HEATHKIT® MANUAL

for the

512 MHz FREQUENCY COUNTER

Model IM-2420

595-2384-09

HEATH COMPANY • BENTON HARBOR, MICHIGAN

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 Phone Numbers

8:00 A.M. to 12 P.M. and 1:00 P.M. to 4:30 P.M., EST, Weekdays Only

R/C, Audio, and Electronic Organs	(616) 982-3310
Amateur Radio	(616) 982-3296
Test Equipment, Weather Instruments and Home Clocks	(616) 982-3315
Television	(616) 982-3307
Aircraft, Marine, Security, Scanners, Automotive, Appliances and General Products	(616) 982-3496
Computers — Hardware	(616) 982-3309
Computers — Software: Operating Systems, Languages, Utilities	(616) 982-3860
Computers — Software: Application Programs	(616) 982-3884
Heath Craft Wood Works	(616) 982-3423

YOUR HEATHKIT 90-DAY LIMITED WARRANTY

Consumer Protection Plan for Heathkit Consumer Products

Welcome to the Heath family. We believe you will enjoy assembling your kit and will be pleased with its performance. Please read this Consumer Protection Plan carefully. It is a "LIMITED WARRANTY" as defined in the U.S. Consumer Product Warranty and Federal Trade Commission Improvement Act. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Heath's Responsibility

PARTS — Replacements for factory defective parts will be supplied free for 90 days from date of purchase. Replacement parts are warranted for the remaining portion of the original warranty period. You can obtain warranty parts direct from Heath Company by writing or telephoning us at (616) 982-3571. And we will pay shipping charges to get those parts to you . . . anywhere in the world.

SERVICE LABOR — For a period of 90 days from the date of purchase, any malfunction caused by defective parts or error in design will be corrected at no charge to you. You must deliver the unit at your expense to the Heath factory, any Heathkit Electronic Center (units of Veritechnology Electronics Corporation), or any of our authorized overseas distributors.

TECHNICAL CONSULTATION — 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.

NOT COVERED — The correction of assembly errors, adjustments, calibration, and damage due to misuse, abuse, or negligence are not covered by the warranty. Use of corrosive solder and/or the unauthorized modification of the product or of any furnished componen, will void this warranty in its entirety. This warranty does not include reimbursement for inconvenience, loss of use, customer assembly, set-up time, or unauthorized service.

This warranty covers only Heath products and is not extended to other equipment or components that a customer uses in conjunction with our products.

SUCH REPAIR AND REPLACEMENT SHALL BE THE SOLE REMEDY OF THE CUSTOMER AND THERE SHALL BE NO LIABILITY ON THE PART OF HEATH FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING BUT NOT LIMITED TO ANY LOSS OF BUSINESS OR PROFITS, WHETHER OR NOT FORSEEABLE.

Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

Owner's Responsibility

EFFECTIVE WARRANTY DATE — Warranty begins on the date of first consumer purchase. You must supply a copy of your proof of purchase when you request warranty service or parts.

ASSEMBLY — Before seeking warranty service, you should complete the assembly by carefully following the manual instructions. Heathkit service agencies cannot complete assembly and adjustments that are customer's responsibility.

ACCESSORY EQUIPMENT — Performance malfunctions involving other non-Heath accessory equipment, (antennas, audio components, computer peripherals and software, etc.) are not covered by this warranty and are the owner's responsibility.

SHIPPING UNITS — Follow the packing instructions published in the assembly manuals. Damage due to inadequate packing cannot be repaired under warranty.

If you are not satisfied with our service (warranty or otherwise) or our products, write directly to our Director of Customer Service, Heath Company, Benton Harbor MI 49022. He will make certain your problems receive immediate, personal attention.

Heathkit® Manual

for the

512 MHz
FREQUENCY COUNTER
Model IM-2420

595-2384-09

HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

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INTRODUCTION

The Heathkit Model IM-2420 Frequency Counter is a versatile, laboratory-quality instrument capable of making highly accurate frequency measurements from 5 Hz to 512 MHz. Besides being a frequency counter, this instrument may also be used in period and frequency ratio modes of operation.

The following features are included in this high quality Frequency Counter:

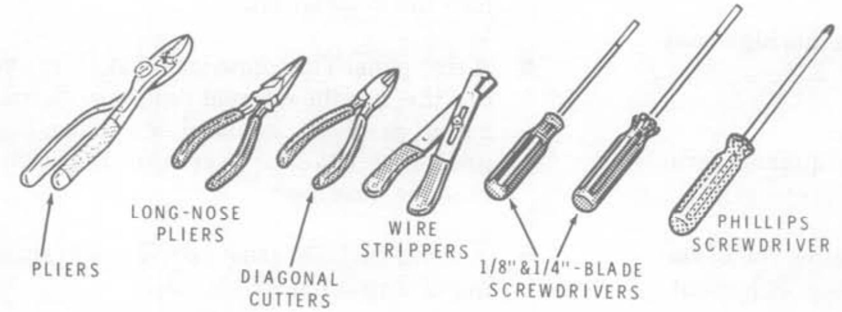
- Frequency, period, and frequency ratio modes of operation.
- Trigger level control that assures you of stable counting when signal noise is present.
- Effective limiting circuits at both inputs to assure you of stable counting as the input signal level is varied over a 60 dB range.
- A proportionally-controlled crystal oven to keep the internal time base extremely accurate over a wide ambient temperature range.
- The use of a high-stability crystal in the time base oscillator to hold the drift to less than 1 part per million per year.
- A Standby/On front-panel Power switch that provides full accuracy the moment you turn the Counter on.
- A rear panel Time Base jack that allows you to either use the internal time base signal as a semi-precision standard or to use a high-precision standard as the Frequency Counter time base.
- A metal enclosure that provides RFI shielding of unwanted RF signals.
- A locking swing-down bail to support the front of the instrument at a more convenient viewing angle.

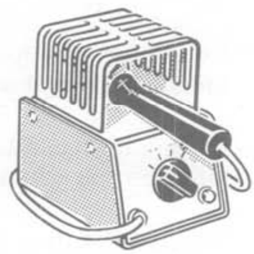
This carefully designed, state-of-the-art Frequency Counter will provide long, reliable performance for your laboratory or workbench.

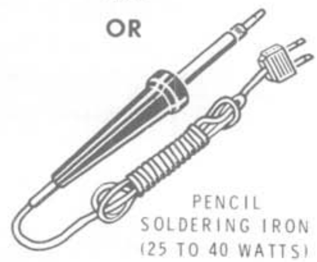
ASSEMBLY NOTES

TOOLS

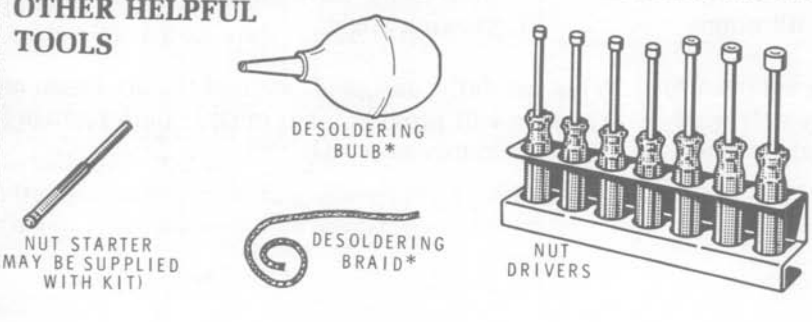
You will need these tools to assemble your kit.







OTHER HELPFUL TOOLS



*TO REMOVE SOLDER FROM CIRCUIT CONNECTIONS.

ASSEMBLY

1. Follow the instructions carefully. Read the entire step before you perform each operation.

2. The illustrations in the Manual are called Pictorials and Details. Pictorials show the overall operation for a group of assembly steps; Details generally illustrate a single step. When you are directed to refer to a certain Pictorial "for the following steps," continue using that Pictorial until you are referred to another Pictorial for another group of steps.

3. Most kits use a separate "Illustration Booklet" that contains illustrations (Pictorials, Details, etc.) that are too large for the Assembly Manual. Keep the "Illustration Booklet" with the Assembly Manual. The illustrations in it are arranged in Pictorial number sequence.

4. Position all parts as shown in the Pictorials.

5. Solder a part or a group of parts only when you are instructed to do so.

6. Each circuit part in an electronic kit has its own component number (R2, C4, etc.). Use these numbers when you want to identify the same part in the various sections of the Manual. These numbers, which are especially useful if a part has to be replaced, appear:

   — In the Parts List,

   — At the beginning of each step where a component is installed,

   — In some illustrations,

   — In the Schematic,

   — In the sections at the rear of the Manual.

7. When you are instructed to cut something to a particular length, use the scales (rulers) provided at the bottom of the Manual pages.

SAFETY WARNING: Avoid eye injury when you cut off excessive lead lengths. Hold the leads so they cannot fly toward your eyes.

SOLDERING

Soldering is one of the most important operations you will perform while assembling your kit. A good solder connection will form an electrical connection between two parts, such as a component lead and a circuit board foil. A bad solder connection could prevent an otherwise well-assembled kit from operating properly.

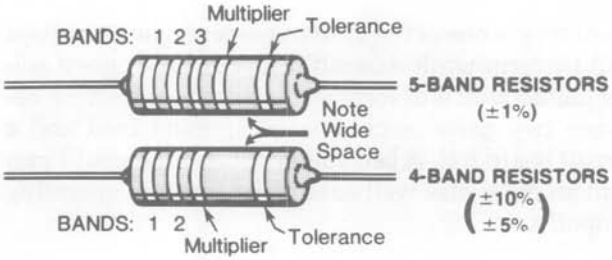
It is easy to make a good solder connection if you follow a few simple rules:

1. Use the right type of soldering iron. A 25 to 40-watt pencil soldering iron with a 1/8" or 3/16" chisel or pyramid tip works best.

2. Keep the soldering iron tip clean. Wipe it often on a wet sponge or cloth; then apply solder to the tip to give the entire tip a wet look. This process is called tinning, and it will protect the tip and enable you to make good connections. When solder tends to "ball" or does not stick to the tip, the tip needs to be cleaned and retinned.

NOTE: Always use rosin core, radio-type solder (60:40 or 50:50 tin-lead content) for all of the soldering in this kit. This is the type we have supplied with the parts. The Warranty will be void and we will not service any kit in which acid core solder or paste has been used.

PARTS



Resistors are identified in Parts Lists and steps by their resistance value in Ω (ohms), kΩ (kilohms), or MΩ (megohms). They are usually identified by a color code of four or five color bands, where each color represents a number. See the "Resistor Color Code" chart. These colors are given in the steps in their proper order (except for the last band, which indicates a resistor's "tolerance"; see the "Resistor Tolerance" chart). You do not need to know the color code.

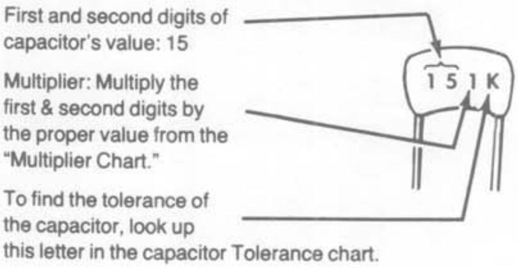
Occasionally, a "precision" or "power" resistor may have the value stamped on it. The letter R, K, or M may also be used at times to signify a decimal point, as in: 2R2 = 2.2 Ω
2K2 = 2.2 kΩ, or 2200 Ω
2M2 = 2.2 MΩ

Precision resistors may also be marked as shown in the following examples. The values of the multipliers are shown in the "Multiplier Chart," and the tolerance values are shown in the "Resistor Tolerance" chart.

Resistor Value — Multiplier — Tolerance

EXAMPLES: 1009C = 100 × 0.1 = 10 Ω, ±0.25%
1001D = 100 × 10 = 1000 Ω, ±0.5%

Capacitors will be called out by their capacitance value in μF (microfarads) or pF (picofarads) and type: ceramic, Mylar®, electrolytic, etc. Some capacitors may have their value printed in the following manner:



RESISTOR COLOR CODE

	Band 1	Band 2	Band 3 (if used)	Multiplier
Color	1st Digit	2nd Digit	3rd Digit	
Black	0	0	0	1
Brown	1	1	1	10
Red	2	2	2	100
Orange	3	3	3	1,000
Yellow	4	4	4	10,000
Green	5	5	5	100,000
Blue	6	6	6	1,000,000
Violet	7	7	7	0.01
Gray	8	8	8	0.1
White	9	9	9	

RESISTOR TOLERANCE

	COLOR OR LETTER	
±10%	SILVER	
± 5%	GOLD	J
± 2%	RED	G
± 1%	BROWN	F
±0.5%	GREEN	D
±0.25%	BLUE	C
±0.1%	VIOLET	B
±0.05%	GRAY	

MULTIPLIER CHART

FOR THE NUMBER:	MULTIPLY BY:	FOR THE NUMBER:	MULTIPLY BY:
0	1	4	10,000
1	10	5	100,000
2	100	8	0.01
3	1000	9	0.1

CAPACITOR TOLERANCE

LETTER	10 pF OR LESS	OVER 10 pF
B	±0.1 pF	
C	±0.25 pF	
D	±0.5 pF	
F	±1.0 pF	±1%
G	±2.0 pF	±2%
H		±3%
J		±5%
K		±10%
M		±20%

EXAMPLES: 151K = 15 × 10 = 150 pF
759 = 75 × 0.1 = 7.5 pF

NOTE: The letter "R" may be used at times to signify a decimal point, as in: 2R2 = 2.2 (pF or μF).

PARTS LIST

Unpack the kit and check each part against the following list. The key numbers correspond to the numbers in the Parts Pictorial (Illustration Booklet, Pages 1 through 3). Return any part that is packed in an individual envelope back to the envelope after you identify it. Keep these parts in the envelopes until they are called for in an assembly step. Do NOT throw away any packing material until you account for all the parts.

To order a replacement part, always include the Part Number. 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 this Manual. For prices, refer to the separate "Heath Parts Price List."

RESISTORS

NOTES:

1. The resistors may be packed in more than one envelope. Open all the resistor envelopes in this pack before you check the resistors against the following list.
2. All color-coded 1% resistors have five color bands (last band brown). This brown band is set aside from the other bands. The last band (brown) will not be called out.
3. All 5% resistors have four color bands (last band gold). The last band (gold) will not be called out.

1/4-Watt, 1%

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	2-753-12	1	3010 Ω (3011F), 25 PPM/°C	R61
A2	6-4991-12	1	4990 Ω, 100 PPM/°C (yel-wht-wht-brn)	R59
A2	6-6531-12	1	6530 Ω, 100 PPM/°C (blu-grn-org-brn)	R58
A1	2-756-12	1	412 kΩ (4123F), 25 PPM/°C	R63

1/4-Watt, 5%

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A3	6-100-12	5	10 Ω (brn-blk-blk)	R4, R23, R29, R36, R73
A3	6-150-12	1	15 Ω (brn-grn-blk)	R30
A3	6-560-12	1	56 Ω (grn-blu-blk)	R31
A3	6-620-12	2	62 Ω (blu-red-blk)	R71, R72
A3	6-680-12	1	68 Ω (blu-gry-blk)	R32
A3	6-101-12	4	100 Ω (brn-blk-brn)	R26, R42, R43, R69
A3	6-121-12	1	120 Ω (brn-red-brn)	R24

Resistors (cont'd.)

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A3	6-151-12	18	150 Ω (brn-grn-brn)	R12, R13, R14, R15, R18, R19, R37, R38, R39, R41, R46, R47, R48, R49, R51, R52, R53, R54
A3	6-181-12	1	180 Ω (brn-gry-brn)	R106
A3	6-221-12	4	220 Ω (red-red-brn)	R5, R17, R57, R74
A3	6-241-12	2	240 Ω (red-yel-brn)	R22, R35
A3	6-471-12	1	470 Ω (yel-viol-brn)	R85
A3	6-561-12	1	560 Ω (grn-blu-brn)	R6
A3	6-821-12	1	820 Ω (gry-red-brn)	R104
A3	6-911-12	2	910 Ω (wht-brn-brn)	R21, R34
A3	6-102-12	14	1000 Ω (brn-blk-red)	R3, R7, R8, R16, R75, R76, R77, R78, R79, R81, R82, R83, R84, R103
A3	6-182-12	1	1800 Ω (brn-gry-red)	R11
A3	6-222-12	3	2200 (red-red-red)	R25, R55, R56
A3	6-472-12	2	4700 Ω (yel-viol-red)	R27, R28
A3	6-822-12	1	8200 Ω (gry-red-red)	R101
A3	6-103-12	2	10 kΩ (brn-blk-org)	R64, R68,
A3	6-153-12	1	15 kΩ (brn-grn-org)	R102
A3	6-183-12	1	18 kΩ (brn-gry-org)	R33
A3	6-473-12	1	47 kΩ (yel-viol-org)	R65
A3	6-563-12	1	56 kΩ (grn-blu-org)	R105
A3	6-104-12	4	100 kΩ (brn-blk-yel)	R2, R44, R45, R66
A3	6-105-12	1	1 MΩ (brn-blk-grn)	R1

CAPACITORS

Mica

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
B1	20-188	1	30 pF	C102
B1	20-190	1	51 pF	C2
B1	20-102	1	100 pF	C7
B1	20-103	1	150 pF	C105
B1	20-139	2	330 pF	C4, C104

Ceramic

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
B2	21-711	3	470 pF (471)	C11,C14, C22
B3	21-140	1	.001 μF (.001 M)	C106
B2	21-717	27	.01 μF (103) square	C8, C9, C12, C13, C15, C17, C18, C19, C20, C21, C23, C25, C26, C27, C28, C29, C33, C45, C47, C48, C49, C51, C52, C53, C54, C55 C56
B4	21-70	1	.01 μF* round	C35
B2	21-192	1	.1 μF (104M)	C3

Electrolytic

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
B5	25-917	3	10 μF	C41, C42, C43
B5	25-915	2	47 μF	C44, C46
B6	25-874	2	470 μF	C36, C37
B6	25-272	2	6000 μF	C38, C39

Tantalum

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
B7	25-837	2	1.5 μF	C31, C32
B7	25-838	1	3.3 μF	C103
B7	25-281	3	39 μF	C5, C16, C24
B7	25-282	1	68 μF	C6

Other Capacitors

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
B8	27-85	1	.22 μF Mylar	C34
B9	29-64	1	.15 μF polycarbonate	C1
B10	31-95	1	2.5-18 pF trimmer	C101

*This part is critical to continued safety. Replace only with a Heath Company part.

DIODES

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
C1	56-86	2	FD777 (TID 777)	D1, D2
C1	56-87	4	HP5	D5, D6, D7, D8
C1	57-65	4	1N4002	D24, D25, D26, D27
C1	56-56	12	1N4149	D3, D4, D9, D11, D12, D13, D14, D16, D17, D18, D19, D21
C1	56-612	1	1N5229B	D15
C1	57-42	2	3A1	D22, D23

TRANSISTORS — INTEGRATED CIRCUITS (IC's)

NOTE: Transistors and integrated circuits are marked for identification in one of the following ways:

1. Part number.
2. Type number. (On integrated circuits this refers only to the numbers; the letters may be different or missing.)
3. Part number and type number.
4. Part number with a type number other than the one shown.

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
D1	417-172	2	MPS6521 transistor	Q101, Q102
D1	417-801	1	MPSA20 transistor	Q9
D2	417-298	1	TIP41B transistor	Q10
D1	417-293	5	2N5770 transistor	Q2, Q4, Q6, Q7, Q8
D1	417-292	2	2N5771 transistor	Q3, Q5
D1	417-828	1	Selected E304 transistor	Q1
D3	443-937	1	SP8685B IC	U3
D4	442-698	1	SL952 IC	U2
D4	443-755	1	74LS04 IC	U6
D4	443-875	2	74LS32 IC	U36, U37
D3	443-781	1	74LS75 IC	U35
D4	443-813	5	74LS90 IC	U12, U13, U14, U15, U24
D3	443-921	5	74LS390 IC	U9, U11, U21, U22, U23
D4	443-26	2	74S00 IC	U4, U7
D4	443-896	1	74S02 IC	U5
D5	442-644	1	78L12 IC	U41
D6	442-54	2	7805 IC	U42, U43

Heathkit®

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.

IC's (cont'd.)

D5	442-646	1	79L12 IC	U39
D3	443-727	1	96L02 IC	U19
D7	442-21	1	1458 IC	U38
D4	443-15	1	7450 IC	U8
D4	443-936	2	7454 IC	U16, U17
D3	443-16	1	7476 IC	U18
D3	443-694	8	9368 IC	U26, U27, U28, U29, U31, U32, U33, U34
D3	443-723	1	10216 IC	U1
D4	443-628	1	74196 IC	U25

OTHER CIRCUIT COMPONENTS

E1	9-103	1	20 kΩ thermistor	R62
E2	19-743	1	200 Ω control with switch	R9/SW1
	54-982	1	Power transformer	T1
E3	60-1	1	Slide switch	SW5
E4	63-1341	1	STBY/ON switch	SW4
E5	63-1363	1	5-wafer switch	SW2
E6	63-1364	1	1-wafer switch	SW3
E7	404-622	1	10 MHz crystal	Y101
E8	411-860	8	7-segment LED (light emitting diode) display	V1, V2, V3, V4, V5, V6, V7, V8
E9	412-632	3	LED lamp	V9, V11, V12
E10	421-20	1	1/2-ampere slow-blow fuse*	F1
E11	65-75	1	Thermal breaker	TB1
	475-15	1	Ferrite bead	FB1

CLIPS — SHELLS — PLUGS — CONNECTORS — SOCKETS

F1	208-14	1	Circuit board clip	
F2	258-735	1	Ground clip	
F3	432-753	7	Large spring connector (1 extra)	
F4	432-866	11	Small spring connector (1 extra)	
F5	432-821	1	6-hole connector shell	
F6	432-970	1	5-hole connector shell	
F7	432-1080	2	3-hole connector shell	
F8	432-825	1	6-pin plug	P1
F9	432-969	1	5-pin plug	P2
F10	432-59	3	BNC connector	J1, J2, J3
F11	434-230	1	8-pin IC socket	
F12	434-298	23	14-pin IC socket	
F13	434-299	18	16-pin IC socket	
F14	434-341	1	14 pin socket	

* This part is critical to continued safety. Replace only with a Heath Company part or exact replacement.

KEY No.	PART No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.

HARDWARE

NOTE: The hardware may be packed in more than one packet. Open all the hardware packets (marked HDW) before you check the hardware against the Parts List.

#2 Hardware

G1	250-212	4	#2 × 3/16" self-tapping screw
G2	250-1459	2	#2 × 3/16" flat phillips head self-tapping screw

#4 Hardware

H1	250-285	2	4-40 × 1/4" screw
H2	250-4	1	4-40 × 3/8" screw
H3	252-2	2	Large 4-40 nut
H4	252-15	1	Small 4-40 nut
H5	254-9	3	#4 lockwasher

#6 Hardware

J1	250-1282	4	6-32 × 1/8" setscrew
J2	250-56	5	6-32 × 1/4" screw
J3	250-32	4	6-32 × 3/8" flat head screw
J4	250-1280	27	6-32 × 3/8" black phillips head screw
J5	250-127	6	#6 × 1/2" self-tapping screw
J6	252-3	12	6-32 nut
J7	254-1	20	#6 internal lockwasher
J8	254-6	1	#6 external lockwasher
J9	255-129	6	6-32 tapped spacer
J10	259-1	2	#6 solder lug

#8 Hardware

K1	250-1186	2	8-32 × 3/8" black screw
K2	252-4	2	8-32 nut
K3	254-2	2	#8 lockwasher

Other Hardware

L1	252-7	3	3/8-32 nut
L2	253-42	2	#10 flat washer
L3	253-15	2	3/8" fiber flat washer
L4	254-4	2	3/8" lockwasher
L5	254-7	2	#3 lockwasher
L6	259-10	1	Long 3/8" solder lug
L7	259-27	3	Short 3/8" solder lug

LINE CORD — WIRE — SLEEVING — CABLE

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
	89-54	1	Line cord	
	340-2	6″	Bare wire	
	344-33	9″	Black wire	
	344-59	24″	Large white wire	
	344-109	18″	Small white wire	
	345-1	2″	Braid	
	346-30	2″	Sleeving	
	346-60	1-1/2″	Clear tubing	
	347-55	36″	8-wire flat cable	

INSULATORS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
M1	73-147	1	Foam gasket	
M2	75-103	1	Insulating paper	
M3	75-736	1	Strain relief	
M4	95-644	1	Thermistor holder	
M5	95-647	1	Styrofoam* cover	
M6	95-648	1	Styrofoam base	

CABINET PARTS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
N1	90-1265-1	1	Cabinet top	
N2	200-1392-1	1	Chassis	
N3	203-2180-1	1	Front panel	
N4	204-2481	1	Front panel bracket	
N5	204-2525	1	Transformer bracket	
N6	210-86	1	Bezel	
N7	266-187	1	Bail	

* Registered Trademark, Dow Chemical Co.

MISCELLANEOUS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
	85-2618-1	1	Display circuit board	
	85-2617-1	1	Main circuit board	
	85-2415-2	1	Oscillator circuit board	
P1	100-1813	1	Crystal oven assembly	R67
P2	203-2097	1	Window	
P3	204-2513	1	Crystal oven bracket	
P4	205-778	1	Alignment tool blade	
P5	206-1350	1	Crystal oven base	
P6	261-32	1	Right front foot	
P7	261-33	1	Left front foot	
P8	261-61	2	Rear foot	
P9	352-31	1	Thermal compound	
P10	354-7	2	Cable tie	
P11	422-1	1	Fuse block	
P12	431-42	1	Terminal strip	
P13	438-55	1	Polarizing pin	
P14	455-54	2	Nylon bearing	
P15	462-1099	2	Small knob	
P16	462-1100	2	Large knob	
P17	485-14	1	Plug button	
P18	490-5	1	Nut starter	
P19	490-14	1	Allen wrench	
P20	490-111	1	IC puller	
	490-185	1	Soder-Wick**	
			Solder	

PRINTED MATERIAL

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
Q1	390-1255	1	Fuse label	
Q2		1	Blue and white label	
	597-260	1	Parts Order Form	
			Assembly Manual (See Page 1 for part number).	

**Registered Trademark, Solder Removal Co.

STEP-BY-STEP ASSEMBLY

OSCILLATOR CIRCUIT BOARD

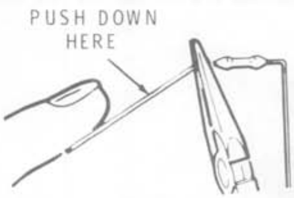
START

In the following steps, you will be given detailed instructions on how to install and solder the first part on the circuit board. Read and perform each step carefully. Then use the same procedure whenever you install parts on a circuit board.

( ) Position the oscillator circuit board as shown with the printed side (not the foil side) up.

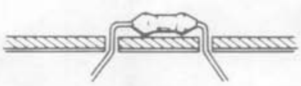
NOTE: When you install a component that has its value printed on it, position the value marking up, so it can be easily read. Diodes should be mounted with their type or part number up, if possible.

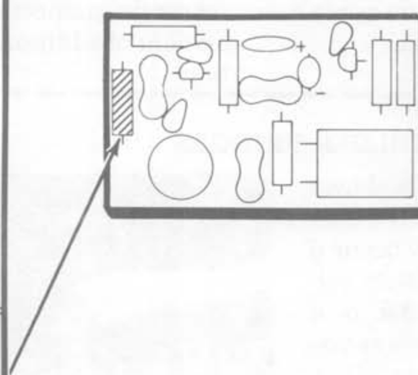
( ) Hold an 820 Ω (gry-red-brn) resistor with long-nose pliers and bend the leads straight down to fit the hole spacing on the circuit board.



( ) R104: Push the leads through the holes at the indicated location on the circuit board. The end with color bands may be positioned either way.

( ) Press the resistor against the circuit board. Then bend the leads outward slightly to hold the resistor in place.



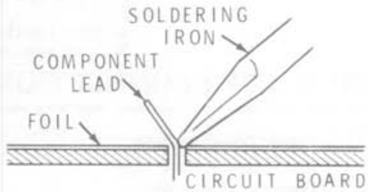


PICTORIAL 1-1

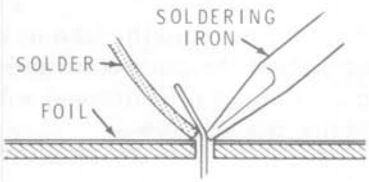
CONTINUE

( ) Turn the circuit board over and solder the resistor leads to the foil as follows:

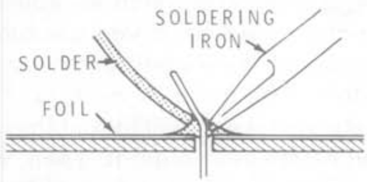
1. Push the soldering iron tip against both the lead and the circuit board foil. Heat **both** for two or three seconds.



2. Then apply solder to the other side of the connection. IMPORTANT: Let the heated lead and the circuit board foil melt the solder.



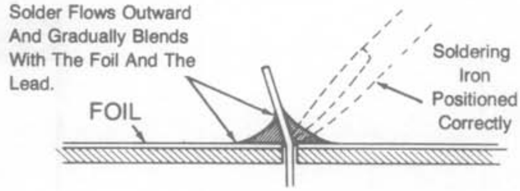
3. As the solder begins to melt, allow it to flow around the connection. Then remove the solder and the iron and let the connection cool.



( ) Cut off the excess lead lengths close to the connection. WARNING: Clip the leads so the ends will not fly toward your eyes.

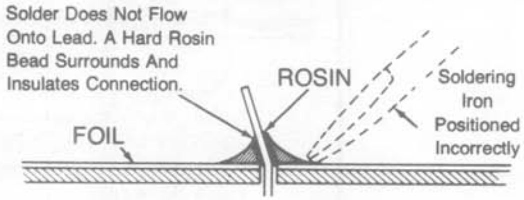
( ) Check each connection. Compare it to the illustration on Page 12. After you have checked the solder connections, proceed with the assembly on Page 13. Use the same soldering procedure for each connection.

A GOOD SOLDER CONNECTION

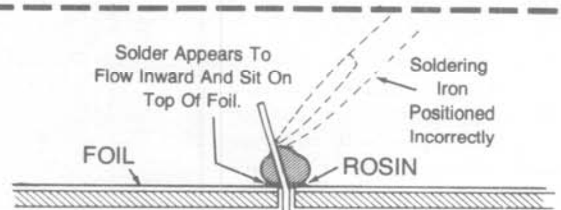


When you heat the lead and the circuit board foil at the same time, the solder will flow evenly onto the lead and the foil. The solder will make a good electrical connection between the lead and the foil.

POOR SOLDER CONNECTIONS



When the lead is not heated sufficiently, the solder will not flow onto the lead as shown above. To correct, reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection.

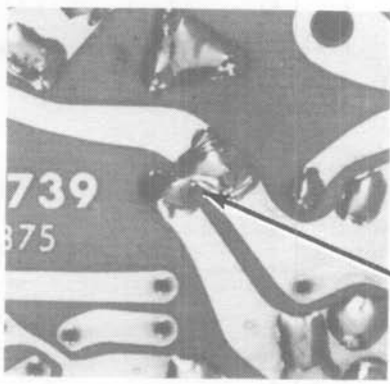


When the foil is not heated sufficiently the solder will blob on the circuit board as shown above. To correct, reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection.

SOLDER BRIDGES

A solder bridge between two adjacent foils is shown in photograph **A**. Photograph **B** shows how the connection should appear. A solder bridge may occur if you accidentally touch an adjacent previously soldered connection, if you use too much solder, or if you "drag" the soldering iron across other foils as you remove it from the connection. A good rule to follow is: always take a good look at the foil area around each lead before you solder it. Then, when you solder the connection, make sure the solder remains in this area and does not bridge to another foil. This is especially important when the foils are small and close together. NOTE: It is alright for solder to bridge two connections on the same foil.

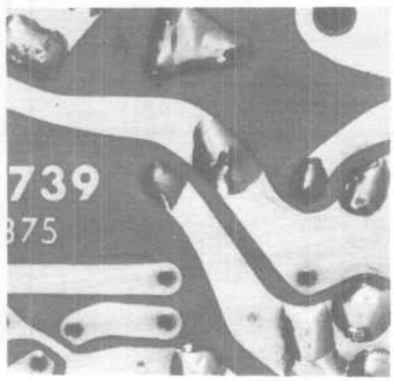
Use only enough solder to make a good connection, and lift the soldering iron straight up from the circuit board. If a solder bridge should develop, turn the circuit board foil-side-down and heat the solder between connections. The excess solder will run onto the tip of the soldering iron, and this will remove the solder bridge. NOTE: The foil side of most circuit boards has a coating on it called "solder resist." This is a protective insulation to help prevent solder bridges.



A

SOLDER BRIDGE

B



START

NOTE: Make sure you installed the resistor in Pictorial 1-1.

( ) R106: 180 Ω (brn-gray-brn).

( ) R105: 56 kΩ (grn-blu-org). NOTE: The circuit board may be marked 10K at this location.

( ) R101: 8200 Ω (gry-red-red).

( ) R102: 15 kΩ (brn-grn-org).

IMPORTANT: When you are instructed to "cut off the excess lead lengths," as in the following step, make sure you cut each lead off as close to the foil as possible.

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

( ) R103: 1000 Ω (brn-blk-red). NOTE: The circuit board may be marked 2200 at this location.

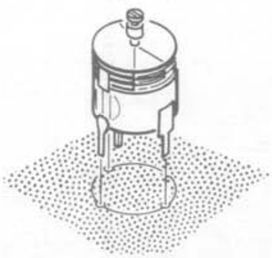
( ) C104: 330 pF mica.

( ) C105: 150 pF mica.

( ) C102: 30 pF mica.

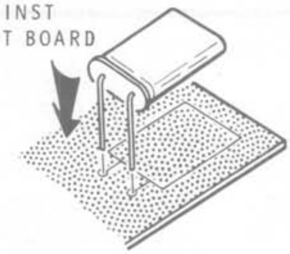
( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) C101: 2.5-18 pF trimmer. Solder the lugs to the foil. Then cut off the excess lug lengths.



CONTINUE

( ) Y101: 10 MHz crystal (#404-622). First bend each lead at a right angle 1/16" from the bottom of the crystal. Use long-nose pliers. Carefully insert the leads into the circuit board holes. Then position the crystal down against the circuit board and solder the leads to the foil. Finally, cut off the excess lead lengths.

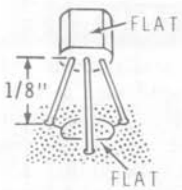


PICTORIAL 1-2

START

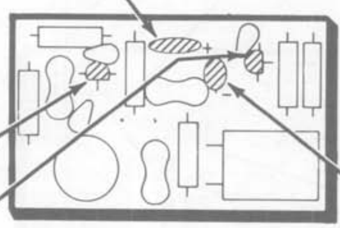
( ) C106: .001 μF (.001M) ceramic. Solder the leads to the foil and cut off the excess lead lengths.

NOTE: When you install a transistor in each of the following steps, align its flat with the flat on the board. Insert the leads into their correct holes. Position the transistor 1/8" above the board. Then solder the leads to the foil and cut off the excess lead lengths.



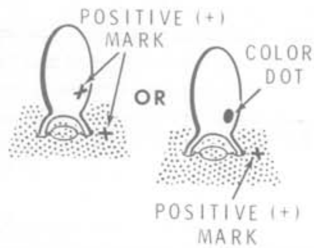
( ) Q101: MPS6521 transistor (#417-172).

( ) Q102: MPS6521 transistor (#417-172).



CONTINUE

NOTE: When you install a tantalum capacitor, match the positive (+) mark, or color dot on the capacitor with the positive (+) mark on the board.



( ) C103: 3.3 μF tantalum. Solder the leads to the foil and cut off the excess lead lengths.

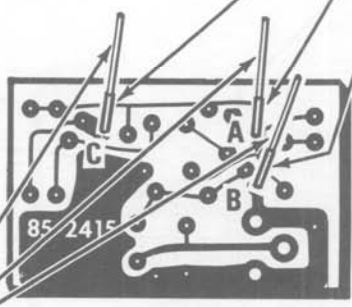
PICTORIAL 1-3

START

( ) Position the circuit board as shown with the foil side up.

( ) Remove a 3/4" length of insulation from one end of a 3" large white wire. Cut the insulation into three 1/4" lengths. Remove and discard the remaining insulation. Cut the bare wire into three 1" lengths. NOTE: Use the three 1" lengths of bare wire in the next step.

( ) Install 1" bare wires in holes A, B, and C. Insert each wire from the foil side of the circuit board. Make sure the end of each wire is flush with the lettered side of the circuit board. Then solder each wire to the foil.



CONTINUE

( ) Place a 1/4" of wire insulation, set aside earlier, on each of the three bare wires you installed in the last step. Push the insulation down against the foil side of the circuit board.

Circuit Board Checkout

Carefully inspect the circuit board for the following most commonly made errors.

( ) Unsoldered connections.

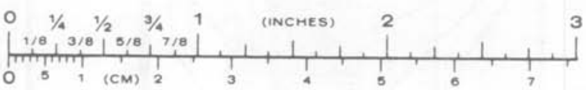
( ) Poor solder connections.

( ) Solder bridges between foils.

( ) Transistors for the proper **type** and **installation**.

( ) Tantalum capacitor for the correct position of the positive (+) or dot-marked lead.

Set the oscillator circuit board aside until it is called for in a step.



PICTORIAL 1-4

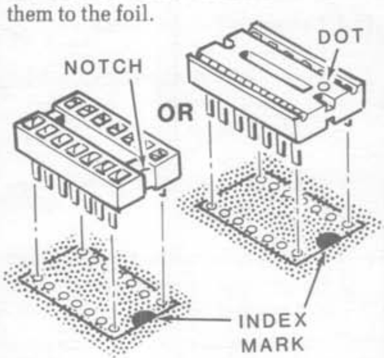
DISPLAY CIRCUIT BOARD

START

( ) Position the display circuit board on your work area as shown.

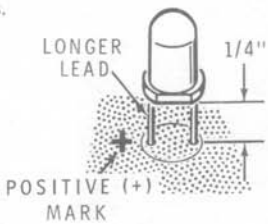
( ) R85: 470 Ω (yel-viol-brn).

NOTE: Before you install an IC socket, make sure the pins are straight. If there is any kind of identification mark (notch, dot, arrowhead, etc.) at or near one end of the socket, place this marked end toward the index mark on the circuit board (this index mark should still be visible after you install the socket). Then start the pins into the circuit board holes and solder them to the foil.

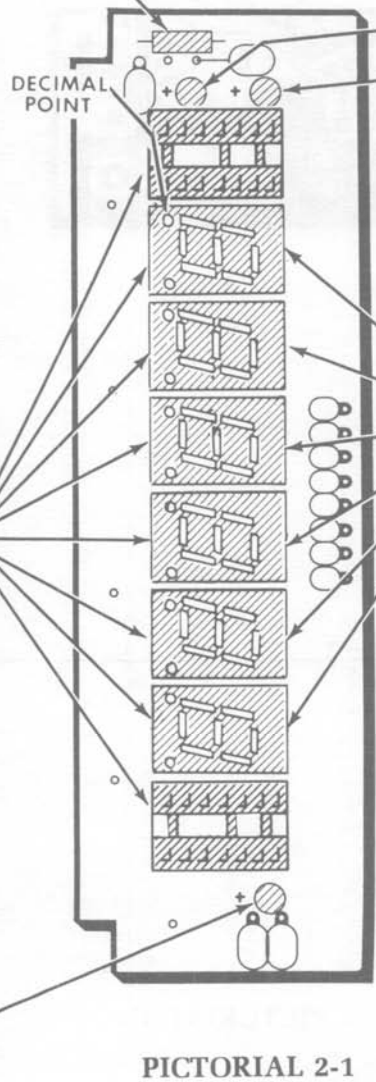


( ) Install eight 14-pin IC sockets at locations V1 through V8.

NOTE: When you install an LED lamp, match the longer end of the lamp with the positive (+) mark on the circuit board. **Position the lamp 1/4" above the circuit board.** Then solder the leads to the foil and cut off the excess lead lengths.



( ) V9: LED lamp (#412-632).



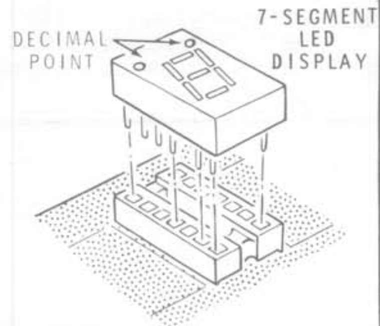
PICTORIAL 2-1

CONTINUE

( ) V12: LED lamp (#412-632).

( ) V11: LED lamp (#412-632).

( ) V2-V7: Install a 7-segment light-emitting diode (LED) display in each of the indicated **six** IC sockets. Position the decimal points of each display as shown. Press each display firmly into its socket.



NOTE: You will install the remaining two LED displays later.

Circuit Board Checkout

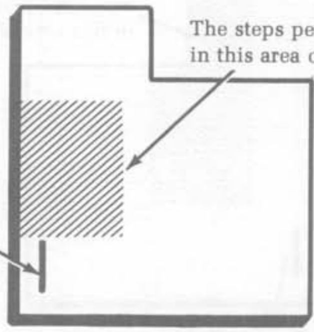
Carefully inspect the circuit board for the following most commonly made errors.

( ) Unsoldered connections.
( ) Poor solder connections.
( ) Solder bridges between foils.
( ) LED lamps for proper installation.
( ) LED displays for proper installation.

Set the display circuit board aside until it is called for in a step.

MAIN CIRCUIT BOARD

IDENTIFICATION DRAWING



START

( ) Position the main circuit board as shown in the Identification Drawing with the printed side up.

NOTE: Only a portion of the circuit board is shown in the following Pictorials. The small "Identification Drawing" at the top of the page shows the area of the circuit board to be assembled.

( ) R45: 100 kΩ (brn-blk-yel).

( ) R75: 1000 Ω (brn-blk-red).

( ) R74: 220 Ω (red-red-brn).

( ) R44: 100 kΩ (brn-blk-yel).

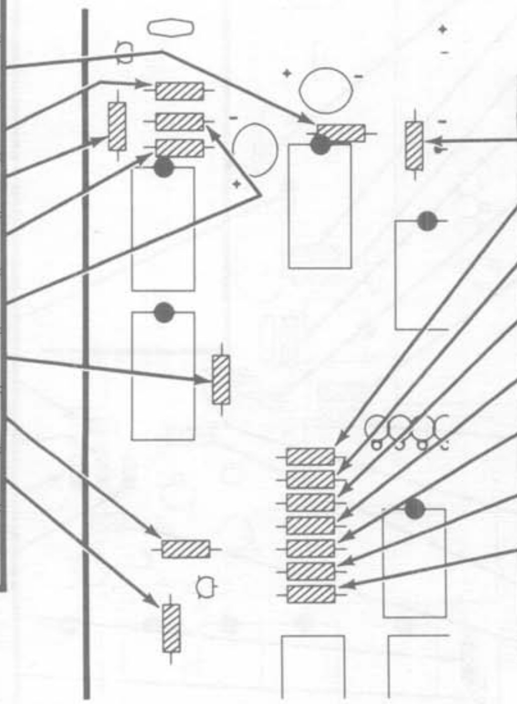
( ) R76: 1000 Ω (brn-blk-red).

( ) R55: 2200 Ω (red-red-red).

( ) R56: 2200 Ω (red-red-red).

( ) R57: 220 Ω (red-red-brn).

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



CONTINUE

( ) R69: 100 Ω (brn-blk-brn).

( ) R83: 1000 Ω (brn-blk-red).

( ) R84: 1000 Ω (brn-blk-red).

( ) R79: 1000 Ω (brn-blk-red).

( ) R81: 1000 Ω (brn-blk-red).

( ) R82: 1000 Ω (brn-blk-red).

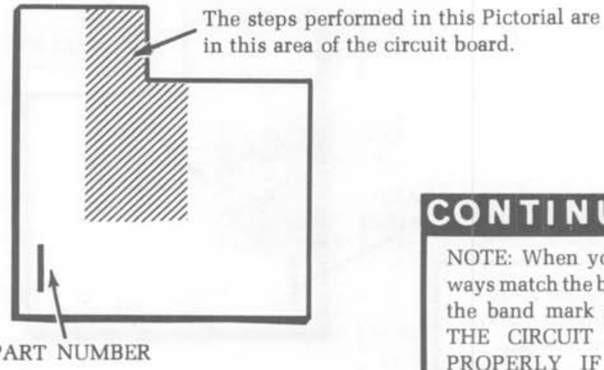
( ) R77: 1000 Ω (brn-blk-red).

( ) R78: 1000 Ω (brn-blk-red).

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

PICTORIAL 3-1

IDENTIFICATION DRAWING



START

( ) R68: 10 kΩ (brn-blk-org).

( ) R66: 100 kΩ (brn-blk-yel).

( ) R65: 47 kΩ (yel-viol-org).

( ) R64: 10 kΩ (brn-blk-org).

( ) R58: 6530 Ω, 1% (blu-grn-org-brn).

( ) R61: 3010 Ω (3011F), 1%.

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

( ) R63: 412 kΩ (4123F), 1%.

( ) R59: 4990 Ω, 1% (yel-wht-wht-brn).

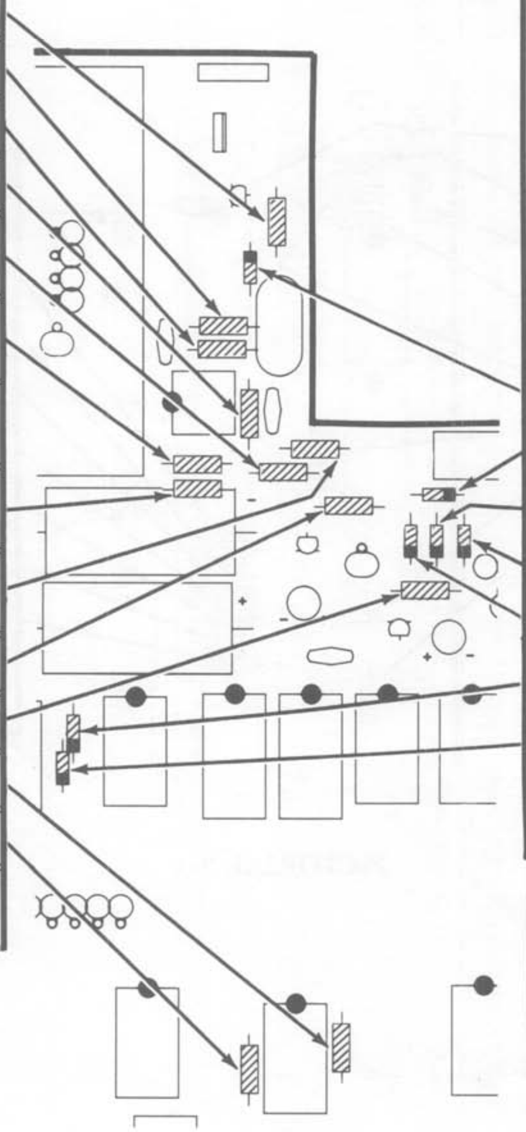
( ) R71: 62 Ω (blu-red-blk).

( ) R72: 62 Ω (blu-red-blk).

( ) R43: 100 Ω (brn-blk-brn).

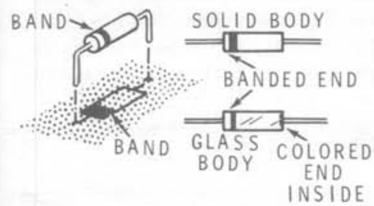
( ) R41: 150 Ω (brn-grn-brn).

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



CONTINUE

NOTE: When you install a diode, always match the band on the diode with the band mark on the circuit board. THE CIRCUIT WILL NOT WORK PROPERLY IF A DIODE IS INSTALLED BACKWARDS. See Detail 3-2A.



If your diode has a solid body, the band is clearly defined. If your diode has a glass body, do not mistake the colored end inside the diode for the banded end. Look for a band painted on the outside of the glass.

( ) D21: 1N4149 diode (#56-56).

( ) D26: 1N4002 diode (#57-65).

( ) D24: 1N4002 diode (#57-65).

( ) D25: 1N4002 diode (#57-65).

( ) D27: 1N4002 diode (#57-65).

( ) D15: 1N5229B diode (#56-612).

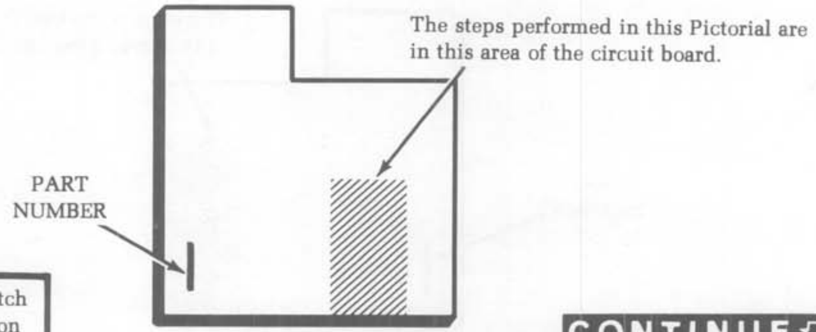
( ) D14: 1N4149 diode (#56-56).

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

Detail 3-2A

PICTORIAL 3-2

IDENTIFICATION DRAWING



START

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

( ) D17: 1N4149 diode (#56-56).

( ) D13: 1N4149 diode (#56-56).

( ) D12: 1N4149 diode (#56-56).

( ) R38: 150 Ω (brn-grn-brn).

( ) R24: 120 Ω (brn-red-brn).

( ) R17: 220 Ω (red-red-brn).

( ) R23: 10 Ω (brn-blk-blk).

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

( ) R22: 240 Ω (red-yel-brn).

( ) R18: 150 Ω (brn-grn-brn).

( ) R13: 150 Ω (brn-grn-brn).

( ) R12: 150 Ω (brn-grn-brn).

( ) R5: 220 Ω (red-red-brn).

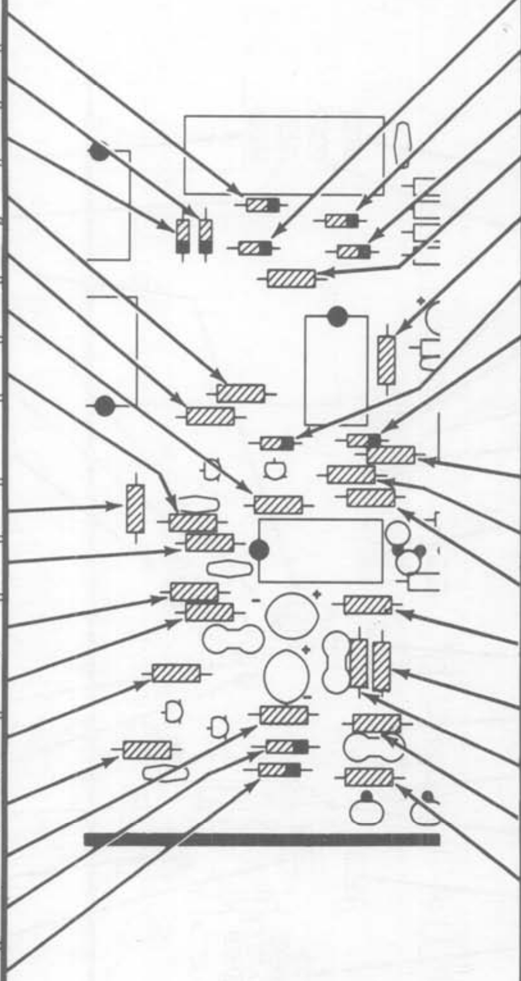
( ) R4: 10 Ω (brn-blk-blk).

( ) R3: 1000 Ω (brn-blk-red).

( ) D2: FD777 diode (#56-86).

( ) D1: FD777 diode (#56-86).

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



CONTINUE

( ) D19: 1N4149 diode (#56-56).

( ) D16: 1N4149 diode (#56-56).

( ) D18: 1N4149 diode (#56-56).

( ) R42: 100 Ω (brn-blk-brn).

( ) R25: 2200 Ω (red-red-red).

( ) D3: 1N4149 diode (#56-56).

( ) D4: 1N4149 diode (#56-56).

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

( ) R21: 910 Ω (wht-brn-brn).

( ) R19: 150 Ω (brn-grn-brn).

( ) R16: 1000 Ω (brn-blk-red).

( ) R7: 1000 Ω (brn-blk-red).

( ) R15: 150 Ω (brn-grn-brn).

( ) R14: 150 Ω (brn-grn-brn).

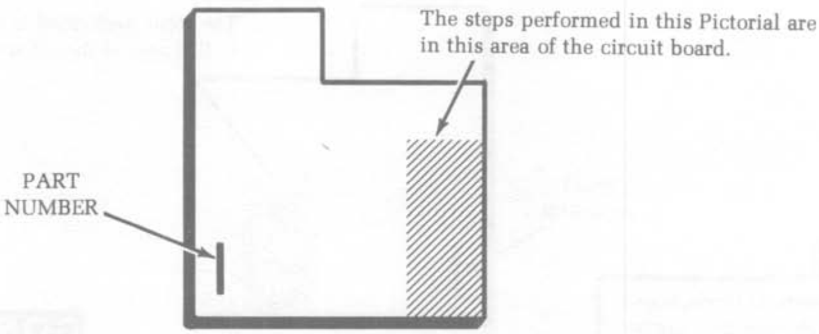
( ) R2: 100 kΩ (brn-blk-yel).

( ) R1: 1 MΩ (brn-blk-grn).

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

PICTORIAL 3-3

IDENTIFICATION DRAWING



START

( ) R46: 150 Ω (brn-grn-brn).

( ) R47: 150 Ω (brn-grn-brn).

( ) R53: 150 Ω (brn-grn-brn).

( ) R52: 150 Ω (brn-grn-brn).

( ) R54: 150 Ω (brn-grn-brn).

( ) R51: 150 Ω (brn-grn-brn).

( ) R73: 10 Ω (brn-blk-blk).

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

( ) R39: 150 Ω (brn-grn-brn).

( ) R11: 1800 Ω (brn-gry-red).

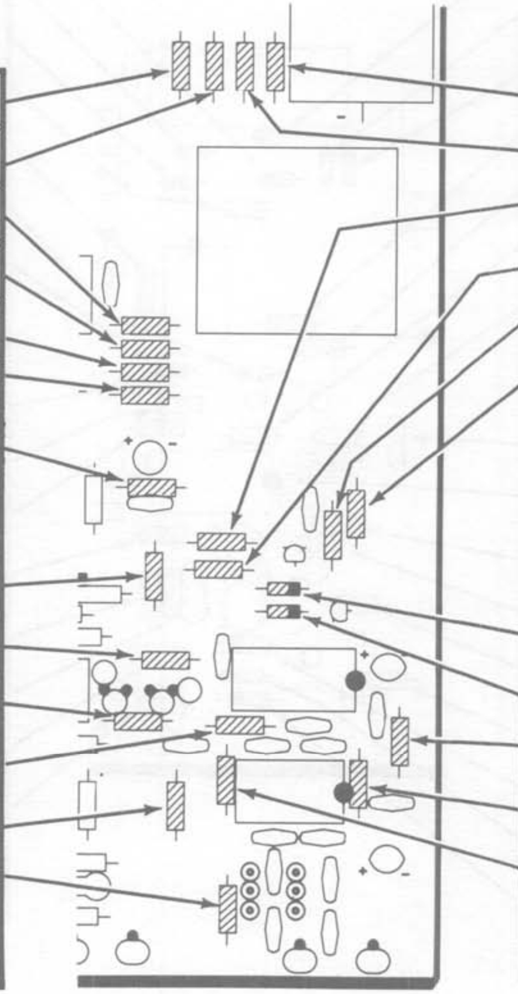
( ) R8: 1000 Ω (brn-blk-red).

( ) R33: 18 kΩ (brn-gry-org).

( ) R6: 560 Ω (grn-blu-brn).

( ) R26: 100 Ω (brn-blk-brn).

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



CONTINUE

( ) R49: 150 Ω (brn-grn-brn).

( ) R48: 150 Ω (brn-grn-brn).

( ) R37: 150 Ω (brn-grn-brn).

( ) R34: 910 Ω (wht-brn-brn).

( ) R35: 240 Ω (red-yel-brn).

( ) R36: 10 Ω (brn-blk-blk).

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

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

( ) D11: 1N4149 diode (#56-56).

( ) D9: 1N4149 diode (#56-56).

( ) R29: 10 Ω (brn-blk-blk).

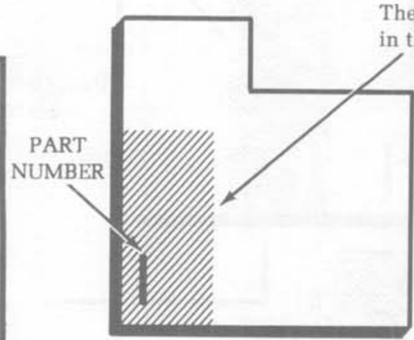
( ) R32: 68 Ω (blu-gry-blk).

( ) R31: 56 Ω (grn-blu-blk).

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

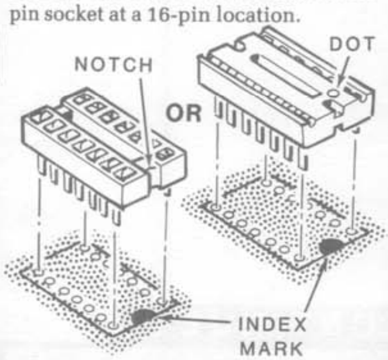
PICTORIAL 3-4

IDENTIFICATION DRAWING



START

NOTE: Before you install an IC socket, make sure the pins are straight. If there is any kind of identification mark (notch, dot, arrowhead, etc.) at or near one end of the socket, place this marked end toward the index mark on the circuit board (this index mark should still be visible after you install the socket). Then start the pins into the circuit board holes and solder them to the foil. Do NOT install a 14-pin socket at a 16-pin location.



( ) 16-pin IC socket at U35.

( ) 16-pin IC socket at U18.

( ) 16-pin IC socket at U21.

( ) 16-pin IC socket at U27.

( ) 16-pin IC socket at U26.

CONTINUE

( ) 14-pin IC socket at U8.

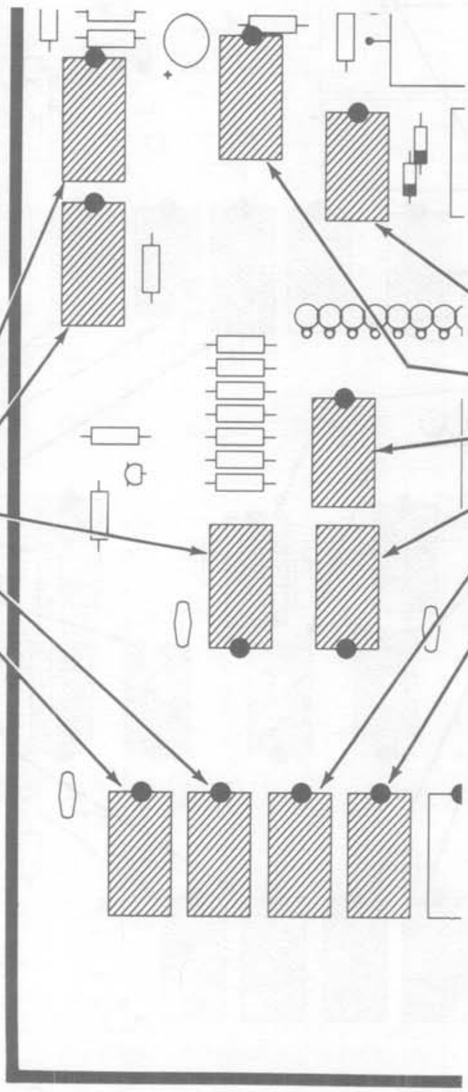
( ) 16-pin IC socket at U19.

( ) 14-pin IC socket at U36.

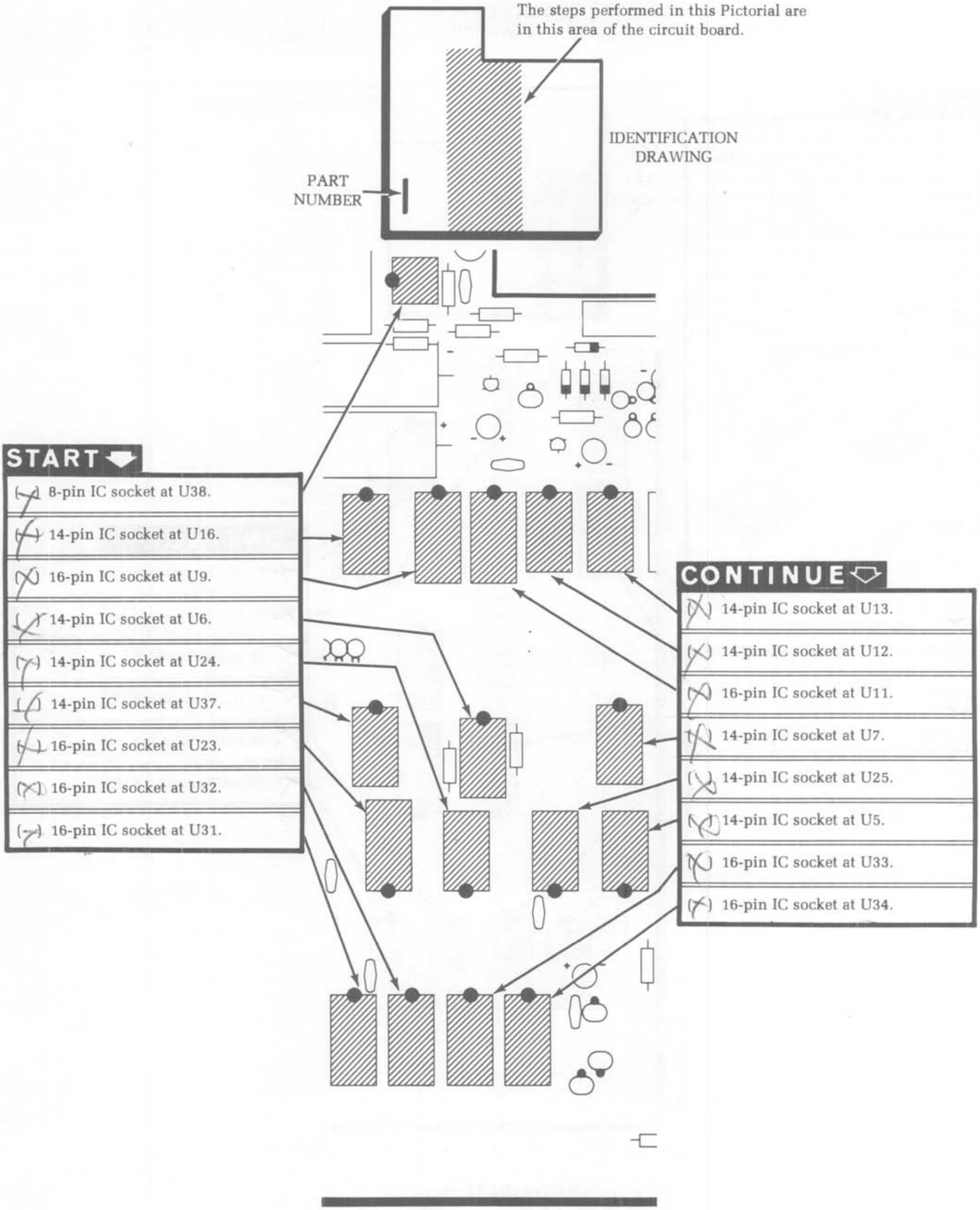
( ) 16-pin IC socket at U22.

( ) 16-pin IC socket at U28.

( ) 16-pin IC socket at U29.

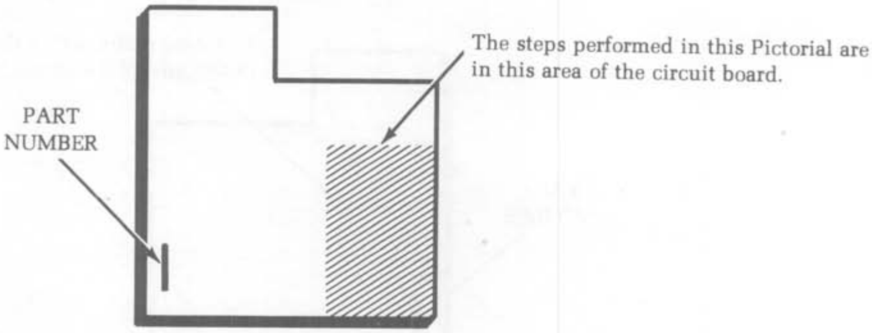


PICTORIAL 3-5



PICTORIAL 3-6

IDENTIFICATION DRAWING



START

( ) 14-pin IC socket at U17.

( ) 14-pin IC socket at U15.

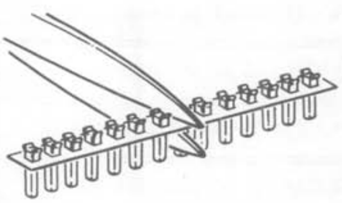
( ) 14-pin IC socket at U14.

( ) 14-pin IC socket at U4.

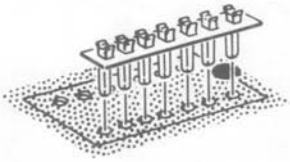
( ) 16-pin IC socket at U3.

( ) 16-pin IC socket at U1.

( ) Locate the strip with 14 pin sockets. Then cut this strip into two halves as shown. Use a pair of scissors.

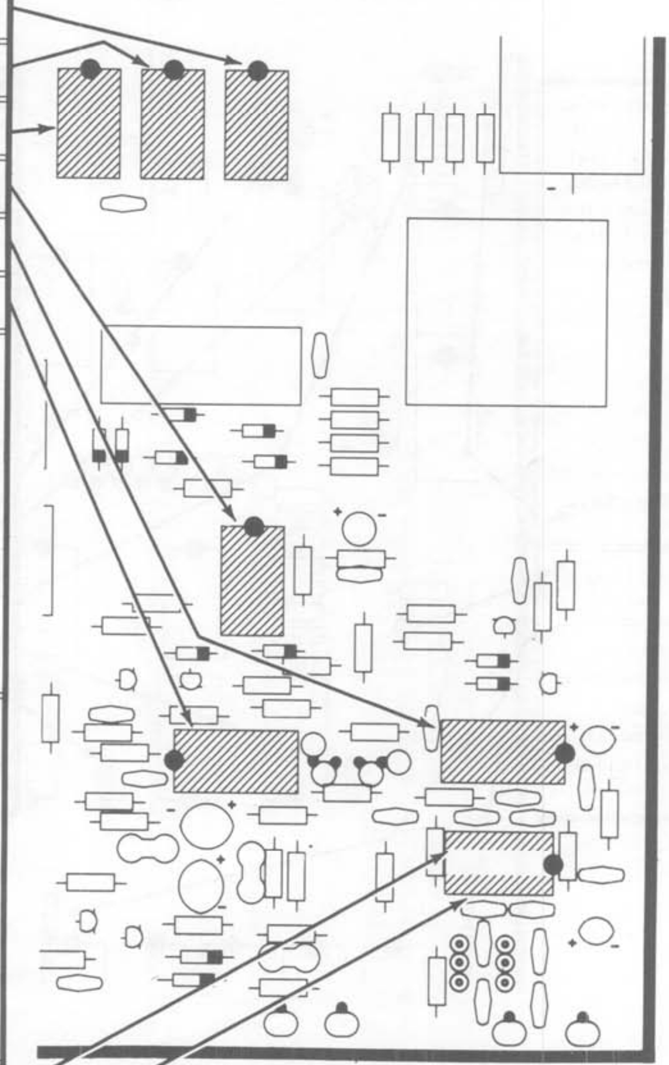


NOTE: You will install the socket strips in the following steps. Insert the pin sockets in their respective holes. Push the assembly all the way down against the circuit board before you solder the pin sockets to the foil.

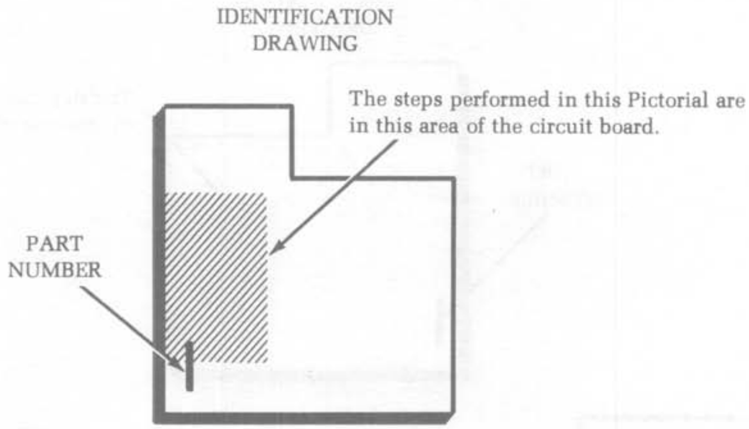


( ) 7-pin socket strip at U2.

( ) 7-pin socket strip at U2.

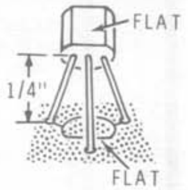


PICTORIAL 3-7



START

NOTE: When you install a transistor in each of the following steps, align its flat with the flat on the circuit board. Insert the leads into their correct holes. Position the transistor 1/4" above the board. Then solder the leads to the foil and cut off the excess lead lengths.



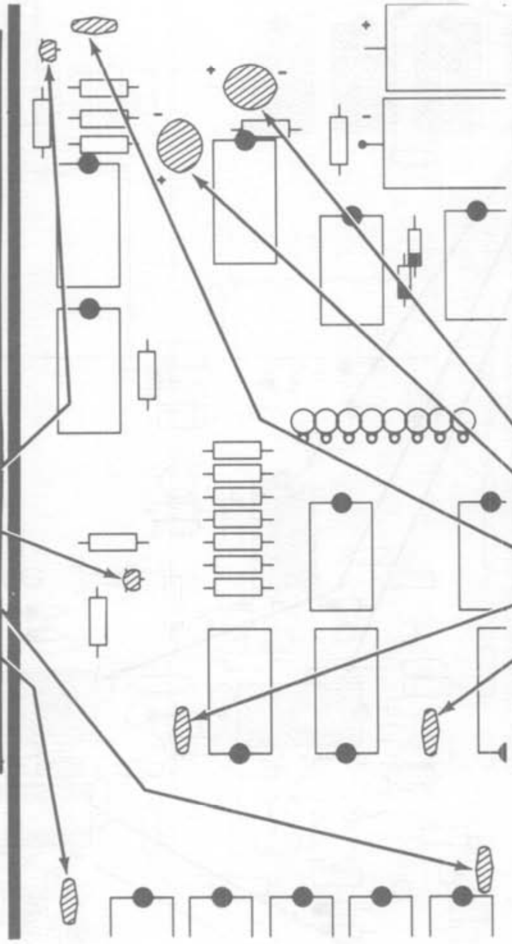
( ) Q8: 2N5770 transistor (#417-293).

( ) Q7: 2N5770 transistor (#417-293).

( ) C53: .01 μF (103) ceramic.

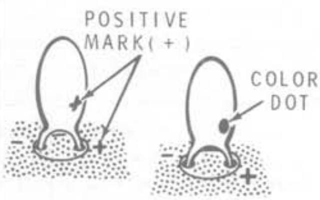
( ) C52: .01 μF (103) ceramic.

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



CONTINUE

NOTE: When you install a tantalum capacitor, match the positive (+) mark or color dot on the capacitor with the positive (+) mark on the circuit board.



( ) C32: 1.5 μF tantalum.

( ) C31: 1.5 μF tantalum.

( ) C29: .01 μF (103) ceramic.

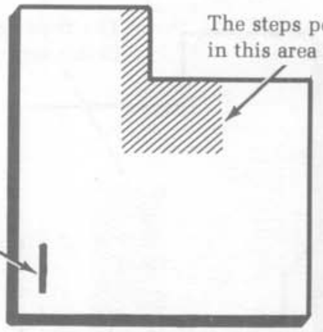
( ) C48: .01 μF (103) ceramic.

( ) C49: .01 μF (103) ceramic.

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

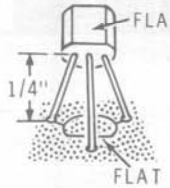
PICTORIAL 3-8

IDENTIFICATION
DRAWING



START

NOTE: When you install a transistor or integrated circuit (IC) in each of the following steps, align its flat with the flat on the circuit board. Insert the leads into their correct holes. Position the transistor or IC 1/4" above the circuit board. Then solder the leads to the foil and cut off the excess lead lengths.



( ) Q9: MPSA20 transistor (#417-801).

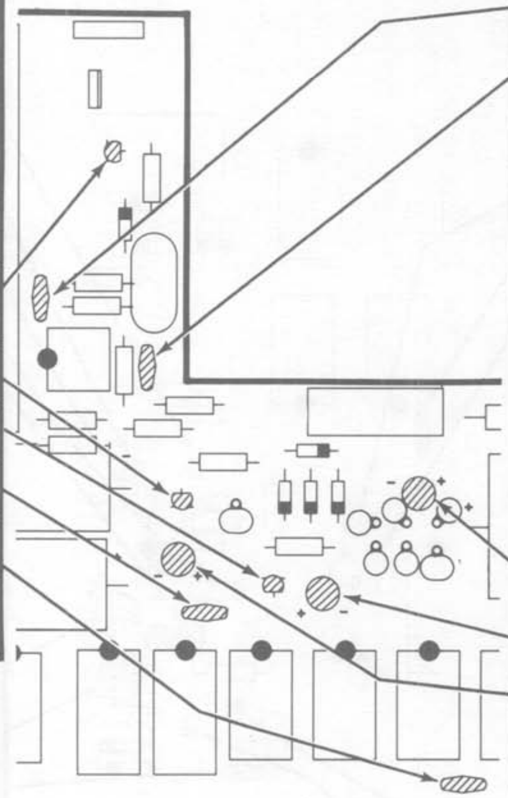
( ) U39: 79L12 IC (#442-646).

( ) U41: 78L12 IC (#442-644).

( ) C27: .01 μF (103) ceramic.

( ) C28: .01 μF (103) ceramic.

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



CONTINUE

( ) C55: .01 μF (103) ceramic.

( ) C56: .01 μF (103) ceramic.

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

NOTE: When you install an electrolytic capacitor, be sure to match the positive (+) mark on the capacitor with the positive (+) mark on the circuit board, or match the negative (−) mark on the capacitor with the negative mark on the circuit board.

( ) C43: 10 μF electrolytic.

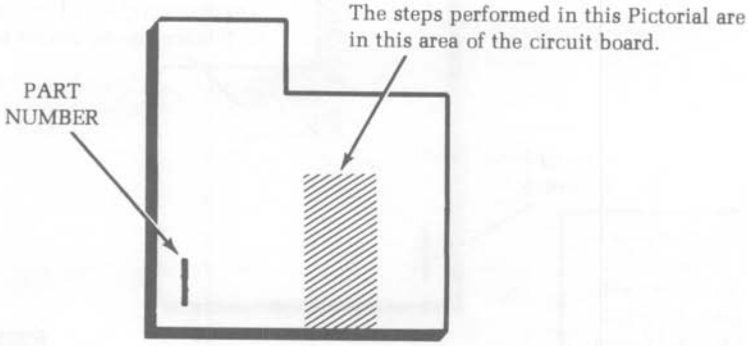
( ) C42: 10 μF electrolytic.

( ) C41: 10 μF electrolytic.

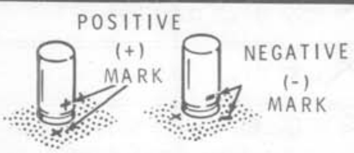
( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 3-9

IDENTIFICATION DRAWING



START



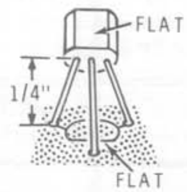
( ) C44: 47 μF electrolytic.

( ) C51: .01 μF (103) ceramic.

( ) C54: .01 μF (103) ceramic.

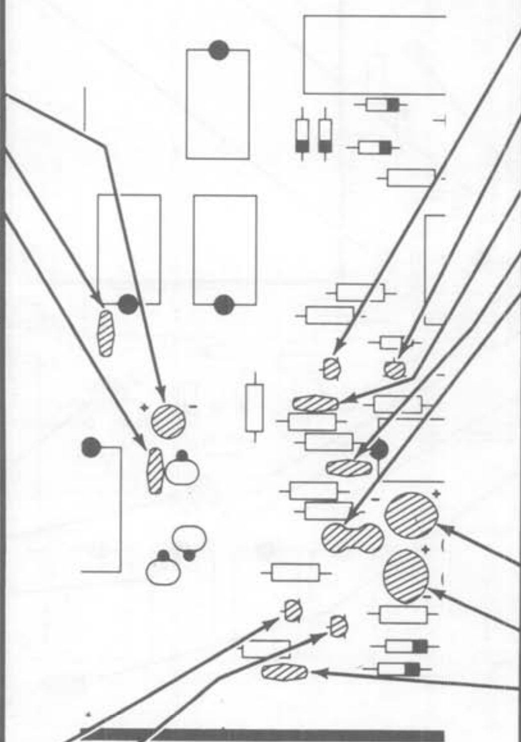
( ) Solder the leads to the foil and cut off the excess lead lengths.

NOTE: When you install a transistor in each of the following steps, align its flat with the flat on the circuit board. Insert the leads into their correct holes. Position the transistor 1/4" above the circuit board. Then solder the leads to the foil and cut off the excess lead lengths.



( ) Q2: 2N5770 transistor (#417-293).

( ) Q1: Selected E304 transistor (#417-828).



CONTINUE

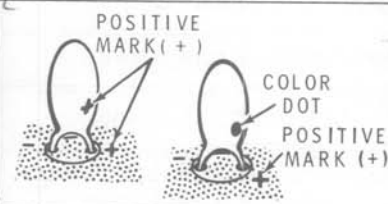
( ) Q4: 2N5770 transistor (#417-293).

( ) Q3: 2N5771 transistor (#417-292).

( ) C9: .01 μF (103) ceramic.

( ) C45: .01 μF (103) ceramic.

( ) C4: 330 pF mica.



( ) C5: 39 μF tantalum.

( ) C6: 68 μF tantalum.

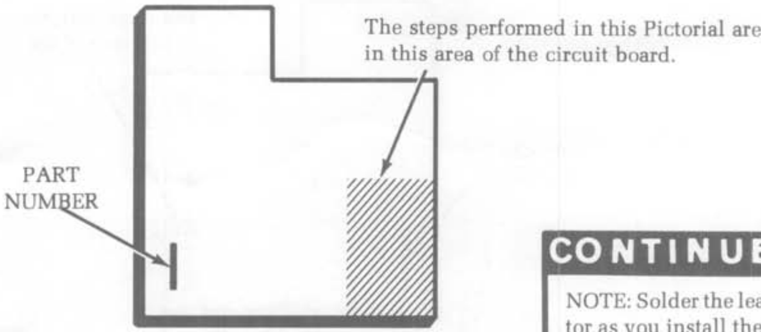
( ) C3: .1 μF (104M) ceramic.

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

PICTORIAL 3-10

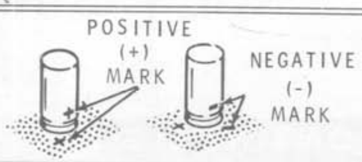
Heathkit®

IDENTIFICATION DRAWING



START

( ) C33: .01 μF (103) ceramic.



( ) C46: 47 μF electrolytic.

( ) C26: .01 μF (103) ceramic.

( ) C47: .01 μF (103) ceramic.

( ) C25: .01 μF (103) ceramic.

( ) C22: 470 pF (471) ceramic.

( ) C19: .01 μF (103) ceramic.

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

( ) C8: .01 μF (103) ceramic.

( ) C7: 100 pF mica.

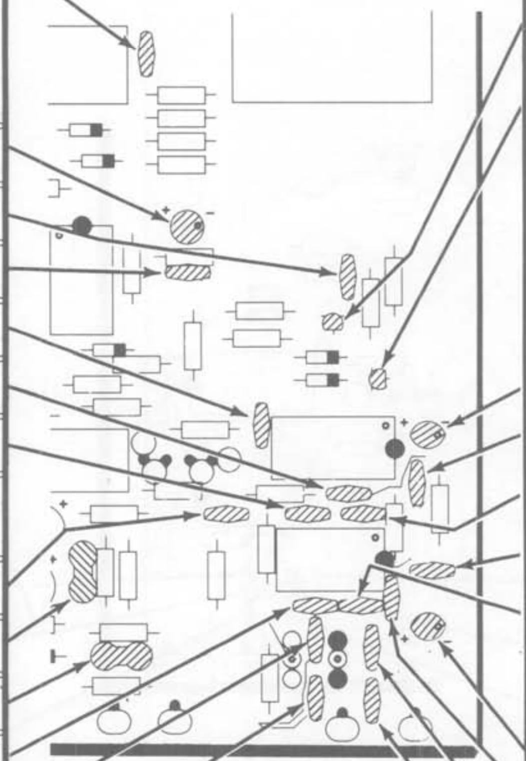
( ) C2: 51 pF mica.

( ) C17: .01 μF (103) ceramic.

( ) C14: 470 pF (471) ceramic.

( ) C11: 470 pF (471) ceramic.

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

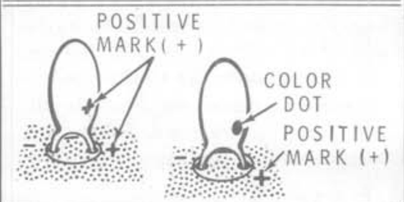


CONTINUE

NOTE: Solder the leads of each transistor as you install them in the next two steps. Then cut off the excess lead lengths.

( ) Q6: 2N5770 transistor (#417-293).

( ) Q5: 2N5771 transistor (#417-292).



( ) C24: 39 μF tantalum.

( ) C23: .01 μF (103) ceramic.

( ) C21: .01 μF (103) ceramic.

( ) C15: .01 μF (103) ceramic.

( ) C18: .01 μF (103) ceramic.

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

( ) C16: 39 μF tantalum.

( ) C20: .01 μF (103) ceramic.

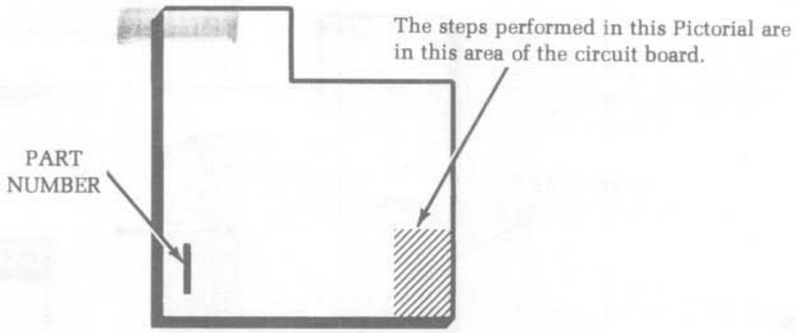
( ) C12: .01 μF (103) ceramic.

( ) C13: .01 μF (103) ceramic.

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

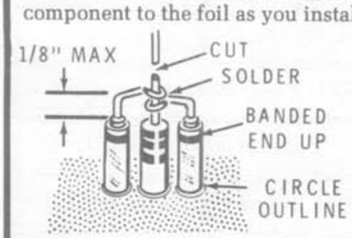
PICTORIAL 3-11

IDENTIFICATION
DRAWING



START

NOTE: Mount the following resistor and two diodes vertically, with the top lead of each diode connected to the top lead of the resistor as shown. Be sure the lead **opposite the banded end** of each diode is **down** over the circle outline on the circuit board. Solder each component to the foil as you install it.



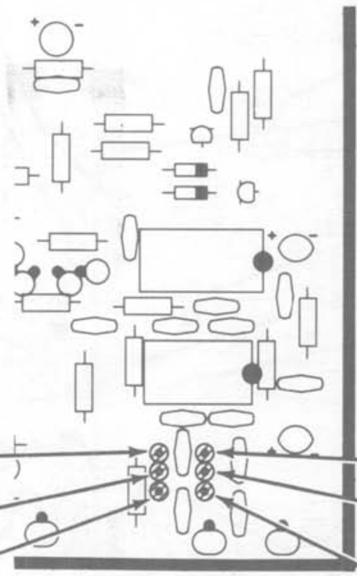
( ) D7: HP5 diode (#56-87).

( ) R28: 4700 Ω (yel-viol-red).

( ) D6: HP5 diode (#56-87).

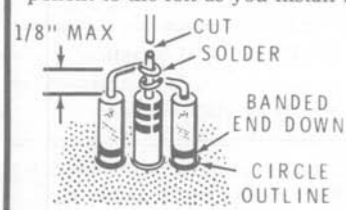
( ) Solder the top three leads together and cut off the excess lead lengths.

IMPORTANT In the following steps, make sure you install the two diodes with the banded end down.



CONTINUE

NOTE: Mount the following resistor and two diodes vertically, with the top lead of each diode connected to the top lead of the resistor as shown. Be sure the lead at the **banded end** of each diode is **down** over the circle outline on the circuit board. Solder each component to the foil as you install it.



( ) D8: HP5 diode (#56-87).

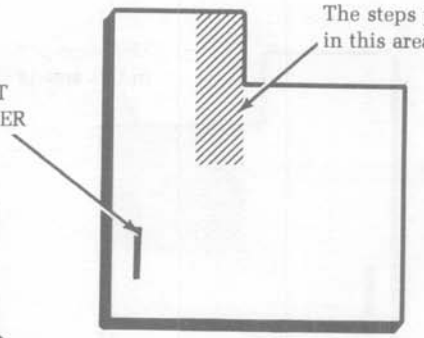
( ) R27: 4700 Ω (yel-viol-red).

( ) D5: HP5 diode (#56-87).

( ) Solder the top three leads together and cut off the excess lead lengths.

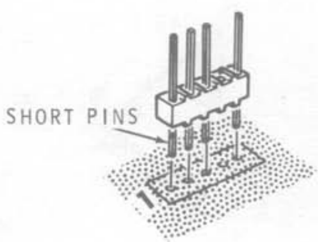
PICTORIAL 3-12

IDENTIFICATION DRAWING

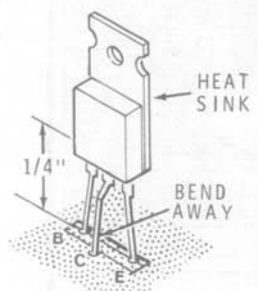


START

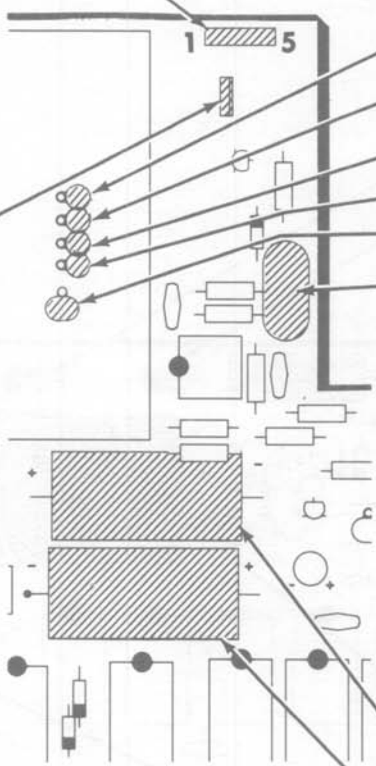
( ) P2: 5-pin plug. First remove the second pin from either end of the plug. Use long-nose pliers. Then install the plug as shown with the shorter pins through the circuit board holes. Finally, solder the pins to the foil.



( ) Q10: TIP41B transistor (#417-298). First bend the center lead away from the heat sink. Then match the heat sink with the two closely spaced lines on the circuit board. Insert the leads into their correct holes. Position the transistor 1/4" above the circuit board. Finally, solder the leads to the foil and cut off the excess lead lengths.



NOTE: To prepare a small wire, as in the following step, first cut it to the indicated length. Then carefully remove 1/4" of insulation from each end by using a very sharp knife or a single-edged razor blade. Be careful not to nick the fine strands of wire underneath. Finally, twist together the fine wire strands and apply a small amount of solder to the bare wire ends to hold the strands in place.



CONTINUE

( ) Prepare four 2" lengths and one 3-1/4" length of **small** white wire.

Connect each of the prepared wires as follows. Solder each wire as you install it. You will connect the free end of each wire later.

( ) 2" small white to hole N.

( ) 2" small white to hole L.

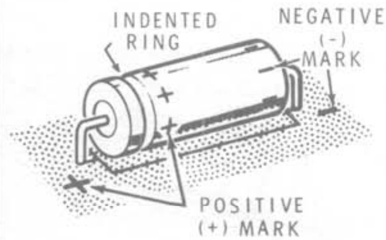
( ) 2" small white to hole K.

( ) 3 1/4" small white to hole J.

( ) 2" small white to hole BE.

( ) C34: .22 μF Mylar.

NOTE: When you install an electrolytic capacitor, be sure to match the positive (+) mark on the capacitor with the positive (+) mark on the circuit board, or match the negative (−) mark on the capacitor with the negative mark on the circuit board.

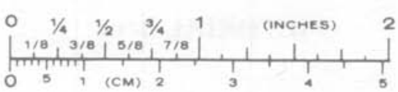


( ) C36: 470 μF electrolytic.

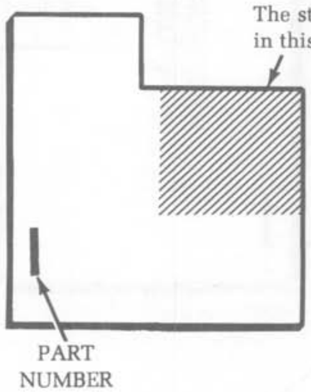
( ) C37: 470 μF electrolytic.

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

PICTORIAL 3-13



IDENTIFICATION
DRAWING



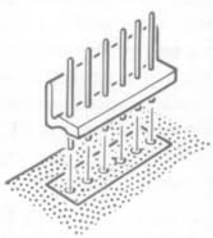
START

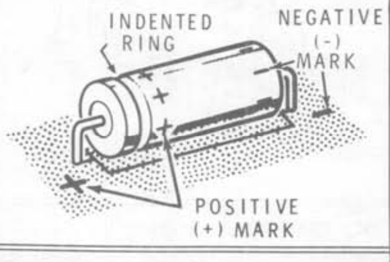
NOTE: When you install a diode in each of the next two steps, position the banded end as shown on the circuit board. Also, mount each diode 1/4" off the circuit board. Solder each diode as you install it. Finally, cut off the excess lead lengths.

( ) D22: 3A1 diode (#57-42).

( ) D23: 3A1 diode (#57-42).

( ) P1: 6-pin plug. Install it as shown and solder the pins to the foil.





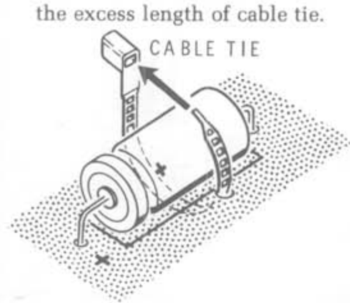
( ) C38: 6000 μF electrolytic.

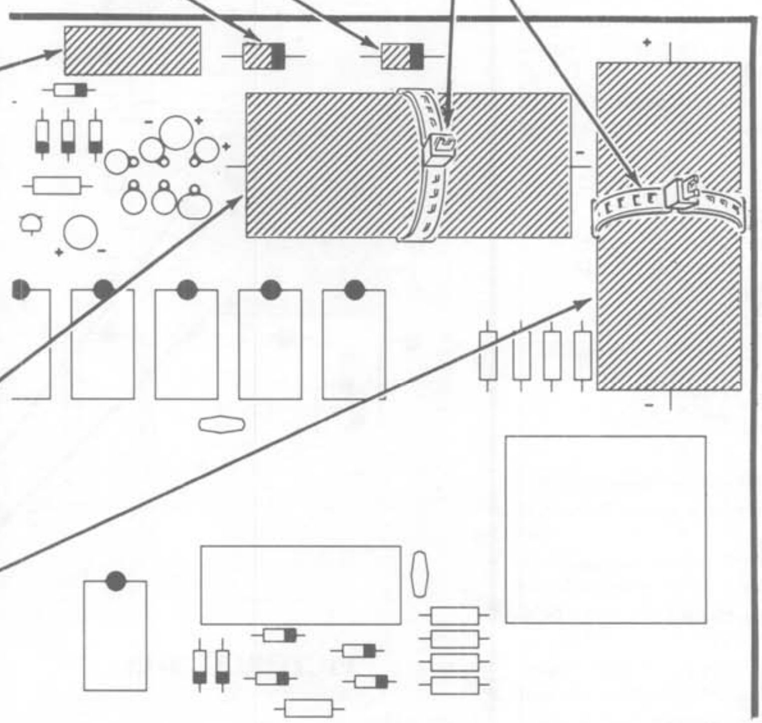
( ) C39: 6000 μF electrolytic.

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

CONTINUE

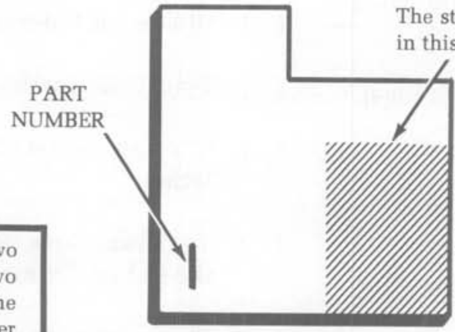
( ) Secure capacitors C38 and C39 to the circuit board with a cable tie at each location as shown. Cut off the excess length of cable tie.

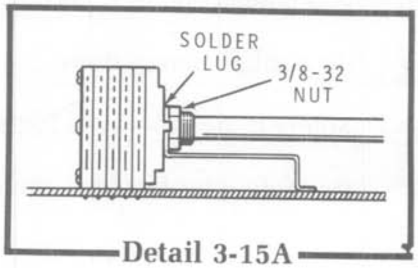




PICTORIAL 3-14

IDENTIFICATION DRAWING





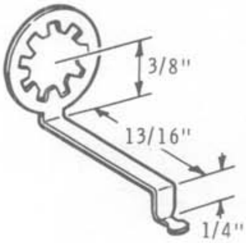
Detail 3-15A

START

NOTE: When you install the next two switches, only solder the indicated two lugs. Solder them to the bottom of the circuit board. You will solder the other lugs later.

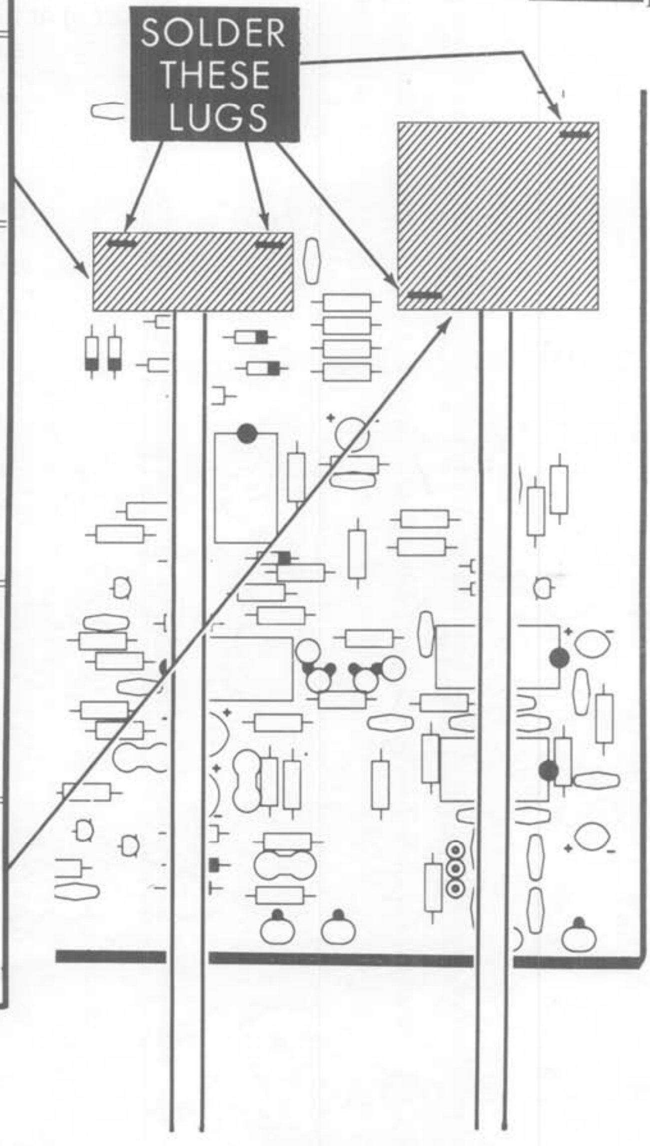
( ) SW3: 1-wafer switch. Be sure the lugs are straight, insert them into the circuit board, and solder the indicated two lugs to the foil. Be sure the switch shaft is parallel with the circuit board.

( ) Preform the long 3/8" solder lug as shown below.

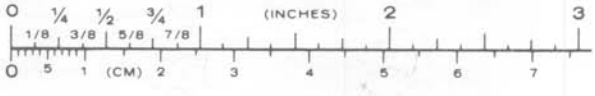


( ) Refer to Detail 3-15A and place the pre-formed solder lug on the shaft of the 5-wafer switch. Start a 3/8-32 nut on the switch bushing. Make sure the solder lug is parallel with the bottom of the switch. Then securely tighten the nut.

( ) SW2: 5-wafer switch. Install it as before. Be sure the switch shaft is parallel with the circuit board. Then solder the indicated two lugs to the foil. NOTE: You will solder the free end of the solder lug to the circuit board later.



PICTORIAL 3-15



Circuit Board Checkout

Carefully inspect the circuit board for the following most commonly made errors.

( ) Unsoldered connections (except switch lugs).

( ) Poor solder connections.

( ) Solder bridges between foil patterns.

( ) Protruding leads which could touch together.

Refer to the illustration where the parts were installed as you make the following visual checks.

( ) Diodes for the proper **type** and **installation**.

( ) Transistors for the proper **type** and **installation**.

( ) IC's U39 and U41 for the proper **type** and **installation**.

( ) Tantalum capacitors for the correct position of the (+) or dot marked lead.

( ) Electrolytic capacitors for the correct position of the (+) or (−) marked lead.

GENERAL ASSEMBLY AND WIRING

Refer to Pictorial 4-1 (Illustration Booklet, Page 4) for the following steps.

( ) Position the main circuit board printed side up on your work surface as shown in the Pictorial.

( ) Fit the bottom edge of the display circuit board into the slot of the main circuit board. See Detail 4-1A, Part A.

( ) Reposition the display circuit board so the pads on the foil side of each board are aligned with each other.

( ) At the front, solder the two circuit board foils together at the two locations shown in Detail 4-1A, Part A.

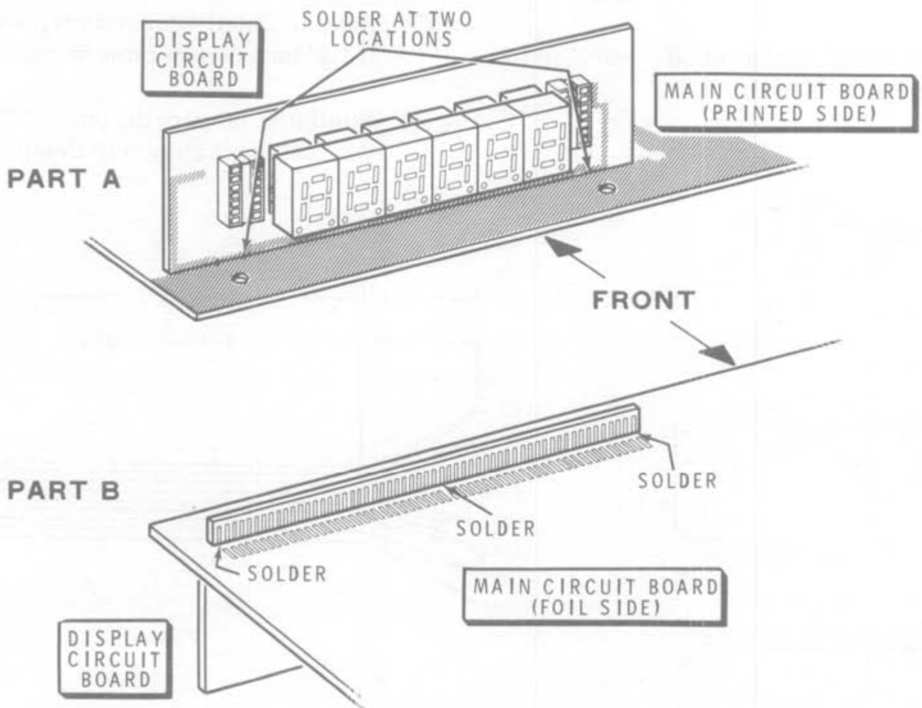
( ) Turn the two circuit boards over as shown in Detail 4-1A, Part B.

( ) With the display circuit board perpendicular to the main circuit board, solder the two end pads and a pad near the center of both boards together as shown in Detail 4-1A, Part B.

( ) Check and see that the display circuit board is still perpendicular to and tight against the main circuit board. If not, heat the soldered connections and reposition the display circuit board as required. NOTE: You may wish to use the crystal oven base as a "tri square". Place it as shown in the Pictorial to make sure the two circuit boards are perpendicular to each other. Then set the crystal oven base aside until it is called for in a step.

( ) Finally, solder all the remaining foil pads of one circuit board to the corresponding pads of the other circuit board.

( ) Carefully examine the solder joints (using a magnifying glass), and remove any solder bridges between foils.



Detail 4-1A

NOTE: The term "hardware" in the following steps refers to the screws, nuts, and lockwashers you will use to mount parts. The phrase "Use 6-32 × 1/4" hardware" for example, means to use a 6-32 × 1/4" screw, one or more #6 lockwashers, and a 6-32 nut at each mounting hole. Refer to the Detail or Pictorial called out in the step for the correct number of lockwashers to use and the correct way to install the hardware. Use the plastic nut starter furnished with this kit to pick up 4-40 and 6-32 nuts and start them on screws.

( ) Mount the front panel bracket to the main circuit board as shown. Use 4-40 × 1/4" hardware. Make sure the edge of the circuit board is even with the front of the bracket before you tighten the hardware.

( ) V1: Install a light-emitting diode (LED) display at V1 on the display circuit board. Position the decimal points of the display as shown in the Pictorial. Press the display firmly into the socket.

( ) V8: Similarly, install the remaining LED display at V8 on the display circuit board.

( ) Locate the 8-wire cable and cut off a 1-3/4" and a 5-1/2" length from this cable.

NOTE: In the following steps, you will separate the short (1-3/4") 8-wire cable into a one-wire, 2-wire and a 5-wire cable. To separate these wires, allow the sharp edges of your cutters to seat in the grooves between them and then cut the wires apart at just one end. See Detail 4-1B. Be careful not to cut the insulation and expose the fine wires.

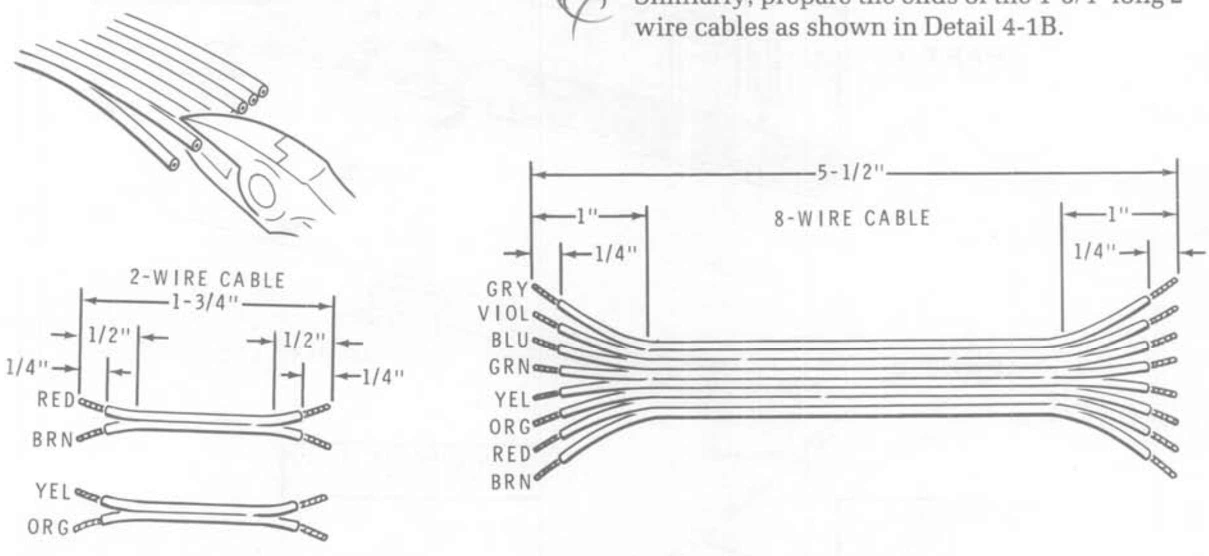
( ) At one end of the short (1-3/4") 8-wire cable, separate the red and orange wires. Also separate the yellow and green, and the gray and violet wires.

( ) Completely separate the brown and red 2-wire cable, the orange and yellow 2-wire cable, and the single gray wire from the other wires. Save this single wire and the 2-wire cables, and discard the three other wires.

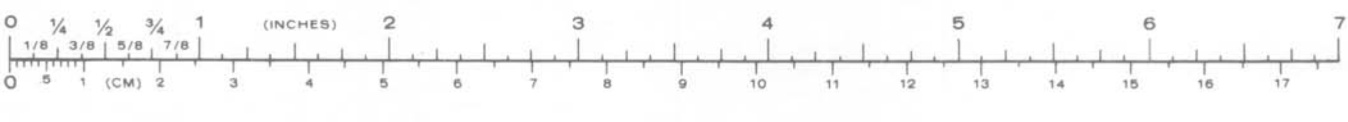
NOTE: When you prepare the ends of the 5-1/2" long, 8-wire cable, pull the wires apart for a length of 1". Then remove 1/4" of insulation from each wire, being careful not to cut the fine wires. Twist together the fine strands of each wire and melt a small amount of solder on them to hold them together.

( ) Refer to Detail 4-1B and prepare the ends of the 5-1/2" long 8-wire cable as shown.

( ) Similarly, prepare the ends of the 1-3/4" long 2-wire cables as shown in Detail 4-1B.



Detail 4-1B



NOTE: 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. Cut off any excess wire end after you solder a connection.

Connect the wires at one end of the 5-1/2" long 8-wire cable to the printed side of the main circuit board as follows:

( ) Brown wire into hole A (S-1).

( ) Red wire into hole B (S-1).

( ) Orange wire into hole C (S-1).

( ) Yellow wire into hole D (S-1).

( ) Green wire into hole E (S-1).

( ) Blue wire into hole F (S-1).

( ) Violet wire into hole G (S-1).

( ) Gray wire into hole H (S-1).

NOTE: When you connect wires to the foil side (not the printed side) of the circuit board, as in the following steps, keep the insulation 1/8" above the board so you get a good solder connection. The circuit board hole callouts are on the printed side of the circuit board.

Connect the wires at the free end of this cable to the foil side of the display circuit board as follows:

( ) Brown wire into hole A (S-1).

( ) Red wire into hole B (S-1).

( ) Orange wire into hole C (S-1).

( ) Yellow wire into hole D (S-1).

( ) Green wire into hole E (S-1).

( ) Blue wire into hole F (S-1).

( ) Violet wire into hole G (S-1).

( ) Gray wire into hole H (S-1).

Connect the wires at one end of the 1-3/4" long 2-wire cables to the printed side of the main circuit board as follows:

( ) Red wire into hole BB (S-1).

( ) Brown wire into hole BA (S-1).

( ) Orange wire into hole BC (S-1).

( ) Yellow wire into hole BD (S-1).

Connect the wires at the free ends of these cables to the foil side of the display circuit board as follows:

( ) Brown wire into hole BA (S-1).

( ) Red wire into hole BB (S-1).

( ) Orange wire into hole BC (S-1).

( ) Yellow wire into hole BD (S-1).

( ) Set the gray wire aside until it is called for in a step.

( ) Mount 6-32 tapped spacers at locations J and K on the **foil** side of the main circuit board. Use 6-32 × 1/4" hardware at each location.

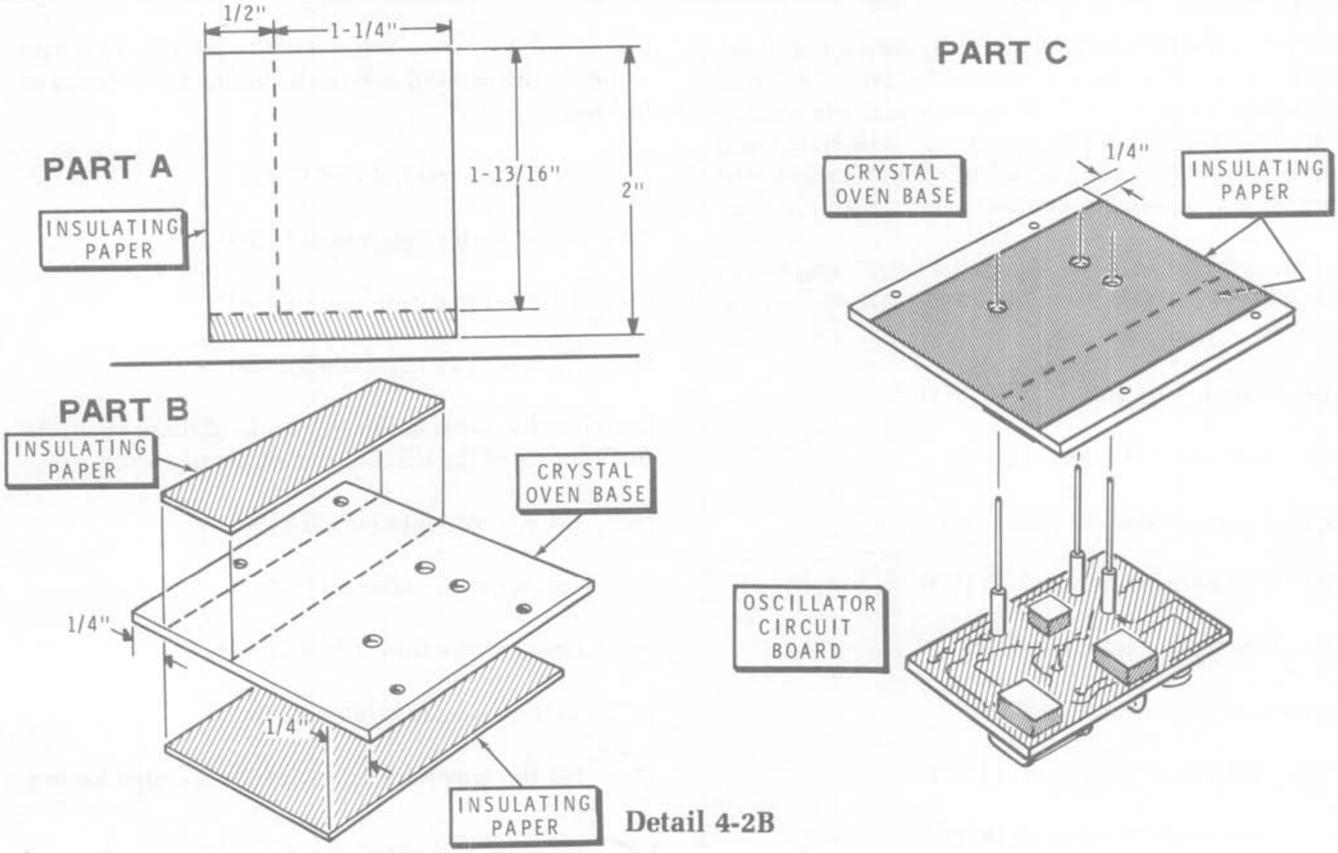
( ) Similarly, mount a 6-32 tapped spacer at location L on the main circuit board.

Refer to Pictorial 4-2 (Illustration Booklet, Page 5) for the following steps.

( ) Refer to Detail 4-2A and place the Styrofoam base on your work surface with the ribbed side **down** and the flat side **up** as shown.

NOTE: In the following step, you will mark the location for several holes needed in the Styrofoam base. A template with these hole locations is included in this Manual (Illustration Booklet, Page 19). You may: 1. Remove this template and use it to mark these locations; or 2. Determine the location for each hole by using the dimensions given on the template.

( ) Use one of the methods listed in the note above and mark the location for each of the seven holes required in the Styrofoam base. See Detail 4-2A. Then use a straight pin to punch a hole all the way through the base at each of the seven locations. Finally, use a cutoff component lead or a small drill bit to enlarge each hole to approximately 1/16".



Detail 4-2B

( ) **Refer to Detail 4-2B, Part A and prepare the insulating paper as shown. Use a pair of scissors or a sharp knife. Save the unused piece of insulating paper for use later.**

Refer to Detail 4-2B, Part B for the following six steps.

( ) Position the crystal oven base with the three larger holes as shown.

( ) Peel away the backing paper from the 1-1/4" × 1-13/16" insulating paper. Then press the insulating paper onto the crystal oven base as shown.

( ) Similarly, install the 1/2" × 1-13/16" insulating paper on the other side of the crystal oven base as shown.

( ) Place a straight pin in the center of one of the larger holes in the crystal oven base and pierce a small hole in the insulating paper.

( ) Similarly, use the straight pin to pierce a small hole at each of the two remaining locations.

( ) Use an awl or other pointed instrument to fully enlarge each of the three holes.

Refer to Detail 4-2B, Part C for the following five steps.

( ) Place the oscillator circuit board foil side up on your work surface as shown.

( ) Make sure every lead and lug on the foil side of the oscillator circuit board has been cut off as close as possible to the foil.

( ) Cut one 1/4" and two 3/8" lengths of foam gasket. Remove the backing paper from one side only of each length of foam gasket. Then press the gaskets onto the foil side of the oscillator circuit board at the locations shown.

( ) Be sure the three wires on the foil side of the oscillator circuit board are straight and perpendicular to the circuit board.

( ) Remove the paper backing from each of the three foam gaskets attached to the oscillator circuit board. Place the crystal oven base over the circuit board as shown in the Detail. Insert the three leads on the circuit board through the corresponding holes in the crystal oven base until the insulation on each wire protrudes through the respective holes in the oven base. Then press the circuit board onto the oven base.

Refer to Detail 4-2C for the following five steps.

( ) R62: Bend both leads of the 20 kΩ thermistor (#9-103) as shown in the Detail. Insert the thermistor leads into the two small holes in the thermistor holder and place the thermistor in the cavity in the holder. Then bend the leads outward slightly to hold the thermistor in place.

WARNING: The thermal compound you will use in the following step helps transfer heat from the crystal oven assembly to the thermistor. The compound is not caustic, but make sure you do not get it into your eyes, ears, nose, mouth, or clothing. Always wash your hands after you use this compound. Keep this and all chemicals out of the reach of children.

( ) Open the thermal compound container as shown in the inset drawing and squeeze enough thermal compound into the cavity of the thermistor holder to fill it completely.

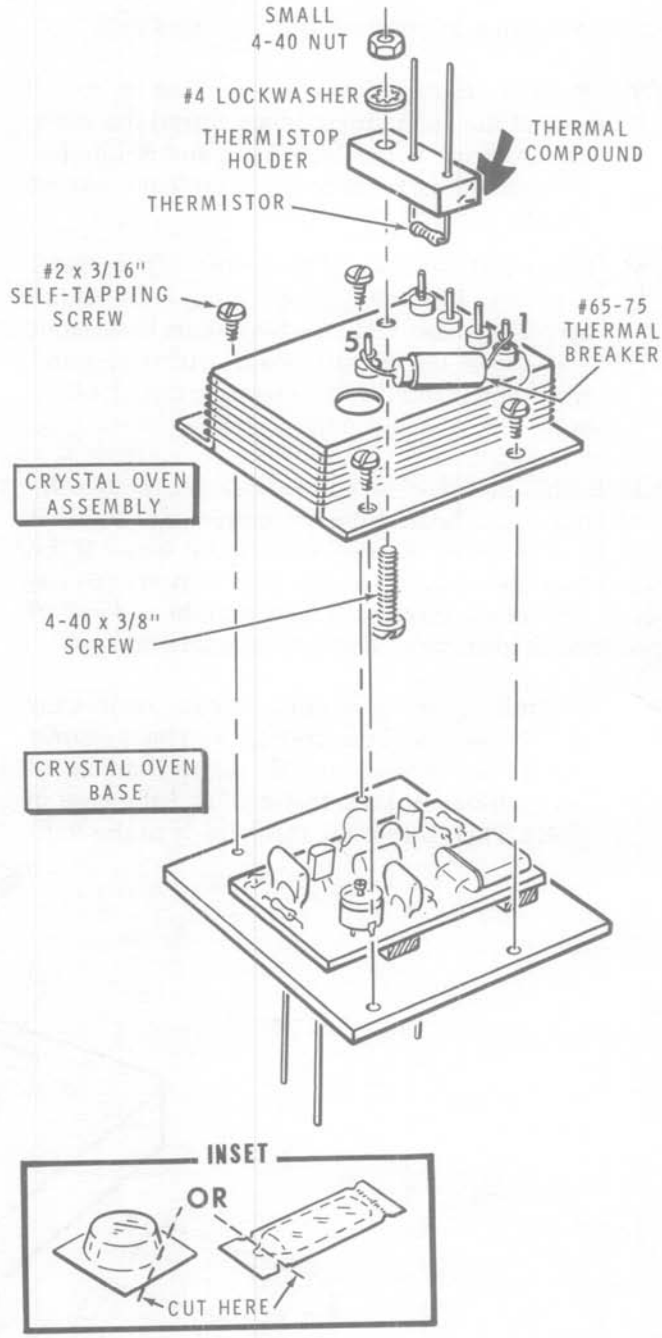
( ) Save the remaining thermal compound for use later.

( ) Mount the thermistor holder on the crystal oven assembly as shown. Use 4-40 × 3/8" hardware.

( ) Connect the thermal breaker (#65-75) between feed-through terminals 1 (NS) and 5 (NS). Position the breaker as shown.

NOTE: If any parts on the circuit board are too high to allow you to install the crystal oven assembly, in the next step, bend them over as necessary to provide clearance.

( ) R67: Position the crystal oven assembly over the crystal oven base as shown. Then secure the oven assembly to the oven base with four #2 × 3/16" self-tapping screws. DO NOT overtighten the screws.



Detail 4-2C

Refer to Detail 4-2D for the following three steps.

( ) Position the Styrofoam base over the indicated area of the main circuit board. Insert the wires coming from holes BE, J, K, L, and N into the corresponding holes in the Styrofoam base as shown.

( ) Insert the three wires at the bottom of the crystal oven base into the corresponding holes in the Styrofoam base. Hold the Styrofoam base about 1/4" above the circuit board with one hand while you insert the three wires in circuit board holes AF, AG, and AH.

NOTE: Should it ever become necessary to remove the oscillator circuit board from the main circuit board, it will be difficult to reinstall this circuit board if the wires that are soldered in the next step are cut too short. Therefore, leave each lead straight and cut off just enough to provide about 1/8" of extra lead length.

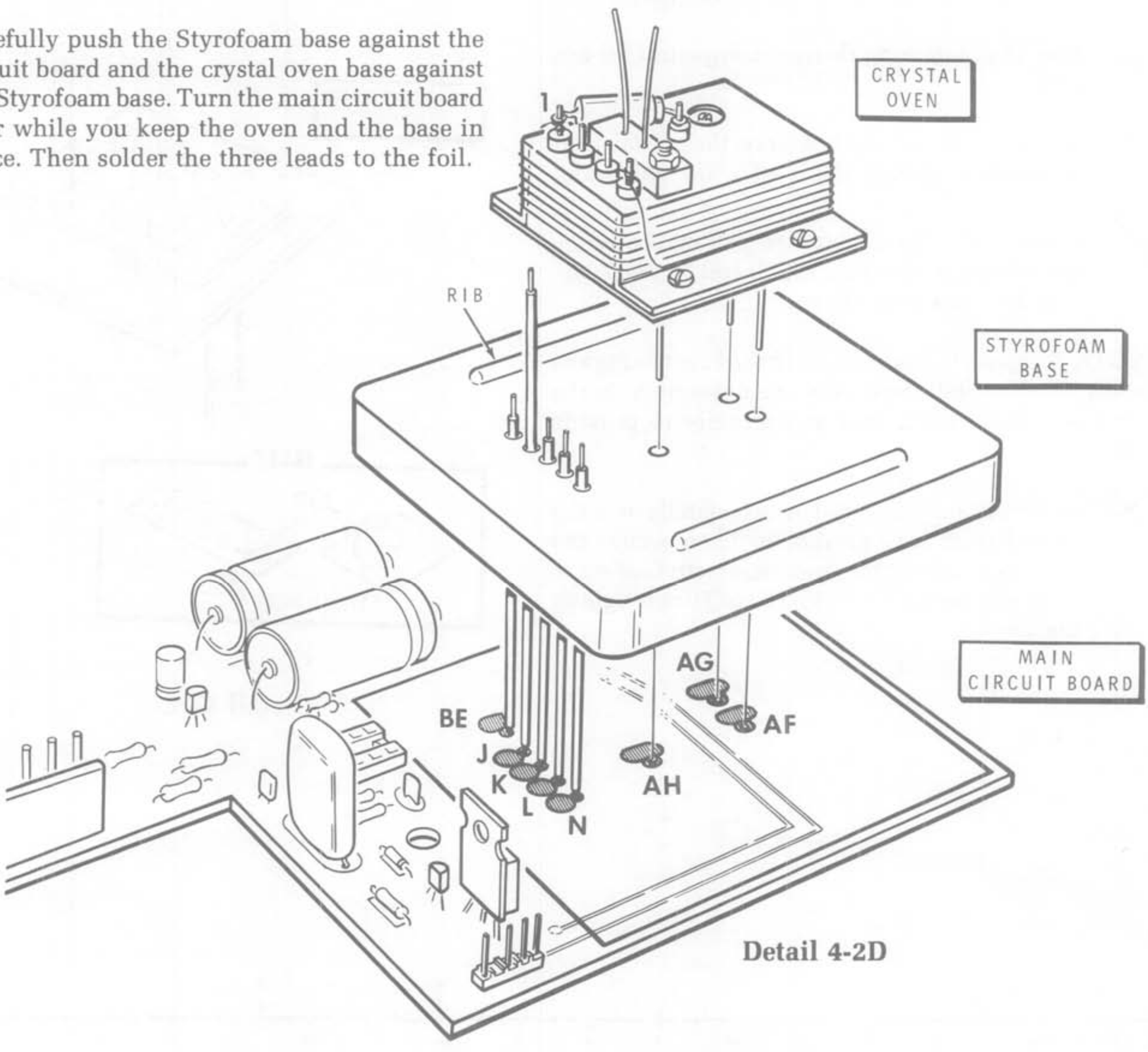
( ) Carefully push the Styrofoam base against the circuit board and the crystal oven base against the Styrofoam base. Turn the main circuit board over while you keep the oven and the base in place. Then solder the three leads to the foil.

NOTE: To insure that the thermistor will "sense" any changes in the crystal oven temperature, it is important that the thermistor make good contact with the metal cover of the oven. Therefore, carefully perform the following three steps.

( ) 1. Push down on both thermistor leads so it touches the metal surface; then bend the leads toward the two center terminals of the crystal oven.

( ) 2. Connect one lead of the thermistor to feed-through terminal 2 (NS). Allow some slack in the lead so some adjustment can be made after soldering.

( ) 3. Similarly, connect the other lead of the thermistor to feed-through terminal 3 (NS).



Detail 4-2D

Connect the free end of each of the five white wires coming from holes BE, J, K, L, and N on the main circuit board to the feed-through terminals in the crystal oven assembly as follows:

( ) Wire from hole BE to feed-through terminal 1 (S-2).

( ) Wire from hole J to feed-through terminal 5 (S-2).

( ) Wire from hole K to feed-through terminal 2 (S-2).

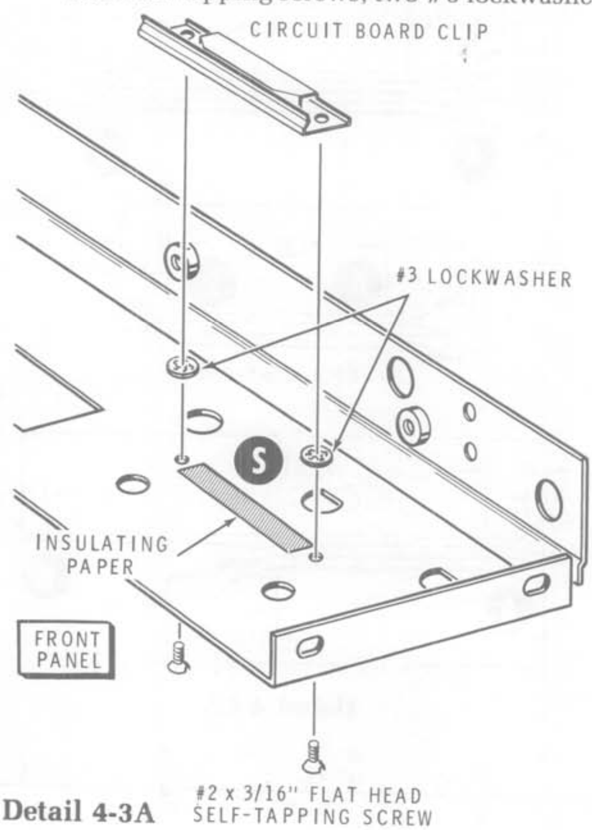
( ) Wire from hole L to feed-through terminal 3 (S-2).

( ) Wire from hole N to feed-through terminal 4 (S-1).

( ) Gently push each lead of the thermistor into the holder to ensure contact with the metal cover of the oven.

Refer to Pictorial 4-3 (Illustration Booklet, Page 6) for the following steps.

( ) Refer to Detail 4-3A and install the circuit board clip on the inside of the front panel at S. Position the clip as shown. Use two #2 × 3/16" flat head self-tapping screws, two #3 lockwashers, and the piece of insulating paper you saved from an earlier step. Trim the insulating paper so that it does not cover the mounting holes. DO NOT overtighten the screws.



Detail 4-3A

( ) Locate the window and remove the protective film.

( ) Place the window against the front panel.

( ) Mount a nylon bearing in the window and front panel at SW2.

( ) Similarly, mount the other nylon bearing at SW3.

( ) Refer to inset drawing #1 and prepare three short 3/8" solder lugs as shown. Use long-nose pliers. You will be using two of these solder lugs in the next two steps. Set the remaining solder lug aside until it is called for in a step.

( ) J2: Mount a BNC connector at J2. Use the hardware supplied with the connector and a prepared 3/8" solder lug. Position the solder lug as shown in the Pictorial.

( ) J1: Similarly, mount another BNC connector at J1.

( ) Position the front panel and the main circuit board as shown in the Pictorial.

( ) Insert the switch shafts into front panel holes SW2 and SW3 respectively. Then push the front end of the circuit board into the circuit board clip mounted on the inside of the front panel.

( ) SW4: Mount the STBY/ON switch at SW4. Use 3/8" hardware. Position the switch as shown in the Pictorial.

( ) R9/SW1: Mount the 200 Ω control with switch at R9/SW1. Use a 3/8" hardware. Position the control with switch as shown in the Pictorial.

( ) Place a soft cloth on your work surface to prevent the bezel from becoming scratched in the following steps.

( ) Position the bezel into place over the window and secure it at T, U, and V with 6-32 × 3/8" flat head hardware.

( ) Refer to inset drawing #2 on Pictorial 4-3 and install the ground clip at X as shown. Use 6-32 × 3/8" flat head hardware.

Refer to Pictorial 4-4 (Illustration Booklet, Page 7) for the following steps.

( ) Solder the remaining lugs of switches SW2 and SW3 to the foil.

( ) Refer to inset drawing #2 on Pictorial 4-4 and solder the free end of the solder lug on switch shaft SW2 to the foil on the printed side of the main circuit board.

( ) Cut each lead of the .15 μF polycarbonate capacitor to 1/2".

IMPORTANT: To ensure that your completed frequency counter operates properly over its entire frequency range, it is very important that you keep the length of each lead and wire in the following steps as short as possible. After you install each component or wire, cut off any excess length on both ends.

( ) C1: Connect the .15 μF polycarbonate capacitor from the main circuit board hole AB (S-1) to the center lug of BNC connector J1 (S-1). Wrap the end of the lead around the lug as shown in inset drawing #1 before you solder the connection.

( ) Cut each lead of the 15 Ω (brn-grn-blk) resistor to 3/4".

( ) R30/FB1: Slide the ferrite bead onto one lead of the 15 Ω resistor. Connect this lead to main circuit board hole AD (S-1). Wrap the end of the other resistor lead around the center lug of BNC connector J2 before you solder the connection.

Connect the following lengths of bare wire from the main circuit board to the front panel assembly as follows:

( ) 3/4" wire from hole AC (S-1) to the solder lug at BNC connector J1 (S-1).

( ) 3/4" wire from hole AE (S-1) to the solder lug at BNC connector J2 (S-1).

( ) Connect a 3/4" bare wire from switch SW1 lug 1 (NS) to lug 2 (S-1).

( ) Locate the 1-3/4" gray wire that you set aside earlier. Then remove 1/4" of insulation from each end and prepare the ends.

( ) Connect the prepared 1-3/4" gray wire, from control R9 lug 2 (S-1) to SW1 lug 4 (S-1).

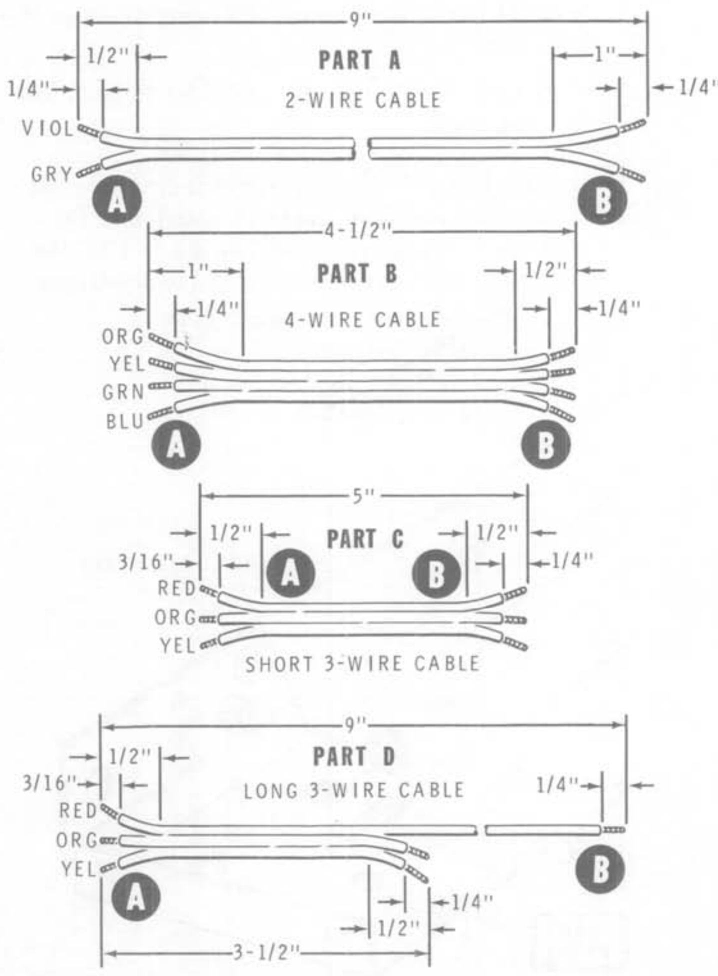
( ) Cut a 9" length of 8-wire cable.

( ) At one end of this cable, separate the wires between the red and orange leads. Also, separate them between the blue and violet wires.

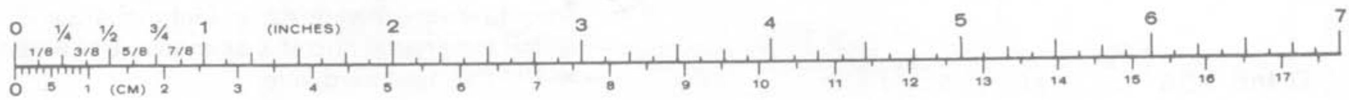
( ) Completely separate the gray and violet 2-wire cable from the other wires. Set this 2-wire cable aside temporarily.

( ) In the same manner, separate the blue, green, yellow, and orange 4-wire cable from the other wires. Set this 4-wire cable aside and discard the red and brown wires.

( ) Refer to Detail 4-4A, Part A and prepare the ends of the 2-wire cable as shown.



Detail 4-4A



Connect end A of the 9" long, 2-wire cable to STBY/ON switch SW4 as follows:

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

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

Connect the wires at end B of this cable to the foil side of the main circuit board as follows:

( ) Violet wire into hole AJ (S-1).

( ) Gray wire into hole AK (S-1).

( ) Cut a 4-1/2" length of the 4-wire cable you set aside earlier. Discard the other length of this cable.

( ) Refer to Detail 4-4A, Part B and prepare the ends of the 4-wire cable as shown.

Connect end A of this cable to the 200 Ω control with switch (R9/SW1) as follows:

( ) Blue wire to control R9 lug 3 (S-1).

( ) Yellow wire to control R9 lug 1 (S-1).

( ) Green wire to switch SW1 lug 1 (S-2).

( ) Orange wire to switch SW1 lug 3 (S-1).

Connect the wires at end B of this cable to the foil side of the main circuit board as follows:

( ) Blue wire into hole U (S-1).

( ) Green wire into hole X (S-1).

( ) Yellow wire into hole Y (S-1).

( ) Orange wire into hole Z (S-1).

( ) Cut a 14" length of 8-wire cable.

( ) At one end of this cable, separate the wires between the brown and red leads. Also, separate them between the yellow and green wires.

( ) Completely separate the brown wire from the other wires. Discard this wire.

( ) Completely separate the red, orange, and yellow 3-wire cable from the green, blue, violet, and gray 4-wire cable. Save both of these cables.

( ) Cut the 14" long 3-wire cable into a 5" and a 9" length.

( ) Refer to Detail 4-4A, Part C and prepare the ends of the 5" long 3-wire cable as shown.

( ) Refer to Detail 4-4B and install a **small** spring connector on each wire at end A of this cable.

( ) Refer to Detail 4-4B and push the spring connectors on this 3-wire cable into a 3-hole connector shell. Be sure the connector shell is positioned with its slots up. Push on the cable until the locking tabs on the spring connectors snap into place.

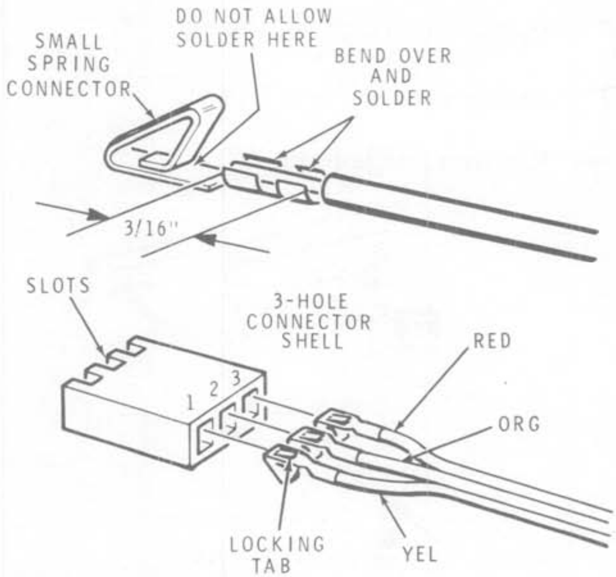
Connect the wires at end B of this cable to the **foil** side of the main circuit board as follows:

( ) Yellow wire into hole P (S-1).

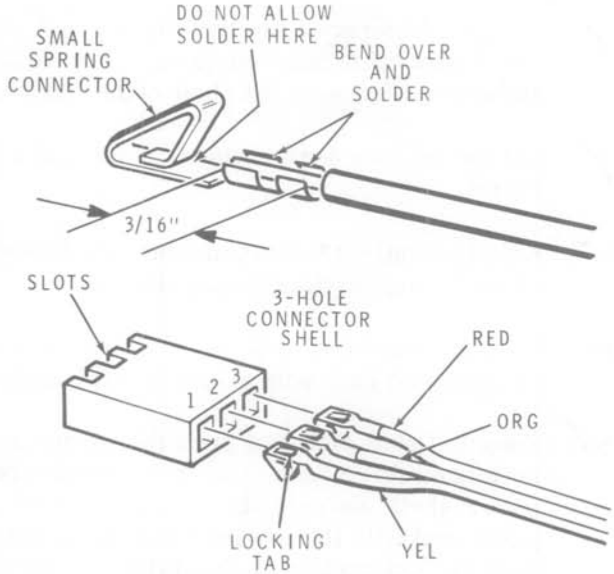
( ) Orange wire into hole Q (S-1).

( ) Red wire into hole R (S-1).

( ) Refer to Detail 4-4A, Part D and prepare the ends of the 9" long, 3-wire cable as shown.



Detail 4-4B



Detail 4-4B (Repeat)

( ) Refer to Detail 4-4B and install a **small** spring connector on each wire at end A of this cable.

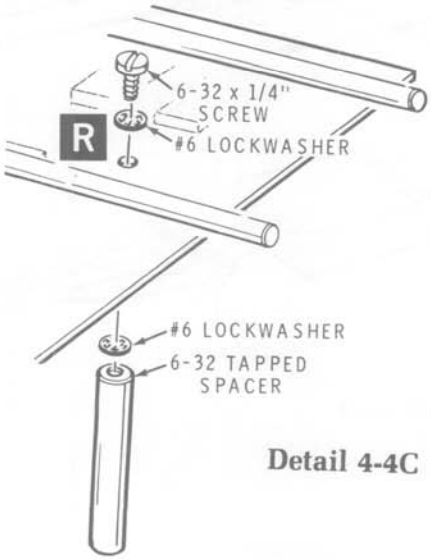
( ) Refer to Detail 4-4B and push the spring connectors on this 3-wire cable into the remaining 3-hole connector shell. Be sure the connector shell is positioned with its slots up. Push on the cable until the locking tabs on the spring connectors snap into place.

Connect the wires at end B of this cable to the **foil** side of the main circuit board as follows:

( ) Yellow wire into hole S (S-1).

( ) Orange wire into hole T (S-1).

( ) Red wire into hole AA (S-1).



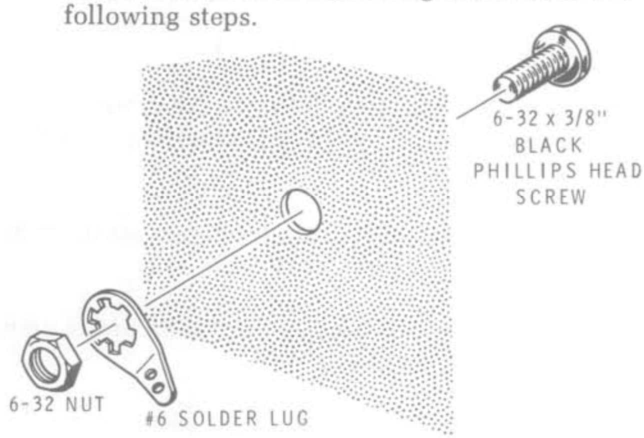
Detail 4-4C

( ) Refer to Detail 4-4C and mount a 6-32 tapped spacer at R on the foil side of the main circuit board. Use 6-32 × 1/4" hardware.

Set the circuit board assembly aside temporarily.

Refer to Pictorial 4-5 (Illustration Booklet, Page 8) for the following steps.

( ) Place a soft cloth on your work surface to prevent the chassis from becoming scratched in the following steps.

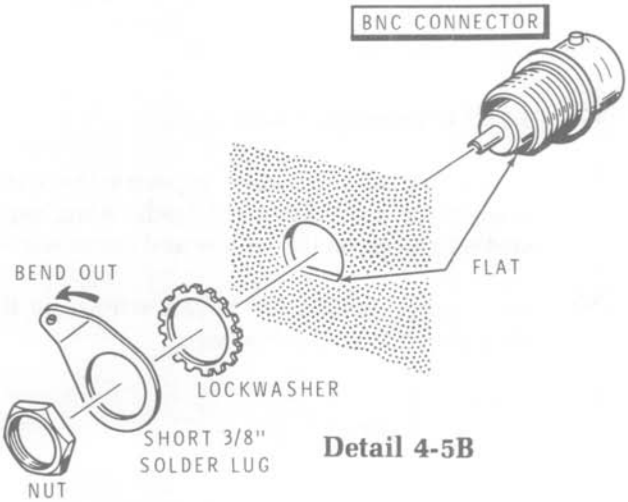


Detail 4-5A

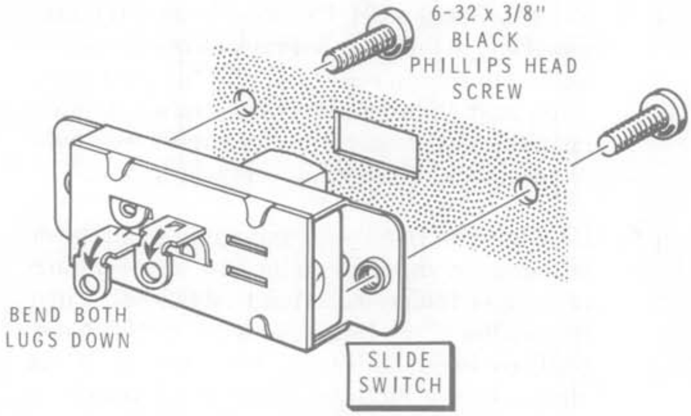
( ) Refer to Detail 4-5A and install a #6 solder lug at A. Use 6-32 × 3/8" black phillips head hardware. Position the solder lug as shown in the Pictorial.

( ) Similarly, install another #6 solder lug at F. Position the solder lug as shown in the Pictorial.

( ) J3: Refer to Detail 4-5B and mount a BNC connector at J3. Use the hardware supplied with the connector and a prepared 3/8" solder lug. Position the solder lug as shown in the Pictorial.



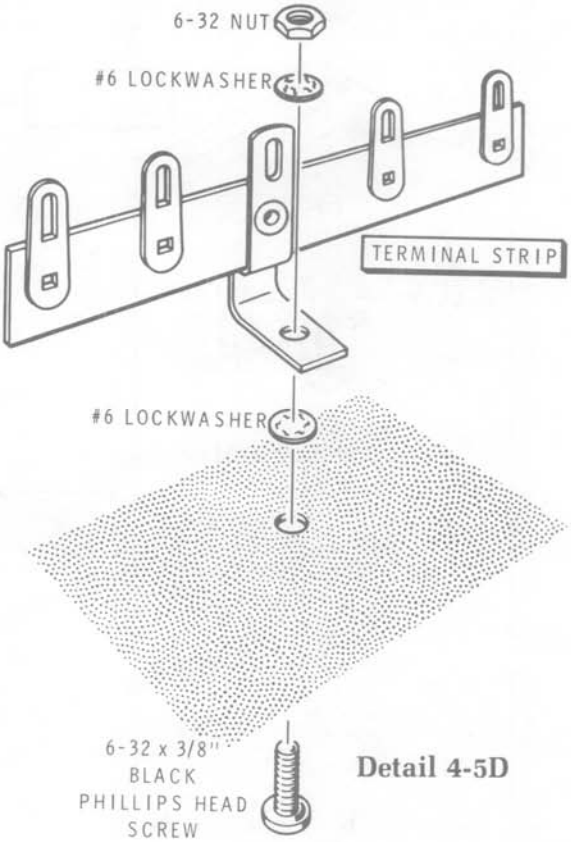
Detail 4-5B



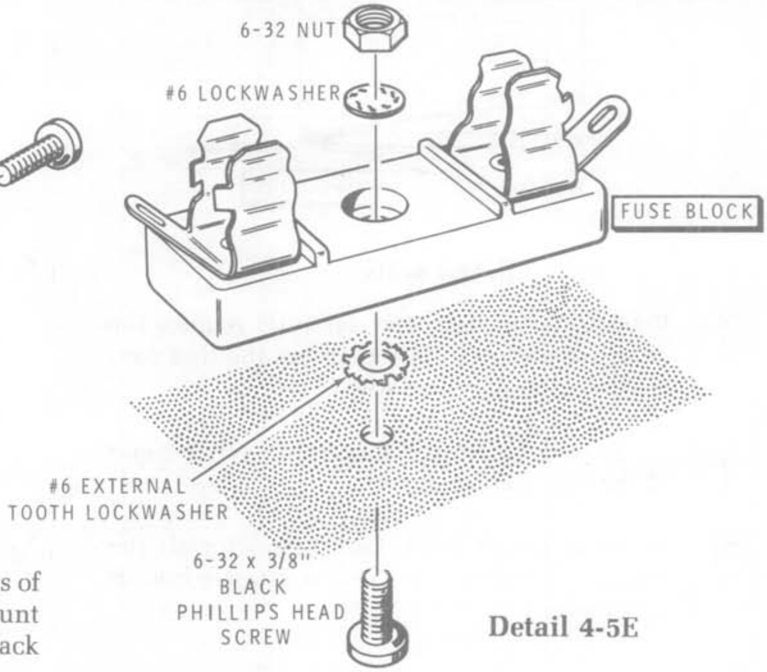
Detail 4-5C

( ) SW5: Refer to Detail 4-5C and bend both lugs of the slide switch down as shown. Then mount the switch at SW5. Use two 6-32 × 3/8" black phillips head screws. Position the switch as shown in the Pictorial.

( ) Refer to Detail 4-5D and mount a terminal strip at H. Use 6-32 × 3/8" black phillips head hardware. Position the terminal strip as shown in the Pictorial.



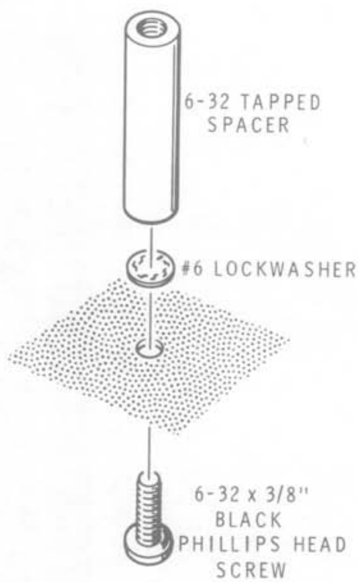
Detail 4-5D



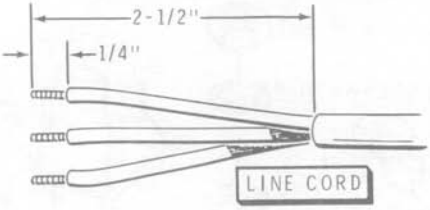
Detail 4-5E

( ) Refer to Detail 4-5E and mount a fuse block at F1. Use 6-32 × 3/8" black phillips head hardware. Position the fuse block as shown in the Pictorial.

( ) Refer to Detail 4-5F and mount a 6-32 tapped spacer at G. Use 6-32 × 3/8" black phillips head hardware.



Detail 4-5F

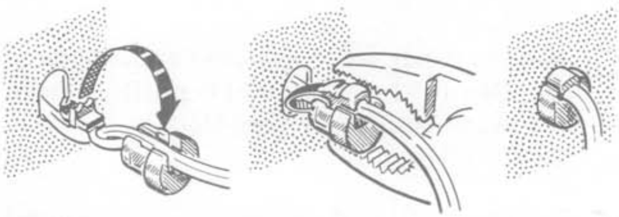


Detail 4-5G

( ) Refer to Detail 4-5G and carefully remove the outer insulation from the end of the line cord opposite the plug as shown.

( ) Again refer to Detail 4-5G and prepare this end of the line cord as shown.

( ) Refer to Detail 4-5H, Part 1 and install the strain relief and line cord at chassis hole B as shown.



Detail 4-5H

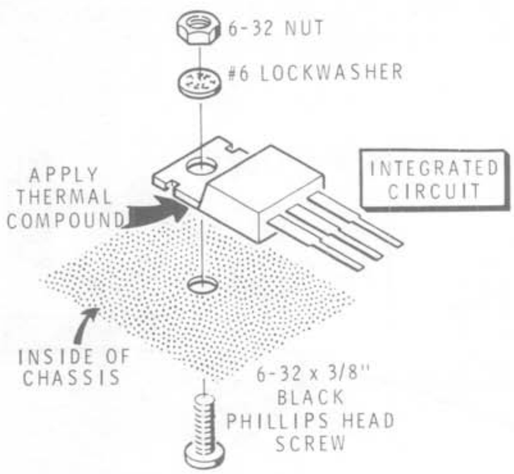
( ) Refer to Detail 4-5H, Part 2 and route the prepared end of the line cord back through the side hole in the strain relief and pull the cord tight. Then push the shoulder of the strain relief into chassis hole B. Secure the strain relief with a #6 × 5/8" black self-tapping screw at hole C.

( ) U42: Refer to Detail 4-5J and apply a thin layer of thermal compound on the bare metal surface of a 7805 integrated circuit (#442-54). Then mount the IC at U42. Use 6-32 × 3/8" black phillips head hardware. Position the IC as shown in the Pictorial. Then use a pencil or marker pen and write "U42" next to the IC on top of the chassis.

( ) U43: In the same manner, mount another 7805 IC (#442-54) at U43. Position the IC as shown in the Pictorial. Write "U43" next to the IC on top of the chassis.

( ) Discard the remaining thermal compound.

( ) WASH YOUR HANDS.



Detail 4-5J

( ) Turn the chassis over as shown in Detail 4-5K.

CAUTION: Do NOT overtighten the screws when you install the feet in the following steps or you will strip out the chassis holes.

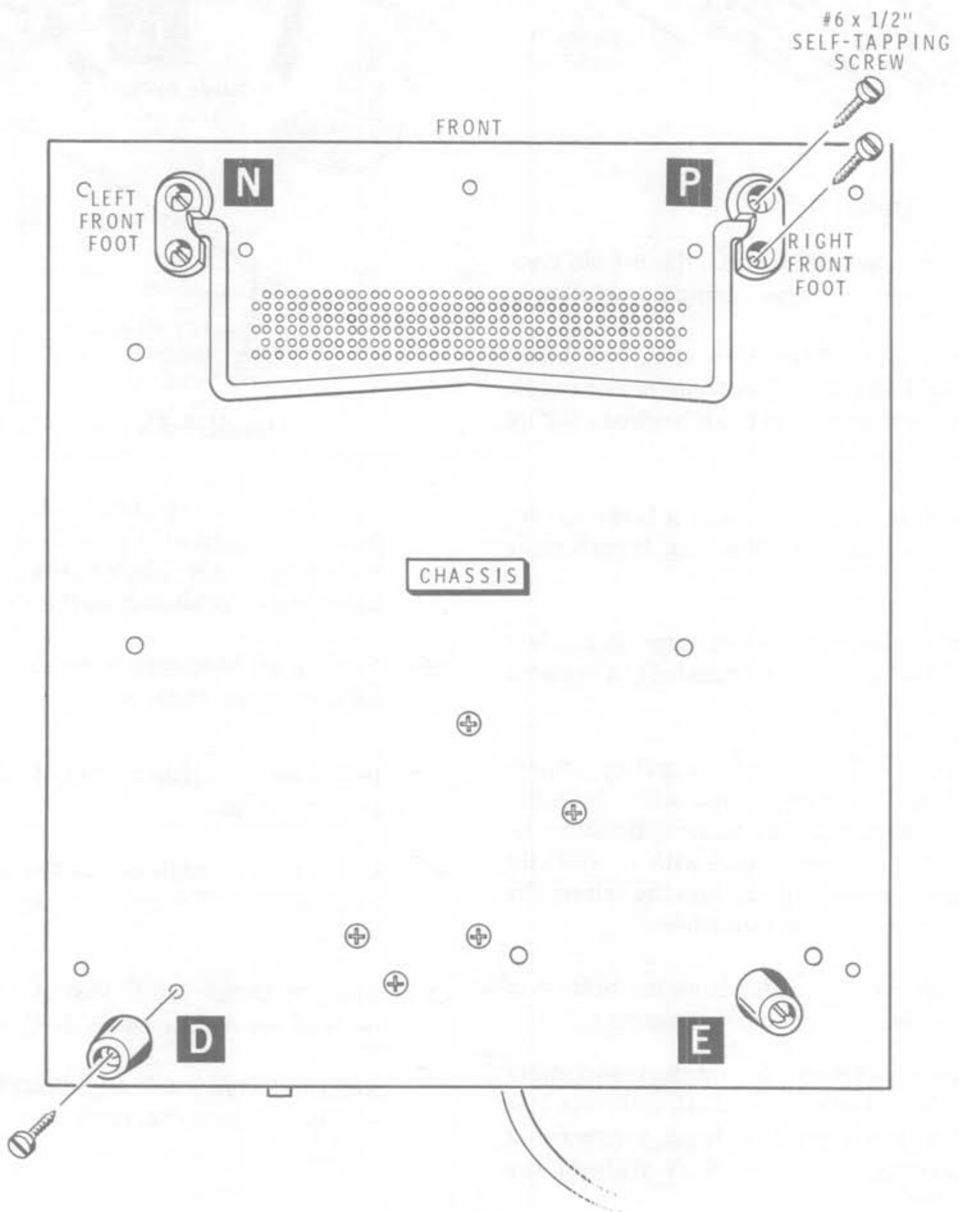
( ) Refer to Detail 4-5K and mount the left front foot at location N on the bottom of the chassis with #6 × 1/2" self-tapping screws. Position the foot as shown.

( ) Fit one end of the bail into the left front foot.

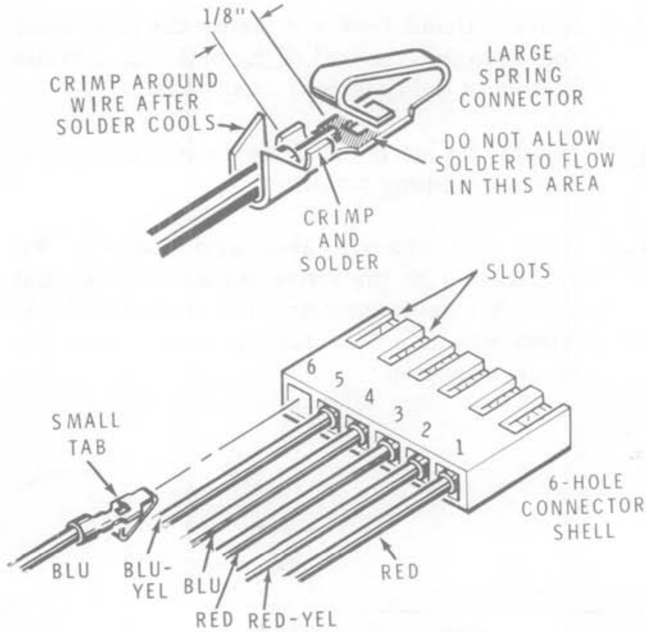
( ) Refer to Detail 4-5K and mount the right front foot onto the free end of the bail and onto the bottom of the chassis at location P.

( ) Mount rear feet at locations D and E with #6 × 1/2" self-tapping screws.

( ) Turn the chassis over and place a #6 lockwasher on the screw at location D on the chassis. See the inset drawing on Pictorial 4-5. Then mount a 6-32 tapped spacer onto the screw as shown.



Detail 4-5K



Detail 4-5L

( ) Locate the power transformer, the 6-hole connector shell and six large spring connectors.

( ) At the free end of the two red, two blue, blue/yellow, and red/yellow transformer wires, cut the exposed bared end of each wire to 1/8" as shown in Detail 4-5L.

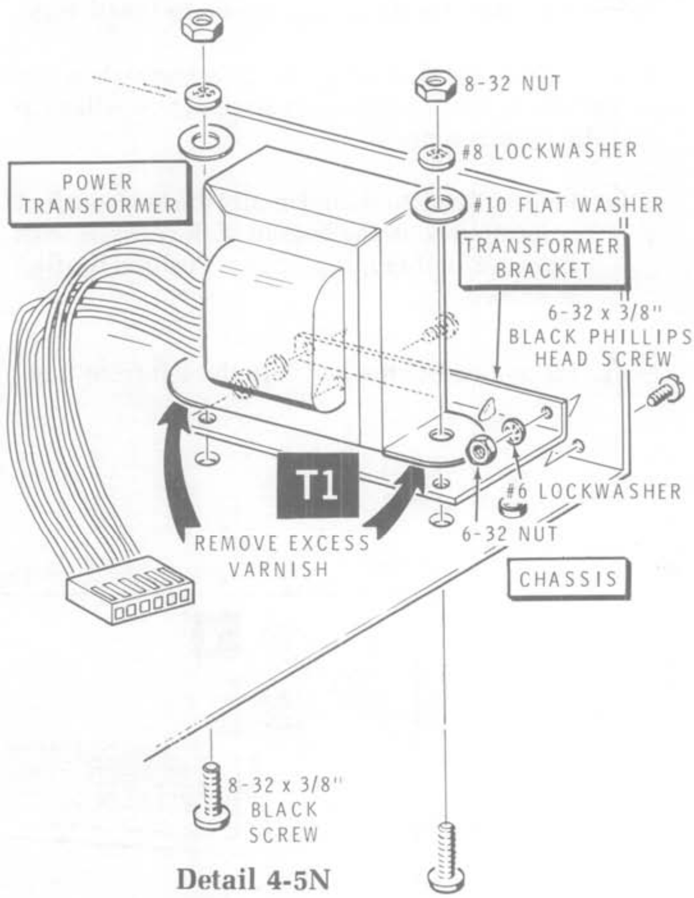
( ) Refer to Detail 4-5L and install a **large** spring connector on each of these six transformer wires.

NOTE: The 6-hole connector shell may be marked with small numbers. Ignore these numbers in the next step.

( ) Refer to Detail 4-5L and push the spring connectors on these six transformer wires into the 6-hole connector shell as shown. Be sure the connector shell is positioned with its slots up Push on each wire until the locking tab on the spring connector snaps into place.

( ) Remove any excess varnish from the bottom of each of the two power transformer feet.

( ) Refer to Detail 4-5N and mount the transformer bracket to the chassis at the location shown. Use 6-32 × 3/8" black phillips head hardware at each mounting hole. DO NOT tighten the hardware yet.



Detail 4-5N

( ) T1: Again refer to Detail 4-5N and mount the power transformer at location T1 on the chassis with 8-32 × 3/8" black hardware. Position the transformer as shown in the Pictorial.

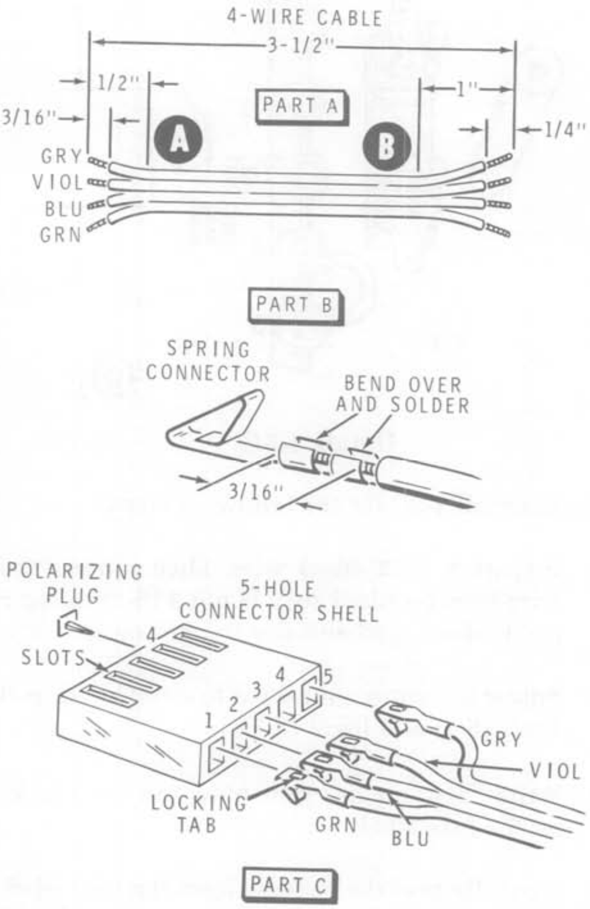
( ) Tighten all hardware to secure the transformer bracket to the chassis.

Refer to Pictorial 4-6 (Illustration Booklet, Page 9) for the following steps.

( ) Cut a 3-1/2" length of the 4-wire cable you set aside earlier. Discard the longer length of this cable.

( ) Refer to Detail 4-6A, Part A and prepare the ends of the 4-wire cable as shown.

( ) Refer to Detail 4-6A, Part B and install a small spring connector on each wire at end A of this cable.



Detail 4-6A

( ) Refer to Detail 4-6A, Part C and push the spring connectors on this 4-wire cable into the 5-hole connector shell. Be sure the connector shell is positioned with its slots up. Push on the cable until the locking tabs on the spring connectors snap into place. NOTE: Do NOT install a connector into hole 4 of the connector shell.

( ) Refer to Detail 4-6A, Part C and install a polarizing plug into hole 4 of the connector shell.

Connect the wires at the free end of the 4-wire cable as follows:

( ) Blue wire to the solder lug at BNC connector J3 (S-1).

( ) Violet wire to the center lug of BNC connector J3 lug 1 (S-1).

( ) Gray wire to switch SW5 lug 2 (S-1).

( ) Green wire to switch SW5 lug 1 (S-1).

NOTE: Refer to the inset drawing on the Pictorial when you are instructed to "make a mechanically secure connection."

Connect the line cord leads as follows:

( ) Black lead to fuse block F1 lug 1 (S-1). Make a mechanically secure connection.

( ) White lead to terminal strip H lug 2 (NS). Make a mechanically secure connection.

( ) Green lead to solder lug A (S-1). Make a mechanically secure connection.

Connect the free end of each of the remaining four transformer leads to terminal strip H as follows:

( ) Black lead to lug 2 (NS). Make a mechanically secure connection.

( ) Black/red lead to lug 1 (NS). Make a mechanically secure connection.

NOTE: Terminal strip H lug 3 will not be used.

( ) Black/green lead to lug 5 (NS). Make a mechanically secure connection.

( ) Black/yellow lead to lug 4 (NS). Make a mechanically secure connection.

( ) Cut both leads of the round .01 μF ceramic capacitor to 1/2".

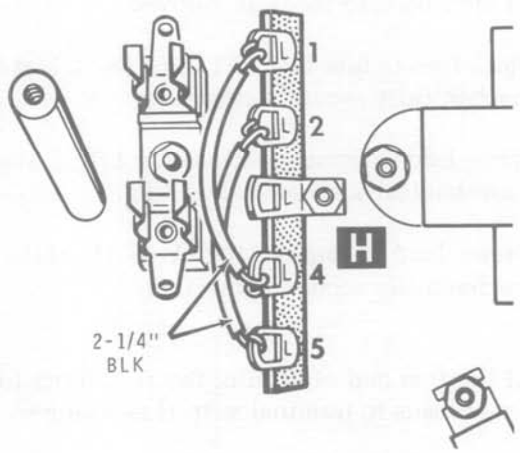
( ) C35: Connect the prepared .01 μF capacitor from terminal strip H lug 1 (NS) to lug 2 (NS). Make mechanically secure connetions.

( ) Prepare a 3" black wire. Then connect the wire from fuse block F1 lug 2 (S-1) to terminal strip H lug 1 (NS). Make mechanically secure connections.

ALTERNATE LINE VOLTAGE WIRING

NOTE: Two different sets of wiring instructions are given in the following steps. One set of instructions is for 120 VAC line voltage (most often used in the U.S.A.), and the other is for 240 VAC line voltage. USE ONLY THE INSTRUCTIONS THAT AGREE WITH THE LINE VOLTAGE IN YOUR AREA.

120 VAC WIRING



Detail 4-6B

Refer to Detail 4-6B for the following steps.

( ) Prepare two 2-1/4" black wires.

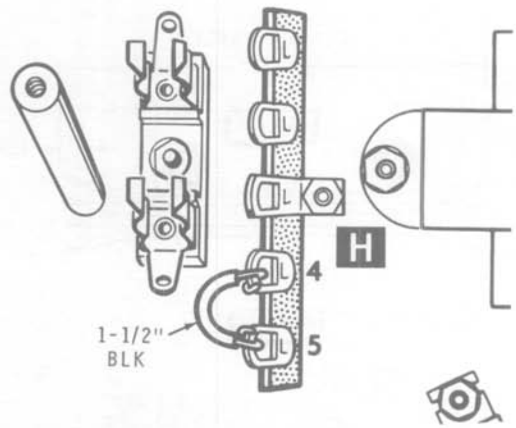
( ) Connect a 2-1/4" black wire from terminal strip H lug 2 (S-4) to lug 5 (S-2). Make mechanically secure connections.

( ) Connect a 2-1/4" black wire from terminal strip H lug 1 (S-4) to lug 4 (S-2). Make mechanically secure connections.

( ) Write "1/2-ampere, slow-blow" in the blanks on the fuse label.

( ) Carefully peel the backing paper from the fuse label. Then press the label onto the chassis as shown in Pictorial 4-6.

240 VAC WIRING



Detail 4-6C

Refer to Detail 4-6C for the following steps.

( ) Prepare a 1-1/2" black wire. Then connect the wire from terminal strip H lug 4 (S-2) to lug 5 (S-2). Make mechanically secure connections.

( ) Solder the wires connected to terminal strip H lug 1 (S-3) and lug 2 (S-3).

( ) Write "1/4-ampere, slow-blow" in the blanks on the fuse label.

( ) Carefully peel the backing from the fuse label. Then press the label onto the chassis as shown in Pictorial 4-6.

NOTE: The plug on the line cord in this kit is for standard 120 VAC outlets. For 240 VAC operation in the U.S.A., cut off the plug and replace it with a permanent plug that matches your 240 VAC receptacle. Be sure your power connection conforms with section 210-21 (b) of the National Electric Code, which reads in part:

> "Receptacles connected to circuits having different voltages, frequencies, or types of current (AC or DC) on the same premises shall be of such design that attachment plugs used on such circuits are not interchangeable."

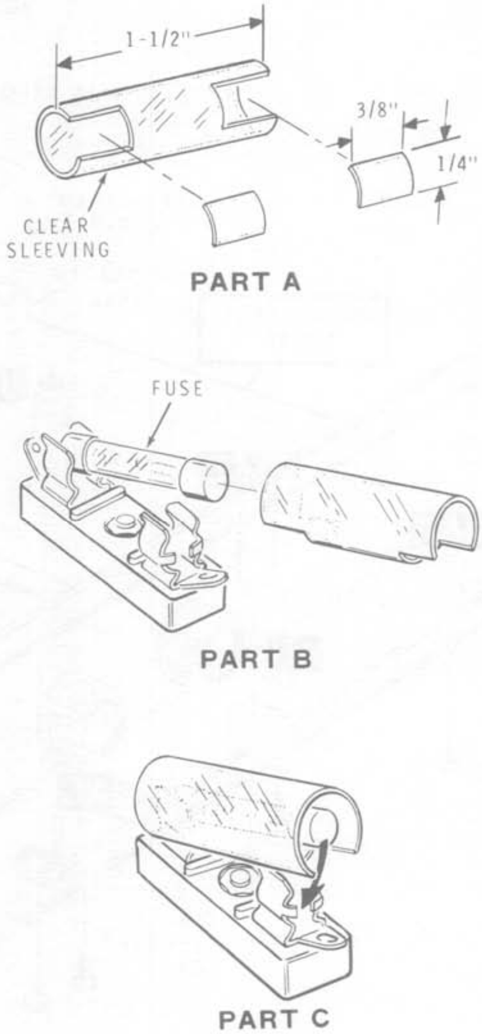
When you install a new plug, make sure it is connected according to your local electrical code. Keep in mind that the green line cord wire is connected to the chassis of the Frequency Counter.

GENERAL ASSEMBLY AND WIRING, Cont'd

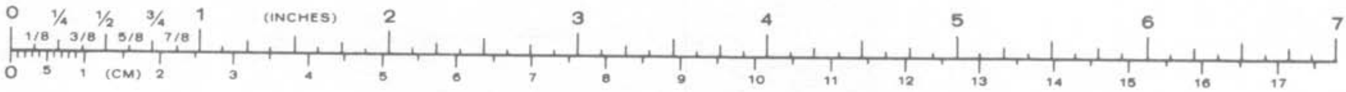
( ) Refer to Detail 4-6D, Part A and cut a 3/8" × 1/4" slot in each end of a 1-1/2" length of clear sleeving. This prepared length of sleeving will be used in the next step.

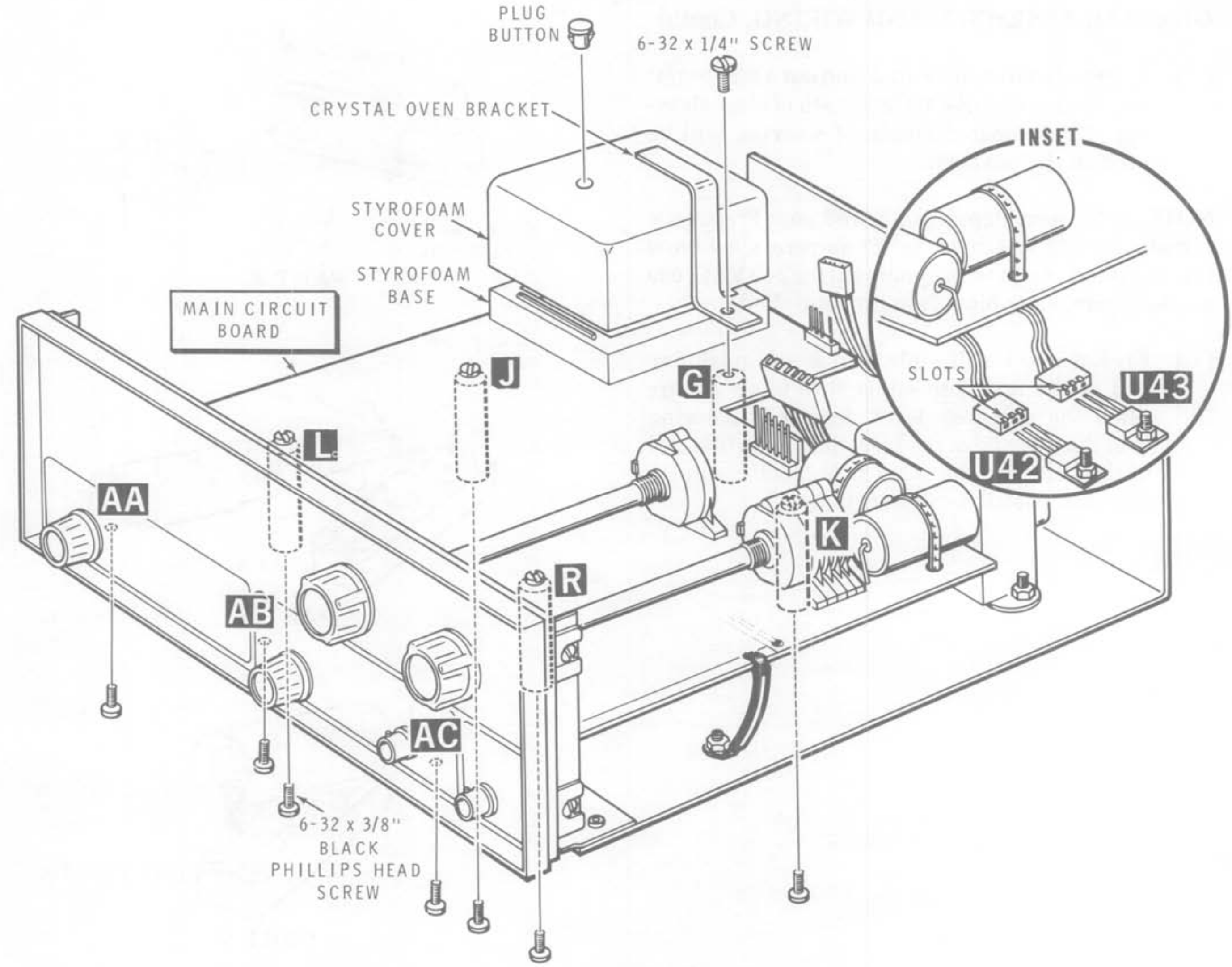
NOTE: In the next step, if you wired your Frequency Counter for 120 VAC, use the 1/2-ampere, slow-blow fuse supplied. If you wired your unit for 240 VAC, use a 1/4-ampere, slow-blow fuse (not supplied).

( ) F1: Refer to Detail 4-6D, Part B and push one end of the fuse into either fuse block clamp. Slide the prepared 1-1/2" length of sleeving over the free end of the fuse; then push this end of the fuse into the other fuse block clamp as shown in Detail 4-6D, Part C.



Detail 4-6D





PICTORIAL 4-7

Refer to Pictorial 4-7 for the following steps.

( ) Position the main circuit board two or three inches above the chassis.

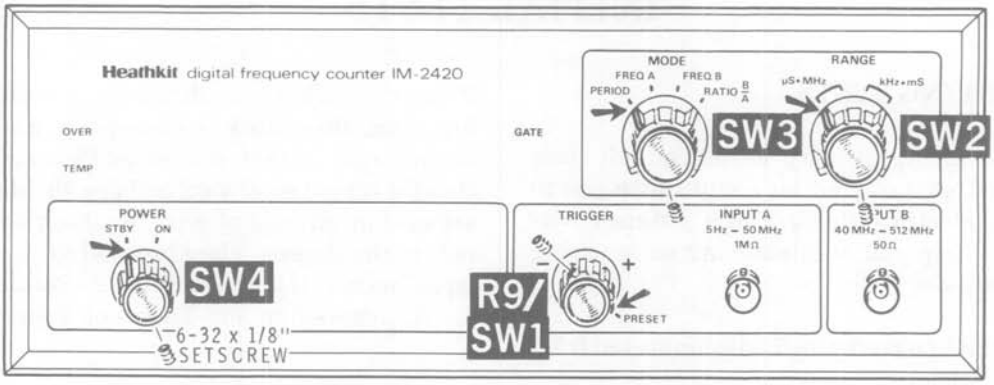
( ) Locate the 3-wire cable connected to holes P, Q, and R on the main circuit board. Push the connector shell onto the pins of integrated circuit U42. Be sure the slots in the connector shell are up as shown. See the inset drawing on Pictorial 4-7.

( ) In the same manner, push the remaining 3-hole connector shell onto the pins of integrated circuit U43.

( ) Position the 4-wire cable and the transformer leads with connector as shown. Then slowly lower the circuit board onto the chassis. Be sure the screws that mount the front feet pass through the corresponding holes in the front panel.

( ) Secure the main circuit board to the chassis with four 6-32 × 3/8" black phillips head screws at location J, K, L, and R.

( ) Secure the chassis to the front panel with three 6-32 × 3/8" black phillips head screws at AA, AB, and AC.



Detail 4-7A

( ) Cut a 2" length of braid.

( ) Connect one end of the 2" braid to the solder lug at F on the chassis. Use the upper hole of the solder lug.

( ) Cut a 1-1/2" length of sleeving.

( ) Slide the prepared sleeving over the 2" braid.

( ) Solder the free end of the 2" braid to the ground foil area indicated in the Pictorial.

( ) Place the Styrofoam cover over the Styrofoam base as shown in the Pictorial. Secure the cover to the base with the crystal oven bracket and a 6-32 × 1/4" screw at G.

( ) Install the plug button in the hole in the Styrofoam cover.

Refer to Detail 4-7A for the following eight steps.

( ) Start a 6-32 × 1/8" setscrew in each of the four knobs. Use the allen wrench supplied with this kit.

( ) Place large knobs on the shafts of switches SW2 and SW3.

( ) Place small knobs on the shafts of control/switch R9/SW1 and switch SW4.

( ) Temporarily tighten the setscrew in each of the four knobs.

( ) Turn the shaft of control/switch R9/SW1 clockwise until you hear a "click."

( ) Turn the shafts of switches SW2, SW3, and SW4 fully counterclockwise.

( ) Loosen the setscrew in each of the four knobs.

( ) Line up the white pointer on each knob as indicated by the arrows on Detail 4-7A. Fasten the setscrews but do not overtighten them.

This completes the Step-by-Step Assembly of your Frequency Counter. Carefully inspect all connections for loose wires or unsoldered connections. Then proceed to the "Initial Tests."

INITIAL TESTS

PRIMARY WIRING TESTS

A wiring error in the primary wiring circuit (line cord, fuse block, etc.) of your kit could cause you to receive a severe electrical shock. These "Primary Wiring Tests" will help you eliminate any such wiring errors that may exist.

(✓) Be sure the line cord plug is disconnected from the AC outlet.

If you do not have an ohmmeter, carefully check the line cord, fuse block, switch SW4, and transformer wiring against that shown in Pictorial 4-6, and in Detail 4-6B or Detail 4-6C on Page 48. Make sure there are no fine strands of wire touching adjacent terminals or the chassis. Then proceed to "Secondary Voltage Checks." If you do not have a voltmeter, proceed to "IC Installation and Tests" on Page 54.

If you have an ohmmeter, refer to Pictorial 5-1 (Illustration Booklet, Page 10) and perform the following resistance measurements. NOTE: You will be instructed to connect one of the ohmmeter leads to ground. This can be the chassis or any metal part mounted on it.

( ) Place the ohmmeter in the R × 10 position.

METER CONNECTIONS		METER READING	POSSIBLE CAUSE OF TROUBLE
EITHER LEAD	OTHER LEAD		
1. Either flat prong of the line cord plug.	Ground	INFINITE	A. Terminal strip H wiring. B. T1.
2. Other flat prong of the line cord plug.	Ground	INFINITE	A. Terminal strip H wiring. B. T1.
3. Round prong of the line cord plug.	Ground	0 Ω	A. Green lead of the line cord not properly connected at solder lug A. See Pictorial 4-6.

( ) Place the ohmmeter in the R × 1 position.

4. Either flat prong.	Other flat prong.	Approximately 13 Ω for 120 wiring and 52 Ω for 240 VAC wiring	A. Terminal strip H wiring. B. T1. C. Fuse F1

This completes the "Primary Wiring Tests." If all tests were satisfactory, proceed to "Secondary Voltage Checks." If any of the tests were not correct, you must make the corrections necessary to obtain the correct readings before you continue.

SECONDARY VOLTAGE CHECKS

WARNING: When the line cord plug is connected to an AC outlet, line voltage is present in the area indicated in Pictorial 5-1 (Illustration Booklet, Page 10). Be careful that you do not contact this voltage or an electrical shock will result.

NOTE: If you do not obtain the proper results in any of the following tests, disconnect the line cord plug from the AC outlet. Then proceed to the "In Case of Difficulty" section of this Manual.

(X) Place the POWER switch in the STBY position if this has not already been done.

( ) Connect the line cord plug to an AC outlet.

( ) Set your voltmeter to measure 50 VAC. Then refer to Pictorial 5-1 and perform the voltage measurements in the chart below.

METER CONNECTIONS		METER READING	POSSIBLE CAUSE OF TROUBLE
EITHER LEAD	OTHER LEAD		
1. Transformer socket, hole 1.	Transformer socket, hole 3.	32 VAC ±20%	See "In Case of Difficulty."
2. Transformer socket, hole 4.	Transformer socket, hole 6.	18 VAC ±20%	See "In Case of Difficulty."

(X) Disconnect the line cord plug from the AC outlet.

(✓) Connect the transformer socket to plug P1 (slots in the socket toward the front of the chassis).

(X) Connect the rear panel socket to plug P2 (slots in the socket toward the rear of the chassis).

IC INSTALLATION AND TESTS

(X) If it has not already been done, set the switches as shown in Pictorial 5-2 (Illustration Booklet, Page 11).

POWER — STBY
TRIGGER — PRESET
MODE — FREQ A.
RANGE — μS•MHz (fully counterclockwise)
10 MHz TIME BASE — INT

Refer to Pictorial 5-2 for the following steps.

NOTES:

1. Make sure you do not short any adjacent terminals or foils when you make tests or voltage measurements. If a probe or test lead slips, for example, and shorts together two adjacent connections, it is very likely to damage one or more of the transistors, diodes, or IC's.

2. Be especially careful when you test any circuit that contains an IC or a transistor. Although these components have an almost unlimited life when used properly, they are much more vulnerable to damage from excess voltage and current than many other parts.

3. Do not remove any components while the unit is turned on.

4. Use a voltmeter with a high input impedance when you measure voltages.

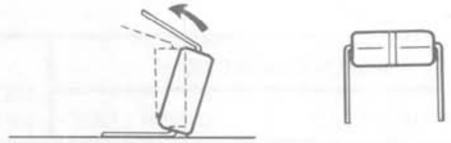
( ) Connect the voltmeter's common lead to the chassis.

( ) Set your voltmeter to measure +1.5 volts DC.

CAUTION: Integrated Circuits (IC's) are complex electronic devices that perform many complicated functions in the circuit. These devices can be damaged during installation. Read all of the following information before you install them.

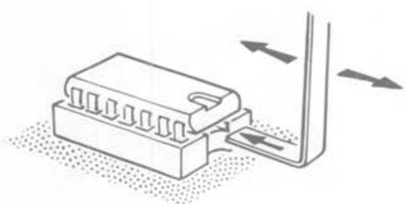
The pins on the IC's are bent out at an angle, so they do not line up with the holes in the IC socket. Do NOT try to install an IC without first bending the pins as described below. To do so may damage the IC pins or the socket, causing intermittent contact.

Before you install an IC, lay it down on its side as shown below and very carefully roll it toward the pins to bend the lower pins into line. Then turn the IC over and bend the pins on the other side in the same manner.



Make sure that the pin 1 end of the IC is positioned over the index mark on the circuit board. Refer to the inset drawing on Pictorial 5-2. Also, make sure that all of the pins are started into the socket. Then press the IC firmly into the socket. NOTE: An IC pin can become bent under the IC and it will appear as though it is correctly installed in the socket.

NOTE: An IC lifter has been furnished so you can remove a dual-in-line IC from its socket if this should be necessary.



Push the shorter end of the lifter in between the IC and the socket and rock the longer portion back and forth. Be very careful, as the IC pins are very easily bent.

Use an ohmmeter to perform the following steps. If you do not obtain the approximate readings indicated in the chart, turn the unit off and correct the difficulty before you proceed.

NEGATIVE (−) LEAD	POSITIVE (+) LEAD	RANGE	METER INDICATION
Gnd	Collector of Q10.	×100	Rise from 0 Ω to infinity (∞) in approximately 10 seconds.
Gnd	Emitter of Q9.	×10k	Approximately 39 kΩ.
Gnd	Base of Q9.	×10k	Approximately 60 kΩ to 150 kΩ.
Gnd	Pin 3 of U38.	×1k	Approximately 3200 Ω.
Gnd	Pin 4 of U38.	×1k	Approximately 5400 Ω.
Gnd	Pin 8 of U38.	×100.	Approximately 900 Ω.

This completes oven circuit tests.

( ) U38: Install an MC1458 IC (#442-21) at U38.

( ) Connect the transformer socket to plug P1 (slots in the socket toward the front of the chassis), if this has not already been done.

( ) Connect the rear panel socket to plug P2 (slots in the socket toward the rear of the chassis), if this has not already been done.

WARNING: When the line cord plug is connected to an AC outlet, line voltage is present in the area indicated in Pictorial 5-1. Be careful that you do not contact this voltage or an electric shock will result.

( ) Connect the line cord plug to an AC outlet.

( ) Measure the voltage at the collector (C) or the metal tab of transistor Q10. It should be +.2 to +1.0 volts DC.

NOTE: The displays, gate, and overrange indicators should not be lit at this time.

( ) Set your voltmeter to measure +15 volts DC.

( ) Continue to monitor the voltage at the collector (C) of transistor Q10. After approximately 5 to 10 minutes, this voltage should slowly increase to above +6 volts DC. NOTE: This verifies that the control circuitry of the crystal oscillator oven is operating properly, and that the oven has reached its correct operating temperature (approximately +75°C).

( ) Place the POWER switch in the ON position. One decimal point should light. Also, the overflow (OVER) indicator should be lit.

Verify the presence of the indicated voltages at the following IC pins:

( ) U38, pin 8: +12 volts DC.

( ) U38, pin 4: −12 volts DC.

( ) U1, pin 1: +5 volts DC.

( ) U26, pin 16: +5 volts DC.

( ) Disconnect the line cord plug from the AC outlet.

( ) U6: Install a 74LS04 IC (#443-755) at U6.

( ) U7: Install a 74S00 IC (#443-26) at U7.

( ) U8: Install a 7450 IC (#443-15) at U8.

( ) U9: Install a 74LS390 IC (#443-921) at U9.

( ) U11: Install a 74LS390 IC (#443-921) at U11.

( ) U12: Install a 74LS90 IC (#443-813) at U12.

( ) U13: Install a 74LS90 IC (#443-813) at U13.

( ) U14: Install a 74LS90 IC (#443-813) at U14.

( ) U15: Install a 74LS90 IC (#443-813) at U15.

( ) U16: Install a 7454 IC (#443-936) at U16.

( ) U17: Install a 7454 IC (#443-936) at U17.

( ) U18: Install a 7476 IC (#443-16) at U18.

( ) U19: Install a 96L02 IC (#443-727) at U19.

( ) Connect the line cord plug to an AC outlet.

( ) Be sure the POWER switch is in the ON position.

( ) With the MODE switch in the FREQ A position, observe the GATE indicator as you turn the RANGE switch clockwise through its ranges. In the first two positions, the indicator should be flashing on and off. In the next to the last position, the indicator should light once every second. In the last position, the indicator should turn off once every 10 seconds.

( ) Disconnect the line cord plug from the AC outlet.

( ) U1: Install a 10216 IC (#443-723) at U1.

( ) U2: Install an SL952 IC (#442-698) at U2.

( ) U3: Install an SP8685B IC (#443-937) at U3.

( ) U4: Install a 74S00 IC (#443-26) at U4.

( ) U5: Install a 74S02 IC (#443-896) at U5.

( ) U21: Install a 74LS390 IC (#443-921) at U21.

( ) U22: Install a 74LS390 IC (#443-921) at U22.

( ) U23: Install a 74LS390 IC (#443-921) at U23.

( ) U24: Install a 74LS90 IC (#443-813) at U24.

( ) U25: Install a 74196 IC (#443-628) at U25.

( ) U26: Install a 9368 IC (#443-694) at U26.

( ) U27: Install a 9368 IC (#443-694) at U27.

( ) U28: Install a 9368 IC (#443-694) at U28.

( ) U29: Install a 9368 IC (#443-694) at U29.

( ) U31: Install a 9368 IC (#443-694) at U31.

( ) U32: Install a 9368 IC (#443-694) at U32.

( ) U33: Install a 9368 IC (#443-694) at U33.

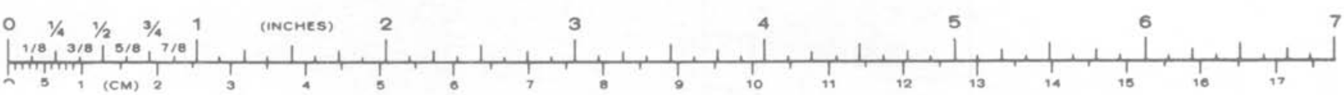
( ) U34: Install a 9368 IC (#443-694) at U34.

( ) U35: Install a 74LS75 IC (#443-781) at U35.

( ) U36: Install a 74LS32 IC (#443-875) at U36.

( ) U37: Install a 74LS32 IC (#443-875) at U37.

( ) Connect the line cord plug to the AC outlet.



( ) For each of the four positions of the MODE switch, rotate the RANGE switch through its ranges while you observe the display. The numbers in the following chart indicate the number of zeros ("0's"), or other numbers, appearing to the right of the decimal point in the display.

MODE SWITCH POSITION	RANGE SWITCH POSITION			
	μS • MHz		kHz • mS	
PERIOD	1	0	2	1
FREQ A	4	5	3	4
FREQ B	3	4	2	3
RATIO $\frac{B}{A}$	4	5	6	7

Indicates the number of zeros ("0's"), or other numbers, appearing to the right of the decimal point in the display.

( ) Disconnect the line cord plug from the AC outlet.

( ) Prepare the ends of the remaining large white wire.

( ) Connect one end of the prepared white wire to the center pin of BNC connector J3. Connect the other end to the center pin of BNC connector J1 (INPUT A).

( ) Set the front panel switches as follows:

POWER — ON.
TRIGGER — PRESET.
MODE — PERIOD.
RANGE — kHz • mS (fully clockwise).
10 MHZ TIME BASE — INT

( ) Connect the line cord plug to an AC outlet.

( ) Observe the display for each position of the MODE switch. Make sure you have the conditions in the following chart. NOTE: Wait 10 seconds to permit the display to update between each reading.

MODE SWITCH POSITION	DISPLAY
PERIOD	.0
FREQ A	OVER 0000.0000
FREQ B	.000
RATIO $\frac{B}{A}$	.0000000

( ) Disconnect the line cord plug from the AC outlet.

( ) Disconnect the white wire.

This completes the Initial Tests. Proceed to the "Calibration" section.

CALIBRATION

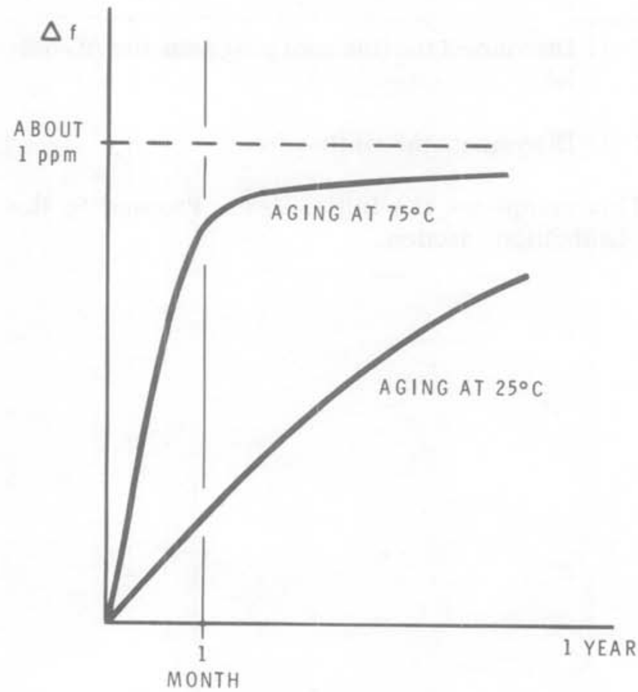
Your Counter is an accurate, laboratory-grade unit. When and how you calibrate the Counter have the greatest effect on its accuracy.

WHEN TO CALIBRATE

You may calibrate your Counter immediately after you finish the "Initial Tests." However, the crystal that controls the oscillator will age (shift frequency)* as time passes, thus shifting the oscillator's frequency and reducing the Counter's accuracy. This shifting occurs with all new crystals and cannot be avoided.

Because of this tendency to shift, you should not spend too much time or effort on the initial calibration. Wait until the crystal has had time to stabilize; then recalibrate the Counter carefully, using laboratory standards for maximum accuracy.

Pictorial 6-1 shows how fast a typical crystal shifts frequency at both 25°C and 75°C. Note that after 14 days at 75°C, about 50% of the frequency shift has occurred; and after 30 days about 90% of the shift is complete.



PICTORIAL 6-1

*Your crystal may shift about ±1, PPM, or 10 Hz, during the first year.

The Counter's oven keeps the crystal at 75°C. So you should plug the Counter in and leave it for at least 14 (preferably 30) days. Then recalibrate it for best results. Review its calibration periodically after that and recalibrate when necessary.

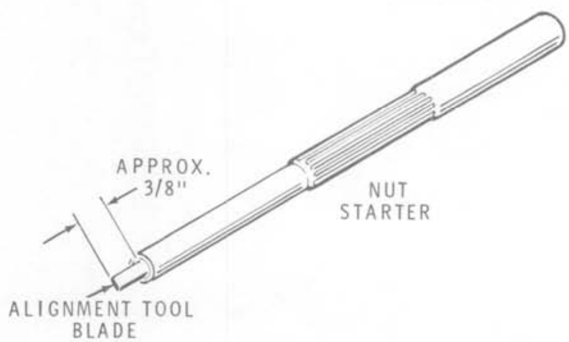
PROCEDURE

Three effective procedures for calibrating your Counter are listed below. When you choose between the first two procedures, consider what equipment you have readily available and how accurate that equipment is. The third method is probably the easiest and most accurate, but the oscilloscope and frequency generator must meet the special requirements listed at the beginning of that procedure.

NOTE: In all the following procedures, the accuracy of your Counter depends upon the accuracy of your standard and how well you do the adjustment.

( ) Refer to Pictorial 6-2 and push the alignment tool blade into the small end of the nut starter as shown. This will be used as an alignment tool in the following steps.

( ) Choose which of the three calibration procedures you will use, and go to that point in the Manual.



PICTORIAL 6-2

Calibration Using A Frequency Counter

Refer to Pictorial 6-3 for the following steps.

( ) Turn both counters on, and allow them to warm up (stabilize) for at least three hours.

( ) Connect a high input impedance probe from your Counter's 10 MHz TIME BASE INPUT/OUTPUT jack (J3) to the high input impedance (1 MΩ) of the calibration (other) counter.

( ) Place the 10 MHz TIME BASE switch (on the rear panel) in the INT position as shown in the Pictorial.

( ) Set the calibration counter to read the output of your Counter with the highest resolution possible.

NOTE: In the following steps, do not leave the plug button out of the Styrofoam cover any longer than necessary. A change in temperature within the oscillator oven will cause the oscillator to change frequency, making calibration difficult.

( ) Remove the plug button and use the alignment tool to adjust the oscillator adjustment capacitor (C101) until the calibration counter reads as close to 10 MHz as possible.

( ) Return the plug button to the Styrofoam cover.

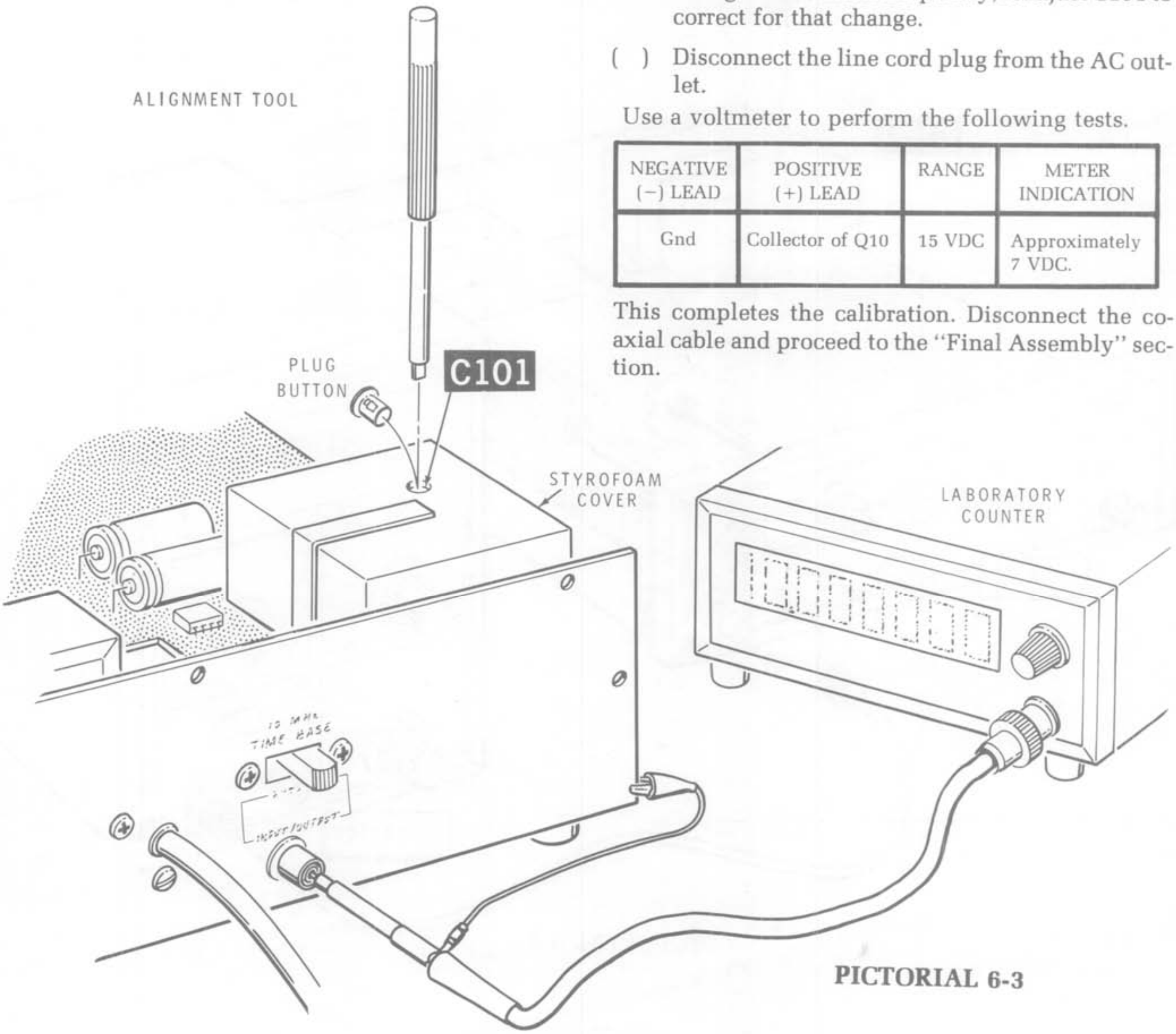
( ) Allow sufficient time (about 1/2 hour) to see if there is any change in the readout. If there is a change in oscillator frequency, readjust C101 to correct for that change.

( ) Disconnect the line cord plug from the AC outlet.

Use a voltmeter to perform the following tests.

NEGATIVE (−) LEAD	POSITIVE (+) LEAD	RANGE	METER INDICATION
Gnd	Collector of Q10	15 VDC	Approximately 7 VDC.

This completes the calibration. Disconnect the coaxial cable and proceed to the "Final Assembly" section.



PICTORIAL 6-3

Calibration Using A Laboratory Standard Frequency Generator

Refer to Pictorial 6-4 for the following steps.

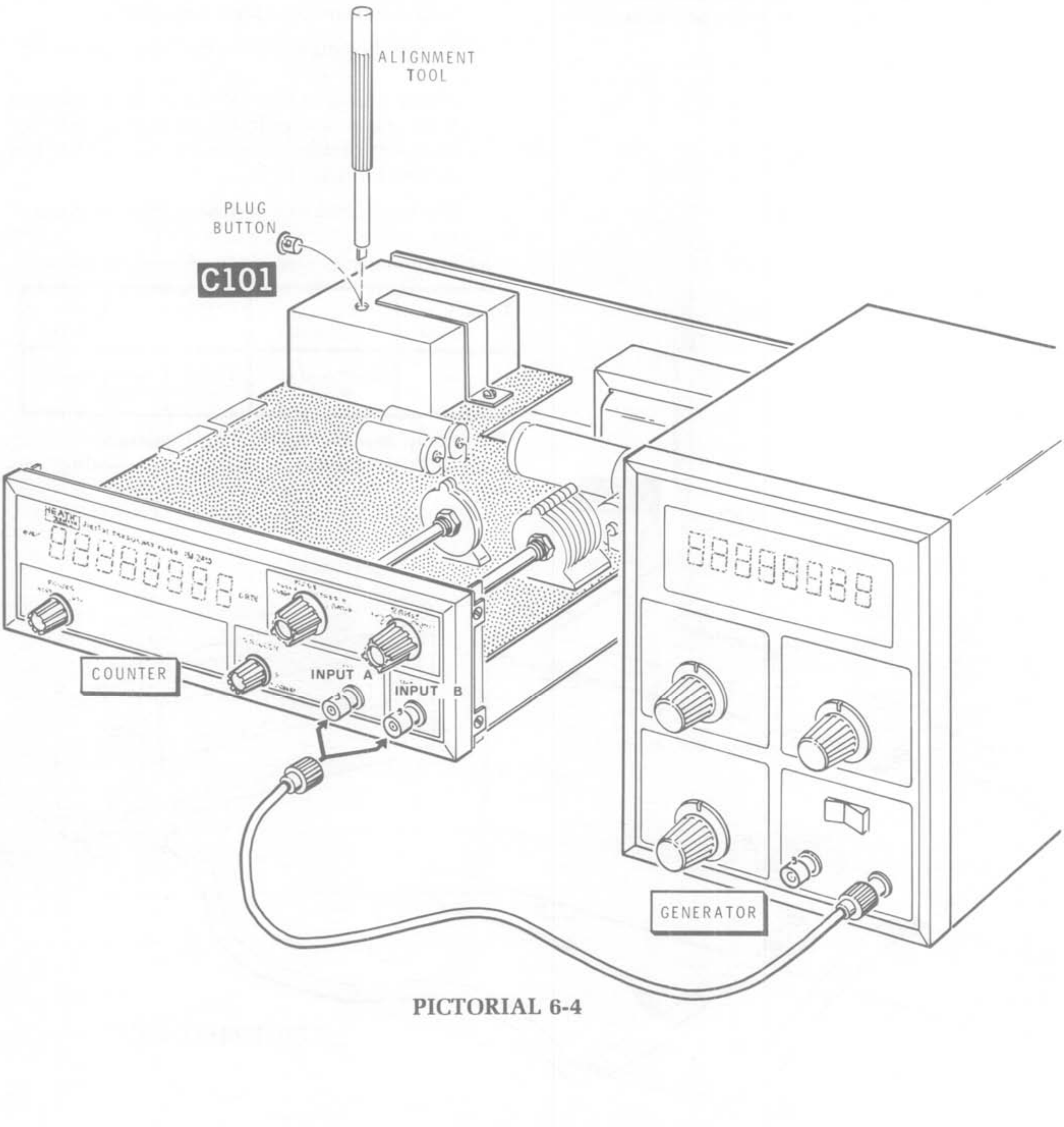
( ) Turn your Counter and the frequency generator on and allow them to stabilize (warm up) for at least three hours.

( ) Connect a coaxial cable from the output of the generator to the correct input (for the generator's frequency) of your Counter.

( ) Set your Counter's MODE switch to select the correct input.

( ) Set your Counter's RANGE switch to its most clockwise position (**kHz•mS**).

( ) Note or select the frequency of the generator. NOTE: In some cases, the selected frequency may be high enough to cause the Counter's OVERrange indicator to light. This does not present a problem, since you are interested only in the least significant digits of the display.



PICTORIAL 6-4

NOTE: In the following steps, do not leave the plug button out of the Styrofoam cover any longer than necessary. The temperature within the oscillator oven can change while the button is out. This will cause the oscillator to change frequency, making calibration difficult.

( ) Remove the plug button and use the alignment tool to adjust the oscillator adjustment capacitor (C101) until the Counter reads as close to the generated frequency as possible.

( ) Return the plug button to the Styrofoam cover.

( ) Allow sufficient time (about 1/2 hour) to see if there is any change in the readout. If there is a change, readjust the oscillator adjustment capacitor (C101) to compensate for that change.

( ) Disconnect the line cord plug from the AC outlet.

Use a voltmeter to perform the following tests.

NEGATIVE (−) LEAD	POSITIVE (+) LEAD	RANGE	METER INDICATION
Gnd	Collector of Q10	15 VDC	Approximately 7 VDC.

This completes the calibration. Disconnect the coaxial cable and proceed to the "Final Assembly" section.

Calibration Using a Laboratory Standard Frequency Generator and an Oscilloscope

NOTE: You will find this procedure easy and effective **if** you have a generator that produces 1 or more frequencies that are whole number multiples of 1 MHz (1, 2, 3) up to any frequency within the response of the oscilloscope, and **if** you have an oscilloscope that has provisions for both X and Y inputs.

Refer to Pictorials 5-2 and 6-5 (Illustration Booklet, Page 11) for the following steps.

( ) Turn your Counter and the frequency generator on, and allow them to stabilize (warm up) for at least three hours.

( ) Connect a high input impedance probe from the Counter's 10 MHz TIME BASE INPUT/OUTPUT jack (J3) to the X input of the scope.

( ) Place the 10 MHz TIME BASE switch (on the rear panel) in the INT position as shown in Pictorial 5-2.

( ) Connect a coaxial cable from the output of the generator to the Y input of the oscilloscope.

( ) Adjust the oscilloscope to obtain a display that does not extend beyond the edges of the screen.

( ) Adjust the generator for a frequency that will produce a simple figure on the screen (1 MHz, 2 MHz, 2.5 MHz, or 5 MHz).

The pattern on the oscilloscope screen represents the frequency relationship at the X and Y inputs. It is called a Lissajous pattern. Those patterns shown in the inset drawing on Pictorial 6-5 correspond to the integer relationships listed.

The figure on the screen will probably appear fuzzy, or be rapidly rotating. This is because the Counter's oscillator is not exactly at 10 MHz.

NOTE: In the following steps, do not leave the plug button out of the Styrofoam cover any longer than necessary. The temperature within the oscillator oven can change when the button is out. This will cause the oscillator to change frequency slightly, and will make calibration difficult.

( ) Remove the plug button and use the alignment tool to adjust the oscillator adjustment capacitor (C101) until the rotating figure slows. Get the figure as still as possible. The speed of rotation shows how closely you have matched the oscillator frequency to that of the generator.

( ) Return the plug button to the Stryofoam cover.

( ) Allow sufficient time (about 1/2 hour) to see if there is any change in the figure's rotation. If the figure is moving rapidly, readjust C101 to slow it again.

Use a voltmeter to perform the following tests.

NEGATIVE (−) LEAD	POSITIVE (+) LEAD	RANGE	METER INDICATION
Gnd	Collector of Q10	15 VDC	Approximately 7 VDC.

( ) Disconnect the line cord plug from the AC outlet.

This completes the calibration. Disconnect the test instruments and proceed to the "Final Assembly" section.

FINAL ASSEMBLY

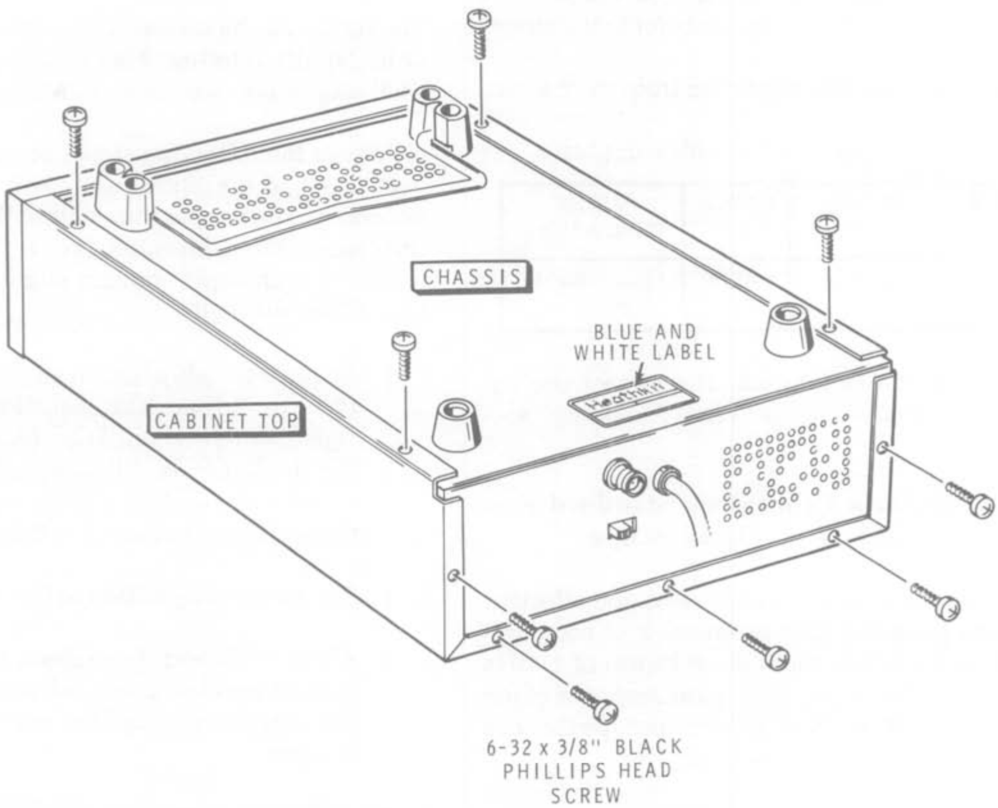
Refer to Pictorial 7-1 for the following steps.

( ) Position the cabinet top upside down on your work area.

( ) Slide the counter into the cabinet top and secure the cabinet in place with nine 6-32 × 3/8" black phillips head screws.

NOTE: The blue and white label that you will install in the following step shows the Model number and Production Series number of your kit. Refer to these numbers in any communications you have with the Heath Company about this kit.

( ) Carefully peel away the backing paper from the blue and white label. Then press the label onto the chassis at the location shown.



PICTORIAL 7-1

OPERATION

Refer to Pictorial 8-1 on Page 12 in the "Illustration Booklet," for a description of the display, controls, and switches.

CAUTION: Use ONLY the center conductor of the input lead of your Counter to check the frequency of an AC line voltage. Connecting the ground input lead to the "hot" (ungrounded) side of an AC line may result in a blown fuse and/or damage to your Counter.

INPUTS

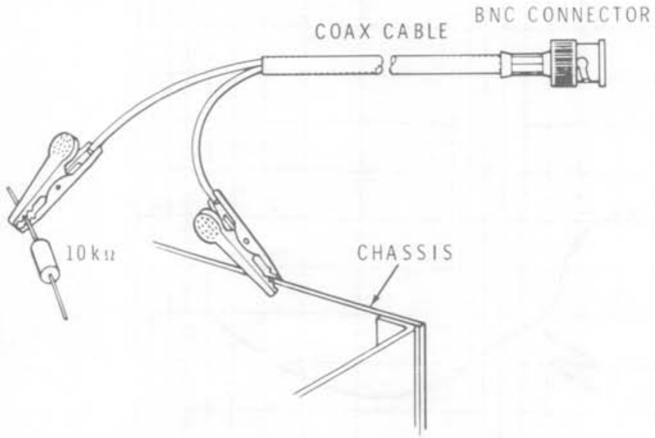
When you measure pulses or square waves of high amplitude and fast rise time (rise time ≤ 50 nanoseconds and amplitude ≥ 200 mV), connect a 10 kΩ, 1/4-watt resistor in series with the test cable (see Pictorial 8-2) to eliminate or reduce reflections in the test cable. This is necessary because reflections will distort the waveform, which can cause erroneous readings — or possibly damage the equipment under test.

Input A has an input impedance of 1 MΩ shunted by approximately 18 pF of capacitance. Capacitive loading can cause the unit under test to change frequency and result in erroneous readings.

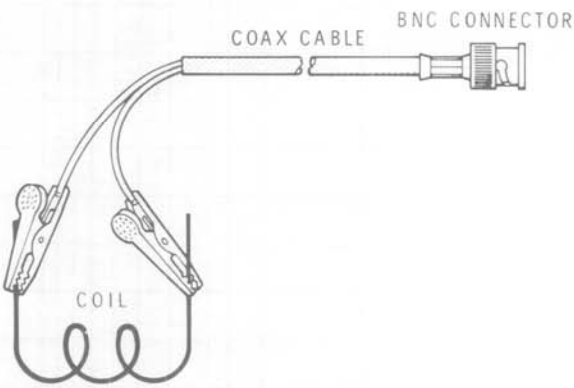
A simple way to reduce reflections and capacitive loading is to use a 10 MΩ, divide-by-10 oscilloscope probe. This decreases the input sensitivity by a factor of 10, but does provide isolation between the unit under test and your Counter. The frequency response of Input A may also be limited by the frequency response of the probe.

When you measure frequencies from a transmitter with a power greater than 1/2-watt, use a whip antenna, such as the Heath Model SMA-2400-1, in place of a direct connection. Another method would be to use a coupling coil made up of three turns of a hook-up wire connected to the end of the coaxial cable, as shown in Pictorial 8-3. Place the coil just close enough to the signal source for the Counter to operate. NOTE: **Do not** connect the ground to the transmitter and place the coil in the same axis as the transmitter coil or around the antenna.

Input B has an input impedance of 50 ohms; therefore, it will properly terminate a 50-ohm transmission line. Signal cables not terminated in their characteristic impedance may cause erratic counting due to reflections. (NOTE: For 50 Ω lines to Input A, you can use the Heath Model SU-511-50, 50Ω termination.) If you use test cables other than 50 ohms, it will then be necessary to use a matching pad to eliminate reflections and capacitive loading. See the following typical sensitivity curves.

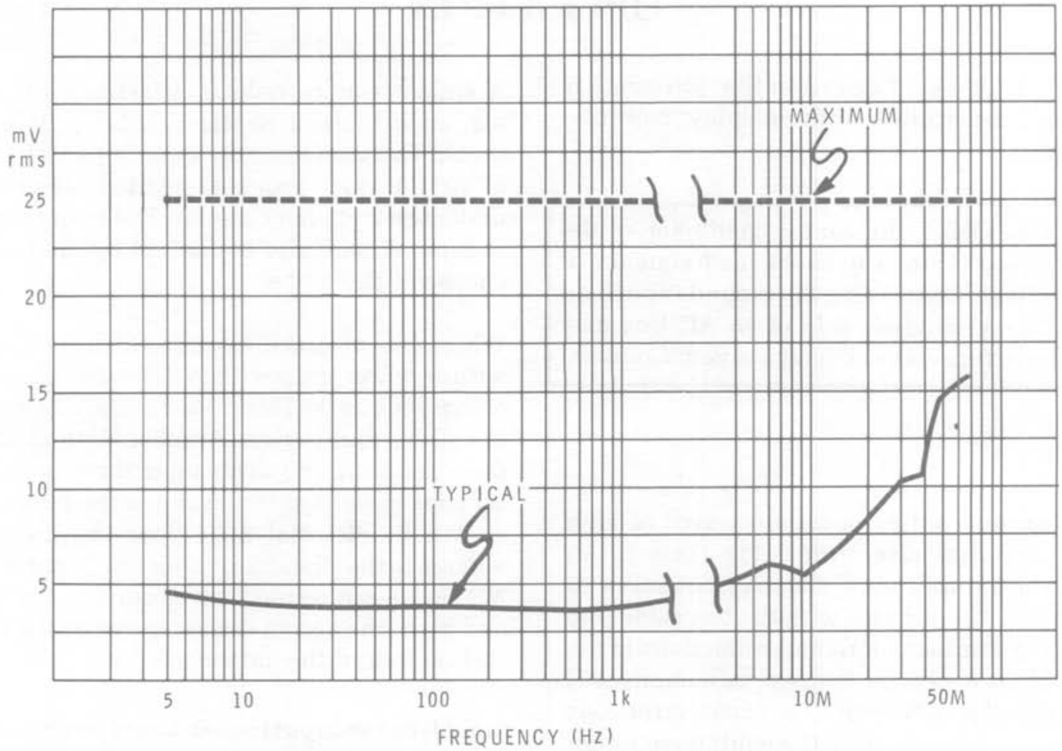


PICTORIAL 8-2

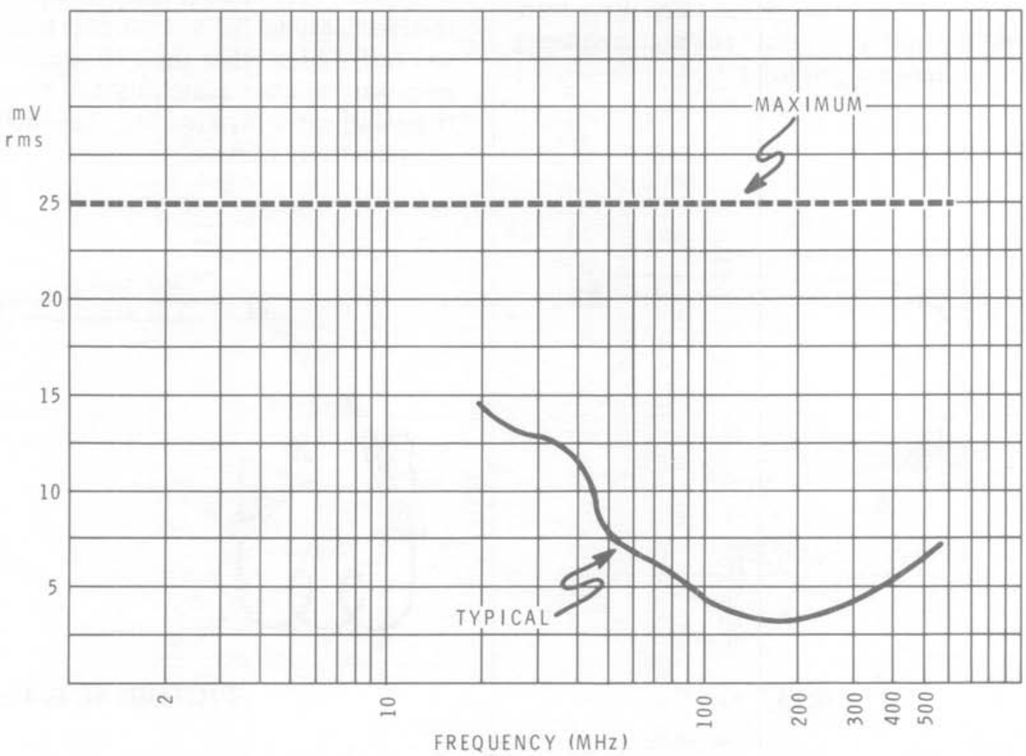


PICTORIAL 8-3

INPUT A SENSITIVITY



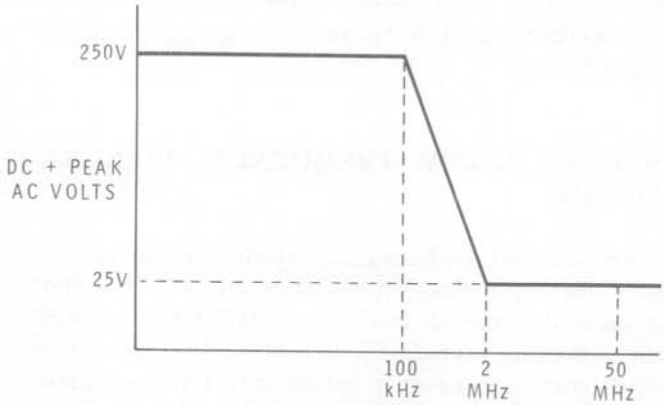
INPUT B SENSITIVITY



MAXIMUM INPUT VOLTAGE

Input A can withstand 250 volts, DC plus peak AC, up to a frequency of 100 kHz. Above this frequency, the maximum input voltage must be derated according to Graph A.

GRAPH A



INPUT A DERATING CURVE

Input B is protected to 5 volts DC plus AC rms throughout its frequency range, as shown in Graph B.

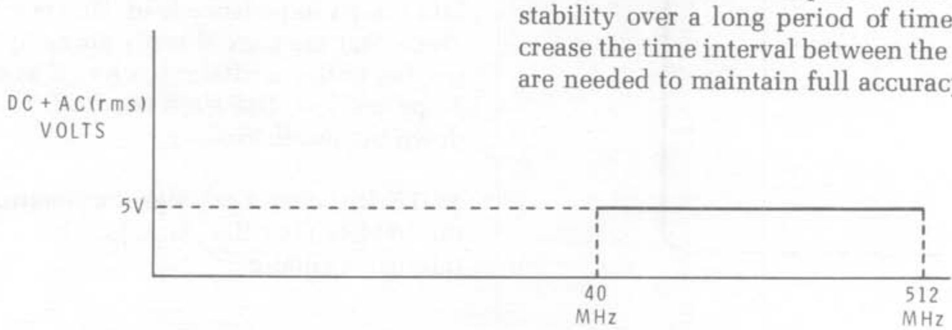
CAUTION:

Do NOT connect a transmitter output directly to an input of this instrument under any circumstances.

FREQUENCY MODE

With the MODE switch in a FREQUENCY position, you can measure any frequency between 5 Hz and 512 MHz. Connect the equipment under test to the appropriate front panel input and read the frequency from the display.

GRAPH B



INPUT B DERATING CURVE

The RANGE switch selects the time (gate time) over which the counting circuitry makes its measurement, and thus, selects the resolution of the display.

As you rotate the RANGE switch clockwise, the gate time increases in decade steps to a maximum of 10 seconds with a resulting resolution of .1 Hz.

RANGE SWITCH POSITION	RESOLUTION	GATE TIME
kHz • mS	.1 Hz	10 Sec.
kHz • mS	1 Hz	1 Sec.
μS • MHz	10 Hz	100 mSec.
μS • MHz	100 Hz	10 mSec.

NOTE: To make it easier to read the display, readings for the shorter gate-times (.1 and .01 seconds) are not updated as often as they could be (for example, the .1 second gate is updated about three times per second).

PERIOD

With the MODE switch in the PERIOD mode, and a signal applied to Input A, the readout will display the period of the input signal. The RANGE switch selects the desired resolution.

WARM-UP/STANDBY

If you intend to use this Frequency Counter for high precision measurements, leave it plugged into the line voltage with the POWER switch in the STBY (Standby) position. This will not greatly reduce the warm-up time; the Counter needs about 30 minutes to warm up thoroughly from a cold start, and this time is only reduced to 20 minutes in the Standby position. But, this **will** keep the oscillator circuit at a constant temperature, protect its components from significant thermal stresses, and help it maintain a higher level of stability over a long period of time. It will also increase the time interval between the calibrations that are needed to maintain full accuracy.

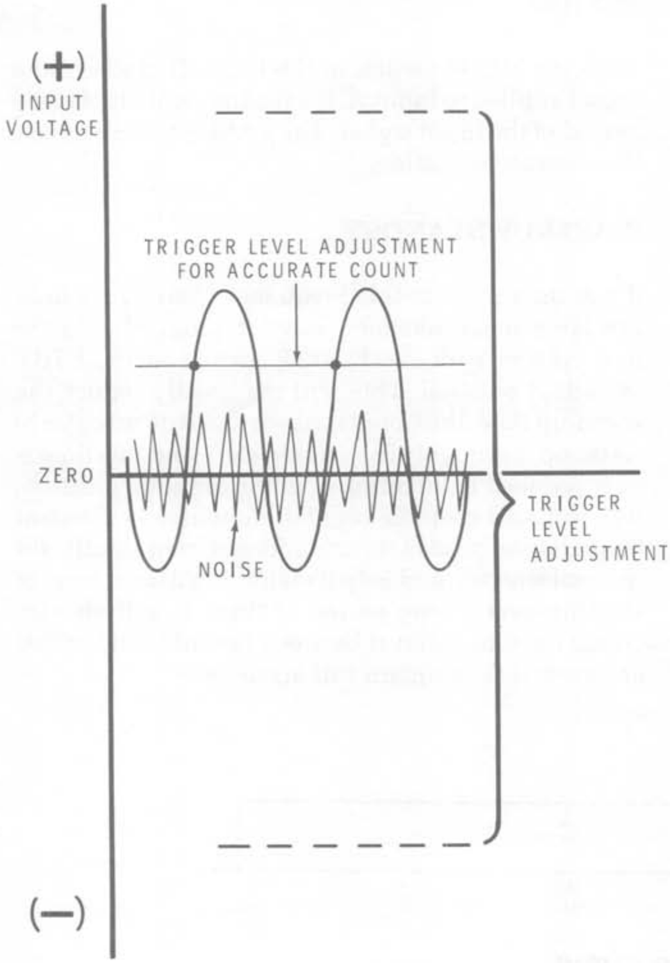
ACCURACY

In the FREQUENCY mode, the accuracy of the Counter depends on the accuracy of the time base oscillator and the inherent ±1 count error of the instrument. Thus, for a ±.1 PPM time base accuracy, the instrument has an accuracy of ±.1 Hz ±1 count for a 1 MHz input signal. Likewise, for a 20 MHz input signal, the instrument has an accuracy of ±2 Hz ±1 count.

TRIGGER LEVEL

The quality of the input signal affects the measurement capabilities of this instrument. A signal with a 40 dB signal-to-noise ratio can cause inaccuracies as well as one with a 20 dB signal-to-noise ratio. For example: a 2V rms signal with a 40 dB signal-to-noise ratio will have 20 mV rms noise content. Since 20 mV rms is more than the input requires to trigger, the instrument will count the noise in addition to the fundamental input signal.

GRAPH C



The TRIGGER level control permits you to adjust the Input A amplifier trigger level above and below the signal zero-crossing point. Varying the control does not amplify or attenuate the input signal level, however, it lets you control the point on the input signal that causes the circuit to trigger a count. This allows you to set the trigger point so that it is above most noise or signal distortion as shown in Graph C. When the TRIGGER level control is set fully clockwise, it presets the trigger point to zero volt, to count very low input levels.

ACCURATE LOW FREQUENCY MEASUREMENTS

Your Counter counts and displays low frequency signals. However, the display error may be ±1 count because the internal clock is not synchronized with the incoming signal. To measure a low frequency signal more accurately, position the RANGE switch to kHz • mS and the FUNCTION switch to PERIOD. Then solve the equation for f (in Hertz) = 1 /period (in seconds).

EXAMPLE: Accurately count a low frequency signal (about 10 Hz) from a signal generator.

The period display is 99.991 mS.

Solve for f = 1/period = 1/.099991 = 10.0009 Hz.

USING THE 10 MHz OUTPUT

You may use the internal 10 MHz oscillator as a source for other devices. Set TIME BASE switch SW5 to the INT position and connect your cable to EXTERNAL OSCILLATOR jack J3. The ON/STBY switch, SW4, must be in the ON position.

The oscillator will produce a TTL-compatible signal into a high impedance load. However, you must be aware that the coaxial cable normally used for connecting to the oscillator has a typical capacitance of 30 pF per foot. Use short test leads to avoid loading down the oscillator.

NOTE: Disconnect any signal generating device from the 10 MHz Time Base jack, J3, whenever you use the internal oscillator.

IN CASE OF DIFFICULTY

This section of the Manual is divided into three parts. The first part, titled "Troubleshooting and Repair Precautions," points out the care that you should use when you service the unit to prevent damaging components.

The second part, titled "Troubleshooting Chart," gives difficulties and likely causes.

The "Special Circuit Tests" gives you specific procedures for testing the time base divider chain and the oven control circuit.

If the "Troubleshooting Chart" does not help you locate the problem, read the "Circuit Description" and refer to the Schematic Diagram (fold-in) to help you determine where the trouble is. Refer to the "Circuit Board X-Ray Views" (Illustration Booklet, Pages 17-18) for the physical locations of parts on the circuit boards.

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

Troubleshooting and Repair Precautions

Be sure you disconnect the line cord before you remove the cabinet from your Counter.

1. Make sure you do not short any adjacent terminals or foils where you make tests or voltage measurements. If a probe or test lead should slip, for example, and short together two adjacent connections, it is very likely to damage one or more of the transistors, diodes, or IC's.

2. Be especially careful when you test any circuit that contains an IC or a transistor. Although these components have an almost unlimited life when used properly, they are much more vulnerable to damage from excess voltage and current than many other parts.

3. Do not remove any components while the unit is turned on.

4. Never apply +5 V, or ground to the output of any IC.

5. When you make repairs, make sure you eliminate the cause as well as the effect of the trouble. If, for example, you find a damaged resistor, be sure you find out what damaged the resistor. If the cause is not eliminated, the replacement resistor may also become damaged when you put the unit back into operation.

6. In several areas of the circuit boards, the foil patterns are quite narrow. When you unsolder a part to check or replace it, avoid excessive heat while you remove the part. A suction-type desoldering tool makes part removal easier.

7. When you are instructed to check a component, make sure the correct part has been properly installed. Then check the solder connections. Check the foils to identify any improper solder connections or solder bridges.

8. When a part is listed on the "Troubleshooting Chart," check not only the part itself, but also check associated circuitry that may cause the listed part to malfunction.

9. When you are troubleshooting display LED's and some of the IC's, it may be useful to interchange similar components (such as U12, U13, U14, and U15 of the divider chain) to help find if one is at fault. Interchange only those parts with the same part number, as shown on the Schematic or Parts List.

Components

To remove a faulty resistor or capacitor, first clip it from its leads. Then heat the solder on the foil and allow each lead to fall out of its hole. Preshape the leads of the replacement part and insert them into the holes in the circuit board. Solder the leads to the foil and cut off the excess lead lengths.

You can remove transistors in the same manner as resistors and capacitors. Make sure you install the replacement transistor with its leads in the proper holes. Then solder the leads quickly to avoid heat damage. Cut off the excess lead lengths.

Foil Repair

To repair a break in a circuit board foil, bridge solder across the break. Bridge large gaps in the foil with bare wire. Lay the wire across the gap and solder each end to the foil. Carefully trim off any excess bare wire.

Troubleshooting Chart

This chart lists the condition and possible cause of several malfunctions. If a particular part or parts are mentioned (LED V9 for example) as a possible cause, check that part to see if it was installed and/or wired correctly. Also, check the other circuit components associated with this part, as these may be the wrong value.

Difficulty	Possible Cause
Display, decimal point, and Gate LED do not light.	1. +5 volt power supply.
Gate LED does not flash in the FREQ A or FREQ B modes.	1. Gate LED V9. 2. Time base divider chain.* 3. 10 MHz oscillator. 4. Time base Int/Ext switch SW5 in Ext position.
A segment of the display does not light.	1. Corresponding latch decoder driver. 2. LED display V1 through V8. 3. Open solder connection between circuit boards.
One digit of display does not light or shows "8" continuously.	1. Latch decoder driver. 2. LED display V1 through V8. 3. Blanking circuitry U36, U37.
Decimal points do not light, or more than one lights at a time.	1. Diodes D16 through D19. 2. LED display V1 through V8.
Leading zeros are not blanked.	1. Blanking circuitry U36, U37. 2. Overflow circuitry U35, U18B. 3. Latch decoder drivers U26 through U34.
Counter works in Freq A and Period modes only.	1. B input; D5--D8, U2, U3, Q5, and Q6. 2. Input selector gate U4D.

(Cont'd.)

*See "Time Base Divider Chain Troubleshooting," on Page 70.

Troubleshooting Charts (cont'd)

Difficulty	Possible Cause
Counter works in Period mode only.	1. Input selector U4. 2. Pulse shaper U5. 3. Count input selector U7D.
Counter does not work in Period mode only.	1. Time base gates U16. 2. Count input select gate U7A. 3. Time base input gate U8D.
Counter works in Freq B mode only.	1. A input; Q1, Q2, U1, Q3, Q4, and U4C. 2. Selector gates U4B, U8A, and U8D.
Counter works in Ratio B/A mode only.	1. Oscillator; Y101, Q101, and Q102. 2. Time base switch SW5 in Ext. 3. Input A/Osc selector gate U8B and inverter U6A.
Counter does not work in any mode. Gate light does flash.	1. Store and reset monostables U19A and U19B. 2. Counter gate U7C.
Low sensitivity in Freq A, Period, and Ratio B/A modes. Gate light does flash.	1. Trigger level control R9 misadjusted or faulty. 2. Input A;Q1, Q2, U1, Q3, Q4.
Low sensitivity in Freq B, Ratio B/A, modes. Gate light flashes.	1. Input B; D5--D8, U2, U3, Q5, and Q6.
10 MHz oscillator will not set to exact frequency. NOTE: Make sure you know the accuracy of the standard.	1. 10 MHz oscillator. 2. Oven heater control.** 3. Y101.
10 MHz oscillator drifts excessively.	1. Oven heater control.**
Counter operates but display is incorrect.	1. Store or reset circuitry U19. 2. Input signal has high noise content. 3. Reflections on input test cable. 4. 10 MHz oscillator not calibrated. 5. Oven heater control.**
Overflow indicator doesn't light.	1. Overflow LED V11. 2. Overflow circuitry; Q8, U35, and U18B.
TEMP indicator cycles on and off.	1. − 12 V supply voltage missing on U38 pin 4. 2. Thermistor R62 defective. 3. Q10 shorted. 4. Q9 defective.

** See "Oven Control Circuit Test," on Page 70.

Special Circuit Tests

OVEN CONTROL CIRCUIT TEST

Perform this test to verify that the oven control circuit is performing correctly.

1. Connect an oscilloscope to the metal tab of Q10. If your Counter has been plugged in for more than 10 minutes and the Styrofoam cover is in place over the oscillator, you should see a square wave with about a 50% duty cycle.

2. Remove the plug button from the Styrofoam cover, and blow into the hole to cool the oven. You should see the waveform increase in duty cycle temporarily, and then settle back when the operating temperature is reached.

TIME BASE DIVIDER CHAIN TROUBLESHOOTING

Perform this test to verify the correct operation of the divider chain or locate any dividers that are not operating correctly.

1. Set the Mode switch in the Freq A position and the Range switch in the fully CCW position.

2. Use an oscilloscope to check for a 10 MHz signal at U9 pin 1.

3. In a similar manner, use the oscilloscope to check for the following frequencies at the points listed:

   1 MHz at U9 pin 7
   100 kHz at U11 pin 1
   10 kHz at U11 pin 7
   1 kHz at U12 pin 14
   100 Hz at U13 pin 14
   10 Hz at U14 pin 14
   1 Hz at U15 pin 14
   .1 Hz at U15 pin 11

   If at any point you do not find the right signal, interchange that IC with one bearing the same part number (U12, U13, U14, and U15 may be interchanged; U9 and U11 may be interchanged with each other only). If the problem moves with the IC, the IC is faulty. If the problem does not move, the problem is with the associated circuitry or connections.

4. Use the oscilloscope to check for 10 MHz at U16 pin 8. Then turn the Range switch clockwise. The signal should change to 1 MHz, 100 kHz, and finally 10 kHz.

5. Repeat the previous step at U17 pin 8. The frequencies you find should be 100 Hz (with the Range switch in the full CCW position), 10 Hz, 1 Hz, and 0.1 Hz. If at any point you do not find the right signal, try exchanging U16 and U17 as you did with the divider chain IC's.

SPECIFICATIONS

FREQUENCY MEASUREMENT MODES

	Input A	Input B
Frequency Range	5 Hz to 50 MHz.	40 MHz to 512 MHz.
Sensitivity (Guaranteed)	25 mV rms.	25 mV rms.
Sensitivity (Typical)	4 to 15 mV rms. See graph on Page 64.	4 to 15 mV rms. See graph on Page 64.
Overload Protection	See graph on Page 65.	See graph on Page 65.
Input Impedance	1 MΩ shunted by <25 pF.	50 Ω nominal.
Display Resolution (LSD)*	.1 Hz to 100 Hz.	1 Hz to 1000 Hz.

PERIOD MEASUREMENT MODE

Input	Input A only.
Range	5 Hz to 10 MHz.
Sensitivity	See Frequency Measurement Modes for Input A, above.
Display Resolution (LSD)*	100 nsec to .1 msec in decade steps.

RATIO B/A MEASUREMENT MODE

Input Frequency Limits	Input A: 5 Hz to 25 MHz. Input B: 40 MHz to 512 MHz.
Effective Measurement Range (Guaranteed)	From 1.6 to 1.024×10^8.
Sensitivity	See "Frequency Measurement Modes," above.

*Least Significant Digit

TIME BASE OSCILLATOR

Frequency	10 MHz.
Setability	±.2 PPM.
Output	Short circuit protected. Will drive 1 standard TTL load.
Crystal Aging Rate	<1 PPM/Yr.
Stability	±.2 PPM, 0 to 40°C.
External Input	TTL or 2.5V rms from 50 Ω source (10 MHz).
Input Protection	Any voltage with peak-to-peak limits between −3.5 and +10 volts.
Oven Operating Temperature	75° ±5°C. 167°F
Warm-up Time*	10 minutes to within ±1 PPM. 20 minutes to within ±.1 PPM.

GENERAL

Sampling Interval	.01 sec, 0.1 sec, 1 sec, and 10 sec.
Sampling Rate	Every 0.1 sec, .33 sec, 1 sec, or 10 sec.
Display	Eight digits.
Power Requirements	120/240 VAC, 50/60 Hz, 6 watts max. in STBY, 40 watts max. in ON.
Dimensions	4-1/4" H × 10"W × 12-1/2"D (10.8 × 25.4 × 31.8 cm).
Weight	6-1/2 lbs (2.8 kg).

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.

*From cold oven (unplugged) start.

CIRCUIT DESCRIPTION

You may use this circuit description when troubleshooting difficult problems or when you wish to gain information for personal satisfaction.

This circuit description is divided into two major sections. The first is the "Basic Circuit Blocks" section, which treats each block of components that is lumped under a title on the schematic. The second section is "Circuit Flow," which shows how the various basic circuit blocks function together in the different modes of operation.

If you are confident of your ability to understand transistor and IC logic, you may wish to skip the "Basic Circuit Blocks" section and begin your reading with the "Circuit Flow" (Page 80). If you encounter problems with any part of the flow description, refer back to the appropriate Basic Circuit Block by the number given in your reading.

This counter contains circuitry that operates on different voltages for logic "high" and "low" levels. Note that U1, U2, and U3 are ECL (emitter coupled logic) devices. As such, they operate on logic highs of at least 4.25 volts (input and output) and logic lows of less than 3.5 volts (input and output).

The TTL (transistor-transistor logic) used elsewhere in the Counter operates on logic highs of at least 2.0 volts (input) or 2.4 volts (output). TTL logic lows are less than 0.8 volt (input) and 0.4 volt (output).

Basic Circuit Blocks

Refer to the Schematic diagram as you read the following pages. The titles on the Schematic match those in this portion of the description. The numbers next to the titles allow you to refer back and forth between the block descriptions and the appropriate parts of the "Circuit Flow" section.

Each Basic Circuit Block description will normally carry three pieces of information about the particular block being discussed. First, the input(s) will be noted. Second, the function/process performed by that block will be explained. And third, the output will be described. In the cases of input and output, the other basic blocks involved will be mentioned so that you will be able to quickly identify them for troubleshooting purposes.

In the following discussion, these terms will be used:

Count Sequence is the entire process followed by the Counter to start the count, count the input signal, stop the count, transfer the final count to the display, and reset the counters for the next count.

Count Period is the time it takes to complete one count. This does not include the time used for the store and reset operations.

Signal Voltage is an input or oscillator signal that is processed through the Counter to produce an output (frequency or period display) that represents the signal.

Control Voltage is a voltage to any logic device that controls whether that device allows the signal voltage to pass or stops it.

#1 -- INPUT A BUFFER; J1, Q1, & Q2

Jack J1 accepts the input signal, which is fed through DC isolation capacitor C1. Resistor R2 and diodes D1 and D2 provide overload protection and C2 improves high frequency response. FET transistor Q1 and transistor Q2 form an impedance converter which provides a high input impedance (1 MΩ) for Input A and a low impedance output for the "Wideband RF Amplifier" (#3). The gain through Q1 and Q2 is about .7.

#2 -- TRIGGER; R9 & SW1

The trigger level control works with either of two DC voltages. One voltage is used when the Trigger switch is in the Preset position. It is a constant reference voltage from U1A pin 11. The other voltage is used when the Trigger is **not** in the Preset position. This voltage is selected by control R9. The selected DC voltage is sent to the "Wideband RF Amplifier" (#3), pin 4, where it is used to determine the bias level at pin 4 of the U1A circuit.

#3 -- WIDEBAND RF AMPLIFIER; U1A & U1B

The amplifier receives two inputs, the AC signal from input A and the DC level from the trigger. It amplifies the voltage differential between pins 4 and 5 by 20 to 30 dB. The output goes to the "Schmitt Trigger" (#4).

Pin 11 of U1 provides a DC bias output. The DC voltage is used as reference to pin 5 of the amplifier, to the Trigger switch (in the Preset position), and to the "Schmitt Trigger."

#4 -- SCHMITT TRIGGER; U1C

The signal input to the Schmitt Trigger at pin 12 is the AC plus DC signal from the "Wideband RF Amplifier (#3). The other input is the fixed (reference) level voltage at pin 13 coming from pin 11 plus a "hysteresis" bias through resistor R17. When the voltage at pin 12 (AC signal plus DC level plus hysteresis effect) matches the voltage at pin 13, the Schmitt Trigger changes state. The hysteresis bias to pin 13 suddenly decreases, reinforcing the "on" state of U1C. When the input at pin 12 drops below this lower level, the "output" (pins 14 and 15) returns to the "off" state. The output goes from pins 14 and 15 to the "Converter" (#5).

#5 -- LEVEL CONVERTER; D3, D4, Q3, & Q4

Q3 is driven differentially by the output of the Schmitt Trigger. The emitter of Q3 is driven directly, while its base is driven through D3, which provides the biasing for Q3. D4 provides temperature compensation for Q3. The transistor operates in such a manner that it changes the signal from ECL to TTL logic levels, while Q4 provides additional buffering.

#6 -- BUFFER; U4C

U4C has one input (pin 10) tied high, while the other (pin 9) is driven by Q4 of the Level Converter. U4C acts as an inverting buffer, with its output (pin 8) going to the "Input Selector" (#11), the "A Input/Oscillator Selector" (#21), and the "Time Base Input Selector" (#25).

#7 -- INPUT B BRIDGE LIMITER; J2 & D5 THROUGH D8

Jack J2, which is terminated by resistor R26, accepts the high frequency input signal and passes it through DC isolation capacitor C11 to a diode bridge limiter. The diodes in the bridge are normally forward biased by the 12-volt supply and allow the input signal to pass. However, as the input signal grows larger, the diodes start to turn off, attenuating the input signal. Even with the diodes in the off condition, some signal will still pass, due to capacitive properties of the diodes. The output of the bridge goes to the "Wideband RF Amplifier" (#8).

#8 -- WIDEBAND RF AMPLIFIER; U2

Pin 10 of U2 accepts the input signal from the limiter. U2 is an ECL compatible, wideband differential preamplifier with voltage gain of 20 to 30 dB. This amplifier is capable of delivering output signals that are self-limited at 1 volt peak-to-peak. The other input to U2 is at pin 11 and is bypassed to ground. The output at pin 3 goes through C21 and C22 to the "Divide-By-Ten, U3" (#9). The output at pin 4 is loaded by resistor R31 to keep U2 balanced.

#9 -- DIVIDE-BY-TEN; U3

U3 receives the output of the "Wideband RF Amplifier" (#8) and divides the input frequency by a factor of ten. The output of U3 goes to the "Converter" (#10).

#10 -- LEVEL CONVERTER; Q5, Q6, D9, & D11

This level converter is identical to the level converter of Input A (#5). Its inputs come from U3 pins 2 and 4 (and 15). Its output from Q6 is at TTL levels and goes to the "Input Selector" (#11) U4D pin 13.

#11 -- INPUT SELECTOR; U4B, U4D, & U4A

Inputs to the selector include two signal inputs. The signal from Input A is applied to U4B pin 5, and the signal from Input B is applied to U4D pin 13.

Three control voltage inputs from Mode switch SW3 determine whether the two NAND gates will allow the input signals to pass. Setting the switch in the Freq A position will supply a logic high at pin 4 and the input A signal will pass. Either the Freq B position or the Ratio B/A position will cause a high to be placed on pin 12 and the input B signal will pass. Whichever frequency signal passes through the NAND gate will also be passed through the third NAND gate U4A. This output goes to the "Pulse Shaper" (#12).

#12 -- PULSE SHAPER; U5

The signal input to the pulse shaper is the string of long duration pulses from the "Input Selector." This signal passes along one path directly to U5A pin 2. At the same time, the signal is inverted three times and delayed for up to 50 nsec through NOR gates U5D, C, and B to U5A pin 3. The resultant output is a pulse of up to 50 nsec, beginning when the input reaches U5A pin 2, and stopping when the delayed input reaches U5A pin 3.

#13 -- COUNT INPUT SELECTOR; U6F, U7A, U7B & U7D

This selector has two signal inputs. Either frequency A or frequency B is applied to U7D pin 12 from the "Pulse Shaper" (#12), and the output of the "Time Base Gates (Period)" is applied to U7A pin 1.

There is only one control input to the count input selector. Mode switch SW3 and inverting amplifier U6F combine to put a control high at U7A pin 2 and a control low at U7D pin 13 whenever the switch is in the Period A position. For all other switch positions, the control voltages are reversed.

NAND gate U7B then produces an output from whichever signal reaches it from the other two NAND gates. This output signal goes to "Counter Gate U7C" (#14).

#14 -- COUNTER GATE; U7C

One input, to pin 9 of the counter gate, is the signal from the "Count Input Selector" (#13). This will be either input A, input B, or the signal from the time base oscillator (in the Period mode).

The other input, to pin 10, is the signal (used as a control voltage) from the "Time Base Flip-Flop" (#26). When this signal is high, the gate passes the signal-to-be-counted. When it is low, the signal-to-be-counted is stopped. The output of the counter gate goes to the "Decade Counters, U25" (#15) for the least significant digit of the display.

Refer also to "Store-Reset Operation," Page 79, for added discussion of how the gate interacts with the other circuitry.

#15 -- DECADE COUNTERS; U21 Through U25

The decade counters are connected in a chain. The first counter (U25) receives a frequency and counts it. On every tenth count, it sends a pulse to the next counter to be counted. Thus, each counter sends its tenth count (overflow) on to the next*, until U21. The overflow of this counter represents overflow of the entire counter and is sent to the "Overflow Circuit" (#18).

The output of the counters is available to the latch decoder drivers and is accepted by them at the end of each count period. A final input to the counters is the reset pulse which resets them to zero in preparation for the next count sequence.

* Note that U21, U22, and U23 are dual decade counters and contain two decade counters. Thus, the tenth count from one decade (pin 7) would go to the input of the other decade (pin 15); then the tenth count of the second decade (pin 9) would go to the next decade input in another IC.

#16 -- LATCH DECODER DRIVERS: U26 THROUGH U34

Each latch decoder driver receives its primary input (one decimal digit, coded in binary) on the four input pins, 1, 2, 6, and 7, from the decade counter section. A secondary input (at pin 3) is the store pulse from "Store Monostable U19A" (#27). In addition, each latch decoder driver has an input and an output which are used by the "Zero Blanking Circuitry" (#19).

When the store pulse is received, each latch decoder driver responds to the binary count that is currently on its corresponding counter. It decodes the binary code and lights the sections of the display that shows the decimal number. Each display is held until the next store pulse causes a new number to be accepted by the latch decoder driver.

#17 -- LED DISPLAY; V1 THROUGH V8

Each LED display digit has seven segments, which can be lit by the display driver to show any decimal number (zero through nine). The seven lines from the driver are connected to the seven segments of the display.

#18 -- OVERFLOW CIRCUITRY; U18B, U35, & Q8

There are three inputs to the overflow circuitry. The first is the tenth count from Decade Divider U21 pin 9 (#15), which indicates display overflow. One or more counts on this line to U18B pin 6 will cause U18B Pin 11 to go high.

The second input is the store signal at U35 pin 13 from Store Monostable U19A (#27). This causes U35 to latch the state of U18B and drive Q8 and V11 (if there was overflow indicated by U21 pin 9).

The third input is the reset signal to U18B from "Reset Monostable U19B" (#28). This occurs just **after** U35 has latched the state of U18B, and it resets U18B for the next count sequence.

The output of the circuit at U35 pin 16 lights the overflow LED (via transistor Q8) and signals latch decoder driver U26 when a display overflow occurs (this output is used as part of #19 -- "Zero Blanking").

#19 -- ZERO BLANKING; U36 & U37

The display digits are easier to read if unnecessary **zeros** on the left of the decimal point are blanked out (for example, 1.0500 MHz is easier to read than 0001.0500 MHz). Zeros for any display digit may be blanked if pin 5 of that display's latch decoder driver is grounded or kept at a low voltage. If the pin 5 is unconnected or kept at a high voltage, the zero will not be blanked.

Each of the OR gates of U36 and U37 serve the same function. Each OR gate detects: (1) If the next higher digit of the display is non-zero (as indicated by a high on pin 4 of the latch decoder driver IC for that digit), and (2) If the decimal point for the next higher digit is lit (as indicated by a high on the decimal point drive line from switch SW2). If either or both of these conditions exist, the OR gate sends a high to the next lower digit (pin 5 of the latch decoder driver IC) telling it not to blank its zeros.

If neither of the conditions is met, the OR gate output is low and the latch decoder driver blanks its zeros.

The highest digit (LED V1) would normally have its zero blanked, since there won't be any numbers higher than it is. However, in the case of overflow,the zero **is** displayed to indicate that there is a number in the overflow. This is done by sending a signal from the output of U35, in the overflow circuitry, to pin 5 of latch decoder driver U26.

#20 -- OSCILLATOR CIRCUIT; Q101, Q102, SW5, D14, & D15

The crystal-controlled, Colpitts-type, oscillator produces a 10 MHz internal time base signal for frequency and period measurement. The oven provides a constant temperature to maintain frequency stability, and C101 allows adjustment of the frequency to exactly 10 MHz. Transistor Q102 provides buffering and a TTL compatible output signal. The output goes thorugh the internal/external time base switch SW5 and past signal limiting diodes D14 and D15 to the "Input A/Oscillator Selector" (#21).

SW5 switches the internal oscillator in and out of the circuit, to allow you to use an external oscillator. Jack J3 provides an output from the internal oscillator for external use, and also accepts the input from an external oscillator.

#21 -- INPUT A/OSCILLATOR SELECTOR; 1/2 of U8

This selector receives two signal inputs. The Input A signal is applied to gate A pin 1, and the 10 MHz time base signal is applied to gate B pin 9. There is only one control input to the selector. Mode switch SW3 and inverting amplifier U6A combine to put a control high on gate A pin 13 and a control low on gate B pin 10 whenever the Mode switch is in the Ratio B/A position. The control voltages are reversed for all other switch positions. NOR gate C inverts whichever signal is allowed to reach it, and sends the signal to the "Time Base Divider Chain" (#22).

#22 -- TIME BASE DIVIDER CHAIN; U9, U11 THROUGH U15

This frequency divider chain receives the signal that is output by the "Input A/Oscillator Selector" (#21). The divider chain has eight divide-by-ten circuits, in six IC's, which divide the input frequency. The basic frequency and the first three divisions (÷ 10, ÷ 100, ÷ 1000) of that frequency provide the output to the "Time Base Gates (Period Mode)" (#23). The last four divisions of the frequency provide the output to the "Time Base Gates (Frequency Mode)" (#24). The fourth division (÷ 10,000) is not used.

#23 -- TIME BASE GATES (Period Mode); U16

While these gates are active in all modes of operation, their output is only used during the Period mode. During that mode, the frequency of the signal inputs to the gates from the "Time Base Divider Chain" (#22) are 10 MHz, 1 MHz, 100 kHz, and 10 kHz at pins 9, 13, 2, and 4, respectively. The control inputs come to pins 10, 1, 3, and 5 from Range switch SW2 wafer A. For any position of the switch, only one gate will have a high control voltage and will therefore allow its signal input to pass. That single frequency is the output which goes to the "Count Input Selector" (#13).

#24 -- TIME BASE GATES (FREQUENCY MODES); U17

These gates are used as part of the count process in all modes of operation **except** the Period mode, when the "Time Base Gates (Period Mode)" (#23) are used. The signal inputs are the four outputs of the time base divider chain. These signals may originate from the time base oscillator (in frequency measurement modes) or from Input A (in the ratio measurement mode).

The control voltages to the gates come from Range switch SW2 wafer A. For any position of the switch, only one gate will have a high control voltage and will allow the input signal to pass. That single frequency is the output which goes to "Time Base Input Selector" (#25).

#25 -- TIME BASE INPUT SELECTOR; 1/2 of U8

There are two signal inputs and two control voltage inputs to the gates. One signal input is frequency A from "Buffer U4C" (#6) to gate D pin 2, present whenever there is an input A. The other is the output of the "Time Base Gates (Frequency Mode); (#24) to gate E pin 5. The two control inputs to the gates are a high to gate D pin 3 from mode switch SW3 in the Period mode, or a high to gate E pin 4 (through inverter U6F) from the Mode switch in all other positions.

The output of the time base input selector is the selected time base frequency to "Time Base Flip-Flop" U18A (#26).

#26 -- TIME BASE FLIP-FLOP; U18A

The primary input to U18A is the time base signal from the "Time Base Selector" (#25); this input goes to the clock input pin 1. The flip-flop reacts to the negative-going edge of the wave from the selector, sending its output (pin 15) high at the first edge and sending it low at the next. This produces the time base for a single count period the "Counter Gate" (#14).

There is another process in the Counter, involving U18A inputs on pin 3 (clear) and pin 4 (reset) and additional outputs from pin 15. Refer to "Store-Restore Operation," Page 79, for additional information.

#27 -- STORE MONOSTABLE; U19A, U6B, & U6C

The input to U19A pin 3 is the time base pulse from "Time Base Flip-Flop U18A" (#26). The store monostable responds only to the negative-going edge of this input. When the U18A output goes low at the end of a count period and stops the counters from receiving any more input signal to be counted, U19A generates a positive pulse at pin 6 and a negative pulse at pin 7. These pulses are about 50 msec long due to the R44, C31 time constant.

The negative pulse output from pin 7 ($\overline{\text{STORE}}$) goes to reset the time base flip-flop and latch the final count into the latch decoder drivers; inverting amps U6B and U6C are used to provide additional drive capability. The positive pulse output from pin 6 (STORE) goes to U35 of the "Overflow Circuitry" (#18), and to the input of the "Reset Monostable" (#28).

Refer to Store-Reset Operation, Page 79, for a discussion of the way blocks #14, #26, #27, and #28 interact during the count sequence.

#28 -- RESET MONOSTABLE; U19B

The input to the reset monostable is the positive pulse at pin 11 from the store monostable. The monostable triggers on the negative-going edge of the pulse from the store mono. The reset mono then produces a positive pulse on pin 10 (RESET) and a negative pulse on pin 9 ($\overline{\text{RESET}}$). These pulses are the same length (about 50 msec) as those from the store monostable.

The pulses reset the slower portions of the time base divider chain (with the positive pulse), reset the decade counters (with the positive pulse), and reset U18B of the overflow circuit (with the negative pulse).

Refer to Store-Reset Operation, Page 79, for discussion of the way blocks #14, #26, #27, and #28 interact during the count sequence.

#29 -- GATE LAMP DRIVER; Q7

The gate lamp driver receives its input from the "Time Base Flip-Flop" (#26). When this input is high (counter gate U7C is passing the signal-to-be-counted), Q7 is on and gate lamp LED V9 is also on. When the count period ends, U18A turns Q7 off and the gate lamp goes out between count periods.

#30 -- MODE AND RANGE SWITCHES; SW2 & SW3

These switches are used to supply voltage from the +5 volt supply to circuit elements, either as a control voltage or for LED decimal point drive. Range switch SW2 wafer A sends a control voltage to the #23 and #24 "Time Base Gates" (period and frequency modes); the other wafers direct the voltage from the Mode switch to the appropriate LED decimal point for the chosen range setting. Because of the interconnections between the B, C, D, & E wafers of the Range switch, diodes D16 through D19 are used to prevent voltage from being fed back to the Mode switch and supplying false control voltages to the rest of the Counter's circuitry.

Mode switch SW3 supplies drive voltage through the Range switch to the decimal point LED's, and control voltage to selected parts of the circuit, depending on the switch position. It is the control voltage from this switch that determines the mode of operation of the Counter. Refer also to the "Circuit Flow" portion of the description for discussion of the modes of operation.

In each of its positions, the Mode switch has two types of output, control and LED drive voltages. These voltages are controlled by the switch position, as follows:

SWITCH POSITION	CONTROL VOLTAGE GOES TO:	LED DRIVE VOLTAGE GOES TO:
Period	#13 -- Count Input Selector	SW2, wafer B
Freq A	#11 -- Input Selector, U4B	SW2, wafer D
Freq B	Via D12 to #11 -- Input Selector, U4D	SW2, wafer C
Ratio B/A	#21 -- Input A / Osc Selector, and via D13 to #11 - - Input Selector, U4D	SW2, wafer E

#31 -- OVEN HEATER CONTROL; U38, Q9, & Q10

The Oven Heater Control circuitry senses the temperature of the oven with thermistor R62. This thermistor forms a resistance bridge circuit along with R61, R58, and R59. As the oven temperature changes from the 75°C design point, the resistance of the thermistor changes, unbalancing the bridge. This imbalance causes a change in the output voltage of differential amplifier U38A. The output of U38A goes through R64 to pin 5 of U38B.

U38B is a voltage-controlled, pulse-width-modulated oscillator. As the voltage to U38B increases, the (positive) pulse width of the output increases. The output of U38B goes to Q9 and Q10, which form the current driver for the oven heater wire, R67.

If the oven cools slightly, the resistance of R62 increases. This unbalances the bridge, making U38A pin 3 more positive than pin 2. This increases the output at pin 1. This voltage increases the pulse width (duty cycle) of U38B's output. Heater R67 then suplies more heat to the oven.

Thermal breaker CB1 is normally closed and connected in series with the heater supply. If the oven temperature rises to approximately 90°C, TB1 opens the heater circuit and turns on LED 12 on the Display circuit board.

~~187.6°F~~
194°F

#32 -- POWER SUPPLY; T1, D22 THROUGH D27, & U39 THROUGH U42

Transformer T1 receives the input line voltage and provides two AC outputs, 33 VAC center-tapped for the 12-volt sources, and 17 VAC center-tapped for the 5-volt sources. The diode pairs rectify the voltage and the IC's provide the voltage regulation. Note that the ±12-volt sources and the unregulated rectified voltage from point J are not affected by the position of the Standby-On switch SW4. That is because these voltages are used to maintain the temperature in the oscillator oven whenever the counter is plugged in.

STORE-RESET OPERATION

During the count period, the "Time Base Flip-Flop" (#26) has a positive output on pin 15. This enables the "Counter Gate" (#14) to pass the frequency-to-be-counted. At the end of the count period, the flip-flop is triggered by the negative-going edge of the signal from the "Time Base Input Selector" (#25).

The flip-flop then changes state, with its output going low. This stops the counter gate from passing the frequency-to-be-counted and turns off the gate driver. In addition, the negative-going edge of the output from the flip-flop triggers the "Store Monostable" (#27), which stays triggered for about 50 msec due to the RC time constant of R44 and C31.

During that time, the "STORE" output (pin 6) is high. It goes to the "Overflow Circuitry" (#18), U35 pin 13, to lock the overflow condition (if one exists). The $\overline{\text{STORE}}$" output is a low which does three things: (1) At the time-base flip-flop, it takes the J input low and prevents the flip-flop from changing state (beginning another count period) during the store operation. (2) At the latch decoder drivers, it causes them to accept the count on the counters and display it on the LED's. (3) At the reset monostable, the **end** of the "STORE" pulse (after 50 msec) triggers the reset.

The reset monostable also stays set for about 50 msec, due to the RC time constant of R45 and C32. The "$\overline{\text{RESET}}$" output at pin 9 goes low and does three things: (1) It goes to the time base flip-flop (pin 3) to stop it from changing state (beginning another count period) during the reset operation. (2) It resets the first decade counter, U25. (3) It resets the input flop-flop of the overflow circuitry, U18B.

The "RESET" output at pin 10 goes high and does two things: (1) It resets time base divider chain IC's U12 through U15 to the count of **nine** and holds them there as long as it is high. (2) It resets decade counters U21 through U24 to zero and holds them as long as it is high.

After about 50 msec, the reset monostable returns to its normal state with the following results. The latch decoder drivers have stored the count for display, the divider chain is ready (at 9999 for the last four dividers), and the time base flip-flop is released and is able to respond to the first pulse from the divider chain.

This will begin a new count period which will last from the first pulse at the time base flip-flop until the second pulse at the time base flip-flop.

Circuit Flow

Refer to the four block diagrams and the schematic diagram as you read the following pages. In this portion of the description, the operation of the various building blocks will not be discussed in depth; this was done in the Basic Blocks portion.

One block diagram is shown for each of the Counter's four modes of operation. Please note the following facts about the diagrams before beginning:

1. Only the primary signal paths are shown. Control voltage paths and non-primary circuitry (such as power supply and gate lamp) are not included. Refer to the schematic for these, if necessary.
2. Heavy lines show the path of primary signals. Dotted heavy lines show a dead-end path for a primary signal (the signal will be available along that path, but will not be used by the circuitry).
3. Arrowheads on the diagram show the direction of signal flow.
4. Numbers and titles on the diagrams refer directly to the numbers and titles used in the Basic Blocks portion; use these for easy location of circuit discussion in the Basic Blocks portion.
5. The layout of the block diagrams is similar to the schematic to make it easy for you to go from one to the other.

The discussion for each mode of operation will trace the signal flow, mentioning where it is "accepted" by the logic device (allowed to continue through the circuit) and where it is "rejected" (not allowed to continue). Whether a signal is accepted or rejected is determined by the control voltage present at the AND and NAND gate where the signal is received. To aid with quick analysis of the circuit flow, the discussion identifies control voltage points by IC and pin numbers.

FREQUENCY A MODE

Refer to the Frequency A Block Diagram (Illustration Booklet, Page 13) as you read the following paragraphs.

In the frequency count modes, the frequency is processed through the circuitry to the gate in box L. The box C, E, G, K, and M series opens the gate at box L for either 10 msec, 100 msec, 1 sec, or 10 sec. While the gate is open, the frequency is counted at box R. The decimal point is adjusted to give the count in terms of kHz or MHz.

The frequency-to-be-counted signal comes into box A through jack J1 and is amplified and converted to TTL voltage levels. The signal then goes from box A to boxes D, E, and K. It is rejected at box E because the control voltage at U8A pin 13 is low. It is also rejected at box K because the control voltage at U8D pin 3 is low.

However, the signal is accepted at box D because the control voltage at U4B pin 4 is high. Box D performs the functions of input selection and changing the signal-to-be-counted into a series of very narrow pulses.

The signal from box D goes to box H where it is accepted because the control voltage at U7D pin 13 is high (this control voltage comes through inverting amp U6F) The signal passes through box H and goes to box L.

Box L treats the signal from box H as signal-to-be-counted, and treats the input from box M as a control signal. When the signal from box M is high (one count period), the signal-to-be-counted is accepted by box L. When the signal is low (between count periods, due to the store and reset cycles) box L rejects the signal-to-be-counted.

Box L sends the signal-to-be-counted to box R where it is counted, and then displayed at the end of each count sequence.

The time-base signal is generated by the oscillator at box C. The signal is sent to box E, where it is accepted because the control voltage at U8B pin 10 is high (the control voltage comes through inverting amp U6A). The time-base signal frequency is then divided by the divider chain.

Some frequencies go through box F, which sends one frequency on to box H; box H rejects this input because the control voltage to U7A pin 2 is low. The four lowest frequencies from box E are sent to box G. Only one of these is allowed to go on to box K. Range switch SW2A provides a high control voltage to one of the AND gates (U17 A, B, C, or D), allowing the time-base frequency for that gate to pass.

Box K accepts the time-base signal because the control voltage at U8E pin 4 is high (the control voltage comes through inverting amp U6F). The output of box K goes to box M.

Box M divides the signal from box K by two, producing a high control voltage that is equal to one count period, followed by an equally long low control voltage (except as modified by the input from the store-reset process circuits--see "Store-Reset Operation," Page 79). The box M output goes to box L as a control voltage and to box N to initiate the store-reset process.

FREQUENCY B MODE

Refer to the Frequency B Block Diagram (Illustration Booklet, Page 14) as you read the following.

In the frequency count modes, the frequency is processed through the circuitry to the gate in box L. The box C, E, G, K, and M series opens the gate at box L for either 10 msec, 100 msec, 1 sec, or 10 sec. While the gate is open, the frequency is counted at box R. The decimal point is adjusted to give the count in terms of kHz or MHz.

The frequency-to-be-counted signal comes into box B through jack J2 and is amplitude limited, amplified, divided by ten, and converted to TTL voltage levels. The signal then goes from box B to box D. It is accepted at box D because the control voltage at U4D pin 12 is high.

From this point on, the process is exactly the same as in the Frequency A Mode.

Box D performs the functions of input selection and changing the signal-to-be-counted into a series of very narrow pulses.

The signal from box D goes to box H where it is accepted because the control voltage at U7D pin 13 is high (this control voltage comes through inverting amp U6F). The signal passes through box H and goes to box L.

Box L treats the signal from box H as signal-to-be-counted, and treats the input from box M as a control signal. When the signal from box M is high (one count period), the signal-to-be-counted is accepted by box L. When the signal is low (between count periods; due to the store and reset cycles), box L rejects the signal-to-be-counted.

Box L sends the signal-to-be-counted to box R where it is counted, and then displayed at the end of each count sequence.

The time-base signal is generated by the oscillator at box C. The signal is sent to box E, where it is accepted because the control voltage at U8B pin 10 is high (the control voltage comes through inverting amp U6B). The time-base signal frequency is then divided by the divider chain.

Some frequencies go through box F, which sends one frequency on to box H; box H rejects this input because the control voltage to U7A pin 2 is low. The four lowest frequencies from box E are sent to box G. Only one of these is allowed to go on to box K. Range switch SW2A provides a high control voltage to one of the AND gates (U17A, B, C, or D), allowing the time-base frequency for that gate to pass.

Box K accepts the time-base signal because the control voltage at U8E pin 4 is high (the control voltage comes through inverting amp U6F). The output of box K goes to box M.

Box M divides the signal from box K by two, producing a high control voltage that is equal to one count period, followed by an equally long control voltage (except as modified by the input from the store-reset process circuits--see "Store-Reset Operation," Page 79). The box M output goes to box L as a control voltage and to box N to initiate the store-reset process.

RATIO B/A MODE

Refer to the Ratio B/A Block Diagram (Illustration Booklet, Page 15) as you read the following.

In the Ratio B/A mode, the cycles of frequency B that occur during 10^5, 10^6, 10^7, or 10^8 cycles of frequency A are counted. The decimal place is positioned correctly to indicate the ratio of B cycles per single cycle of frequency A. The Range switch setting determines how many cycles of frequency A are used, and where the decimal point is placed.

The A frequency signal comes into box A through jack J1 and is amplified and converted to TTL voltage levels. The signal then goes from box A to boxes D, E, and K. It is rejected at box D because the control voltage at U4B pin 4 is low. It is also rejected at box K because the control voltage at U8D pin 3 is low.

However, the signal is accepted at box E because the control voltage at U8A pin 13 is high. Note that this same control voltage is inverted through U6A and is then used to stop the oscillator signal at U8B pin 9 (control voltage at pin 10).

The A frequency signal is then divided by the divider chain.

Some frequencies from the chain go to box F, which sends one frequency on to box H; box H rejects this input because the control voltage to U7A pin 2 is low. The four lowest frequencies from box E are sent to box G. Only one of these is allowed to go on to box K. This is because Range switch SW2A provides a high control voltage to one of the AND gates (U17A, B, C, or D), allowing the divided A frequency signal for that gate to pass.

Box K accepts this time-base signal because the control voltage at U8E pin 4 is high (the control voltage comes through inverting amp U6F). The output of box K goes to box M.

Box M divides the signal from box K by two, producing a high control voltage that is equal to one count period, followed by an equally long low control voltage (except as modified by the input from the store-reset process circuits--see "Store-Reset Operation," Page 79). The box M output goes to box L as a control voltage and to box N to initiate the store-reset process.

The B frequency comes in to box B through jack J2 and is amplitude limited, amplified, divided by ten, and converted to TTL voltage levels. The signal then goes from box B to box D. It is accepted at box D because the control voltage at U4D pin 12 is high.

Box D performs the functions of input selection and changing the B frequency into a series of very narrow pulses.

The signal from box D goes to box H, where it is accepted because the control voltage at U7D pin 13 is high (this control voltage comes through inverting amp U6F). The signal passes through box H and goes to box L.

Box L treats the signal from box H (B frequency/10) as signal-to-be-counted, and treats the input from box M (A frequency divided by 10^5, 10^6, 10^7, or 10^8) as a control signal. When the signal from box M is high (one cycle of the divided-down A frequency), the signal-to-be-counted is accepted by box L. When the signal is low (between count periods, due to the store and reset cycles), box L rejects the signal-to-be-counted).

Box L sends the signal-to-be-counted to box R where it is counted, and then displayed at the end of each count sequence.

PERIOD MODE

Refer to Period Block Diagram, (Illustration Booklet, Page 16) as you read the following.

During the Period mode, the gate in box L turns on for one cycle of frequency A. While the gate is on, the count circuitry in box R counts the units of time coming from the box C oscillator through boxes E, F, and H. Depending on the Range switch, these units of time may be equal to .1 μsec, 1 μsec, 10 μsec, or 100 μsec.

The signal whose period is to be measured comes in to box A through jack J1 and is amplified and converted to TTL voltage levels. The signal then goes from box A to boxes D, E, and K. It is rejected at box D because the control voltage at U4B pin 4 is low. It is also rejected at box E because the control voltage at U8A pin 13 is low. Note that this same control voltage is inverted through U6A and is then used to make U8B accept the oscillator (box C) input.

However, the signal is accepted at box K because the control voltage at U8D pin 3 is high. The output of box K goes to box M.

Box M divides the signal from box K by two, producing a high control voltage that is equal to one count period, followed by an equally long low control voltage (except as modified by the input from the store-reset process circuits--see "Store-Reset Operation," Page 79). The box M output goes to box L as a control voltage and to box N to initiate the store-reset process.

Box C produces the signal that is counted to produce the period measurement. This signal goes from box C to box E. The signal is accepted at box E because the control voltage at U8B pin 10 is high (the control voltage comes through inverting amp U6A). Box E contains the divider chain, which reduces the input frequency by factors of ten. Some frequencies (including the basic 10 MHz) are sent to box F and some are sent to box G.

One of the frequencies received by box G is sent to box K, where it is rejected because the control voltage at U8E pin 4 is low (this control voltage comes through inverting amp U6F).

One of the frequencies received by box F is allowed to go to box H. This is because Range switch SW2A provides a high control voltage to only one of the AND gates (U16A, B, C, or D), allowing the signal to pass that gate.

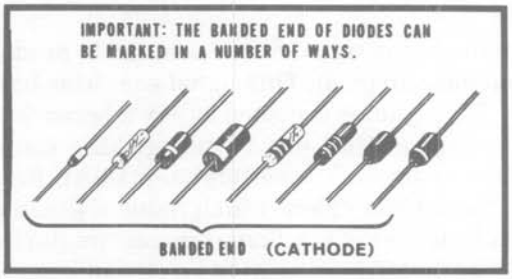
Box H accepts the signal from box F because the control voltage at U7A pin 2 is high. Box H passes the signal along to box L.

Box L treats the signal from box H (the oscillator frequency divided by 1, 10, 100, 0r 1000) as the signal-to-be-counted, and treats the input from box M (A frequency) as the control signal. When the control signal is high (one cycle of the A frequency), the signal-to-be-counted is accepted by box L. When the signal is low (between count periods, due to the store and reset cycles), box L rejects the signal-to-be-counted.

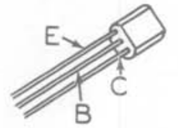
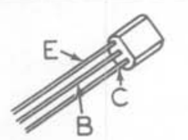
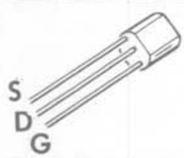
Box L sends the signal-to-be-counted to box R where it is counted, and then displayed at the end of each count sequence.

SEMICONDUCTOR IDENTIFICATION CHARTS

DIODES

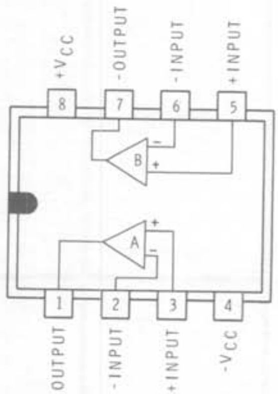
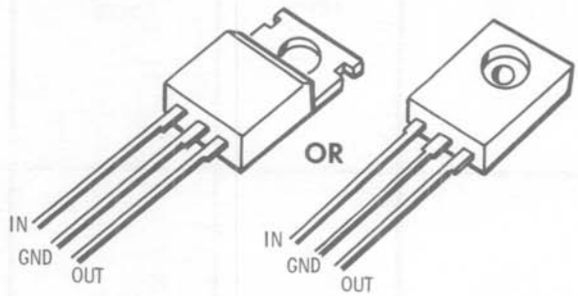
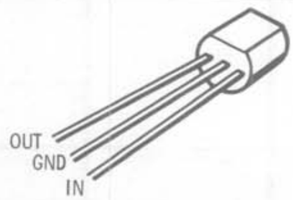
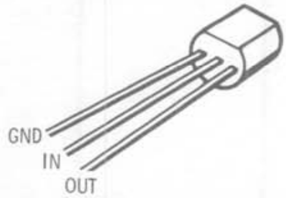
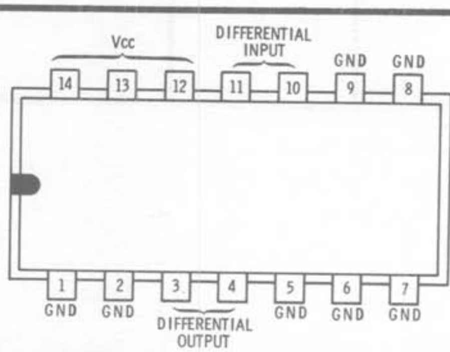
CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
D3, D4, D9, D11, D12, D13, D14, D16, D17, D18, D19, D21	56-56	1N4149	
D1, D2,	56-86	FD777	
D5, D6, D7, D8	56-87	FH1100 or N1100	
D15	56-612	1N5229B	
D22, D23	57-42	3A1	
D24, D25, D26, S27	57-65	1N4002	

TRANSISTORS

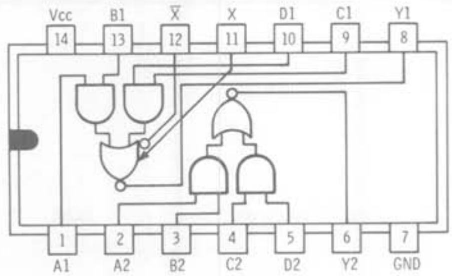
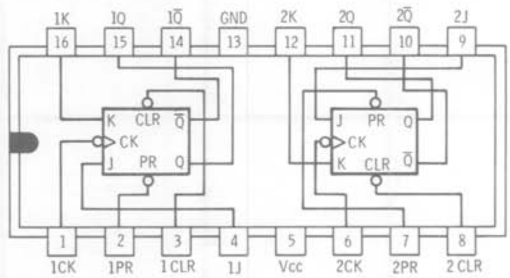
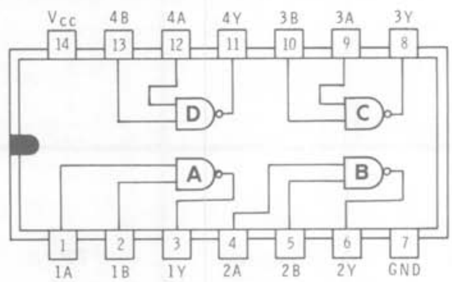
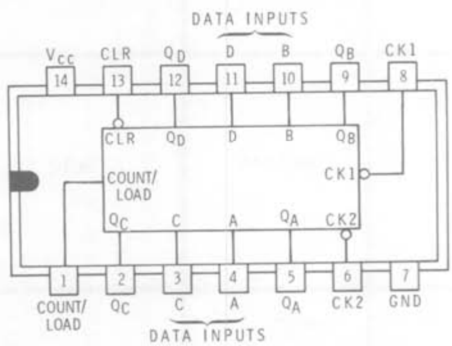
CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
Q3, Q5	417-292	2N5771	
Q2, Q4, Q6, Q7, Q8	417-293	2N5770	
Q101, Q102	417-172	MPS6521	
Q10	417-298	TIP41B	
Q9	417-801	MPSA20	
Q1	417-828	Selected E304*	

*Specially selected 417-802

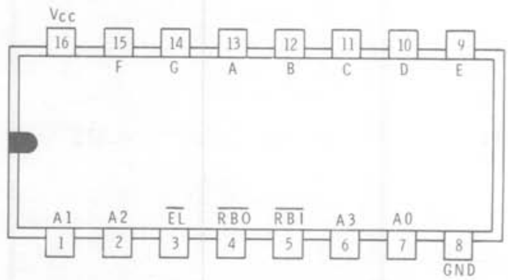
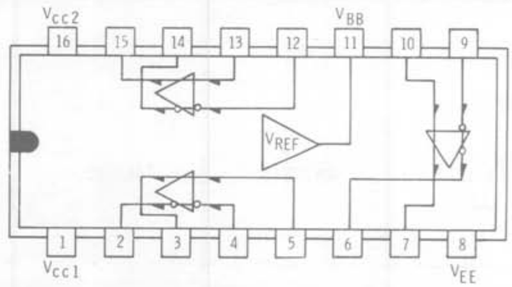
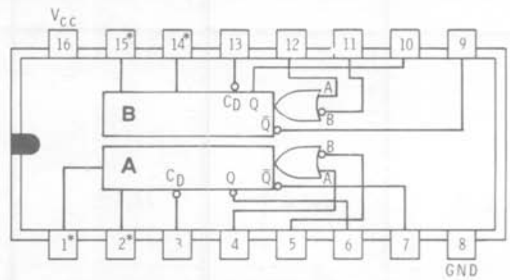
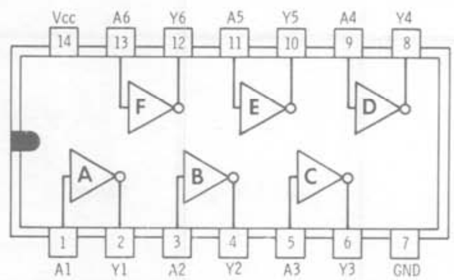
INTEGRATED CIRCUITS

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
U38	442-21	1458	
U42, U43	442-54	7805	
U41	442-644	78L12	
U39	442-646	79L12	
U2	442-698	SL952	

Integrated Circuits (Cont'd.)

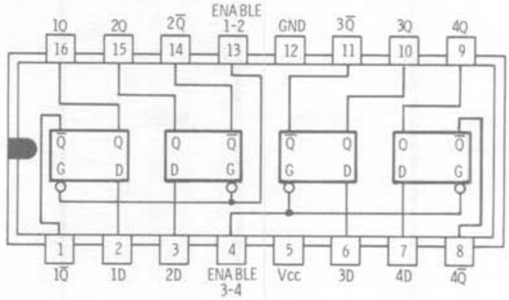
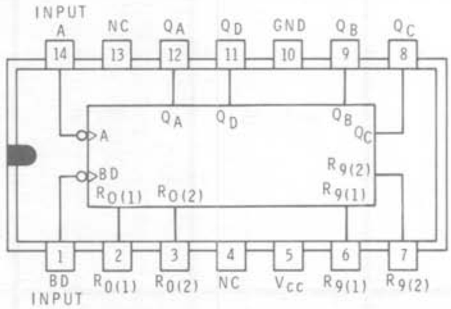
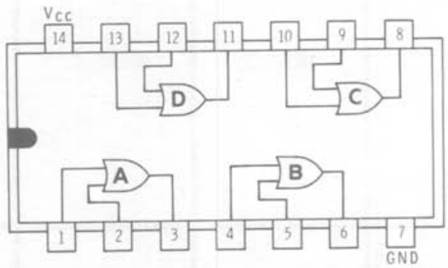
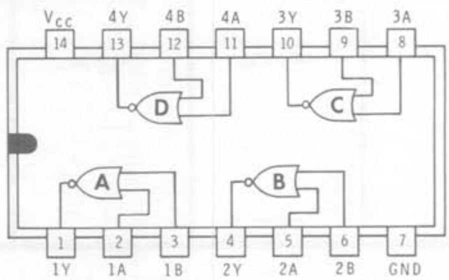
CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
U8	443-15	7450	
U18	443-16	7476	
U4, U7	443-26	74S00	
U25	443-628	74196	

Integrated Circuits (Cont'd.)

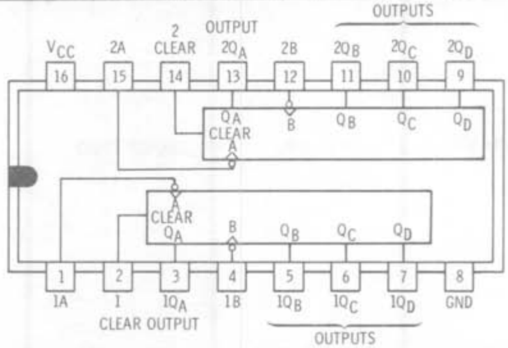
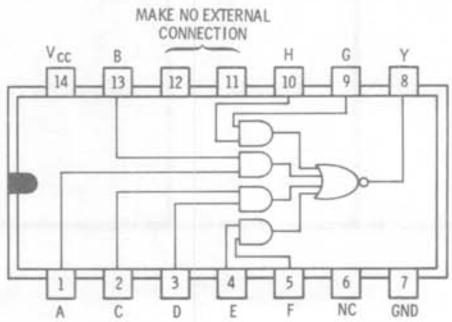
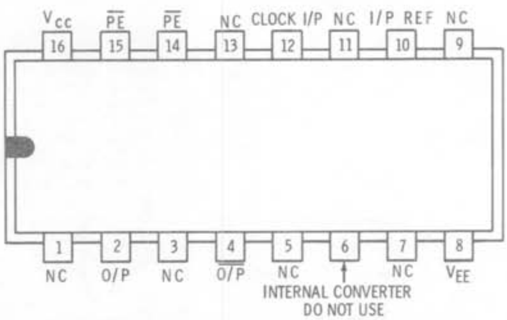
CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
U26, U27, U28, U29, U31, U32, U33, U34	443-694	9368	
U1	443-723	10216	
U19	443-727	96L02	
U6	443-755	74LS04	

*RC time constant network

Integrated Circuits (Cont'd.)

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
U35	443-781	74LS75	
U12, U13, U14, U15, U24	443-813	74LS90	
U36, U37	443-875	74LS32	
U5	443-896	74S02	

Integrated Circuits (Cont'd.)

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
U9, U11, U21 U22, U23	443-921	74LS390	
U16, U17	443-936	7454	
U3	443-937	SP8685B	

LED's

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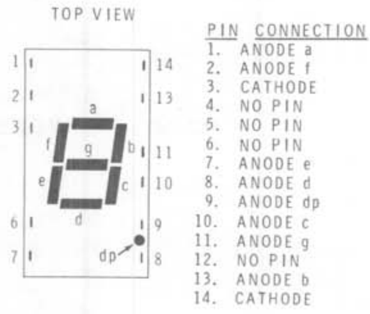
<tr><td>V1 through V8</td><td>411-860</td><td>5082-7760</td><td>
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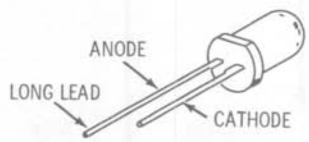
<tr><td>V9, V11</td><td>412-632</td><td>NLS5076A</td><td>
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CUSTOMER SERVICE

REPLACEMENT PARTS

Please provide complete information when you request replacements from either the factory or Heath Electronic Centers. Be certain to include the **HEATH** part number exactly as it appears in the parts list.

ORDERING FROM THE FACTORY

Print all of the information requested on the parts order form furnished with this product and mail it to Heath. For telephone orders (parts only) dial 616 982-3571. If you are unable to locate an order form, write us a letter or card including:

- Heath part number.
- Model number.
- Date of purchase.
- Location purchased or invoice number.
- Nature of the defect.
- Your payment or authorization for COD shipment of parts not covered by warranty.

Mail letters to: Heath Company
Benton Harbor
MI 49022
Attn: Parts Replacement

Retain original parts until you receive replacements. Parts that should be returned to the factory will be listed on your packing slip.

OBTAINING REPLACEMENTS FROM HEATH ELECTRONIC CENTERS

For your convenience, "over the counter" replacement parts are available from the Heath Electronic Centers listed in your catalog. Be sure to bring in the original part and purchase invoice when you request a warranty replacement from a Heath Electronic Center.

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 and invoice number.
- Copies of all correspondence relevant to the service of the kit.
- A brief description of the difficulty.
- Authorization to return your kit COD 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. Do not include the kit Manual.) 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

HEATH ZENITH

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