

This breakdown occurs when the reverse collector-to-emitter voltage becomes great enough to suddenly cause excessive collector current to flow.

Figure 3-11 is a typical display. However, other proper displays may have different slopes after the breakdown point. The collector-to-emitter breakdown of bipolar transistors is sometimes used in an input circuit to protect an FET from large signals, as shown below.



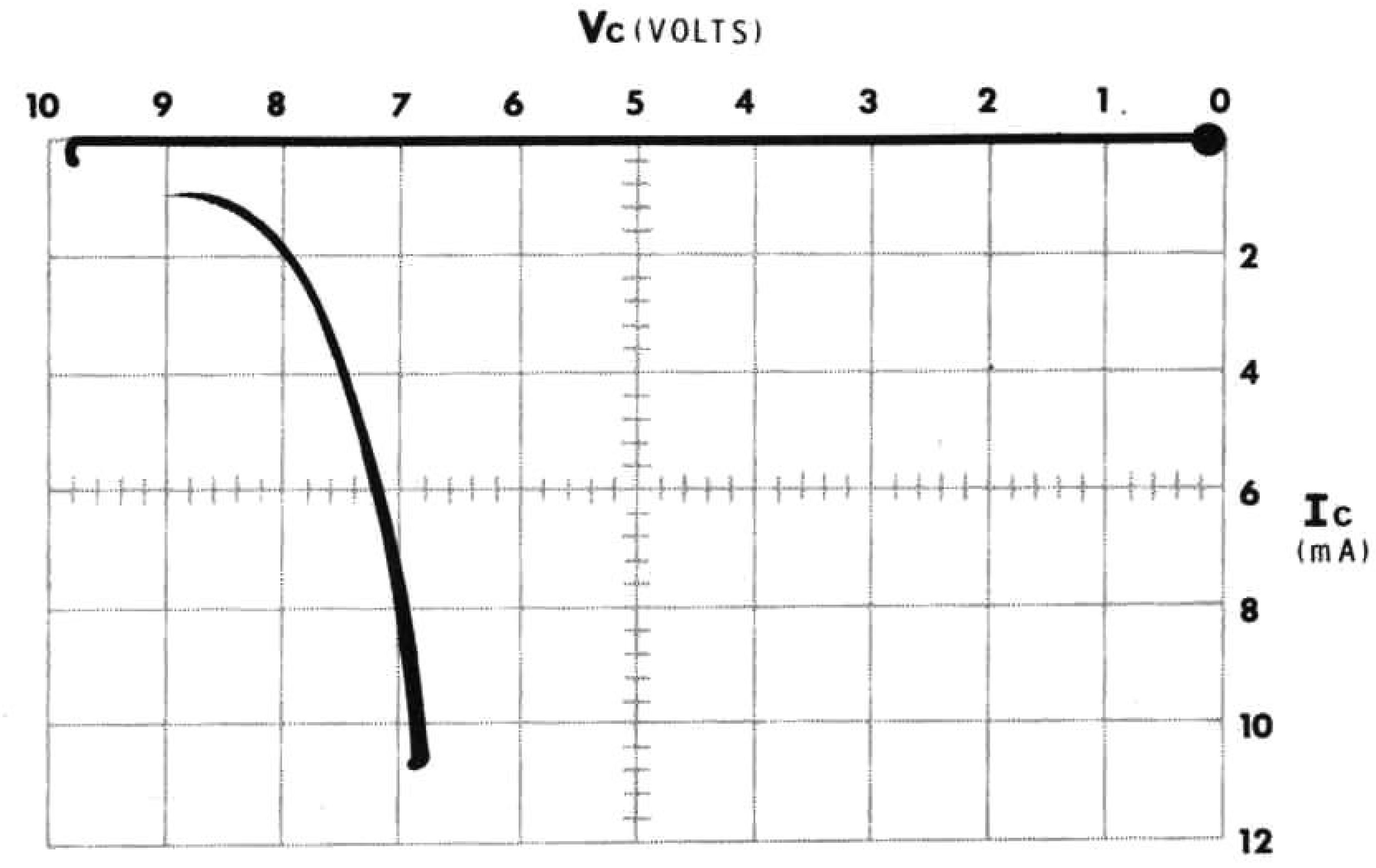


Figure 3-11

THERMAL HEATING

MPSA20:

HORIZONTAL SENSITIVITY	5 Volts/Div.
VERTICAL SENSITIVITY	50 mA/Div.
POLARITY	NPN
STEPS/FAMILY	4 Steps
STEP RANGE	2 mA/Step
LIMITING RESISTOR	50

Looping can be caused by collector capacitance and inductance, in certain cases by the Curve Tracer itself (see "Curve Tracer Characteristics"), and by thermal heating. If current causes heat that cannot be adequately dissipated, then looping is produced. In the forward sweep, heat is produced. This heat increases or decreases current flow (depending the temperature coefficient of the device). Therefore, on the return sweep, a different amount of current flows because of the time lag required for cooling to occur. This difference appears as looping.

CAUTION: Do not make a transistor produce excessive looping. This is not normal and may damage or destroy the device.

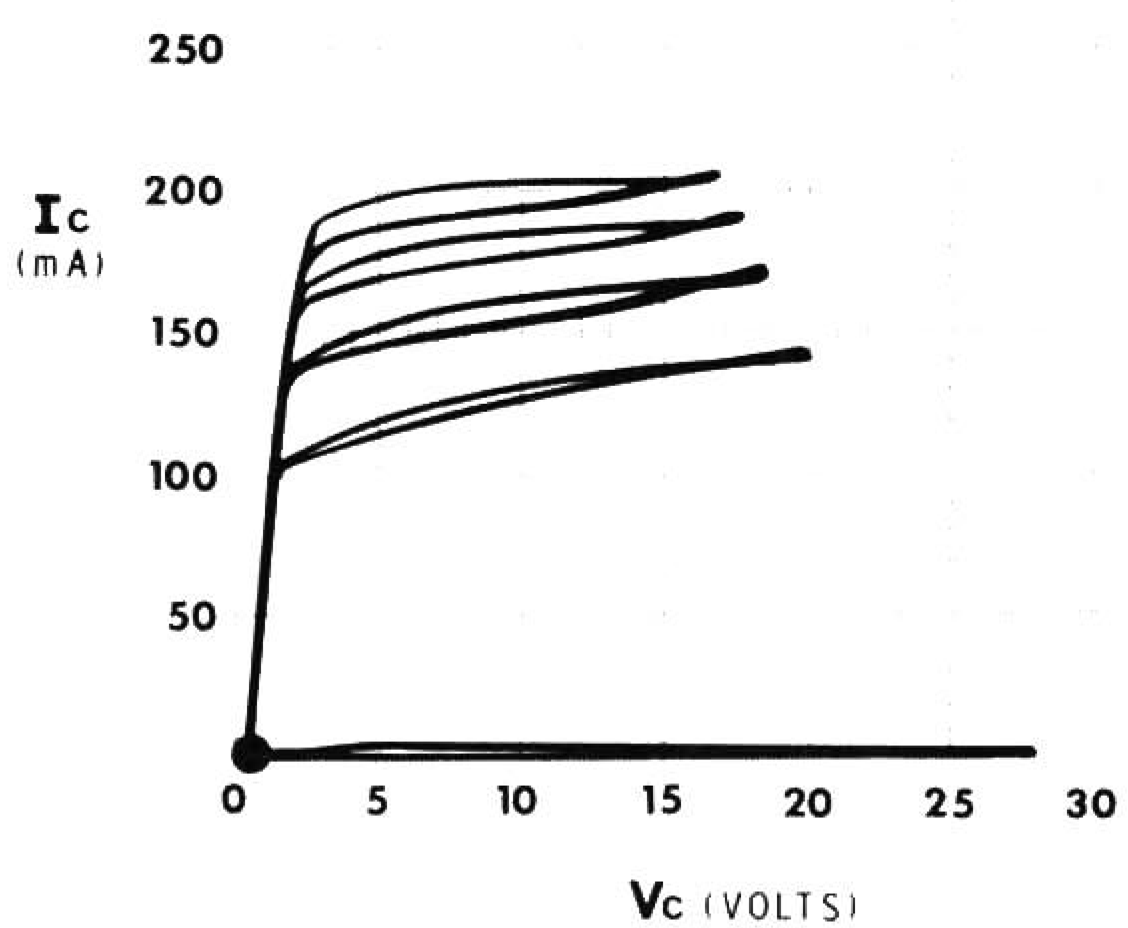


Figure 3-12

THERMAL RUNAWAY

MPSA20:

This test will damage or destroy the device.

HORIZONTAL SENSITIVITY	5 Volts/Div.
VERTICAL SENSITIVITY	50 mA/Div.
POLARITY	NPN
STEPS/FAMILY	4 Steps
STEP RANGE	.5 mA/Step
LIMITING RESISTOR	50

High current produces excessive heat and causes "thermal runaway." The curves will roll towards the top of the screen until the device is permanently damaged or destroyed.

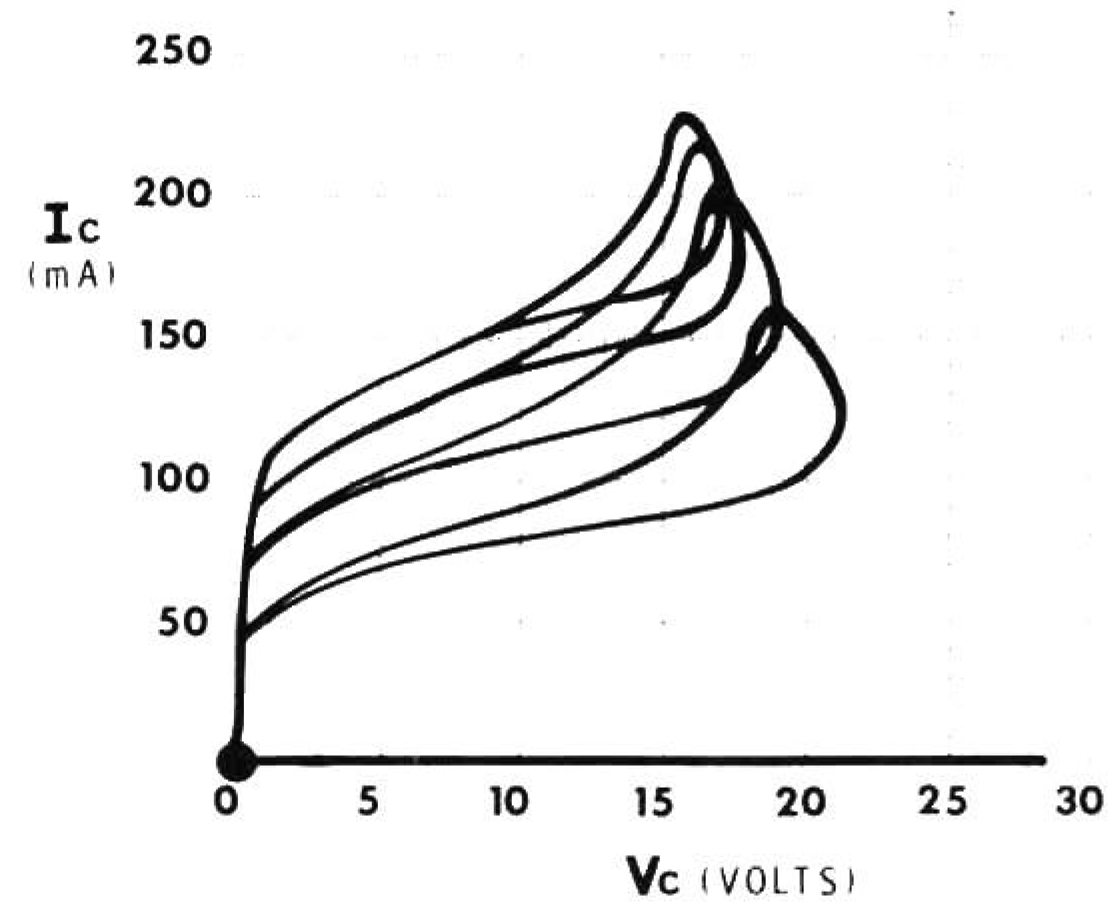
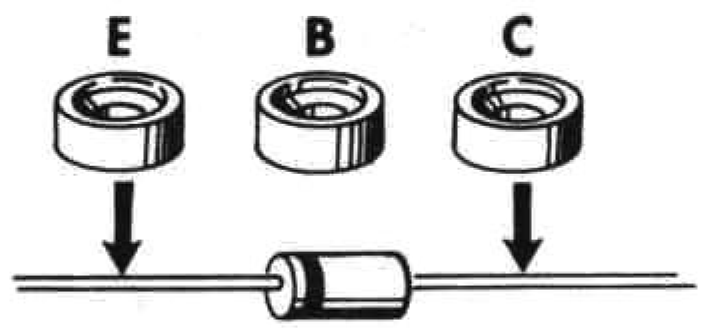
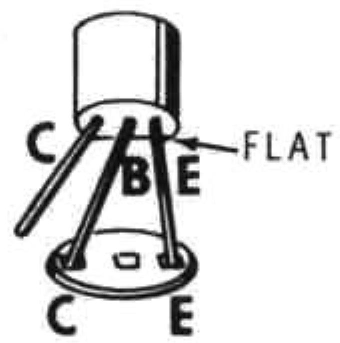


Figure 3-13

DIODE FORWARD CONDUCTION





MPSA20: Base to Emitter. Install the E and B leads of the transistor in the E and C socket holes as shown.

HORIZONTAL SENSITIVITY	.1 Volt/Div.
VERTICAL SENSITIVITY	.5 mA/Div.
POLARITY	NPN
STEPS/FAMILY	Counterclockwise (has no effect)
STEP RANGE	.002 mA/Steps
LIMITING RESISTOR	1 k

Diodes conduct easily in one direction and do not conduct in the reverse direction. To test a diode, apply the sweep voltage across the device. The step voltage and current are not used, and the STEPS/FAMILY control is not used.

For diodes, only one curve is displayed. From this you can measure forward voltage drop and diode resistance. No current flows until the sweep voltage exceeds the junction barrier. This voltage drop is about 0.3 volt for germanium diodes and 0.6 volt for silicon diodes. Then, above this point, current increases rapidly as the voltage is increased.

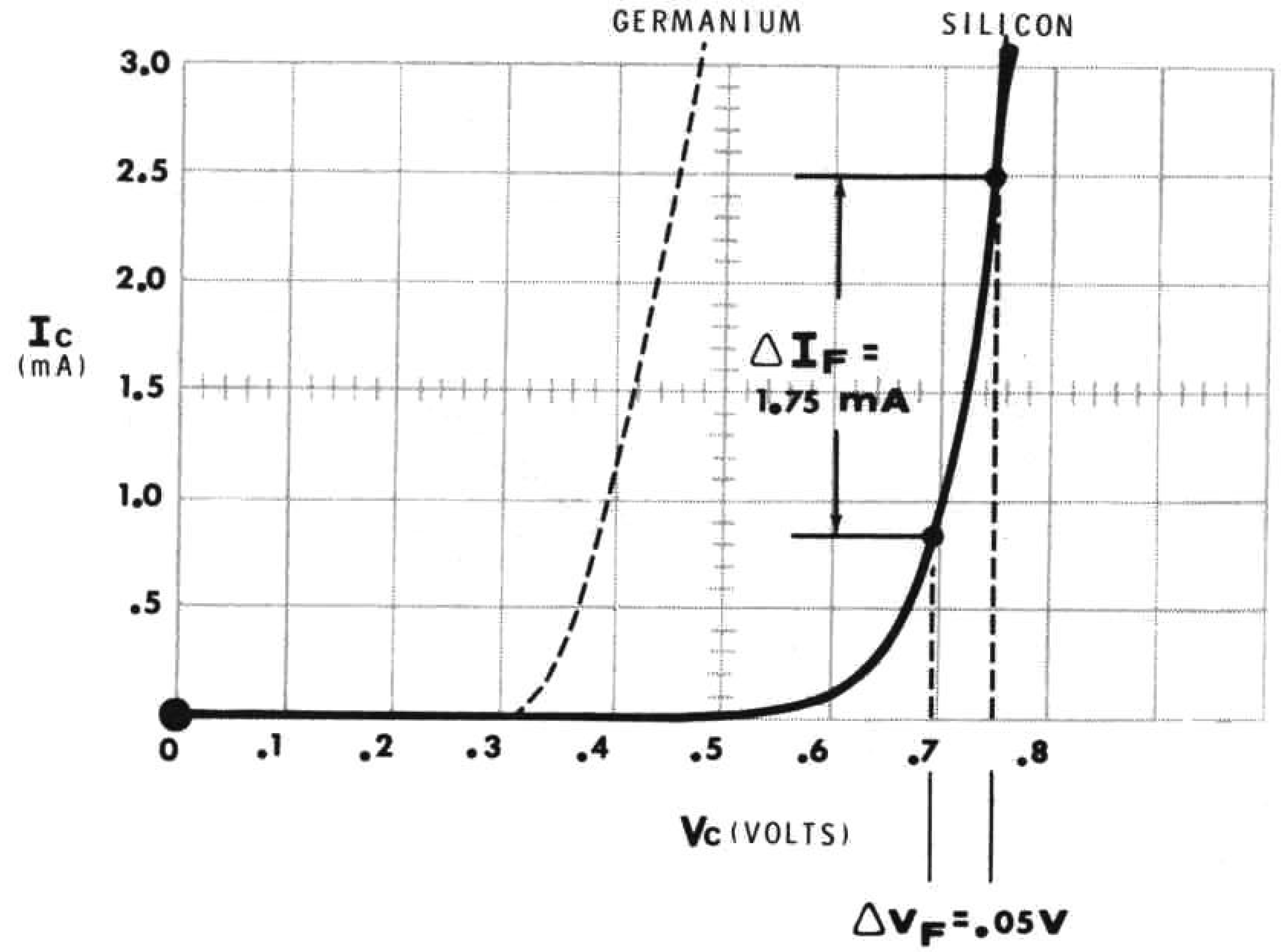


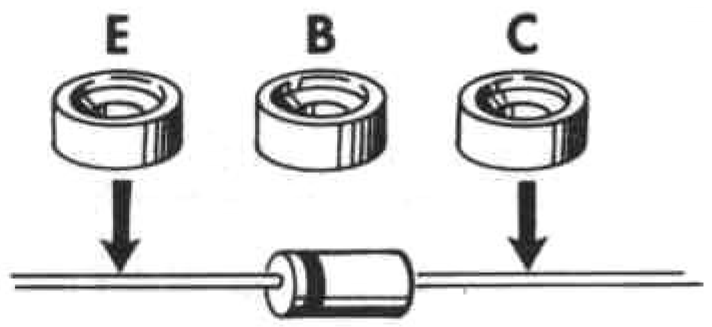
Figure 3-14

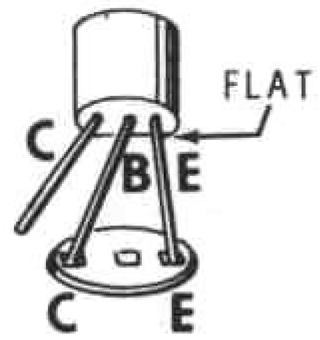
The dynamic resistance of a diode equals the change in forward voltage (V_F) divided by the change in forward current (I_F).

$$R_D = \frac{\Delta V_F}{\Delta I_F} = \frac{.05V}{1.75\ mA} = 28.57\ \Omega$$

When you test a conventional diode, connect it as shown.

DIODE REVERSE BREAKDOWN





MPSA20: Base to Emitter. Install the E and B leads of the transistor in the E and C socket holes as shown.

HORIZONTAL SENSITIVITY	1 volt/Div.
VERTICAL SENSITIVITY	.5 mA/Div.
POLARITY	PNP
STEPS/FAMILY	Counterclockwise (has no effect)
STEP RANGE	.002 mA/Step
LIMITING RESISTOR	1 k

Diode reverse breakdown is the voltage point where the diode begins to conduct current independent of voltage.

Position the dot in the upper right-hand corner.

When you test a conventional diode, connect it as shown. Be sure to use a sufficiently high limiting resistor so the diode is not damaged by excessive current. Germanium diodes may show leakage. (See upper left-hand corner of the Figure.)

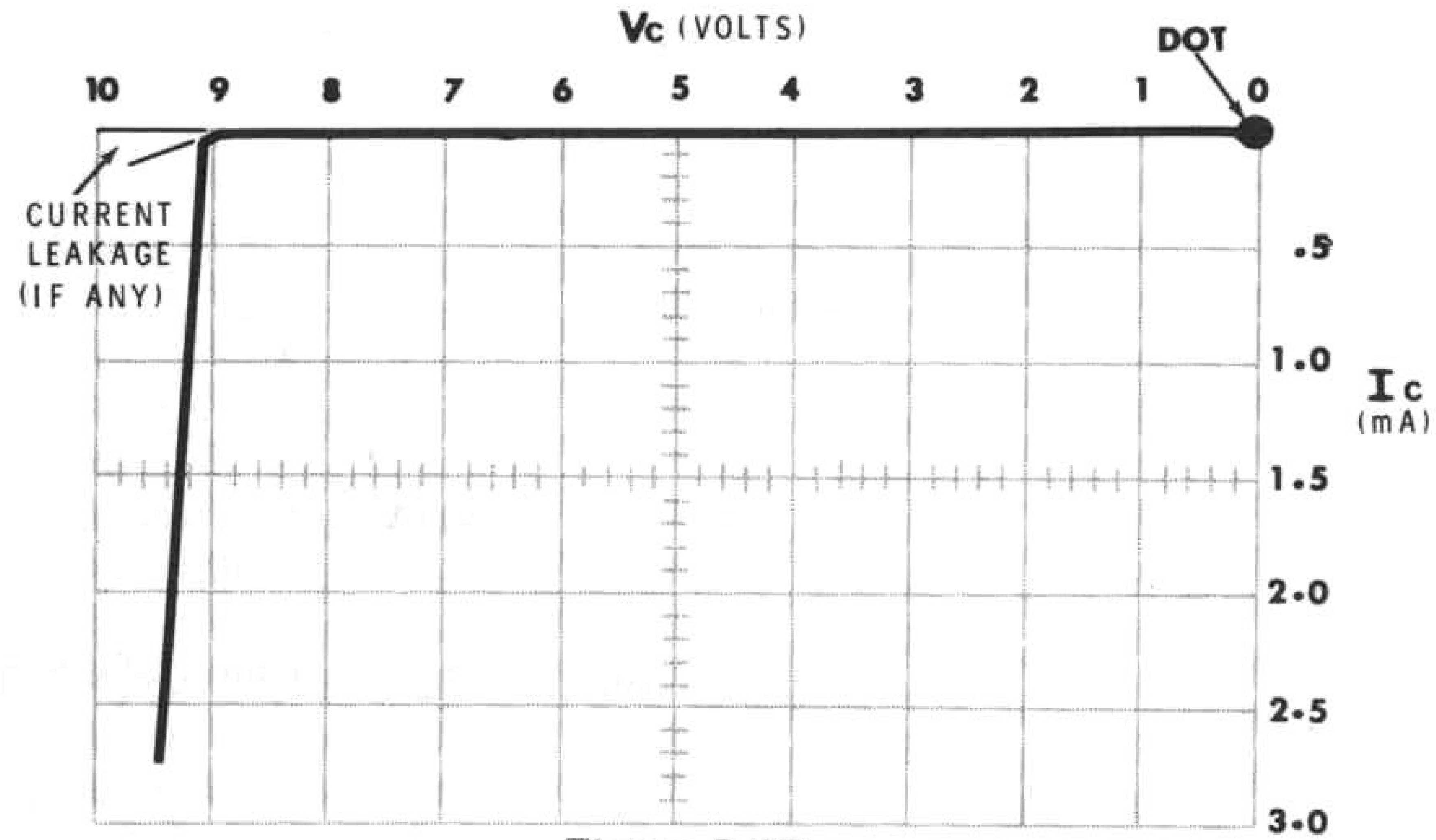


Figure 3-15

ZENER DIODES

HORIZONTAL SENSITIVITY	5 volts/Div.
VERTICAL SENSITIVITY	.5 mA/Div.
POLARITY	PNP
STEPS/FAMILY	Counterclockwise (has no effect)
STEP RANGE	.002 mA/Step
LIMITING RESISTOR	10 k

Zener diodes are like conventional diodes except that they are designed to operate in the reverse breakdown mode. The knee is the point where this breakdown begins. The sharper the knee, the better the zener is. Some zeners may have some leakage current before breakdown. This leakage can be measured as shown.

The dynamic impedance (the ratio of a change of voltage to a change of current in the breakdown region) can be determined by picking two points and calculating this ratio. The better zeners have a lower dynamic impedance.

$$Z \text{ (dynamic impedance)} = \frac{\Delta V_C}{\Delta I_C} = \frac{2.5\text{V}}{1.5\text{ mA}} = 1667\ \Omega.$$

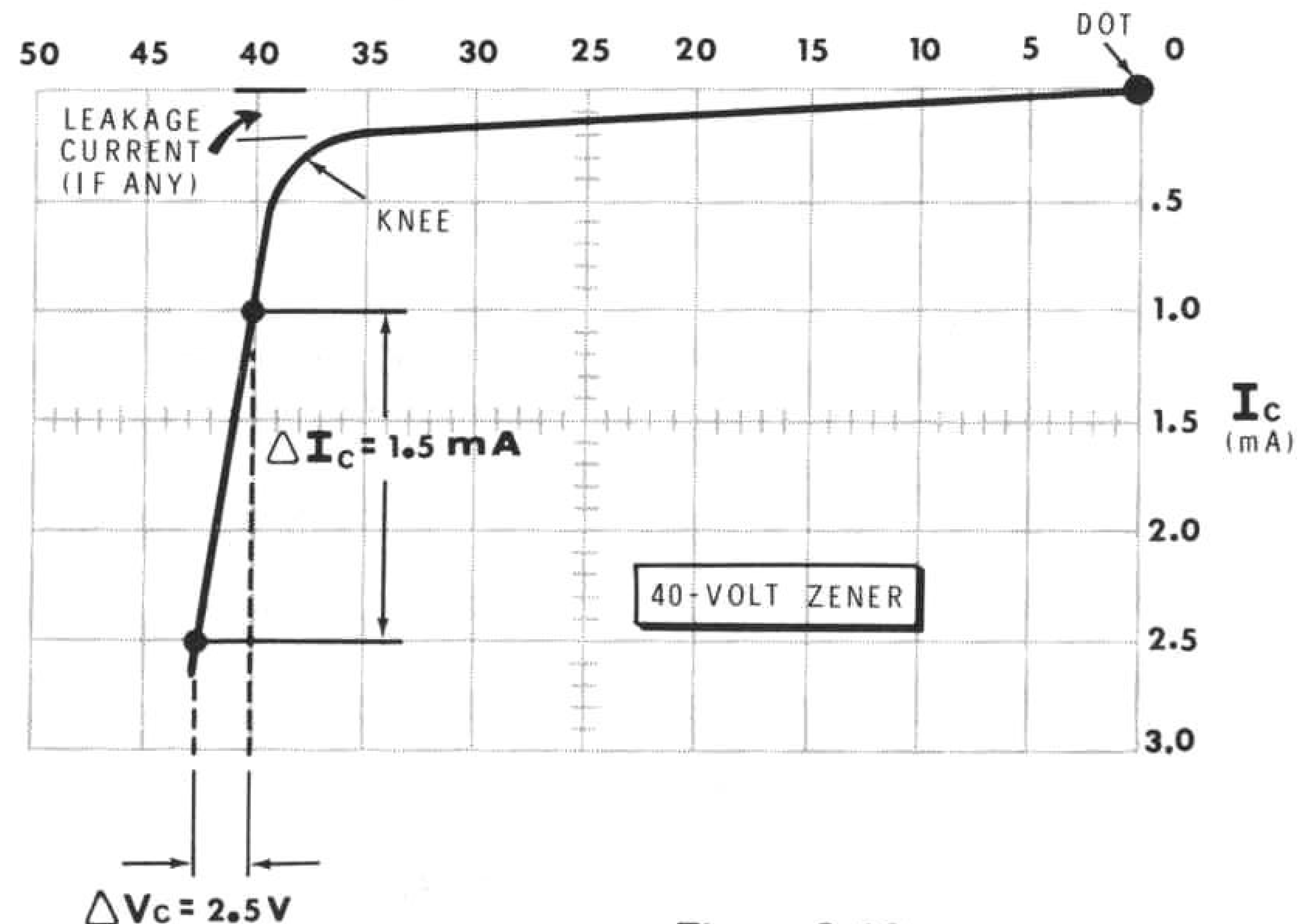


Figure 3-16

CURVE TRACER LIMITS

High-Voltage Transistor, To 200 Volt Limit

HORIZONTAL SENSITIVITY	20 Volts/Div.
VERTICAL SENSITIVITY	2 mA/Div.
POLARITY	NPN
SWEEP RANGE	0-200 V
STEPS/FAMILY	4 Steps
STEP RANGE	.02 mA/Step
LIMITING RESISTOR	10 k

NOTES:

1. Do not exceed the specifications of the device.
2. Be sure to set the SWEEP RANGE switch back to 0-40 V after you finish any high voltage tests.
3. Use as high a limiting resistance as practical.

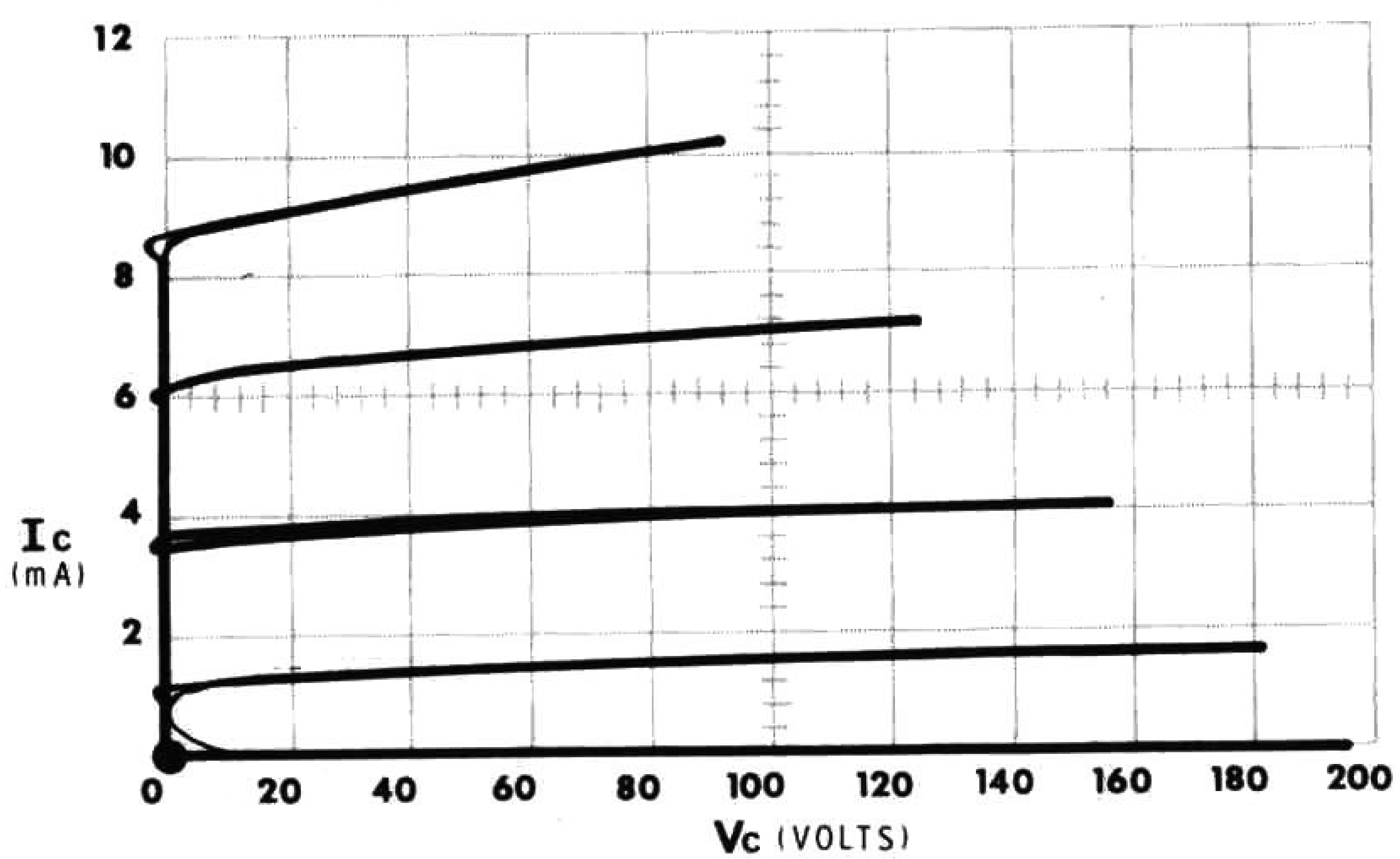


Figure 3-17

Power Transistor, To 1-Ampere Limit

HORIZONTAL SENSITIVITY	50 Volts/Div.
VERTICAL SENSITIVITY	200 mA/Div.
POLARITY	NPN
STEPS/FAMILY	8 Steps
STEP RANGE	2 mA/Step
LIMITING RESISTOR	10

The Curve Tracer limits the current above 1000 mA. This may produce distortion (crowding of the curves) at the top of the waveform.

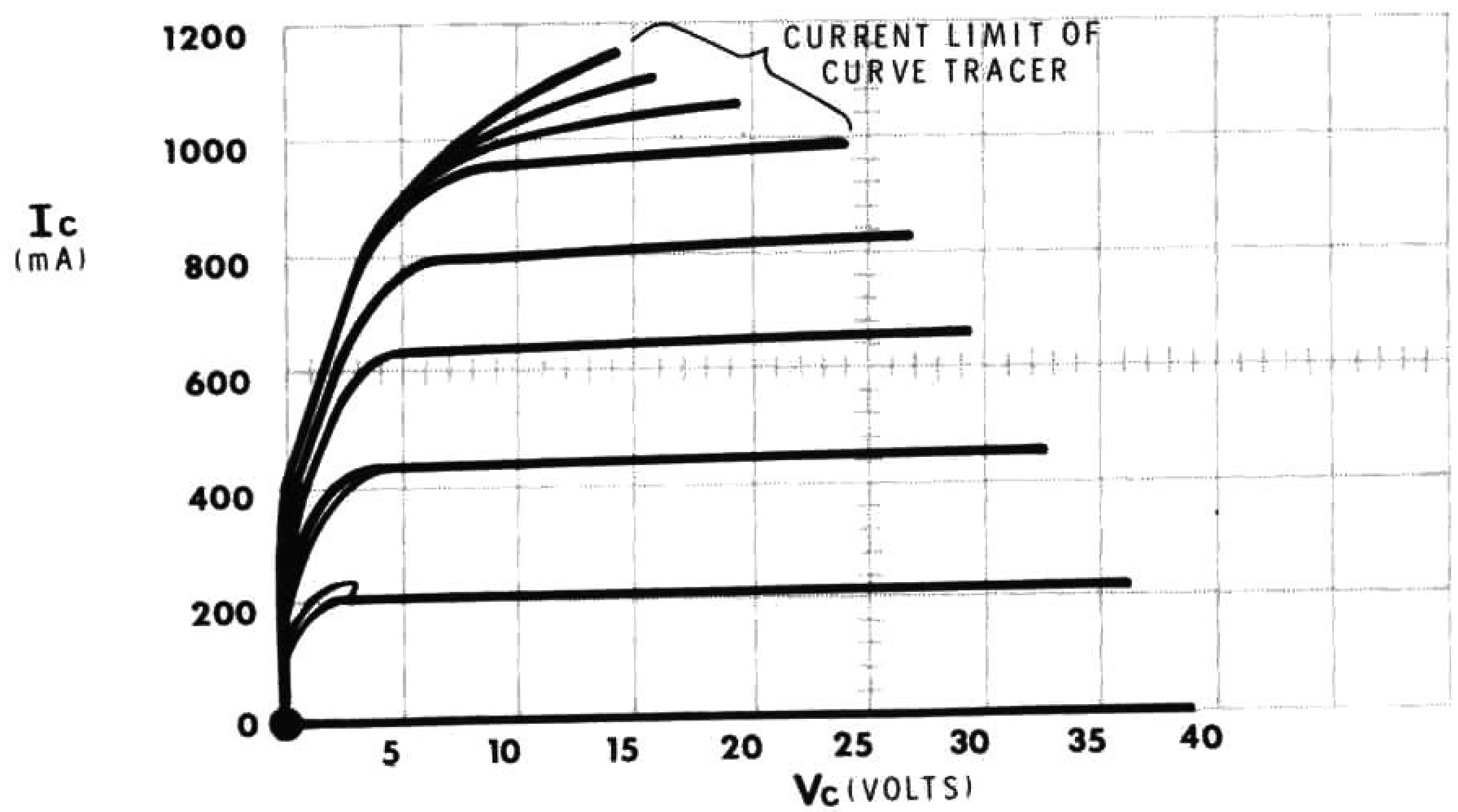


Figure 3-18

GENERAL FET DISPLAY

HORIZONTAL SENSITIVITY	1 Volt/Div.
VERTICAL SENSITIVITY	1 mA/Div.
POLARITY	N Chan.
STEPS/FAMILY	Fully Clockwise
STEP RANGE	.1 Volt/Step
LIMITING RESISTOR	1 k

Testing FET's (including MOS FET's) is similar to testing bipolar transistors (NPN's and PNP's). However, instead of a graph of collector current versus collector voltage at various base currents, FET curves are a graph of drain current versus drain voltage at various gate voltages.

To test an FET, the STEP RANGE switch is placed in a "VOLTS/STEP" position so the Curve Tracer will supply constant voltage steps rather than constant current steps. Also, the polarity of the step voltage is reversed in relation to the sweep voltage. The zero base current step of a bipolar transistor usually produces no collector current. However, in an FET, the zero gate voltage produces the highest drain current. Then each reverse bias voltage step results in less drain current. Therefore, what is the base line in regular transistors is the top line in Figure 3-19.

Some MOS FET's can be damaged by static electricity carried by the person handling the device. Therefore, discharge any static charge by touching ground with one hand before and while handling the MOS FET with the other hand.

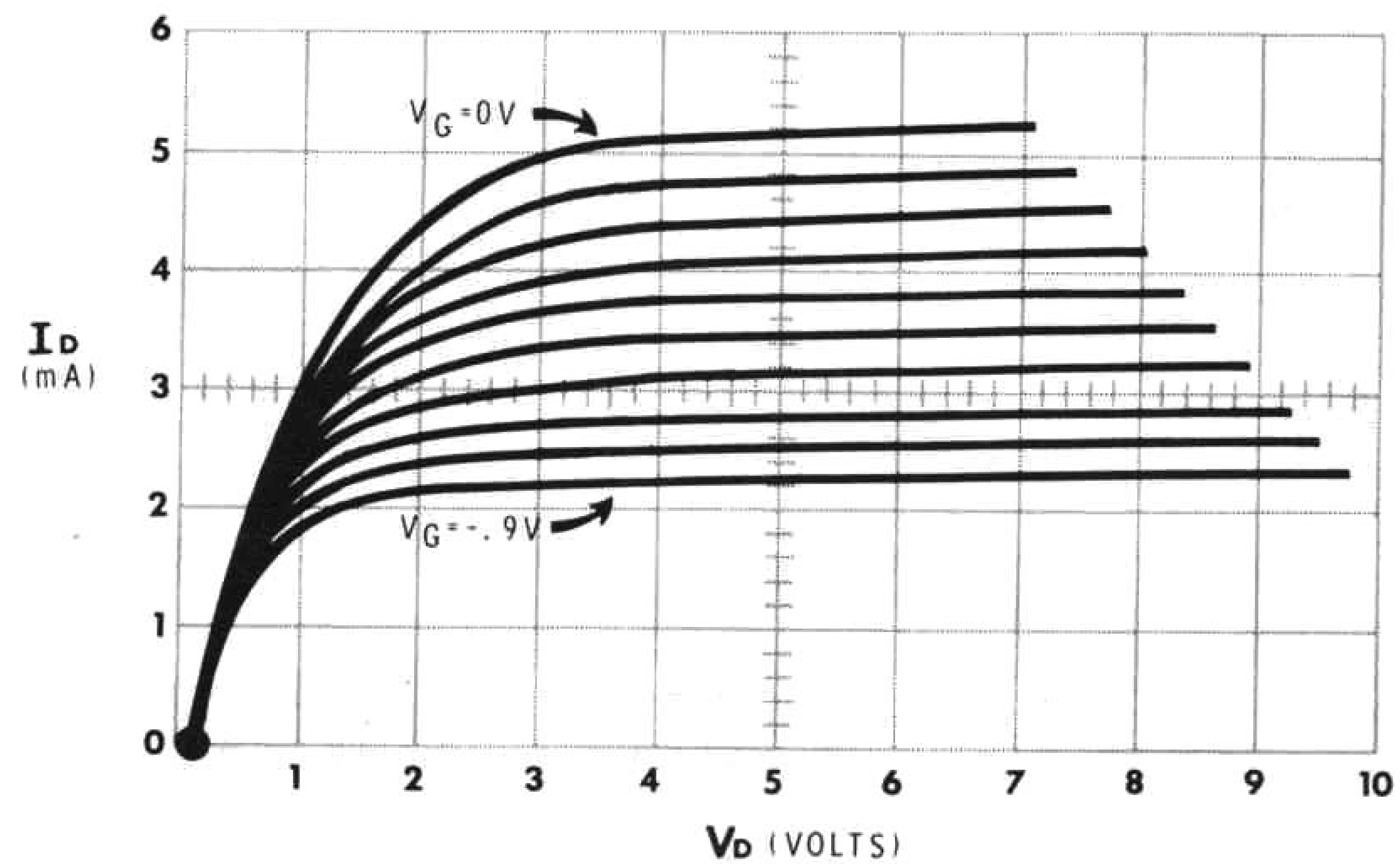


Figure 3-19

To test the few enhancement mode FET's, disconnect the gate lead from the Curve Tracer and connect a DC bias supply to provide forward bias voltage. Be sure the common of the supply is connected to the circuit ground of the Curve Tracer. (Connect a test lead between the supply and S jack of the Curve Tracer.)

When you test dual-gate MOS FET's, either ground or bias the gate not being tested-do not leave it open circuited.

FET PINCHOFF AND TRANSCONDUCTANCE

HORIZONTAL SENSITIVITY	1 Volt/Div.
VERTICAL SENSITIVITY	1 mA/Div.
POLARITY	N Chan.
STEPS/FAMILY	5 Steps
STEP RANGE	.5 Volt/Step
LIMITING RESISTOR	1 k

If the reverse bias voltage steps are of a high enough value, drain current stops and "pinchoff" is attained. The approximate value of pinchoff is found by noting which step produces no drain current (I_D). In the example, the 5th step (all higher steps will fall in the same place as the 5th step) produces no drain current. Thus pinchoff occurs between -2.0 volts (4th step) and -2.5 volts (5th step).

The gain of an FET is the gate-to-drain forward transconductance (gm). This is the ratio of change in drain current to the change in gate voltage at a given drain voltage. Transconductance is measured in μmhos.

To calculate gm:

1. Note the difference in drain current between two curves (ΔI_D) at the same drain voltage (V_D).
2. Note the change in gate voltage (ΔV_G) from the STEP RANGE switch.
3. Then gm - $\dfrac{\Delta I_D}{\Delta V_G}$

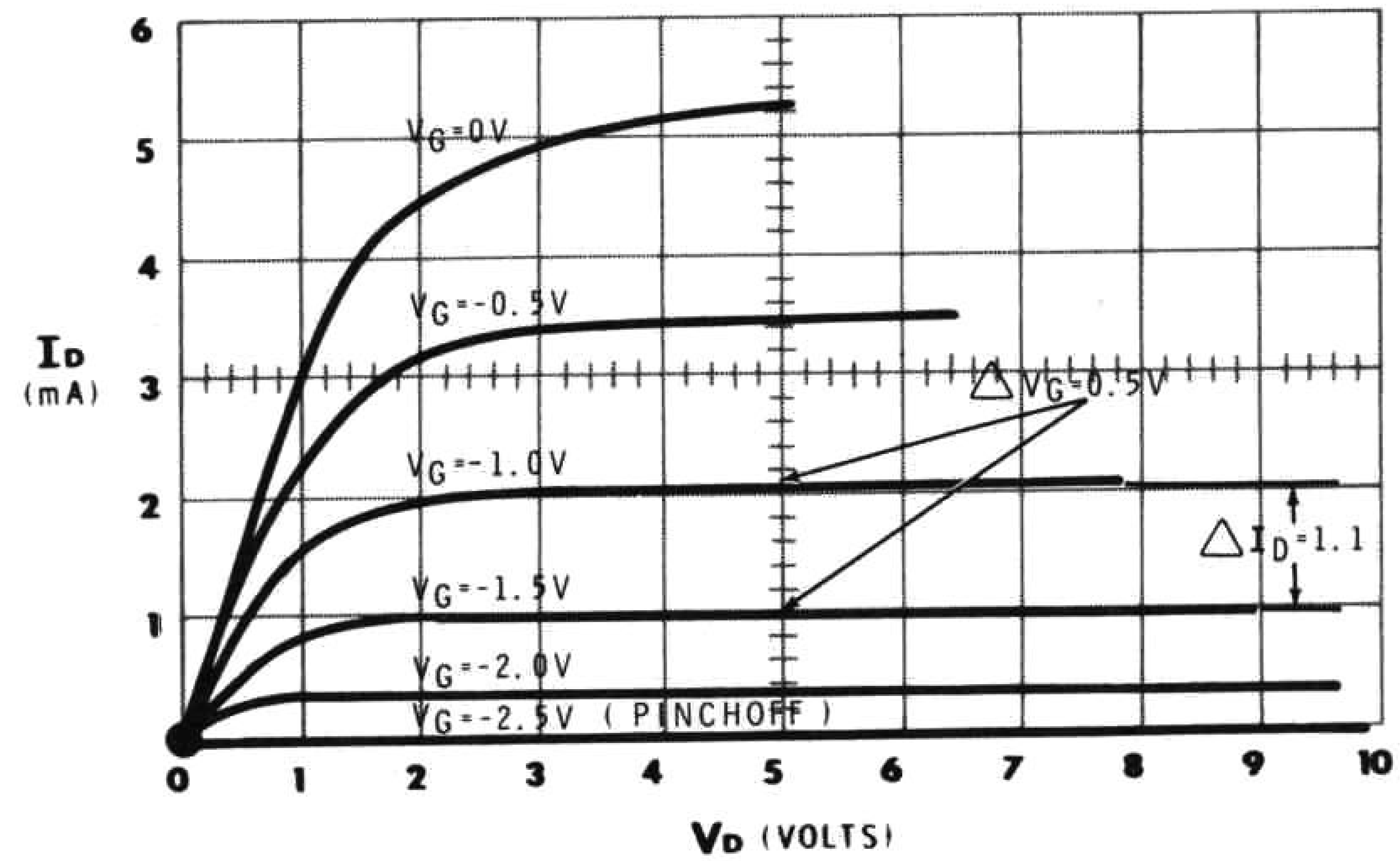


Figure 3-20

$$gm = \frac{1.1 \text{ mA}}{.5 \text{ V}} = \frac{1100\ \mu A}{.5} = 2200\ \mu\text{mhos at } V_D \text{ of 5 volts.}$$

NOTE: Like beta, gm depends on the point of measurement. As you can see by the nonlinearity of the curves in Figure 3-20, gm is not a constant.

FET BREAKDOWN (Figure 3-21)

HORIZONTAL SENSITIVITY	10 Volts/Div.
VERTICAL SENSITIVITY	1 mA/Div.
POLARITY	N Chan.
SWEEP RANGE	0-200 V
STEPS/FAMILY	4 Steps
STEP RANGE	.2 Volt/Step
LIMITING RESISTOR	10 k

As the sweep voltage is increased, a point is reached where the FET breaks down. At this point drain current becomes independent of gate voltage and rises sharply until limited by the Curve Tracer. If it were not for this limiting, the FET would be destroyed. Keep the test short so the transistor is not damaged by too much heat.

NOTE: FET's are more easily damaged by high voltage than are bipolar transistors.

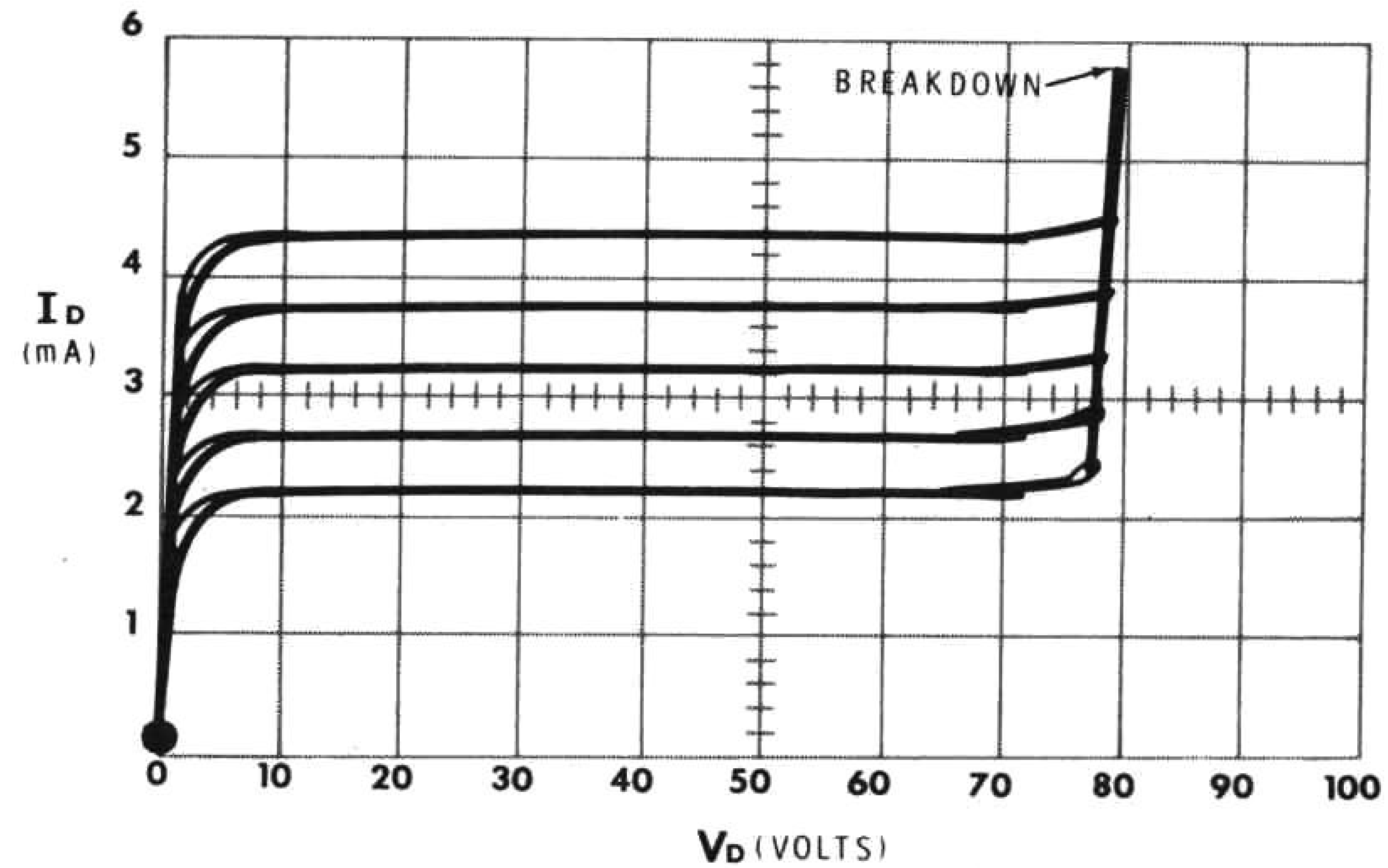


Figure 3-21

TUNNEL DIODE (Figure 3-22)

HORIZONTAL SENSITIVITY	.1 Volt/Div.
VERTICAL SENSITIVITY	2 mA/Div.
POLARITY	NPN
STEPS/FAMILY	Fully counterclockwise
STEP RANGE	------
LIMITING RESISTOR	1 k

Tunnel diodes are p-n junction devices with a negative resistance or "tunnel" region. The "tunnel" makes it possible to use the diode as an amplifier, oscillator, or pulse generator. The diode conducts very easily in one direction (at a much lower voltage than conventional signal diodes), but the tunnel is in the direction of the higher resistance. These diodes are normally operated at very low voltage and current levels.

NOTE: Carefully select the limiting resistor so the diode does not oscillate.

Connect the diode to a transistor socket: Cathode to the emitter connector, and anode to the collector connector. A trace will not normally be displayed in the negative resistance region.

The following characteristics can be measured directly from the display.

I_p – peak current, start of tunnel region

I_v – valley current, end of tunnel region

V_p – peak voltage, start of tunnel region

V_v – valley voltage, end of tunnel region

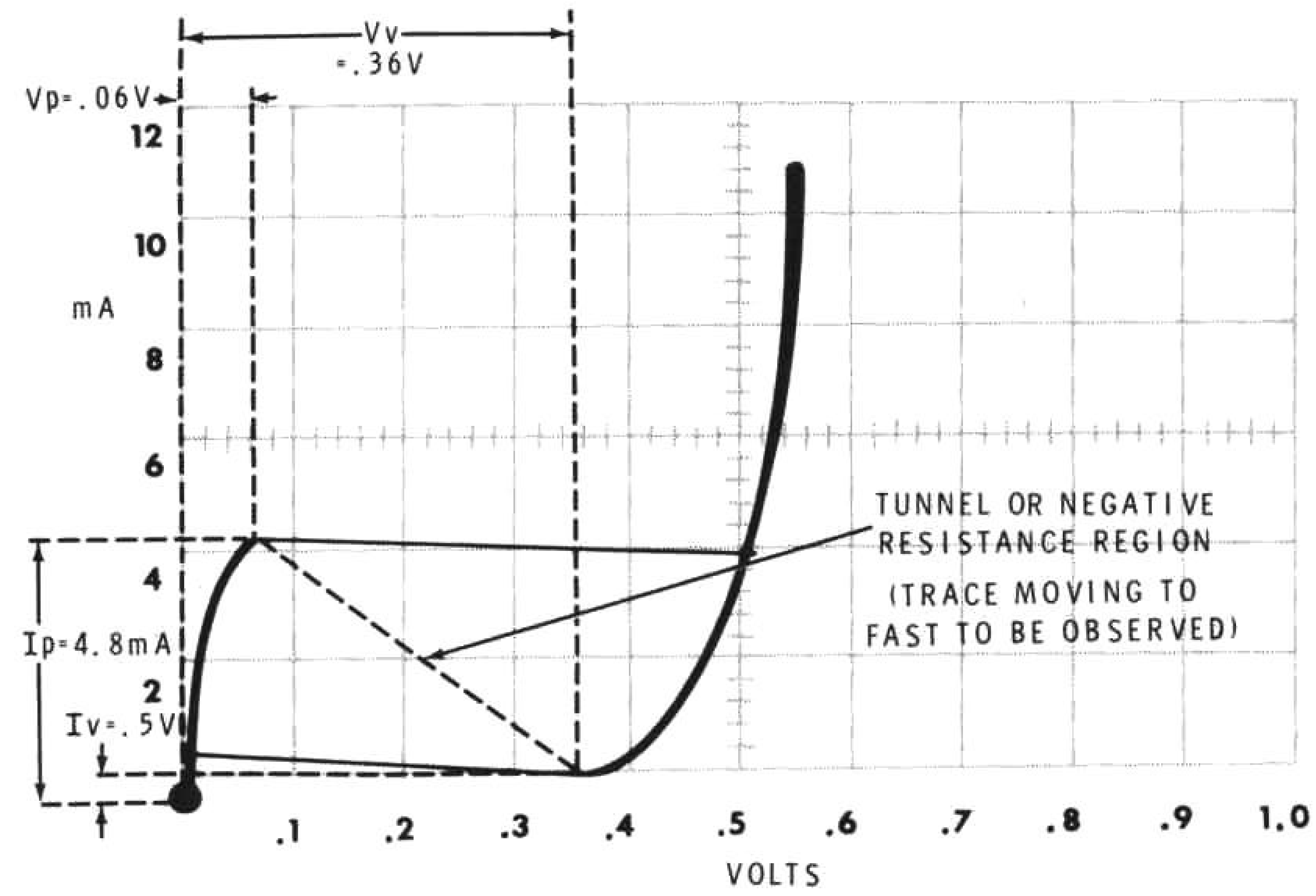


Figure 3-22

The average negative resistance can be calculated from these values.

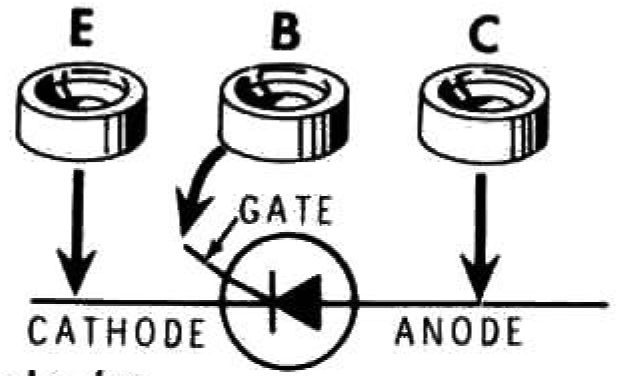
$$\text{Average negative resistance} = \frac{V_V - V_P}{I_P - I_V} = \frac{.36\text{ V} - .06\text{ V}}{4.8\text{ mA} - .5\text{ mA}} = \frac{.3\text{ V}}{4.3\text{ mA}} = 69.8\ \Omega.$$

SCR

An SCR (silicon controlled Rectifier or Thyristor) is a four layer p-n-p-n device with three terminals; cathode, anode, and gate. In the "on" state, the SCR behaves much like a diode. However, unlike a diode, the SCR also has an "off" state and does not conduct in either direction.

If the forward blocking voltage is exceeded, the SCR will turn on. The SCR will then stay on until the anode to cathode current drops below a certain value (called the holding current).

Forward Blocking Voltage And Holding Current



HORIZONTAL SENSITIVITY	20 Volts/Div.
VERTICAL SENSITIVITY	5 mA/Div.
POLARITY	NPN
STEPS/FAMILY	Fully counterclockwise
STEP RANGE	.002 mA/Step
LIMITING RESISTOR	10 k

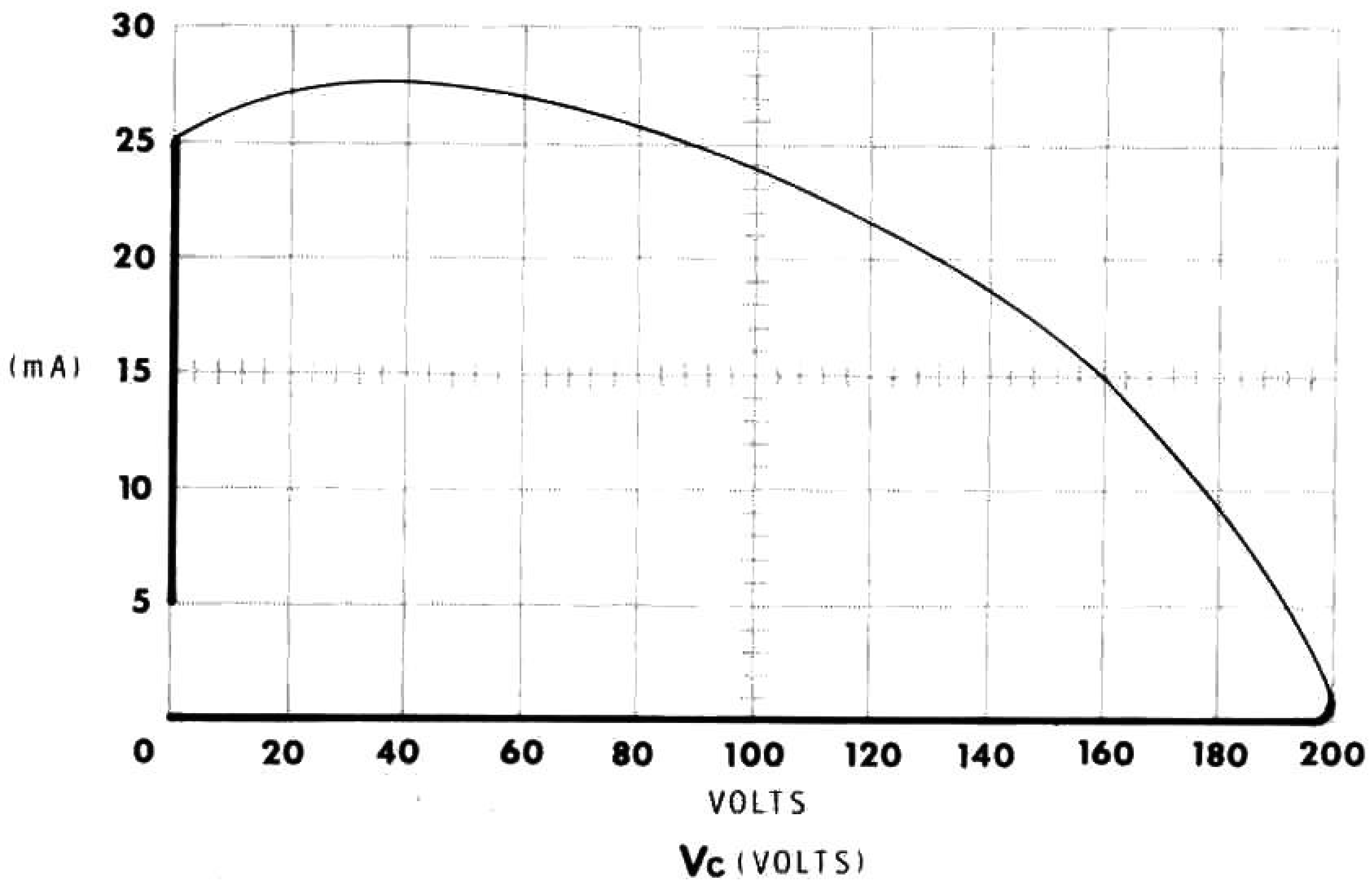


Figure 3-23

For the example in Figure 23, the forward blocking voltage is 200 volts and the holding current is 5 mA.

Reverse Blocking Voltage And Leakage Current

The procedure is the same as for testing a reverse biased diode. Be sure you are in the PNP mode and the STEPS/FAMILY control is fully counterclockwise.

Gate Trigger Current

The gate current needed to turn on the SCR depends on the anode-to-cathode voltage. The following example shows how to determine this current.

HORIZONTAL SENSITIVITY	5 Volts/Div.
VERTICAL SENSITIVITY	200 mA/Div.
POLARITY	NPN
STEPS/FAMILY	1 Step
STEP RANGE	.002 mA/Step
LIMITING RESISTOR	50

NOTE: To set the STEPS/FAMILY control for 1 step, position the NORM-CAL switch to the CAL position and adjust the STEPS/FAMILY control until two dots appear. Then reposition the switch back to the NORM position.

Turn the STEP RANGE switch clockwise until a vertical line appears as in Figure 3-24. The trigger current is then between the step range just selected and the previous step. If the 10 mA/step position is reached and no vertical line appears, turn the STEPS/FAMILY control slowly clockwise. When the line appears, use the NORM-CAL switch to determine how many steps were required and multiply the number by 10 mA.

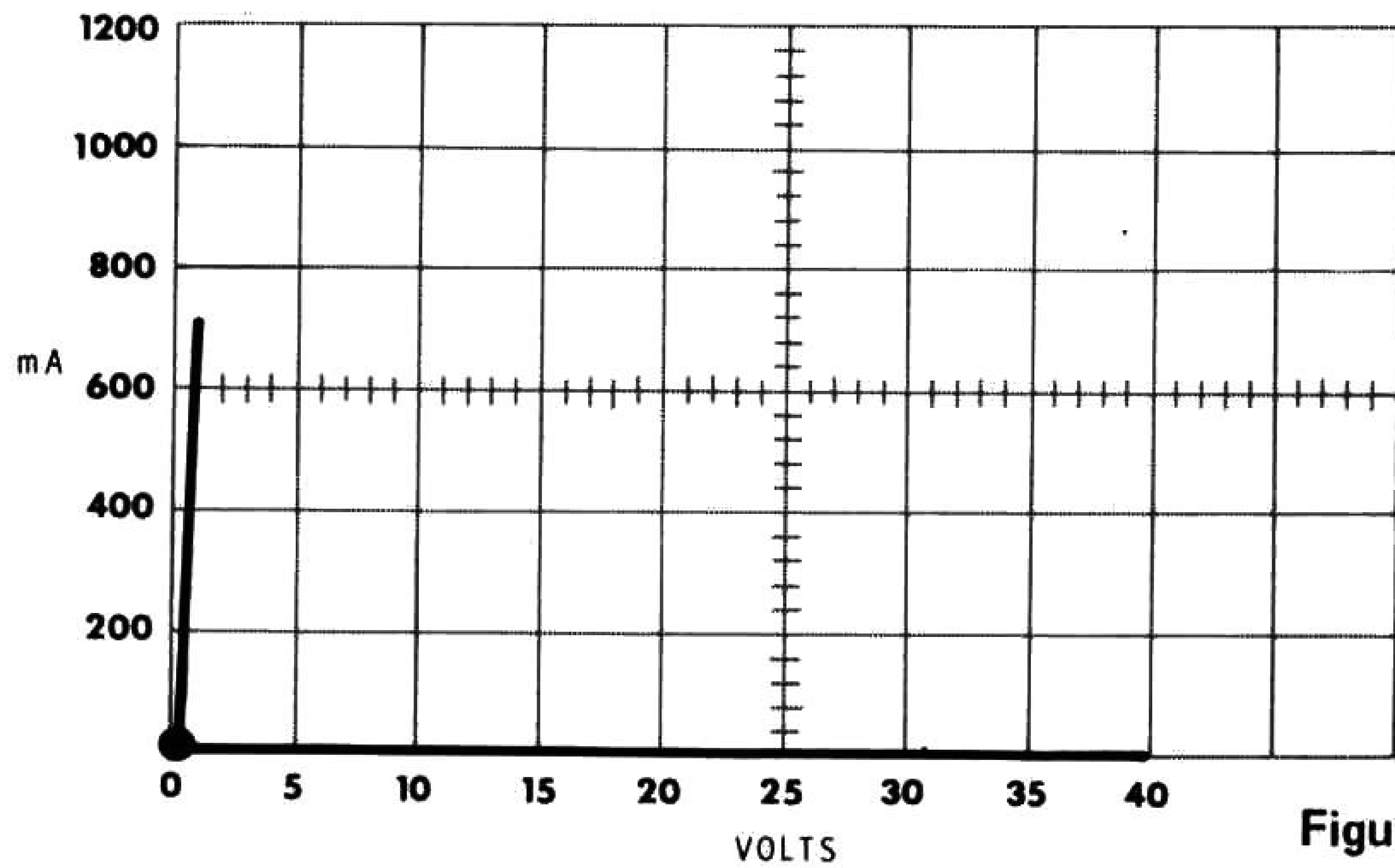


Figure 3-24

Forward Conduction

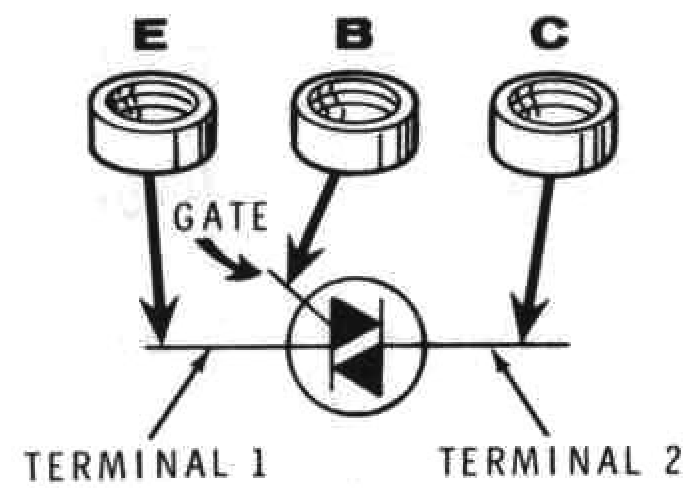
HORIZONTAL SENSITIVITY	.2 Volt/Div.
VERTICAL SENSITIVITY	50 mA/Div.
POLARITY	NPN
STEPS/FAMILY	1 Step
STEP RANGE	.05 mA/Step
LIMITING RESISTOR	0

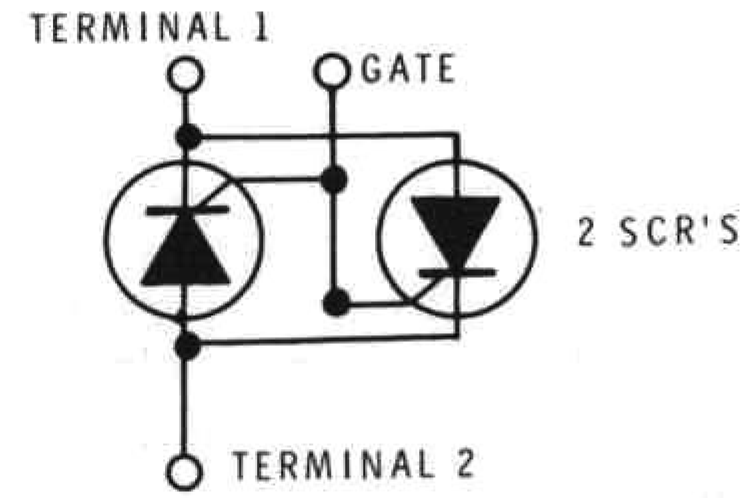
The forward voltage drop of an SCR is similar to that of a forward biased diode and the voltage depends on the selected current.

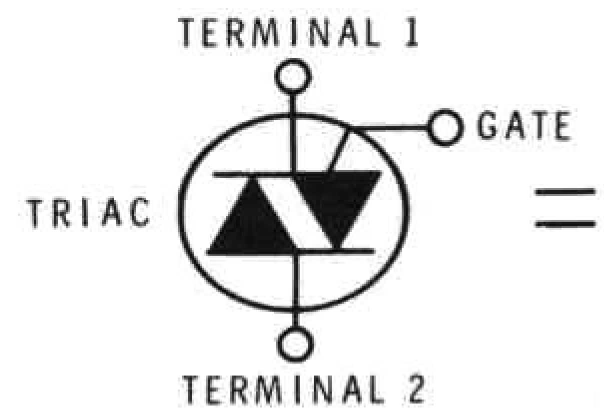
With two volts applied, the forward voltage drop of the SCR in Figure 3-25 is approximately 0.9 volt at a current of 250 mA. From these values the instantaneous watts dissipated in the device can be determined. W = VI = .9V X 250 mA = .225 watts.

TRIAC

Triacs may be tested the same as SCR's except that the forward tests should be performed in both directions and there will be no reverse blocking voltage measurement. This is because a triac is the same as two SCR's in parallel, but oriented in opposite directions.







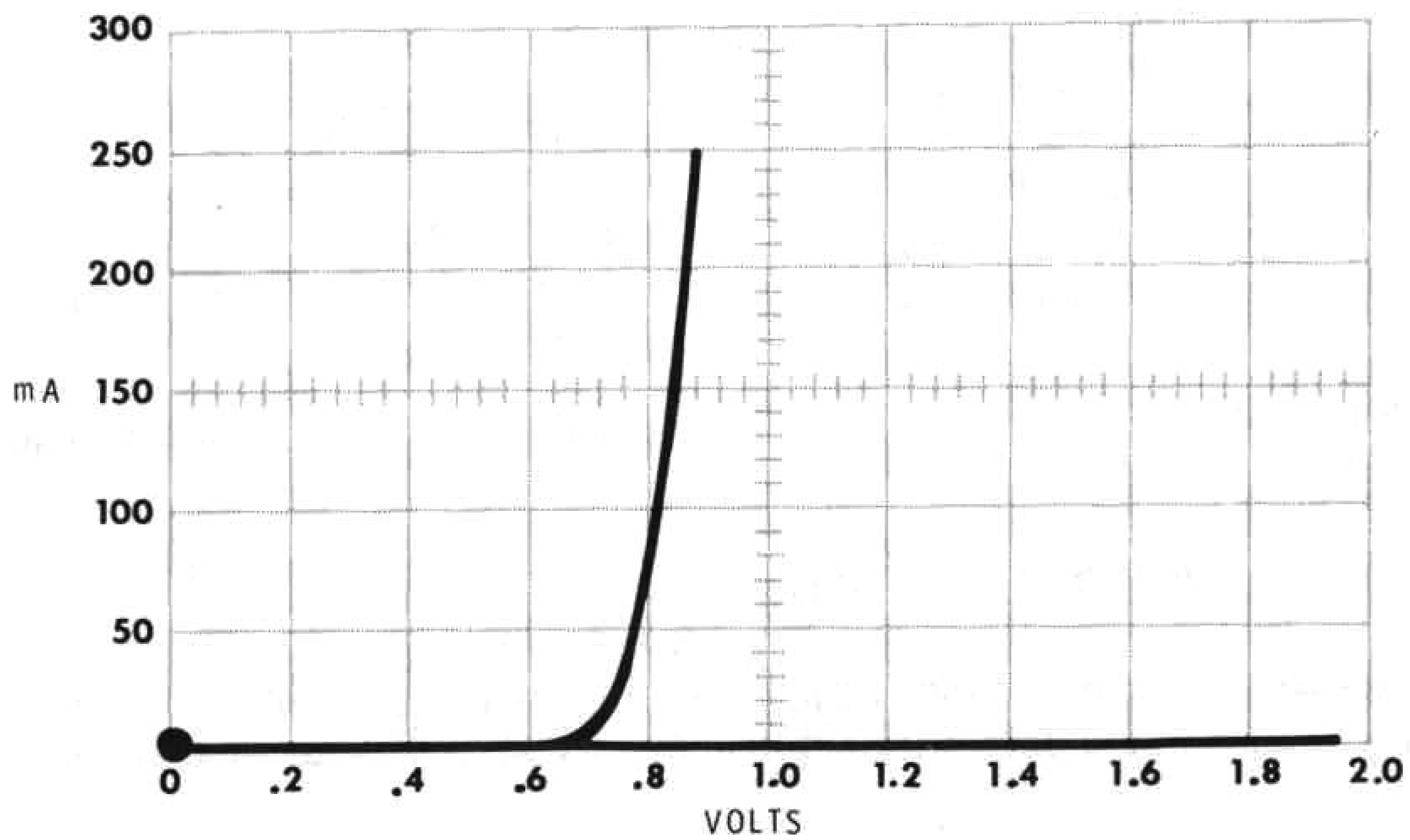


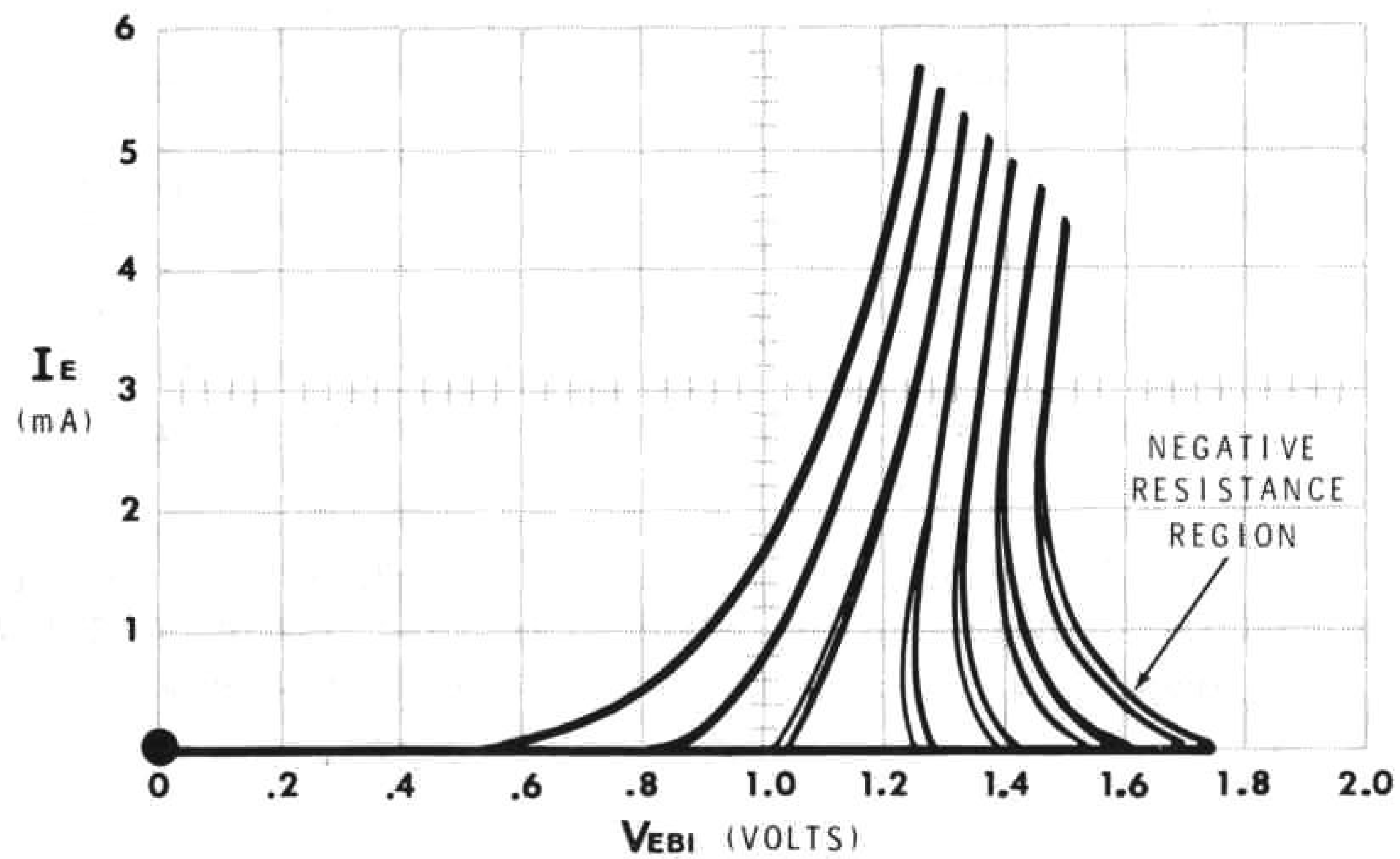
Figure 3-25

UJT

HORIZONTAL SENSITIVITY	.2 Volt/Div.
VERTICAL SENSITIVITY	1 mA/Div.
POLARITY	NPN
STEPS/FAMILY	6 Steps
STEP RANGE	.5 mA/Step
LIMITING RESISTOR	100

A unijunction transistor (UJT) is a single junction device with three terminals. Conduction between base 1 and base 2 is purely resistive until an emitter current is applied. A small trigger current applied to the emitter causes a negative resistance condition. The value of trigger voltage is dependent upon the voltage between base 1 and base 2.

When tested, the step current is applied from base 2 to base 1. This step current causes a step voltage across B_2 and B_1. The sweep voltage is applied to the emitter of the UJT. For each increase in B_2 B_1 voltage, more emitter trigger voltage is required. See Figure 3-26.



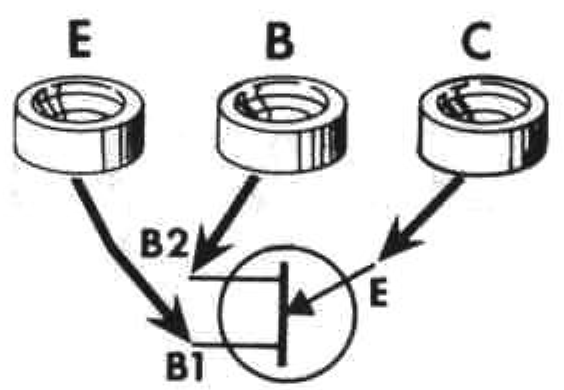
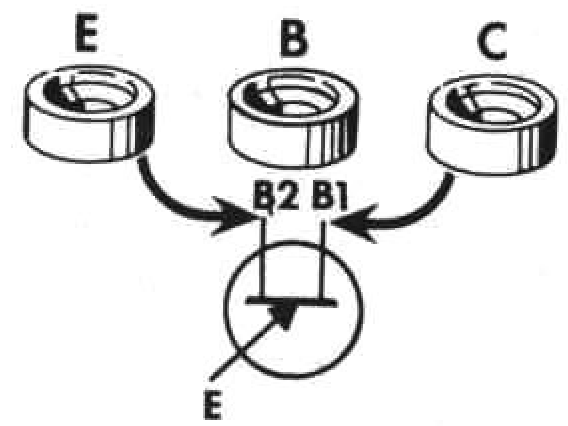


Figure 3-26

UJT (R_{BB})

HORIZONTAL SENSITIVITY	1 Volt/Div.
VERTICAL SENSITIVITY	1 mA/Div.
POLARITY	NPN
STEPS/FAMILY	0
STEP RANGE	Not used
LIMITING RESISTOR	1 k

Interbase resistance (R_{BB}) can be displayed by connecting base 1 and base 2 to the collector and emitter jacks of the Curve Tracer and leaving the emitter lead open circuited. This displays a linear trace of forward current (I_F) versus interbase voltage (V_{BB}). $R_{BB} = V_{BB}/I_F = \frac{9V}{3\ mA} = 3\ k\Omega$



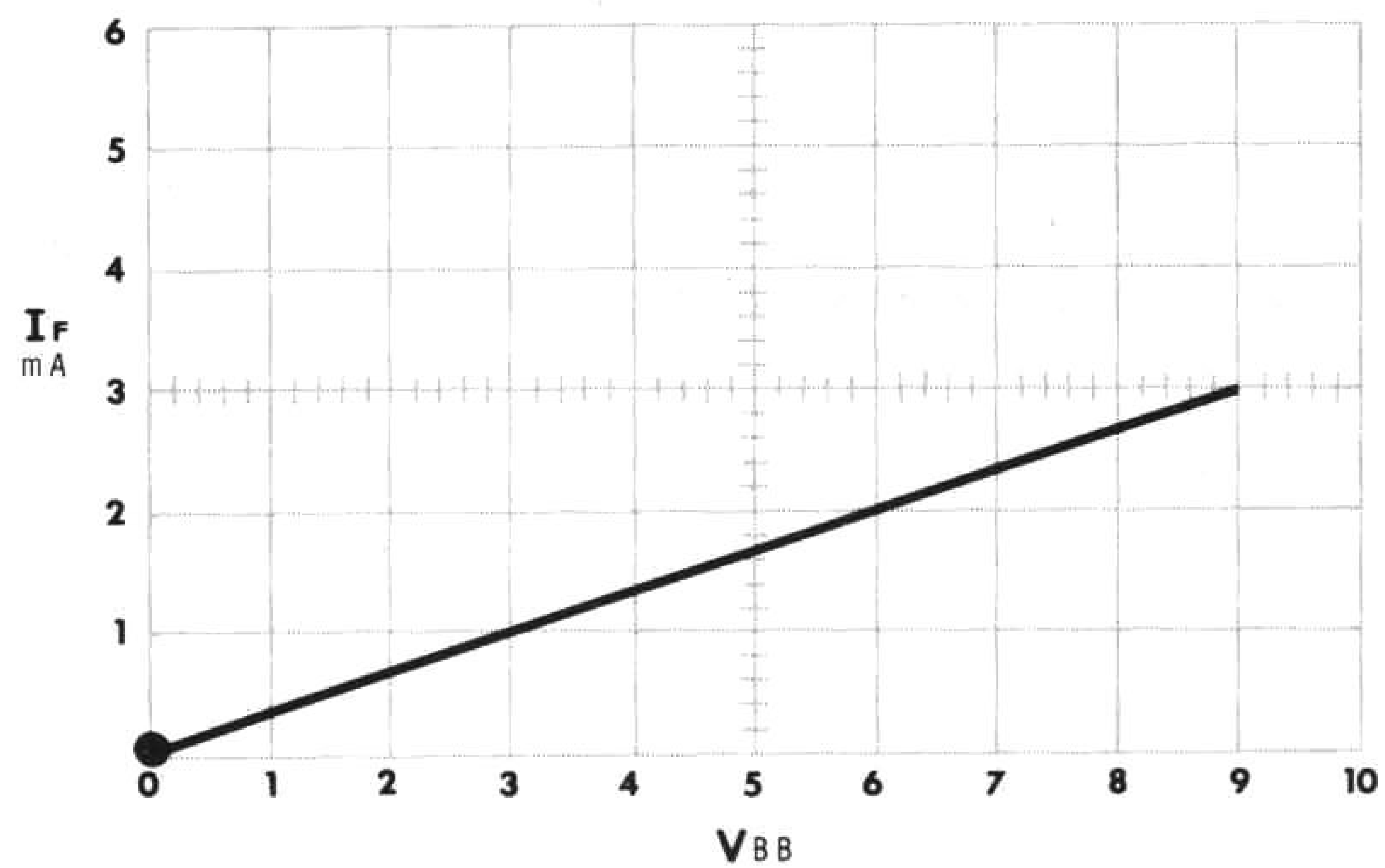


Figure 3-27

IN CASE OF DIFFICULTY

Begin your search for any trouble that occurs after assembly by carefully following the steps listed below in the "Visual Tests." After the "Visual Tests" are completed, refer to the "Troubleshooting Chart."

NOTE: Refer to the "Circuit Board X-Ray Views" on Page 97 for the physical location of parts on the circuit boards.

VISUAL TESTS

1. Recheck the wiring. Trace each lead in colored pencil on the Pictorial as it is checked. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the kit builder.

2. About 90% of the kits that are returned to the Heath Company for repair do not function properly due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections to make sure they are soldered as described in the "Soldering" section of the "Kit Builders Guide." Be sure there are no solder bridges.

3. Check to be sure that all transistors and diodes are in their proper locations. Make sure each lead is connected to the proper point.

4. Check to be sure that each IC is properly installed in its socket, and the pins are not bent out or under the IC. Also be sure the IC's are installed in their correct positions.

5. Check the values of the parts. Be sure in each step that the proper part has been wired into the circuit, as shown in the Pictorial Diagrams. It would be easy, for example, to install a 510 Ω (green-brown-brown) resistor where a 150 Ω (brown-green-brown) resistor should have been installed.

6. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring.

7. Look between the circuit board and the chassis to be sure all leads have been cut off.

8. A review of the "Circuit Description" may also help you to determine where the trouble is.

If the trouble is still not located after the "Visual Tests" are completed, and a voltmeter is available, check voltage readings against those shown on the "Schematic Diagram" (fold-out from Page 103). Read the "Precautions for Troubleshooting" below before taking any measurements. NOTE: All voltage readings are taken with a high-impedance voltmeter. Voltages may vary as much as ±20%.

NOTE: In an extreme case where you are unable to resolve a difficulty, refer to the "Customer Service" information inside the rear cover of this Manual. Your Warranty is located inside the front cover.

PRECAUTIONS FOR TROUBLESHOOTING

1. Be cautious when testing IC and transistor circuits. Although they have almost unlimited life when used properly, they are much more vulnerable to damage from excessive voltage or current than tubes.

2. Be sure you do not short any terminals to ground when making voltage measurements. If the probe should slip, for example, and short across components or voltage sources, it is very likely to cause damage to one or more IC's, transistors, or diodes.

3. High voltages are exposed in the Curve Tracer when the line cord is plugged into an AC outlet. Refer to the "Chassis Photographs" on Page 100 for the location of these high voltage areas.

TROUBLESHOOTING CHART

The following chart lists the "Condition" and the "Possible Cause" for a number of malfunctions. If a particular part or parts are mentioned (transistor Q201, for example, or resistor (R104) as a possible cause, check these parts to see if they are incorrectly installed or wired. Also check to see if an improper part was installed at that location. It is also possible on rare occasions for a part to be faulty.

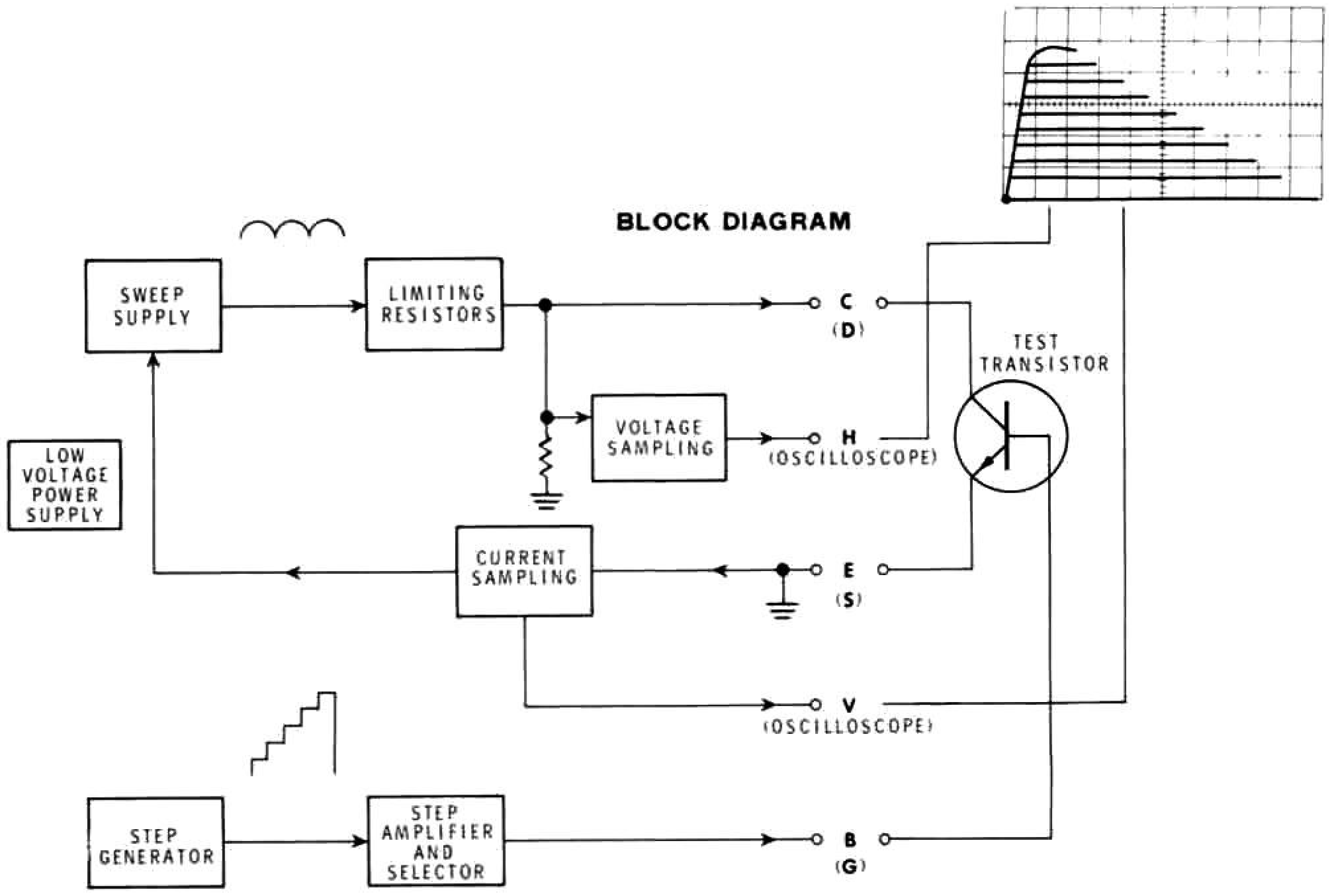
CONDITION	POSSIBLE CAUSE
No horizontal or vertical deflection.	1. Sweep Range and Polarity switches not firmly in their proper position. 2. Transistors Q1, Q2, Q3, Q4. 3. Switch S1.
Dot on oscilloscope deflects off scale when Signal Tracer is turned on.	1. IC1, IC2. 2. ±15.5 volt power supply. 3. Oscilloscope sensitivity too high.
In CAL position, diagonal dots not obtained.	1. Steps/Family control at too far counterclockwise. 2. Oscilloscope not set to proper sensitivity. 3. IC3, IC6. 4. Q5, Q6, or Q13, Q14. 5. ±15.5 volt power supply.
No horizontal deflection.	1. Check oscilloscope's horizontal control settings. 2. Check for proper range of Horizontal Sensitivity switch (on Curve Tracer). 3. Check value of limiting resistor (may be too high). 4. Horizontal Sensitivity switch. 5. IC1 (interchange with IC2).

CONDITION	POSSIBLE CAUSE
No vertical deflection.	1. Check oscilloscope's vertical control settings. 2. Check for proper range of Vertical Sensitivity switch (on Curve Tracer). 3. Check for proper position of Step Range switch. 4. Check Steps/Family control (turn clockwise). 5. Check value of limiting resistor (may be too high). 6. Vertical Sensitivity switch. 7. IC2 (substitute with IC1). 8. Output fuse of step amplifier. 9. Left-right socket selector switch.
Some base steps missing.	1. Check setting of Steps/Family control 2. Base fuse. 3. Q11, Q12.
Display curves have excessive looping.	1. Oscilloscope is on AC input. 2. Device under test is too hot. 3. May be normal if tested "in circuit."
Pilot lamp does not light.	1. Line Fuse. 2. No AC power to Curve Tracer. 3. Pilot lamp.

SPECIFICATIONS

Sweep Voltage Ranges	0-40 volts at 1 ampere maximum. 0-200 volts at 200 milliamperes maximum.
Sweep Voltage Sampling	.1, .2, .5, 1, 2, 5, 10, 20, and 50 volts/division ±3%.
Sweep Current Sampling	.5, 1, 2, 5, 10, 20, 50, 100, and 200 milliamperes/division ±3%.
Sweep Dissipation Resistors	0, 10, 50, 100, 500, 1000, 5000, 10 k, 50 k, 100 k, 500 k, 1 M ±10%.
Step Currents Available	.002, .005, .01, .02, .05, .1, .2, .5, 1, 2, 5, and 10 milliamperes/step, ±3%, ±250 nanoamperes offset current maximum.
Step Voltages Available	.05, .1, .2, .5, and 1 volt/step, ±3%, ±5mV maximum offset voltage.
Polarity Available	PNP and NPN (P Channel – N Channel).
Calibration Source	9 volts ±2% in 1 volt steps.
Oscilloscope Requirements	Vertical sensitivity of 1 volt/cm. Horizontal sensitivity of 0.5 volt/cm. Bandwidth to 20 kHz or greater. (DC-coupled oscilloscope is recommended.)

(Continued on next page)



BLOCK DIAGRAM

Operating Temperature Range	10°C to 40°C. Temperature variation, referenced at 25°C, will have a maximum effect of ±1% on all other specifications.
Line Voltage	110 to 130 or 220 to 260 VAC.
Dimensions	11-1/4" W x 10" D x 4-1/2" H.
Weight	Approximately 8-1/2 lbs.

The Heath Company reserves the right to discontinue products and to change specifications at any time without incurring any obligation to incorporate new features in products previously sold.

CIRCUIT DESCRIPTION

Refer to the Schematic Diagram (fold-out from Page 103) and the Block Diagram (fold-out from Page 92) while you read this "Circuit Description."

The Block Diagram shows the basic parts of the Curve Tracer. The sweep supply applies pulsating DC through the current limiting resistors to the collector (or drain) of the transistor under test, and also through the voltage sampling circuitry to the horizontal input of an oscilloscope. The current that flows through the transistor under test is sampled and applied to the vertical input of an oscilloscope. The base (or gate) is stepped with constant current (or voltage) from the step generator and amplifier. The effect of this staircase waveform on the output parameters of the device under test is monitored by the oscilloscope.

SWEEP SUPPLY

The sweep supply produces a floating, pulsating DC (0-40 volts at 1 ampere, or 0-200 volts at 200 milliamperes) that is both current limited and voltage adjustable.

Resistor R1 is a current limiting resistor for lamp PL1, and resistors R2 and R3 provide loading for the high voltage winding of transformer T1. Diodes D1, D2, D3, and D4 rectify the AC and produce two positive voltages. Either voltage can be selected by the Sweep Range switch, SW2. Capacitors C2 and C3 are noise filters.

Due to circuit capacitance that affects the positive supply, at times "looping" can be seen on the oscilloscope screen. This looping is caused by stray capacitance coupled to ground through the sweep circuitry and wiring, and the secondary sweep windings of transformer T1. To minimize this looping, stray capacitance is injected into the circuit from a supply of the opposite polarity (D15, D16, and R4) through loop control R5 and capacitor C1.

The voltage selected by the Sweep Range switch is applied to Sweep Voltage control R6 and the collectors of transistors Q1, Q2, and Q3. The Sweep Voltage control sets the amount of voltage that is applied to the base of these transistors and, therefore, controls the amplitude of the output signal on the emitter of Q1. The other two sections of switch SW2 select proper load resistors (R12 and R13) and current sensing resistors (R8 and R9). As the current through the current sensing resistors reaches its rated limit, the voltage across these resistors turns on transistor Q4, which places a less positive voltage at the base of transistor Q3. This turns off Q3, Q2, and Q1 to limit the current.

The Polarity switch selects either a positive or negative voltage, depending on the type of device being tested.

LIMITING RESISTORS

Limiting Resistor switch SW4 selects the proper resistance (zero ohms through 1 megohm) to protect the device being tested from excessive current.

VOLTAGE SAMPLING

Resistors R26 through R33 form a divider network to monitor the voltage at C (D). This voltage from the divider is applied to IC1, amplified by five, and applied to the horizontal output to an oscilloscope.

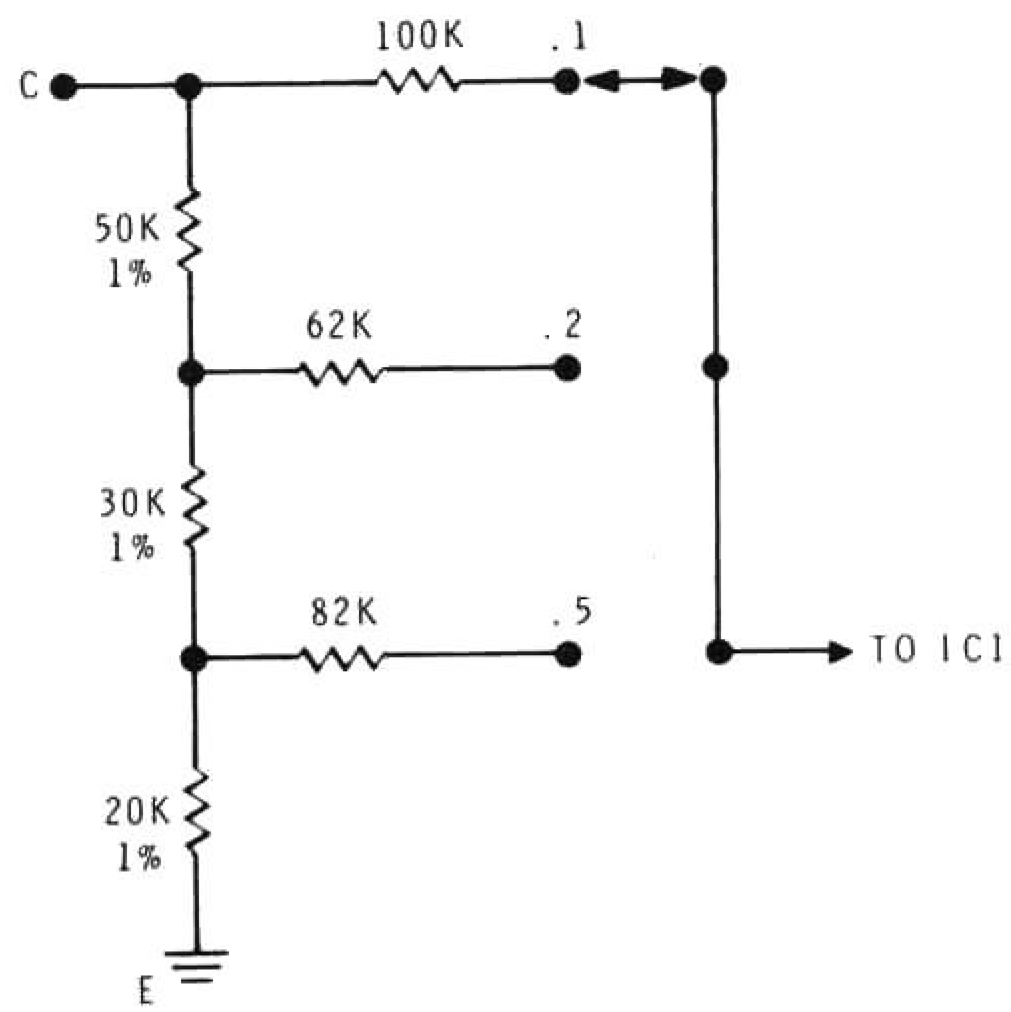


Figure 4-1

Figure 4-1 is a partial schematic showing the divider network in the .1, .2, and .5 V/div. positions. The 100 kΩ, 62 kΩ, and 82 kΩ resistors provide input protection and equalization of input impedance for minimum DC shift between ranges.

IC1 is used as a noninverting amplifier. The output of the IC is then five times greater than the input because of the voltage divider, R34 and R35.

CURRENT SAMPLING

The current that flows through the device under test also flows through the selected sensing resistance and back to the sweep supply. The voltage drop across the sensing resistors is inverted and amplified by IC2, and applied to the "V" (vertical) output connector to an oscilloscope. Diodes D9 through D12 protect the sensing resistors from excessive voltage. IC2 has a gain of 10 because of the 10:1 ratio between resistors R104 and R106.

LOW VOLTAGE POWER SUPPLY

For the positive supply, the AC from the low voltage winding of the transformer is rectified by diodes D5 and D6. Capacitor C5 then filters the pulsating DC. Resistor R36 limits the current to the zener diode, D15, which is again filtered by capacitor C6. The emitter of transistor Q13 follows the constant voltage that is at its base. Resistor R37 drops the 15 volts to 5 volts and capacitor C7 filters this voltage.

The negative supply is similar to the positive supply. However, instead of using a simple current limiting resistor to protect the zener diode, a constant current source is used; R38, R39, Q15, and Q16. This insures constant current through the zener diode in spite of changes in line voltage. This zener is the precision voltage reference for the step generator switching transistors.

STEP GENERATOR

The step generator produces a precision staircase waveform. Each time the sweep supply goes to zero volts, the step generator switches to the next higher step. The available steps are zero through nine.

Each time the line voltage passes through zero, transistor Q5 or Q6 generates a sync pulse (120 pulses per second). These pulses are applied to decade counter IC6 which counts these pulses and converts them to BCD (bindary coded decimal) on four output lines (A, B, C, and D). These pulses are capacitor coupled to the four switching transistors; Q7, Q8, Q9, and Q10. As these transistors turn on and off, they switch precision amounts of current into the minus (–) summing junction of IC3. See Figure 4-2. IC3 changes these current steps into voltage steps.

STEP	OUTPUT OF IC6				TRANSISTORS					
	A	B	C	D	Q7	Q9	Q10	Q8	UNITS OF CURRENT	TOTAL UNITS OF CURRENT
0	0	0	0	0	OFF	OFF	OFF	OFF	0 + 0 + 0 + 0	0
1	1	0	0	0	ON	"	"	"	1 + 0 + 0 + 0	1
2	0	1	0	0	OFF	ON	"	"	0 + 2 + 0 + 0	2
3	1	1	0	0	ON	ON	"	"	1 + 2 + 0 + 0	3
4	0	0	1	0	OFF	OFF	ON	"	0 + 0 + 4 + 0	4
5	1	0	1	0	ON	"	ON	"	1 + 0 + 4 + 0	5
6	0	1	1	0	OFF	ON	ON	"	0 + 2 + 4 + 0	6
7	1	1	1	0	ON	ON	ON	"	1 + 2 + 4 + 0	7
8	0	0	0	1	OFF	OFF	OFF	ON	0 + 0 + 0 + 8	8
9	1	0	0	1	ON	"	"	ON	1 + 0 + 0 + 8	9

NOTE: Q7 switches 1 unit of current, Q9 switches 2 units of current, Q10 switches 4 units of current, and Q8 switches 8 units of current.

Figure 4-2

The decade counter, IC6, automatically resets itself after the ninth step. To reset sooner, a sampling of the staircase is taken from resistors R48 through R52, connected to the Steps/Family control, and then through transistor Q17 to Q18. Normally, Q17 and Q18 are turned on and hold the reset line of IC6 low. However, by adjusting the Steps/Family control, the base of Q17 becomes less positive and transistors Q17 and Q18 turn off and reset IC6 to the 0 step, which turns Q17 and Q18 back on. Thus the Step-Family control will reset the counter after any desired step.

The gain of IC3 is switchable to produce gains of .05, .1, .2, .5, and 1. With the Cal/Norm switch in the Cal position, the 1 volt/step waveform is coupled to the "V" and "H" outputs for oscilloscope calibration. In normal operation, the waveform is applied to SW3 and then to SW9 where the waveform may be switched into the plus (+) or minus (-) input of IC5.

IC5 supplies a voltage gain of +1 or -1, depending on the positions of switches SW3 and S9. Transistors Q11 and Q12 provide current gain and apply the signal through the selected resistor (R86 through R94) to the base of the transistor under test.

For constant current steps, the output from transistors Q11 and Q12 is coupled through the feedback resistor, R83, to IC5 to produce a gain of one. The output from transistors Q11 and Q12 is also coupled through the selected resistor (R86 through R94) to the base of the transistor under test. IC4, a voltage follower, monitors the offset voltage of the test transistor and adds this offset voltage to the voltage at IC5. Because IC5, and Q11 and Q12 have a gain of one, the offset voltage appears on both sides of the resistor selected by the Step Range switch, and the current per step is solely a function of the precision resistor selected and the voltage per step selected.

IC4 has a very high input impedance (many megohms) and therefore does not load the circuit. Resistor R85 protects IC4 from overload, and diodes D13 and D14 clamp the output voltage to less than ±17 volts in case a device under test fails and the sweep voltage at "C" shorts to "B". Also, fuse F1 will open if an excessive amount of current flows through the diodes.

When voltage steps are required, switch SW9 switches feedback resistor R83 to the base of the transistor under test, grounds IC4 so that no error signal is produced, and inverts the waveform from what it was in the current/step position. Resistor R91 is switched in for all five of the volt/step positions to protect the circuitry in case there is a base to ground short circuit. The switching of the feedback resistor at IC3 determines whether the steps are .05, .1, .2, .5, or 1 volt per step.

CIRCUIT BOARD X-RAY VIEWS

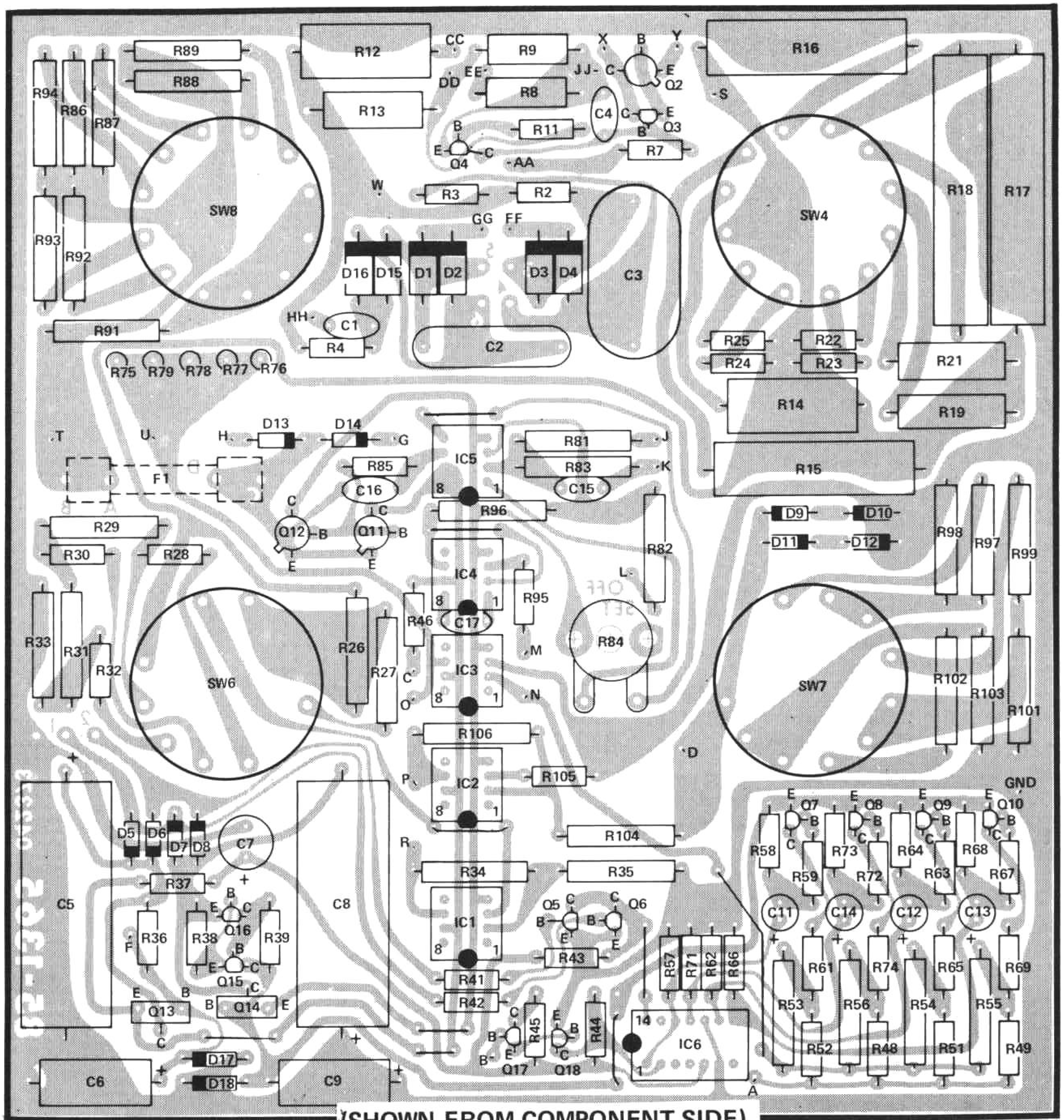
NOTE: To find the PART NUMBER of a component for the purpose of ordering a replacement:

A. Find the circuit component number (R15, C3, etc.) on the X-Ray View or "Chassis Photograph."

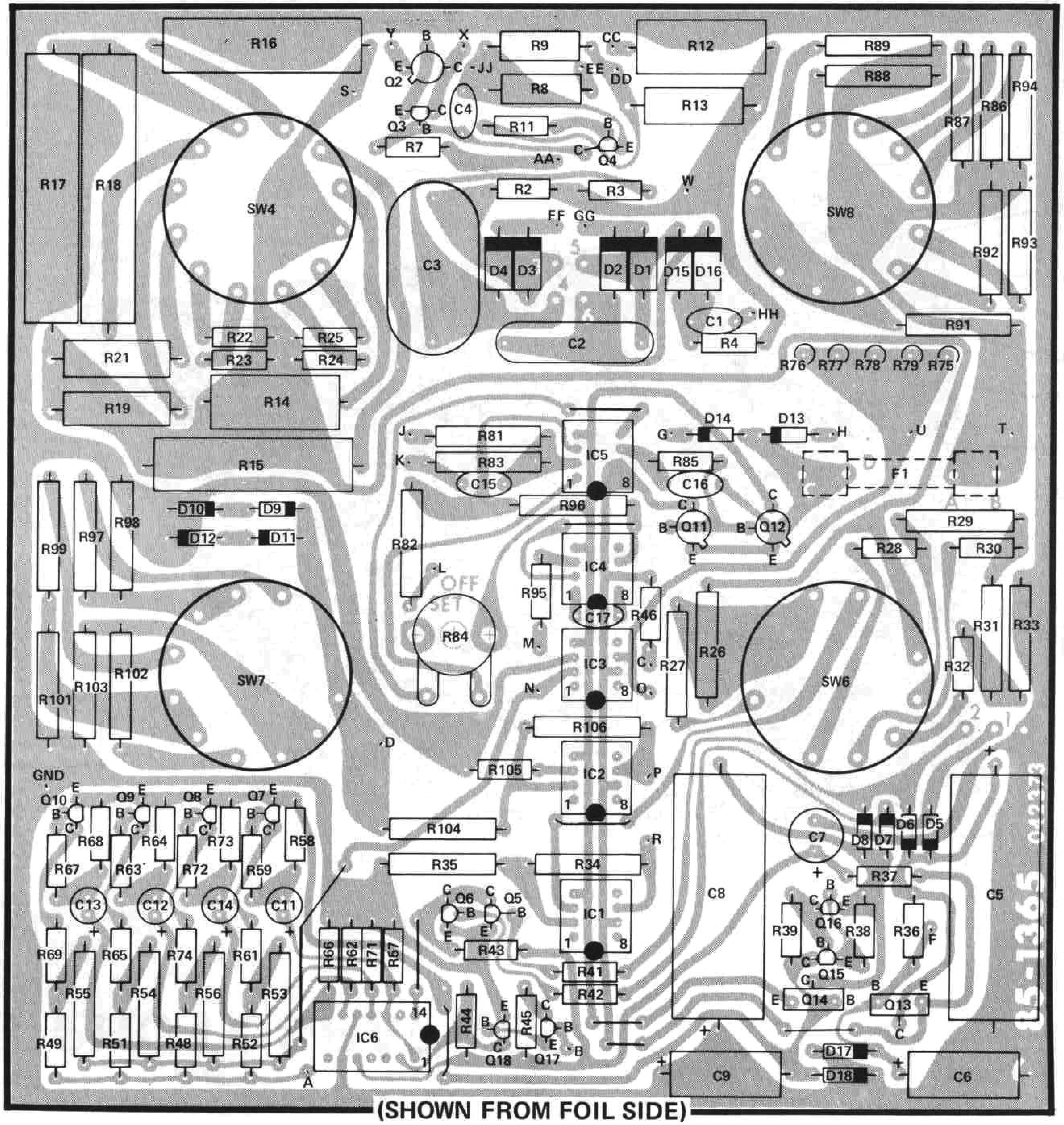
B. Locate this same number in the "Circuit Component Number" column of the "Parts List."

C. Adjacent to the circuit component number, you will find the PART NUMBER and DESCRIPTION which must be supplied when you order a replacement part.

HEATHKIT®

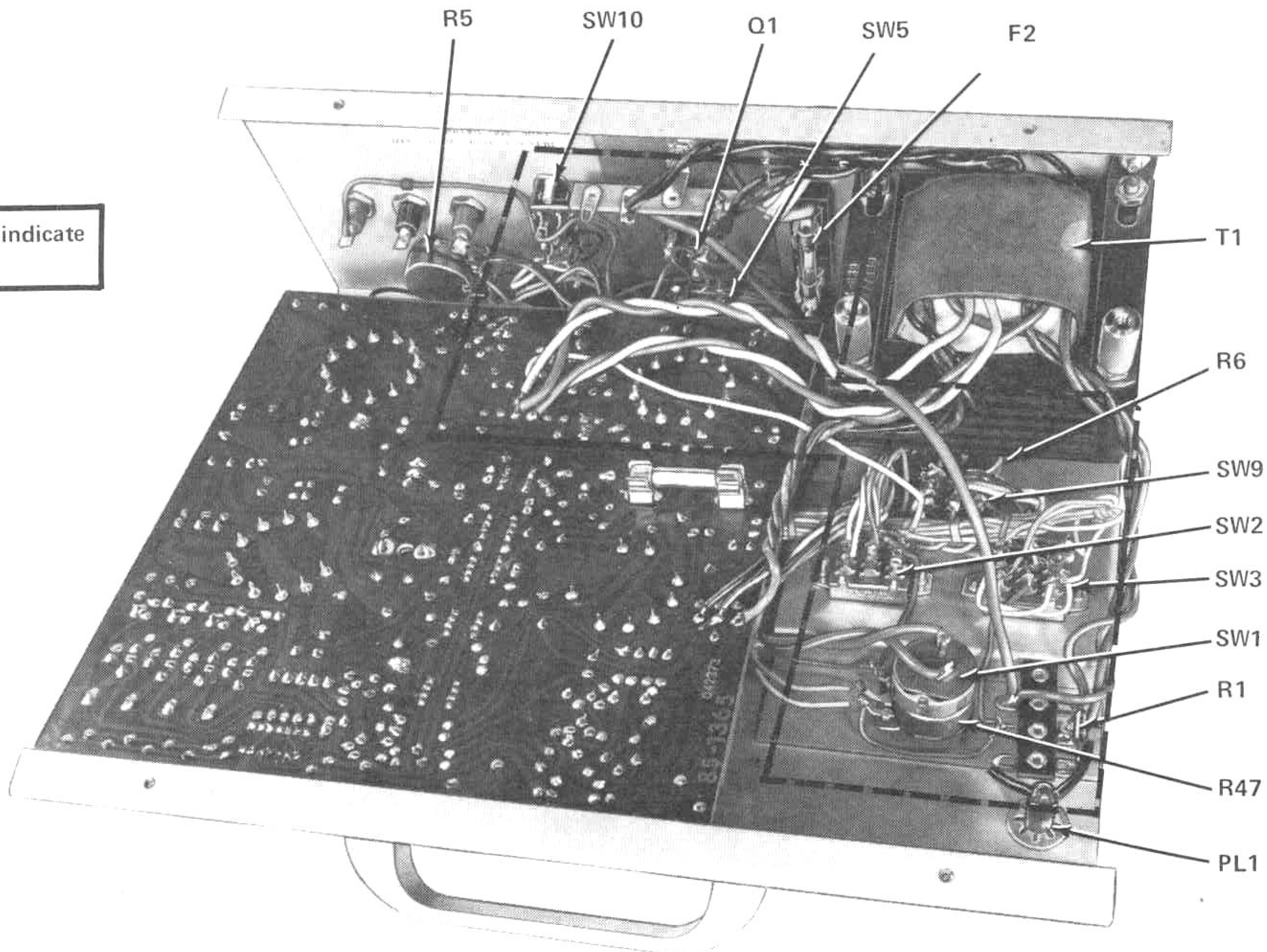


(SHOWN FROM COMPONENT SIDE)


R16
R9
R12
R89
R88
R94
R86
R87
R8
R13
R11
C4
R7
R17
R18
SW4
R2
R3
SW8
C3
D4
D3
D2
D1
D15
D16
R92
R93
C1
R91
C2
R4
R22
R25
R21
R23
R24
R76
R77
R78
R79
R75
R19
R14
D14
D13
R81
IC5
R85
F1
R15
R83
C15
C16
R96
Q11
Q12
R29
D10
D9
D12
D11
R99
R97
R98
R82
R28
R30
IC4
R95
C17
R46
R84
R31
R33
R26
SW7
R101
R103
R102
IC3
R27
SW6
R32
R106
GND
R105
IC2
R104
C7
D8
D7
D6
D5
R35
R34
R37
C8
C5
Q10
Q9
Q8
Q7
R68
R64
R73
R58
R67
R63
R72
R59
C13
C12
C14
C11
Q6
Q5
IC1
Q16
R39
R38
R36
R66
R62
R71
R67
R43
Q15
R69
R65
R74
R61
R55
R54
R56
R53
R41
R42
Q14
Q13
IC6
R44
R45
R49
R51
R48
R52
Q18
Q17
D17
D18
C9
C6
(SHOWN FROM FOIL SIDE)

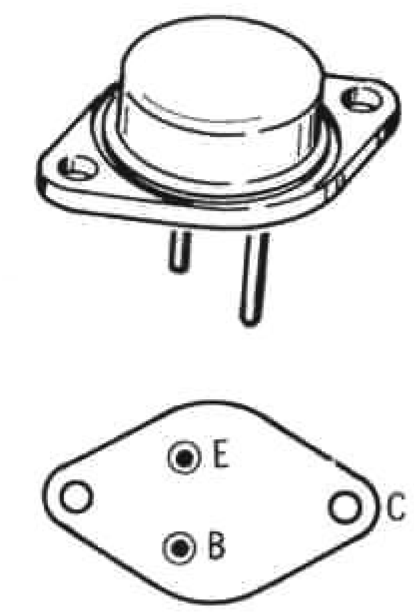
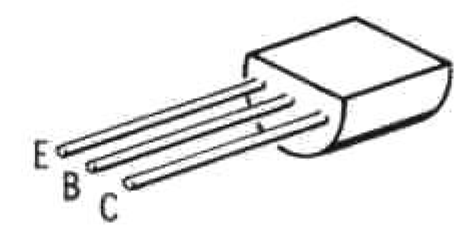
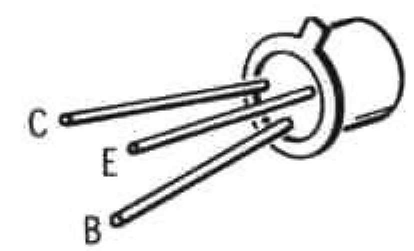
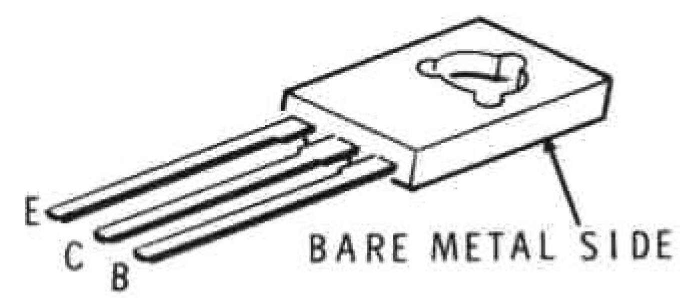
CHASSIS PHOTOGRAPHS

WARNING: Boxed-in areas indicate hazardous voltage locations.

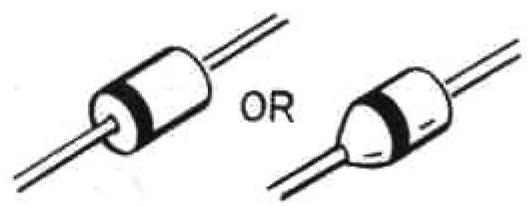
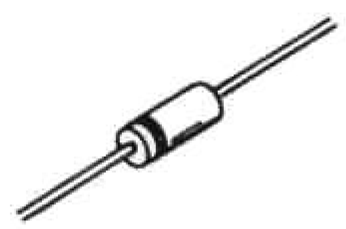
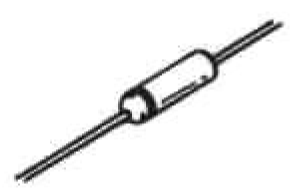


IDENTIFICATION CHARTS

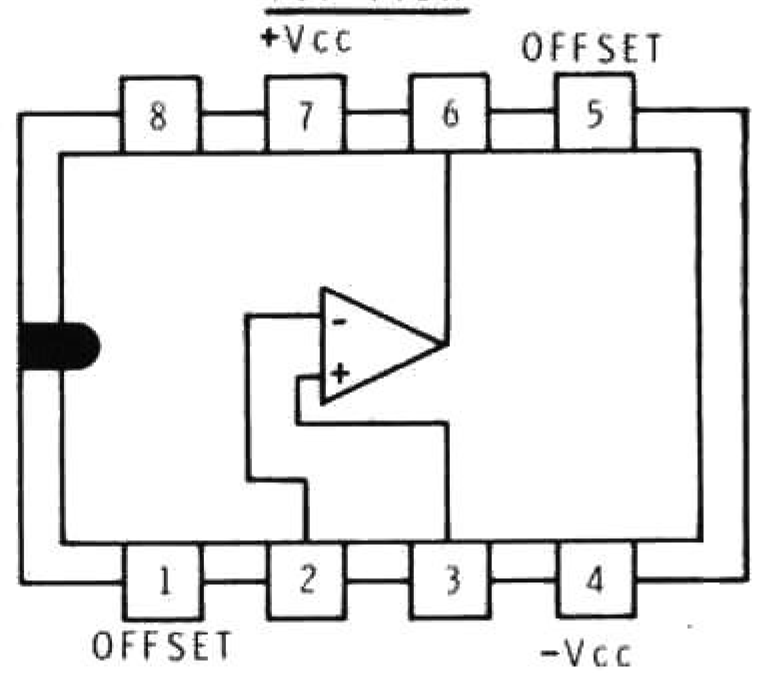
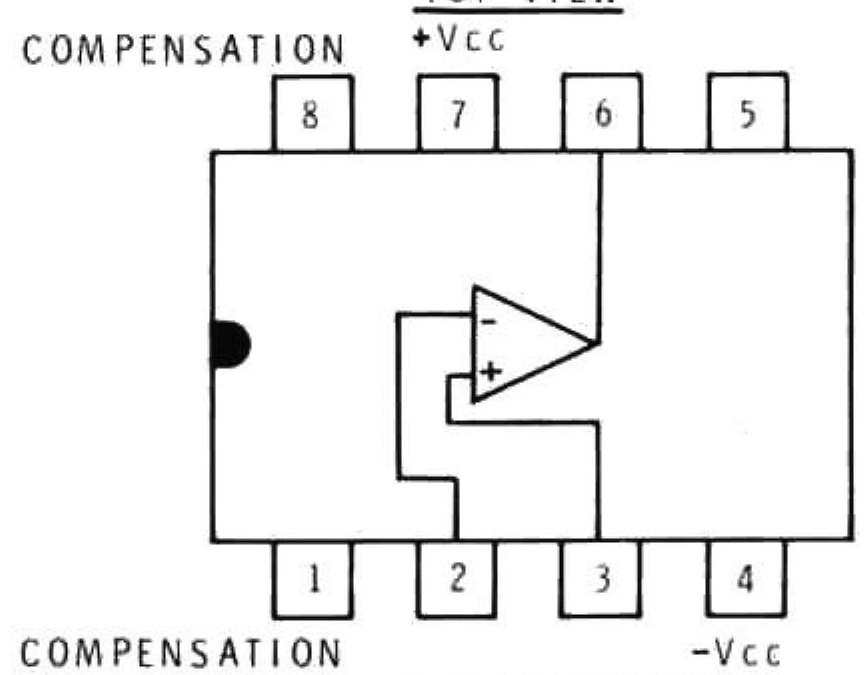
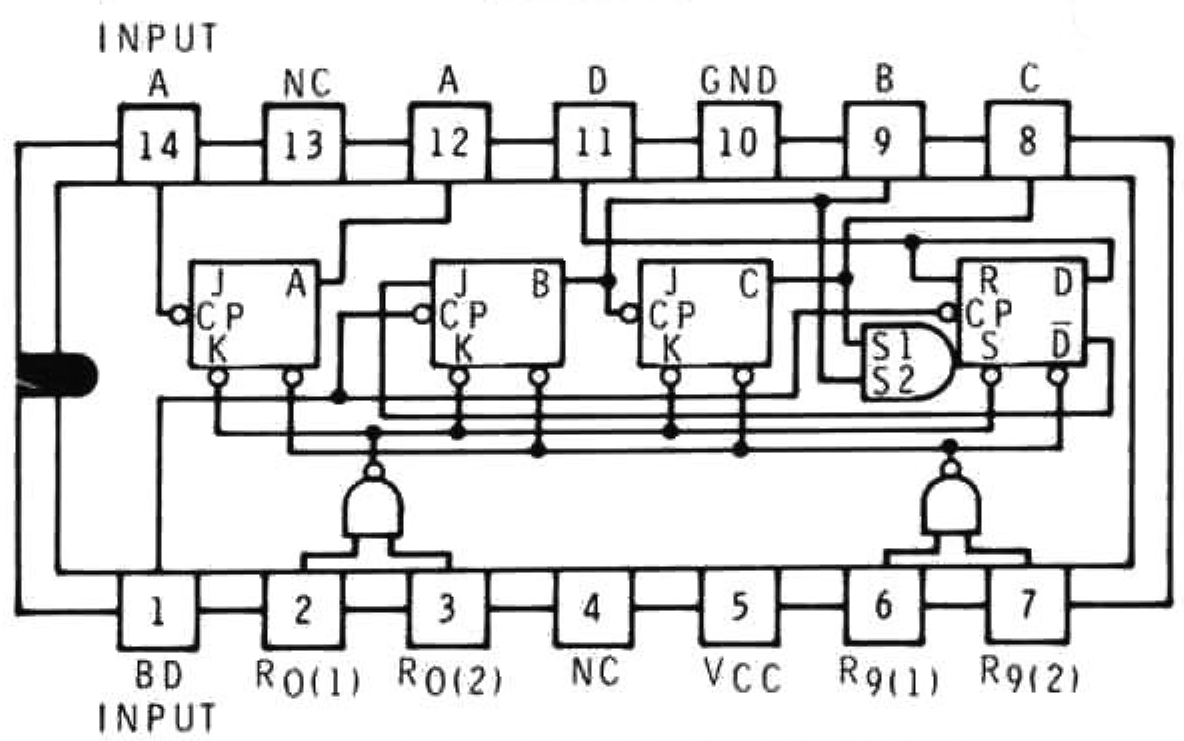
TRANSISTORS

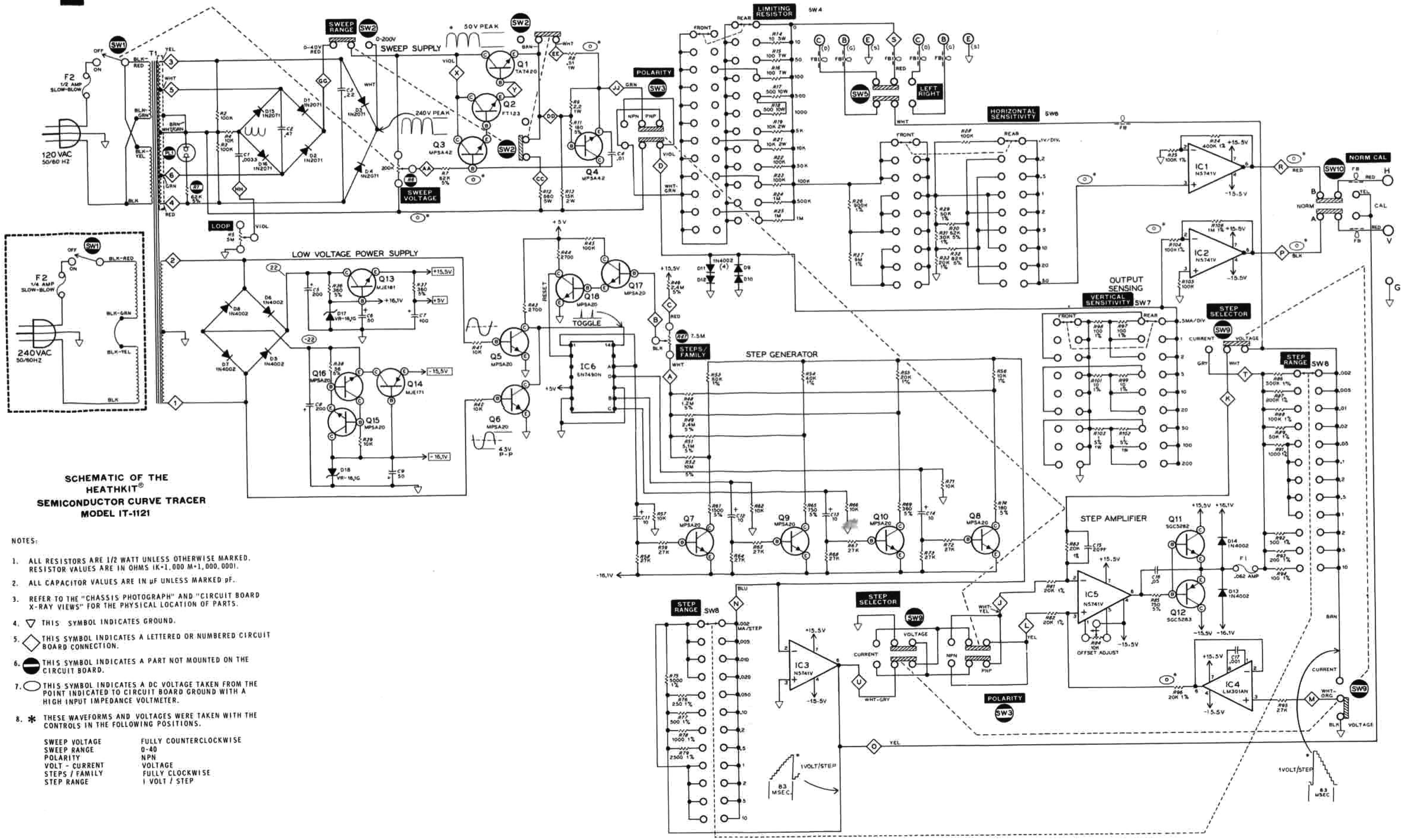
COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED BY	IDENTIFICATION
Q1	417-239	TA7420	
Q3, Q4	417-294	MPSA42	
Q5, Q6, Q7, Q8 Q9, Q10, Q15 Q16, Q17, Q18	417-801	MPSA20	
Q2	417-232	FT123	
Q11	417-269	SGC5282	
Q12	417-270	SGC5283	
Q13	417-818	MJE181	
Q14	417-819	MJE171	

DIODES

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED BY	IDENTIFICATION
D1, D2, D3, D4, D15, D16	57-27	1N2071	
D5, D6, D7, D8, D9, D10, D11, D12, D13, D14	57-65	1N4002	
D17, D18	56-36	VR-16.1G	

INTEGRATED CIRCUITS

COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED BY	IDENTIFICATION
IC1, IC2 IC3, IC5	442-22	N5741V	TOP VIEW  OPERATIONAL AMPLIFIER
IC4	442-39	LM301AN	TOP VIEW  OPERATIONAL AMPLIFIER
IC6	443-7	SN7490N	TOP VIEW  HIGH SPEED BCD DECADE COUNTER



SCHEMATIC OF THE HEATHKIT® SEMICONDUCTOR CURVE TRACER MODEL IT-1121

NOTES:

1. ALL RESISTORS ARE 1/2 WATT UNLESS OTHERWISE MARKED. RESISTOR VALUES ARE IN OHMS (K=1,000 M=1,000,000).
2. ALL CAPACITOR VALUES ARE IN μF UNLESS MARKED pF.
3. REFER TO THE "CHASSIS PHOTOGRAPH" AND "CIRCUIT BOARD X-RAY VIEWS" FOR THE PHYSICAL LOCATION OF PARTS.
4. ▽ THIS SYMBOL INDICATES GROUND.
5. ◇ THIS SYMBOL INDICATES A LETTERED OR NUMBERED CIRCUIT BOARD CONNECTION.
6. ⊖ THIS SYMBOL INDICATES A PART NOT MOUNTED ON THE CIRCUIT BOARD.
7. ⬭ THIS SYMBOL INDICATES A DC VOLTAGE TAKEN FROM THE POINT INDICATED TO CIRCUIT BOARD GROUND WITH A HIGH INPUT IMPEDANCE VOLTMETER.
8. * THESE WAVEFORMS AND VOLTAGES WERE TAKEN WITH THE CONTROLS IN THE FOLLOWING POSITIONS.

SWEEP VOLTAGE	FULLY COUNTERCLOCKWISE
SWEEP RANGE	0-40
POLARITY	NPN
VOLT - CURRENT	VOLTAGE
STEPS / FAMILY	FULLY CLOCKWISE
STEP RANGE	1 VOLT / STEP

CUSTOMER SERVICE

REPLACEMENT PARTS

If you need a replacement part, please fill in the Parts Order Form that is furnished and mail it to the Heath Company. Or, if you write a letter, include the:

- **Part number** and **description** as shown in the **Parts List.**
- Model number and Series number from the blue and white label.
- Date of purchase.
- Nature of the defect.

Please do not return parts to the factory unless they are requested. Parts that are damaged through carelessness or misuse by the kit builder will not be replaced without cost, and will not be considered in warranty.

Parts are also available at the Heathkit Electronic Centers listed in your catalog. Be sure to provide the Heath part number. Bring in the original part when you request a warranty replacement from a Heathkit Electronic Center.

NOTE: Replacement parts are maintained specifically to repair Heathkit products. Parts sales for other reasons will be declined.

TECHNICAL CONSULTATION

Need help with your kit? . . . . Self-Service? . . . . Construction? . . . . Operation? . . . . Call or write for assistance. You'll find our Technical Consultants eager to help with just about any technical problem except "customizing" for unique applications.

The effectiveness of our consultation service depends on the information you furnish. Be sure to tell us:

- The Model number and Series number from the blue and white label.
- The date of purchase.
- An exact description of the difficulty.
- Everything you have done in attempting to correct the problem.

Also include switch positions, connections to other units, operating procedures, voltage readings, and any other information you think might be helpful.

Please do not send parts for testing, unless this is specifically requested by our Consultants.

Hints: Telephone traffic is lightest at midweek. . .please be sure your Manual and notes are on hand when you call.

Heathkit Electronic Center facilities are also available for telephone or "walk-in" personal assistance.

REPAIR SERVICE

Service facilities are available, if they are needed, to repair your completed kit. (Kits that have been modified, soldered with paste flux or acid core solder, cannot be accepted for repair.)

If it is convenient, personally deliver your kit to a Heathkit Electronic Center. For warranty parts replacement, supply a copy of the invoice or sales slip.

If you prefer to ship your kit to the factory, attach a letter containing the following information directly to the unit:

- Your name and address.
- Date of purchase.
- Copies of all correspondence relevant to the service of the kit.
- A brief description of the difficulty.
- Authorization to return your kit C.O.D. for the service and shipping charges. (This will reduce the possibility of delay.)

Check the equipment to see that all screws and parts are secured. (Do not include any wooden cabinets or color television picture tubes, as these are easily damaged in shipment.) Place the equipment in a strong carton with at least THREE INCHES of *resilient* packing material (shredded paper, excelsior, etc.) on all sides. Use additional packing material where there are protrusions (control sticks, large knobs, etc.). If the unit weighs over 15 lbs., place this carton in another one with 3/4" of packing material between the two.

Seal the carton with reinforced gummed tape, tie it with a strong cord, and mark it "Fragile" on at least two sides. Remember, the carrier will not accept liability for shipping damage if the unit is insufficiently packed. Ship by prepaid express, United Parcel Service, or insured Parcel Post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

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