MODEL IB-1100 Frequency Counter

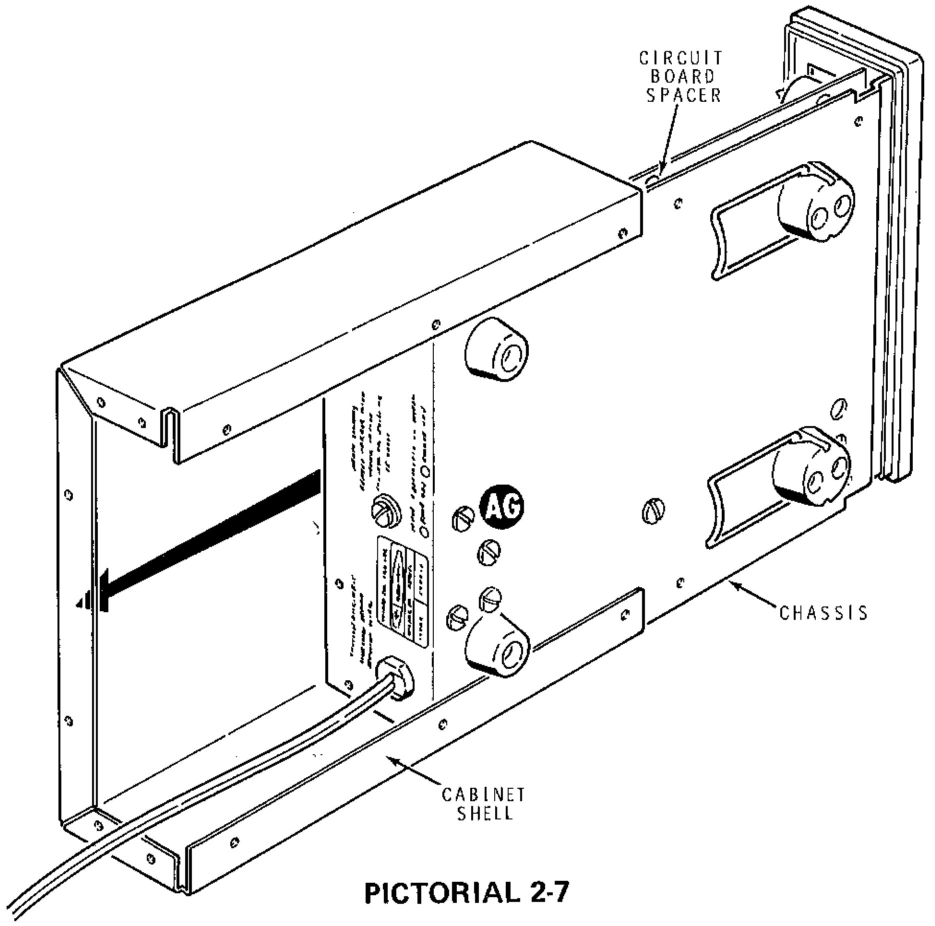
HEATHKIT®

ASSEMBLY MANUAL

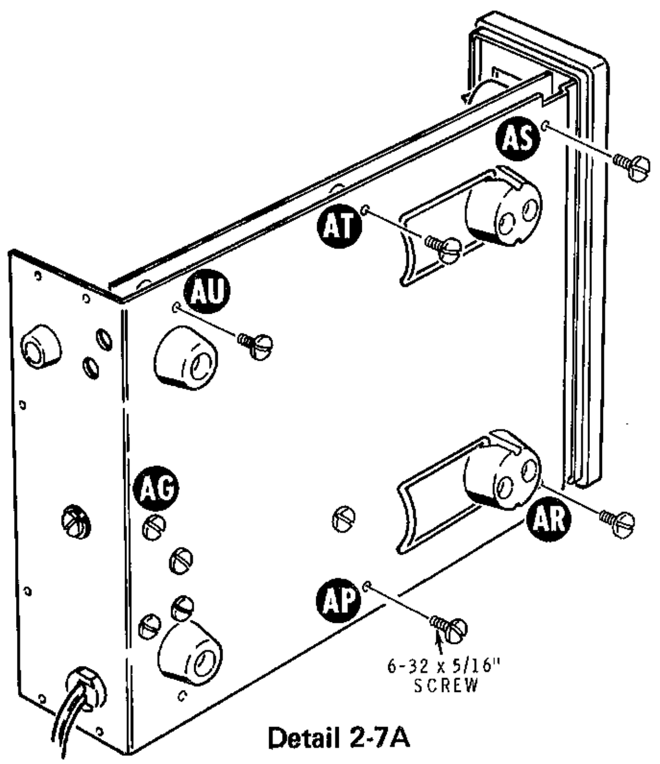
PRICE $2.00

595-1491

FINAL ASSEMBLY



PICTORIAL 2-7



Detail 2-7A

Refer to Pictorial 2-7 for the following steps.

(✓) Refer to Detail 2-7A and remove the five 6-32 x 5/16" screws which hold the circuit board to the chassis at AP, AR, AS, AT, and AU. Do not remove the screw at AG.

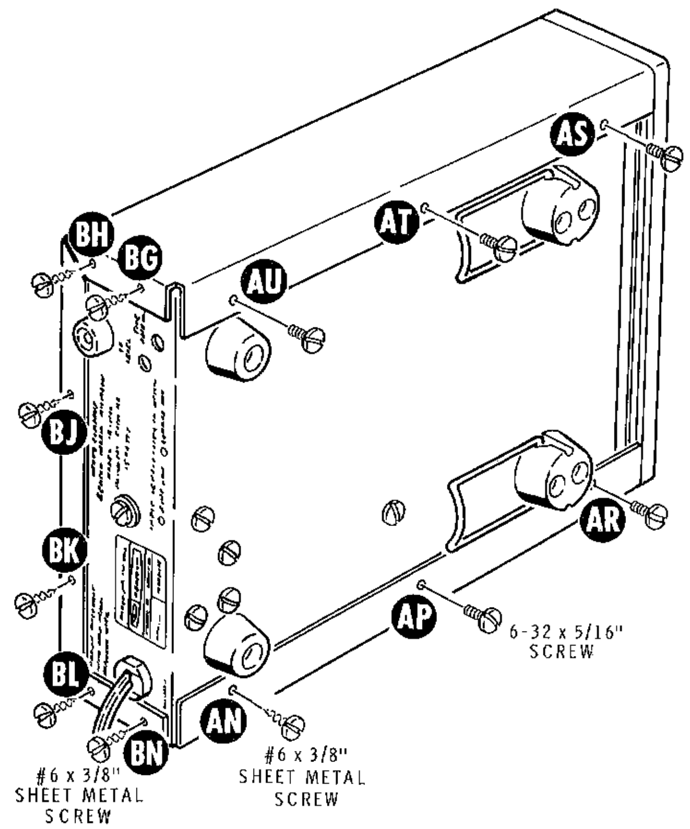
(✓) Refer to Pictorial 2-7 and slide the chassis into the cabinet shell.

(✓) Install six #6 x 3/8" sheet metal screws through the cabinet shell and into the rear panel at BG, BH, BJ, BK, BL, and BN.

(✓) Refer to Detail 2-7B and install 6-32 x 5/16" screws through the cabinet shell, chassis, and into the circuit board spacers at AP, AR, AS, AT, and AU.

(✓) Install a #6 x 3/8" sheet metal screw through the cabinet shell and into the chassis at AN.

This completes the assembly of your Frequency Counter. Proceed to the "Calibration" section.



Detail 2-7B

CALIBRATION

This section of the Manual contains two calibration procedures. If you have access to a reliable frequency counter and/or an accurate frequency generator, proceed to the "With Instruments" procedures on Page 34. If these instruments are not available, proceed with the following "Without Instruments" procedure.

The accuracy of your Counter depends to a great extent upon the care and accuracy that you exercise in performing the following steps. If at any time you do not obtain the results called for in a step, refer to the "In Case of Difficulty" section on Page 36 to correct the problem.

Without Instruments

IMPORTANT: Most communications receivers and standard (AM) broadcast receivers, especially those with a built-in antenna coil, have sufficient sensitivity to produce the audible difference frequency called for in the following steps with the cabinet shell remaining on your Counter. However, if you are unable to hear the difference frequency, try another receiver and/or remove the cabinet shell from your Counter before you assume there is a difficulty.

( ) Turn the Counter on and allow it to warm up for 30 minutes. This is MOST IMPORTANT for an accurate calibration.

( ) Push the RANGE switch to the MHz position.

( ) Remove the test cable from the counter INPUT connector, if it is not already done.

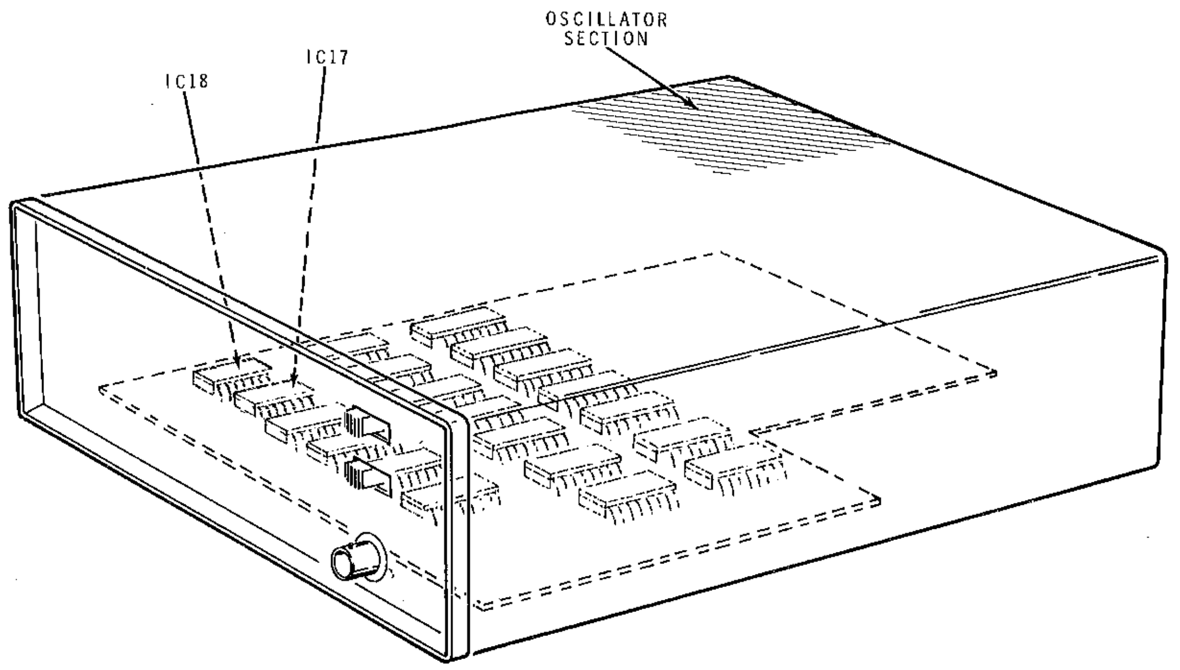


Figure 3-1

CLOCK OSCILLATOR

Your Counter will be calibrated by using a radio receiver to compare the frequency of the Counter's 1 MHz clock oscillator with an accurate radio frequency. Signals from a radio station and from your Counter will be received simultaneously, and adjustments will be made as described later. The radio station signal can be received by two different methods. Select one of the methods and calibrate the oscillator.

1. If you have a general coverage communications receiver, use its AM mode. For best accuracy, tune it to the highest WWV station frequency (25, 20, 15, 10, or 5 MHz) receivable at a satisfactory volume in your area. Temporarily connect an insulated, unshielded wire to the receiver antenna connection and lay the wire over the oscillator section of your Counter in the area shown in Figure 3-1.

A steady tone should be heard which will probably pulsate from one to several times each second. If you do not hear the tone, remove the cabinet shell and place the insulated wire near IC21. This should make the signal audible.

2. Broadcast AM radios can be used by tuning in a station of medium volume and connecting a temporary additional antenna and laying it over the oscillator section of the Counter at the location shown in Figure 3-1. A portable AM broadcast radio can also be used by holding it so its antenna is close to the Counter oscillator section. If the tone of the Counter oscillator is not heard, remove the Counter cabinet shell and bring the temporary antenna wire close to IC17 and IC18, or hold the portable radio within about 2" of these IC's.

( ) When the pulsating tone is heard, refer to Figure 3-2 and insert the screwdriver end of the white alignment tool into hole TIME BASE OSC on the rear chassis lip and into the piston trimmer capacitor.

( ) Engage the end of the alignment tool in the screw slot of the trimmer. Then turn the screw in the direction which reduces the frequency of the pulsations. When the pulsations cease and a steady tone is heard, the adjustment is correct. Carefully withdraw the alignment tool.

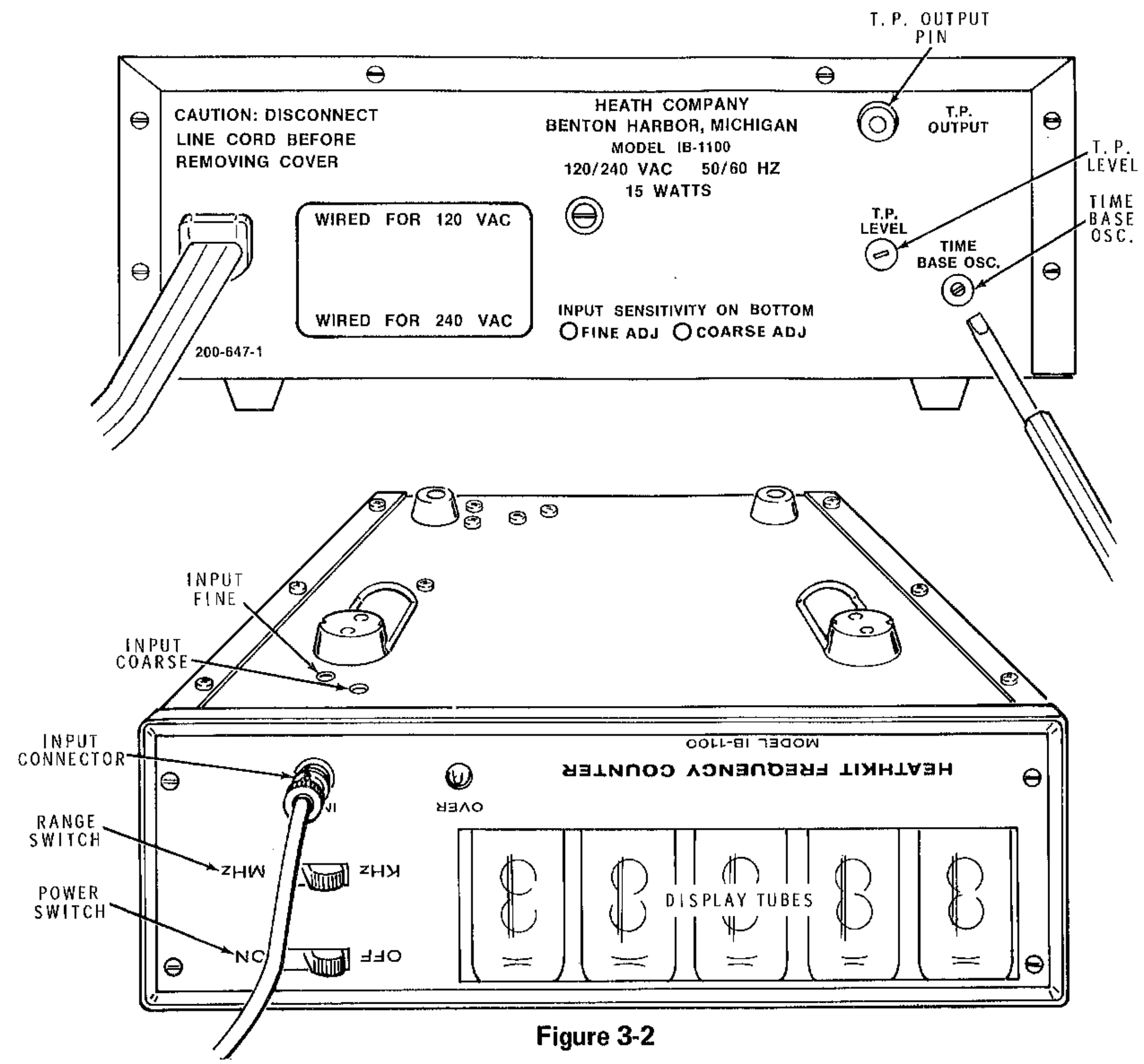


Figure 3-2

INPUT SENSITIVITY

Refer to Figure 3-2 for the following steps.

NOTE: In the following steps the terms clockwise and counterclockwise are used as you view the rear panel from the back of the instrument.

( ) 1. Be sure the TP LEVEL control is fully clockwise and the INPUT FINE control is at midrange.

( ) 2. Connect the test cable to the INPUT connector of the Counter.

( ) 3. Connect the inner lead of the test cable to the TP OUTPUT pin. (The shield lead requires no connection).

( ) 4. Push the RANGE switch to MHz.

( ) 5. If a reading of 01.000 is not displayed, use the screwdriver end of your white alignment tool to adjust the INPUT COARSE control until this reading appears.

( ) 6. Turn the TP LEVEL control counterclockwise very slowly until the 1 MHz reading just disappears or changes to a lower number.

( ) 7. Readjust the INPUT COARSE control very slowly until the 1 MHz reading is again obtained.

( ) 8. Repeat steps 6 and 7 until the TP LEVEL control is turned as far counterclockwise as possible and the counter still displays 1 MHz.

( ) 9. Repeat steps 6, 7, and 8 using the INPUT FINE control.

This completes the calibration of your Frequency Counter. Proceed to the "Operation" section on Page 35.

With Instruments

The accuracy of your Counter depends to a great extent upon the care and accuracy that you exercise in performing the following steps. These steps are designed to be used with precision equipment to calibrate the clock and the input sensitivity of your Counter. If at any time you do not obtain the results called for in a step, refer to the "In Case of Difficulty" section on Page 36 to correct the problem.

NOTE: In the following steps, the cabinet shell should remain on the Counter.

(✓) Turn the Counter on and allow it to warm up for 30 minutes. This is MOST IMPORTANT for an accurate calibration.

INPUT SENSITIVITY

This adjustment requires the use of a signal generator with a continuously variable output from 25 mV to 0.5 volt rms, capable of generating at least a 1 MHz signal.

Refer to Figure 3-3 (fold-out from Page 30) for the following steps.

(✓) 1. Connect the test cable to the INPUT connector of the Counter.

(✓) 2. Connect the Counter test cable to the output of the signal generator.

(✓) 3. Select a frequency between 1 MHz and 30 MHz. Set the signal generator output voltage to approximately 0.5 volt rms.

(✓) 4. If the Counter does not indicate this frequency, use your white alignment tool and adjust the INPUT COARSE control (see Figure 3-2 on Page 33) until the correct frequency is displayed.

(✓) 5. Reduce the signal generator output voltage until the display becomes unstable or goes to zero.

(✓) 6. Slowly readjust the INPUT COARSE control to again obtain a correct display.

(✓) 7. Repeat steps 5 and 6 until you reach the smallest signal generator output voltage that still produces a correct display on the Counter.

(✓) 8. Repeat steps 5, 6, and 7 using the INPUT FINE control.

NOTE: The TP LEVEL control is used only to vary the signal level at the TP OUTPUT during the "Calibration Without Instruments."

CLOCK

This calibration can be performed with either a frequency counter and a signal generator (capable of a 1-30 MHz, 250 mV output) or with a known, stable, laboratory standard frequency. Determine which of these methods you will use. Then complete the steps under the appropriate heading.

Calibration With a Frequency Counter and Signal Generator

Refer to Figure 3-4 (fold-out from Page 30) for the following steps.

NOTE: The accuracy of your Counter, for this type of calibration, is dependent on the accuracy of the test frequency counter.

(✓) Connect the test leads of the test frequency counter to the output terminals of the signal generator.

(✓) Also connect the test leads of your Counter to the output terminals of the signal generator.

(✓) Press the RANGE switch to the kHz position for maximum resolution.

( ) Set the signal generator to any convenient freqency between 1 MHz and 30 MHz at 250 mV to 500 mV output.

( ) Use the white alignment tool and adjust the TIME BASE OSC capacitor (see the inset drawing on Figure 3-4, fold-out from Page 30) until your Counter indicates exactly the same frequency as the test frequency counter.

( ) Disconnect the test leads.

This completes the calibration of your Frequency Counter. Proceed to the "Operation" section.

Calibration With a Known Laboratory Standard Frequency

NOTE: It is essential that the known frequency source (frequency of your choice between 1-30 MHz) be absolutely stable. The accuracy of this type of calibration is entirely dependent on the accuracy of this known frequency.

( ) Connect the known frequency to the test cable of the Counter.

( ) Push the RANGE switch to the kHz position for maximum resolution. NOTE: If the frequency is 100 kHz or higher, the overrange lamp will be lighted.

( ) Use the white alignment tool and adjust the TIME BASE OSC capacitor until the known frequency is exactly indicated on your Counter.

This completes the calibration of your Frequency Counter. Proceed to the "Operation" section.

OPERATION

Refer to Figure 3-5 (fold-out from Page 41) for a description of the display, control, and adjustment functions.

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.

CONTROLS

This Frequency Counter has only two controls: the Power ON/OFF switch and the MHz/kHz Time Base switch. The Time Base switch selects a 1 millisecond time base in the MHz position, or a 1 second time base in the kHz position.

INPUT PROBES AND CABLES

Any standard 10 megohm oscilloscope probe can be used with this Counter. Refer to the Maximum Input Voltage for the maximum AC voltage that can be applied to the INPUT of the Counter at various frequencies. Note that even though the input of the Counter is AC coupled, the DC input level is limited to 200 volts.

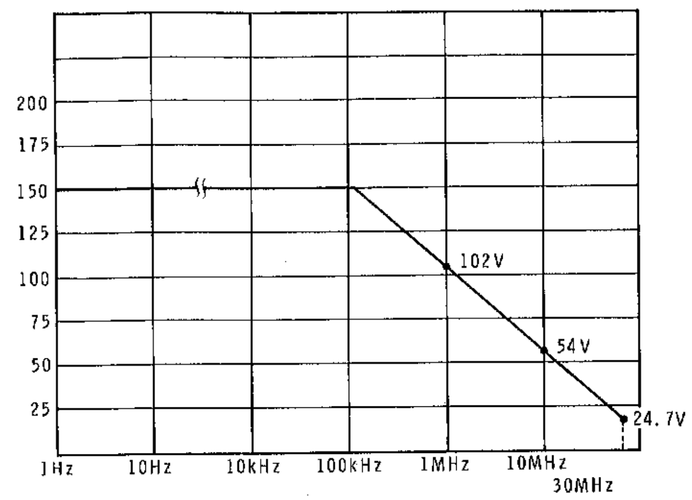
When you connect your Counter to a transmission line, make sure that the line is properly terminated (low standing wave ratio) to avoid possible damage to the equipment under test.

READING THE COUNTER

CAUTION: Avoid any excessive voltages that could damage your Counter. Refer to the Maximum Input Voltage for maximum safe input voltages at various frequencies.

Maximum Input Voltage

Up to a frequency of 10 kHz, the maximum permissible input voltage is 150 volts rms. At frequencies above 100 kHz, the maximum input voltage must be derated according to the following graph.



MAXIMUM INPUT VOLTAGE DERATING CURVE

Unknown Frequencies

To measure an unknown frequency, push the Power switch to ON and the Range switch to kHz. Allow the Counter to reset to zero. Then apply the unknown frequency to the counter input. If the OVER (overrange) lamp lights up, the frequency is higher than 99.999 kHz and the Range switch should be pushed to MHz. If the display then constantly changes in a random manner, the frequency is higher than the Counter's capability, or the input level is too low.

The Display

Frequencies lower than 100 kHz can be read directly to a resolution of ±1 Hz in the kHz position of the Range switch. Frequencies of 100 kHz and higher (within the range of the Counter) can be read to ±1 Hz by using both Range switch positions. A frequency of 12,345,678 Hz would be displayed as follows:

Range Switch	Display	Overrange Lamp
MHz	12.345	Off
kHz	45.678	On

IN CASE OF DIFFICULTY

This three-part section gives suggestions for locating and resolving difficulties.

The first part, "General Troubleshooting Information," deals with difficulties which exist upon completion of the assembly of your kit, and is primarily directed to soldering and assembly problems.

The second part consists of a "Troubleshooting Chart," which gives difficulties and likely causes.

The third part, "Important Wave Shapes," contains charts with significant waveforms.

If the above checks do not locate the problem, the difficulty may be a component. Read the "Circuit Description" (Pages 42 through 45) and refer to the Schematic Diagram (fold-out from Page 55) to help you determine where the trouble is.

NOTE: In an extreme case where you are unable to resolve a difficulty, refer to the "Service" section and Warranty of the "Kit Builders Guide" and to the "Factory Repair Service" information on Page 40 of this Manual.

GENERAL TROUBLESHOOTING INFORMATION

1. Make sure you have power at the transformer primary.

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

3. Most problems result from poor connections and soldering. Use a magnifying glass and check all solder connections to be sure they are soldered as described in the "Soldering" section of the "Kit Builders Guide." Also check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring. Look for solder bridges between circuit board foils. Compare your foil pattern with the "X-Ray Views" on Pages 46 and 47. Many troubles can be eliminated by reheating all connections to make sure they are soldered as described in the "Soldering" section of the "Kit Builders Guide."

4. Make sure that the proper transistor has been installed at each location and that each lead is in the proper hole.

5. Press each integrated circuit into its socket so that each pin will make a secure connection. Be sure that each IC pin is properly installed in its socket and not bent out or under the IC.

6. Check each IC to make sure its index mark matches the half-circle on the circuit board.

7. Check the values of the parts. Make sure the proper part has been wired into the circuit at each location. For example, a 680 Ω (blue-gray-brown) resistor could easily be installed in place of a 68 Ω (blue-gray-black) resistor.

8. Check the continuity of the circuit board foils, including those places where a foil runs through a hole to connect a top foil and a bottom foil together. (Such a hole may also be used for mounting a component.) If you find an open foil, bridge it through the circuit board with a jumper wire. CAUTION: Never run a drill through any circuit board hole, as this will destroy any foil connection that goes through the hole.

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

10. The functional areas of the circuit board are shown on Page 54.

Substitution

Corresponding components of the circuitry for each display tube can be interchanged with the components of another tube. IC's 1 through 5 can be interchanged, for example.

If one display tube shows two digits simultaneously, interchange it with one of the other tubes to determine if the tube or the circuit is faulty. If the circuit is faulty and there are no solder bridges on the associated foil, interchange the decoder/driver IC with one of the others. This method can be used with other single digit problems and can be extended to interchanging the memory latches and the decade counter integrated circuits.

Clock Circuit

Verify that the clock oscillator and divider circuits are operating properly by checking the voltage at pin 12 of IC24. The meter should alternately indicate 0 volts for one second and then four to five volts for one second.

Counting and Display Circuits

As shown in Figure 3-6, a counting and display circuit consists of the decade counter and the associated storage register, decoder/driver, and display tube. A high input impedance voltmeter can be used to check the logic states of only the memory latches, decoder/drivers, and display tubes. For these voltage checks, a "high" is 2.4 VDC or more, whereas a "low" is .8 VDC or less.

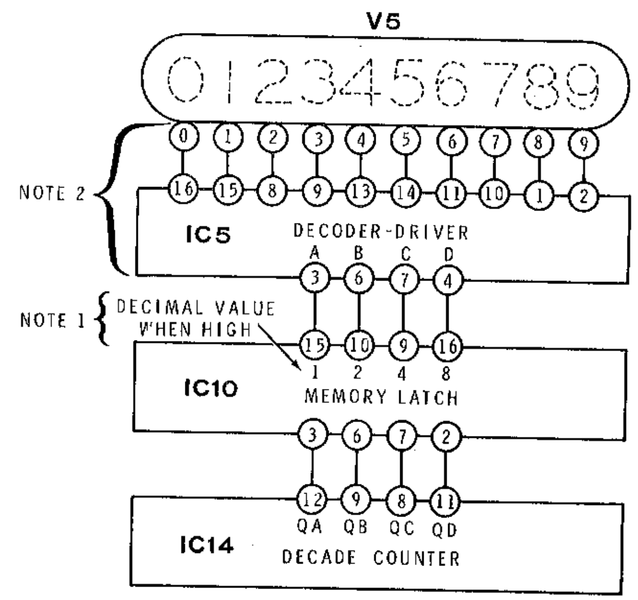


Figure 3-6

The decade counters cannot be accurately checked with a voltmeter, as their outputs change rapidly with the count. The substitution method described above is one way to check them.

NOTES:

1. Add the values of the highs to determine the decimal equivalent. For example, if pins 15 and 9 of IC10 are high (pins 10 and 16 remain low), then the decimal equivalent is 5 (1+4=5). If only pin 16 is high, the decimal equivalent is 8. If all pins are low, the decimal equivalent is 0.

2. All outputs of the decoder/driver will be high except one. The one output which is low will turn on the corresponding number in the display tube. For example, if pin 14 is low, number 5 will be turned on.

EXAMPLE

1. If tube V5 displays a "5" when you know a "3" should be seen, transpose IC14 (in this example) with one of the other decade counters whose display is correct. If V5 still displays a "5," it is reasonable to assume the IC is good. If the display changes to a "3," the IC is probably faulty, although the original IC should be inserted in its socket again to make sure.

2. If the display remains a "5," check the outputs of the memory latch IC10. If pins 15 and 9 are high and pins 16 and 10 are low, then the memory latch is probably good (1+4=5).

3. The decoder/driver, IC5, should have pin 14 low to turn on the 5 in the display tube, and all other output pins should be high. If pin 9 should be low, which turns on the 3 in the display tube, but a 5 is displayed, then the fault is probably in the tube and it should be substituted with one of the others for confirmation.

4. If the foregoing checks are all indicative of a "5," then it is reasonable to assume that the difficulty lies ahead of the counting and display circuits.

CIRCUIT BOARD MAINTENANCE

To obtain access to the foil side of the circuit board for maintenance, follow the numbered steps:

1. Remove the cabinet shell.

2. Unsolder and remove the black wire from the TP output solder lug on the inside of the rear panel.

3. Remove the mounting hardware which secures Q12 to the inside of the rear panel.

4. Carefully slide the circuit board from under the back of the output connector and turn the board up on edge, as when you connected the transformer leads.

5. When you reinstall the circuit board, remember to again push the white wire from the input connector down against the board.

Troubleshooting Chart

CONDITION	POSSIBLE CAUSE
One readout does not reset to zero with the input shorted.	1. Check associated decade counter, memory latch, and decoder/driver IC's.
Readouts will not reset to zero in the kHz or MHz range.	1. Q8. 2. IC23. 3. IC21. 4. IC15, IC16, IC17.
Counter functions normal in MHz range but not in kHz range.	1. IC24. 2. Switch SW2. 3. IC20.
Display tubes will not light.	1. +100-volt supply (D7 and transformer). 2. Check for a solder bridge on the 100-volt line.
One or more display tubes will not light.	1. Check associated tube pins, memory latch (IC6 through IC10) and decoder/driver IC's (IC1 through IC5).
One display tube does not indicate correct numeral from known frequency source.	1. Check associated decade counter, memory latch, and decoder/driver IC's.
Counter resets to zero but will not count.	1. Range switch not firmly pressed to correct position. 2. Insufficient amplitude of input signal. 3. Transistors Q1 through Q7. 4. IC25.
OVER (overrange) lamp does not function or is on continuously.	1. Transistor Q10. 2. IC22. 3. IC24.
Counting sequence is displayed during gating.	1. Memory transfer line, Q9. 2. IC21, IC23.
Decimal point does not light.	1. Resistor R22. 2. Interchange tube V3 with another display tube.
One or more display tube numbers on at all times.	1. Check for solder bridge on associated tube foil and decoder/driver. 2. Open foil between two IC pins in the counting and display circuit. 3. Poorly soldered connection in the counting and display circuit.

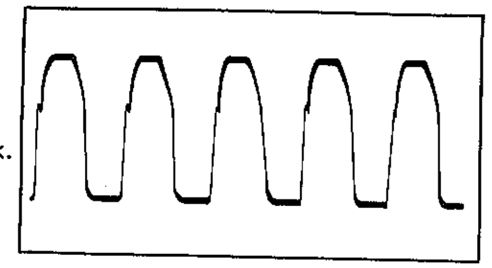
CONDITION	POSSIBLE CAUSE
Numbers displayed with input open, but zeros displayed with input shorted.	1. Push the white wire between hole J and the input connector down against the circuit board.
Random count with input cable disconnected.	1. Scrape paint under BNC connector on back of panel.
Sensitivity reduced after warmup.	1. Failure to allow 30-minute warmup prior to initial adjustment.
All display tubes show all 10 numbers at once.	1. 5 volt supply. 2. Q12, Q13, D5, D6, Q11.
+5 volt supply too high.	1. Q12, Q13.

IMPORTANT WAVE SHAPES

This section presents wave shapes that should be present at various points in your Frequency Counter. The wave shapes are line drawings of photographs of the graticule of a Textronix Model 547 Oscilloscope. A low capacity X10 probe was used and the oscilloscope was set for .1 volt-per-division. The time base is indicated for each drawing. Use the MHz position of the Range switch. All wave shapes are approximately 3.5 to 4.5 volts. The bottom horizontal lines of the wave shapes represent approximately 0 to .4 volts.

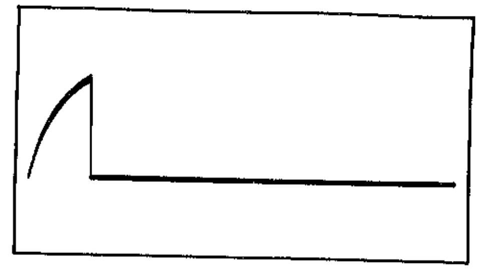
IC 15

Pin 14
.5 µs/Div.
1 MHz clock.



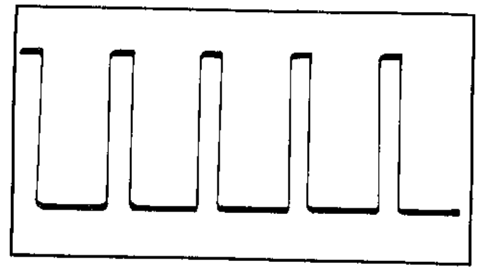
Q 9

Collector
.2 ms/Div.
memory
transfer pulse.



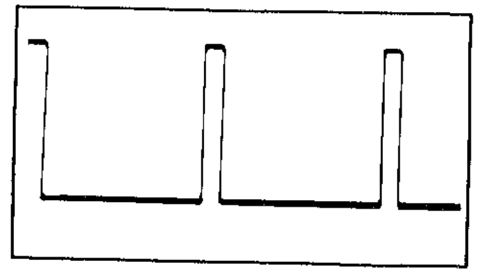
IC 17 *

Pin 11
.5 ms/Div.
divided clock
pulse.



Q 8

Collector
.5 ms/Div.
positive
reset pulse.



Pin
.5 s
div
pul

Pi
.5
1
pu

You
Servi
servic
accep
kit to
listed

To b
warr
deliv
acco
eithe
retu

If it
Elec
Harl
instr

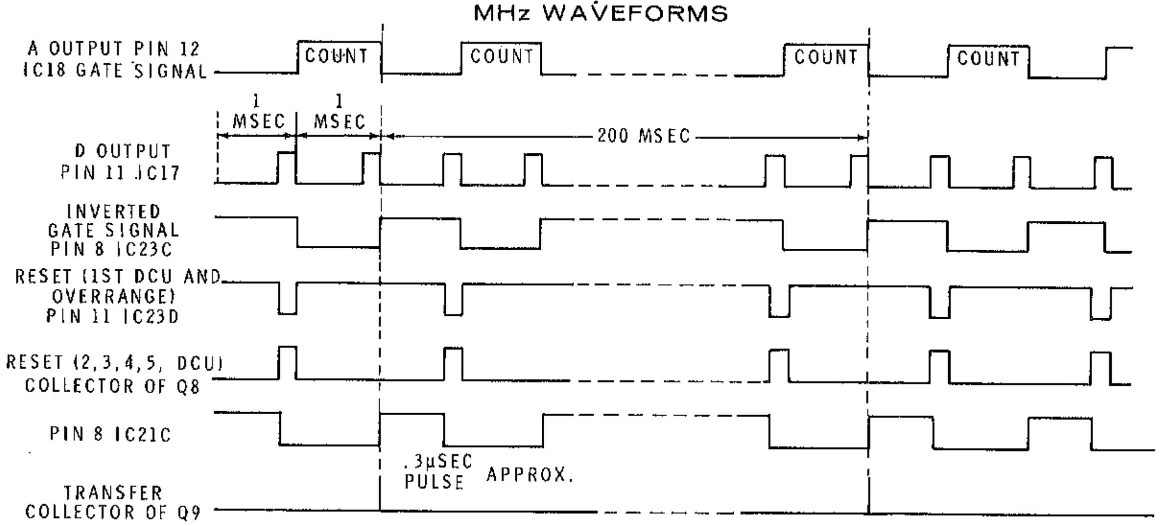
Prep
info

PULSE RELATIONSHIPS OF THE GATING, MEMORY, AND RESET CIRCUIT

TRUTH TABLE
(EACH GATE)

INPUTS A	INPUTS B	OUTPUTS
0	0	1
0	1	1
1	0	1
1	1	0

MHz WAVEFORMS



kHz WAVEFORMS

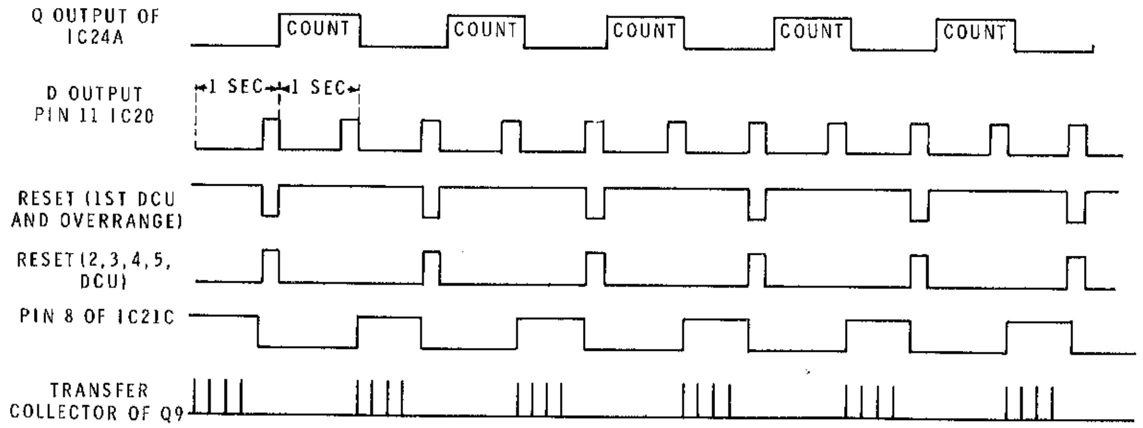
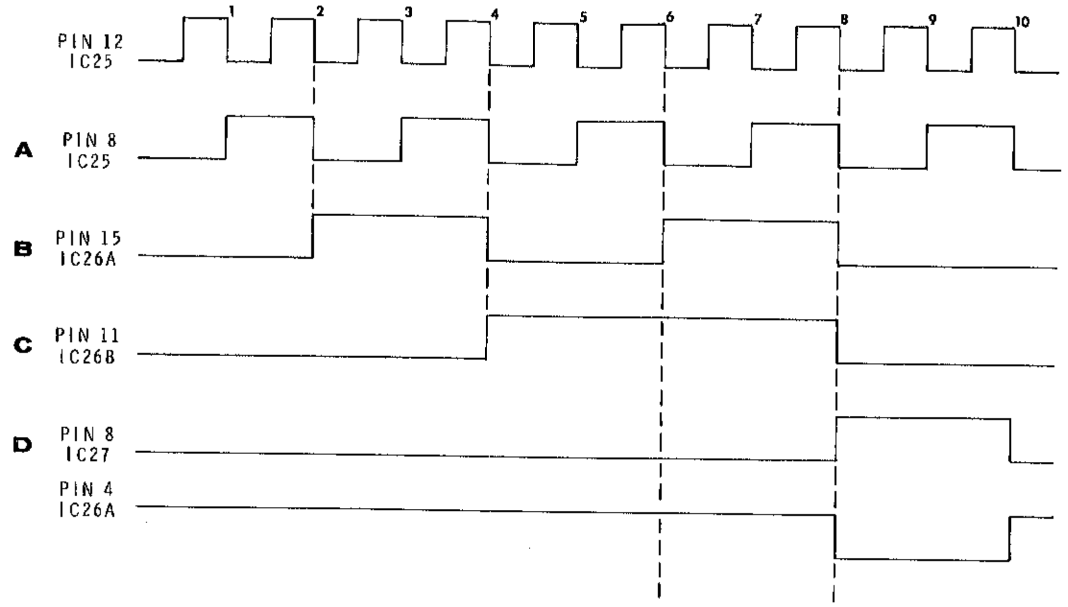


Figure 4-1

PULSE RELATIONSHIPS OF THE FIRST DECADE COUNTER



LOGIC LEVEL

COUNT	A	B	C	D
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

Figure 4-2

CIRCUIT DESCRIPTION

Refer to the Block Diagram (fold-out from Page 45) and to the Schematic Diagram (fold-out from Page 55) while you read this "Circuit Description."

GENERAL

Your Heathkit Frequency Counter includes a 1 MHz clock and scaler that produces an exact time base of 1 second or 1 millisecond. This time base controls all of the gating circuits and determines the overall accuracy of the Counter.

The output of this clock and scaler circuit is applied to the reset, gate, and memory circuits to reset the counters, gate the first decade counter for a precise period, and to transfer the count to the decoder and display tubes.

The input amplifier and Schmitt trigger circuits accept and shape the input signal into a squarewave, and then apply this signal to the first decade counter. When this counter is turned on, the pulses from the input and shaper circuits are counted in BCD (Binary-Coded-Decimal) logic, with each tenth pulse passing to the next decade counter. The outputs of the decade counters are in the 1-2-4-8 or "natural" binary code.

When the transfer pulse is applied to the memory latches, they accept the accumulated BCD count from the decade counters and hold this count at their outputs until the next transfer pulse. The outputs are connected to the decoder/drivers, which translate the BCD count into a decimal count and turn on the proper numbers in the display tubes. Any tenth pulse from the fifth decade counter triggers the overrange detector and readout circuit to cause the overrange (Over) lamp to light. The reset pulse occurs after the transfer pulse and resets the counters to zero for the next counting cycle.

INPUT CIRCUIT

The input circuit consists of a network of capacitors, resistors, transistors, and diodes that function as follows: C1 removes any dc component from the applied input signal. C2 prevents attenuation of high frequency signals, and R2, D1, and D2 prevent overloading of the input transistors.

Input transistors Q1 and Q2 are direct coupled with 100% negative feedback. These transistors provide wide bandwidth, high input impedance, low output impedance, and a gain of near unity.

Transistor Q3 is an amplifier with emitter compensation, and is isolated from the Schmitt trigger circuit by the emitter-follower configuration of transistor Q4.

SCHMITT TRIGGER

The Schmitt trigger circuit is a regenerative bistable circuit which produces a square-wave output each time it is triggered and reset. Schmitt trigger transistors Q5 and Q6 are emitter-coupled for current-mode operation so they will produce the fast switching time required for operation of the first decade counter. Operating current for the trigger is set by resistor R13, while R15 sets the bias of zener diode ZD1 in its zener region.

Input Sensitivity controls R3 and R6, by virtue of dc coupling, adjust the threshold of the Schmitt trigger circuit to insure that very small input signals can be measured with the counter.

Emitter follower transistor Q7 keeps the TTL (transistor-transistor-logic) in the counter circuit from loading the Schmitt trigger circuit.

1 MHz CLOCK AND SCALER

A 1 MHz crystal and gates A and D of IC21 are used to form a TTL — compatible clock. Capacitors C9 and C11 provide the proper capacitive load for the crystal. C11 is variable to allow for precise calibration of the oscillator. Resistors R28, R29, and R31 assure efficient starting of the clock oscillator. Gate B of IC21 provides buffering action between the oscillator and the first decade divider of the time base scaler.

The scaler consists of six decade dividers. The Range switch selects the output from the third or sixth divider for the reset pulse, and either the A output of IC18 or the Q output of IC24A for the input gating pulse. Therefore, the Range switch can provide either a 1-millisecond (MHz) or a 1-second (kHz) time base for the gating, reset, and memory circuits. The A output of IC20 provides the transfer pulse.

GATING, MEMORY, AND RESET

The gating, memory, and reset circuit controls the times that an input signal is gated into the counting circuits, the times that the accumulated information is passed from the counting circuits to the readout circuits, and the times that the counter circuits are reset to zero to begin a new counting cycle.

Figure 4-1 (fold-out from Page 42) shows the pulse relationships of the gating, memory, and reset circuit. Refer to this Figure as you read the following information.

When the Range switch is in the MHz position, the "gate open" signal is a 1-millisecond pulse that is obtained from the A output (pin 12) of IC18. The input signal enters the counters during the millisecond that the logic 1 of the gating signal is present on the J and K inputs of the first flip-flop of the first decade divider (pins 9 and 3 of IC25).

The reset pulse is derived by combining the inverted gate signal with the output of IC17 in IC23D. During the time that both the output of IC17 and the inverted gate signal from IC23C are high, a logic 1 at both inputs of NAND gate IC23D causes a logic 0 reset pulse to be applied to the first DCU (decade counting unit) and to IC24B, the overrange flip-flop. This reset pulse is inverted by Q8 to supply a logic 1 reset pulse to IC's 11 through 14. These reset pulses occur every two milliseconds, immediately prior to the gate opening.

The transfer signal is derived by combining the reset pulse (pin 11 of IC23D) with the inverted gate pulse in NAND gate IC23A. The resultant pulse is then inverted by IC21C.

A transfer pulse cannot occur during a reset pulse because IC23B is inhibited by a logic 0 on its pin 4 from IC21C. The transfer pulse can occur only when pin 4 is at a logic 1 and during a postive-going transition at the A output of IC20, which is differentiated by C12 and R36 and applied to IC23B as a positive spike. IC23B then has a logic 1 at each input and therefore a logic 0 output. The negative output spike is inverted by Q9 and the positive spike is applied as a transfer pulse to IC's 6 through 10, and IC's 22A and 22D.

Although the reset cycle occurs every two milliseconds, the differentiated A output of IC20 allows the transfer pulse to occur only every 200 milliseconds. Therefore, 100 count-reset cycles will occur for every memory update to prevent the appearance (due to the persistence of the human eye) of more than one lighted number in the last digit.

When the Range switch is in the kHz position, the "gate open" signal is a 1-second pulse that is obtained from the Q output (pin 12) of IC24A.

The reset pulse is derived in the same manner as with the Range switch in the MHz position, except that the basic signals are obtained from the D output (pin 11) of IC20 and the Q output of IC24A.

The transfer pulse is also derived in the same manner as with the Range switch in the MHz position, except that the gate reset cycle now occurs every two seconds and the transfer occurs every 200 milliseconds (unless inhibited by the presence of either a reset pulse or a gate-open pulse). Therefore, there are four transfer pulses for every gate reset cycle. These extra pulses, however, will have no effect on the readout since neither the "gate-open" nor reset can occur during their time duration. As a consequence, the same count is simply transferred four times.

FIRST DECADE COUNTER

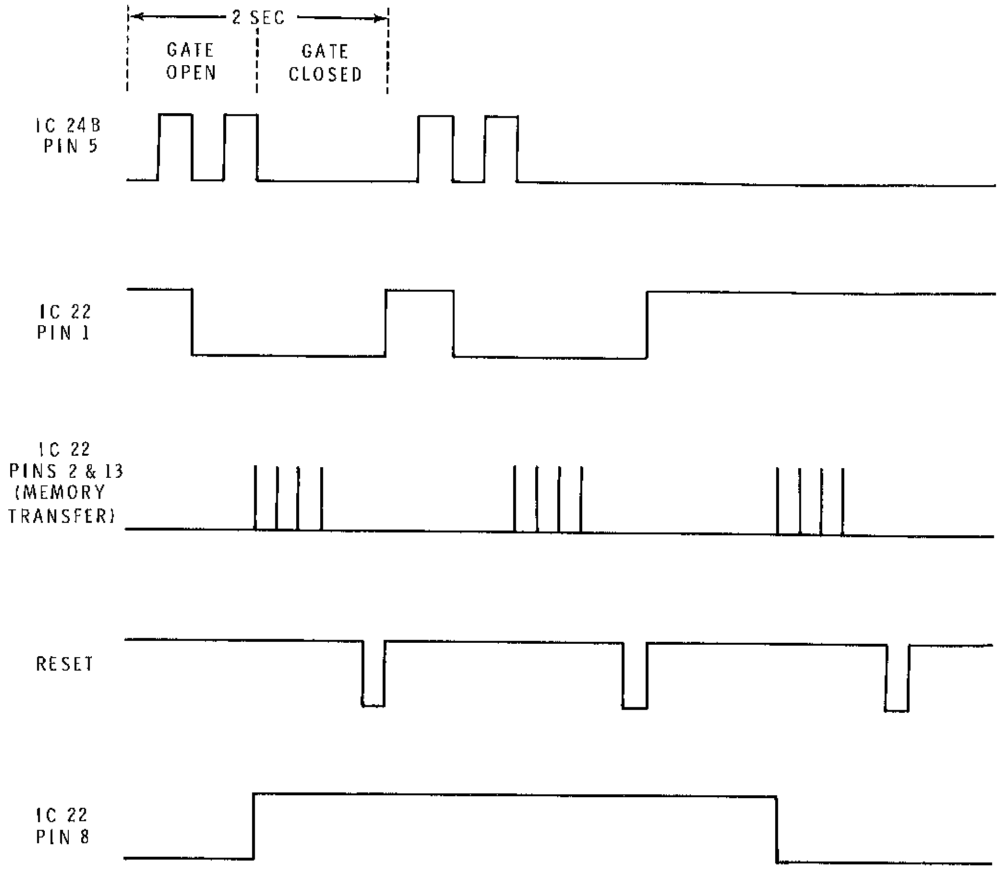
Figure 4-2 (fold-out from Page 42) shows the pulse relationships in the first decade counter (IC25, IC26A, IC26B, IC27). Refer to this Figure as you read the following information.

This circuit is connected as an asynchronous BCD counter, and the flip-flops are triggered by negative-going pulses. Flip-flop IC25 is toggled by the signal from the Schmitt trigger circuit. As IC25 is toggled on every input pulse when both the J and K inputs are at logic 1, the Q output (A) goes to a logic 1 on the 1st, 3rd, 5th, 7th, and 9th counts.

These pulses are then applied to the toggle input of IC26A. However, because of the feedback loop from $\bar{Q}$ of IC27 to the J input of IC26A, IC26A is inhibited on the tenth count. This results in the Q output of IC26A being a logic 1 for the 2nd, 3rd, 6th, and 7th counts. IC26B is toggled by the Q output of IC26A on the 4th and 8th counts. Therefore, the Q output of IC26B is a logic 1 for the 4th, 5th, 6th, and 7th counts.

Two feed-forward loops are incorporated around IC27, which is toggled by the Q output of IC25, to inhibit its toggling on any pulse except the 8th and the 10th count. This is accomplished by connecting the Q outputs of IC26A and IC26B to the J inputs of IC27. As a result, IC27 will toggle only when both of the Q outputs from IC26A and IC26B are at logic 1. This results in the Q output of IC27 being at logic 1 for the 8th and 9th counts only. On the 10th count, IC25 toggles to a logic 0 at its Q output as its J input is a logic 0. IC26A and IC26B will stay at logic 0 as they were not toggled. IC27 is forced to logic 0 because its J input is at logic 0.

Reset is accomplished by taking all clear inputs of the flip-flops to a logic 0. These logic levels are supplied by IC23D. Counting is started when the J and K inputs of IC25 are taken to logic 1, and inhibited when these same inputs are returned to a logic 0. These logic levels are supplied by the A output of IC18 or the Q output of IC24A, as determined by the position of the Range switch.



OVERRANGE DETECTOR PULSE
Figure 4-3

SECOND, THIRD, FOURTH, AND FIFTH DECADE COUNTERS

These counters are asynchronous BCD counters that require a single integrated circuit for each decade. The main difference between the operation of these counters and that of the first decade counter is that no gating is required. This is because none of the subsequent counters can operate unless the first counter is counting and produces a "spillover" or carry pulse. Reset is provided by Q8, and is initiated when the reset lines go to a logic 1 state.

The internal operation of these circuits are similar to that of the first decade counter.

OVERRANGE DETECTION

Figure 4-3 shows the pulse relationships of the overrange detector. Refer to this Figure and the schematic as you read the following information.

If the count passes from 99999 to 100,000, a pulse is produced at the D output (pin 11) of IC14. This spillover toggles IC24B, which is a standard J-K flip-flop. The K input of this IC is tied to logic 0 (ground), which causes the $\bar{Q}$ output to latch in a logic 0 condition whenever the CP input is toggled. The $\bar{Q}$ output remains in this condition until a logic 0 is applied to the C (clear) input.

IC22 is a quad, two-input NAND gate package used as an inverting data latch. The logic level at pin 1 of IC22 will be inverted and transferred to pin 8 (the Q output) when pin 2 and pin 13 are both at logic 1. A logic 0 at these inputs will inhibit transfer. The output of the latch is connected to the base of NPN transistor Q10. Therefore the overrange lamp will light only when there is a logic 1 output from pin 8 of IC22. This results in the visual display (OVER) that indicates a spillover from IC14.

READOUT AND MEMORY LATCHES

The four BCD outputs from each decade counter are connected to a memory latch (IC6, IC7, IC8, IC9, and IC10.) These latches transfer the signals to their outputs only when the transfer line goes to a logic 1. When the transfer line returns to logic 0, the information at the latch outputs is retained even though the logic level at the inputs may change.

The information at the outputs of the memory latches is decoded into a ten-bit code by decoder/drivers IC1 through IC5. This information is then applied to the ten-numeral cold-cathode display tubes. The table of Figure 4-4 shows how this input signal is decoded. A logic 0 is required by each number for turn-on. If a code other than BCD (or a BCD count which exceeds 9) is received by the driver, the display will not register valid information. This condition can occur only when the Counter is first turned on. If this should occur, the next reset and transfer pulse will remove the false codes and the subsequent displays will be valid.

TRUTH TABLE

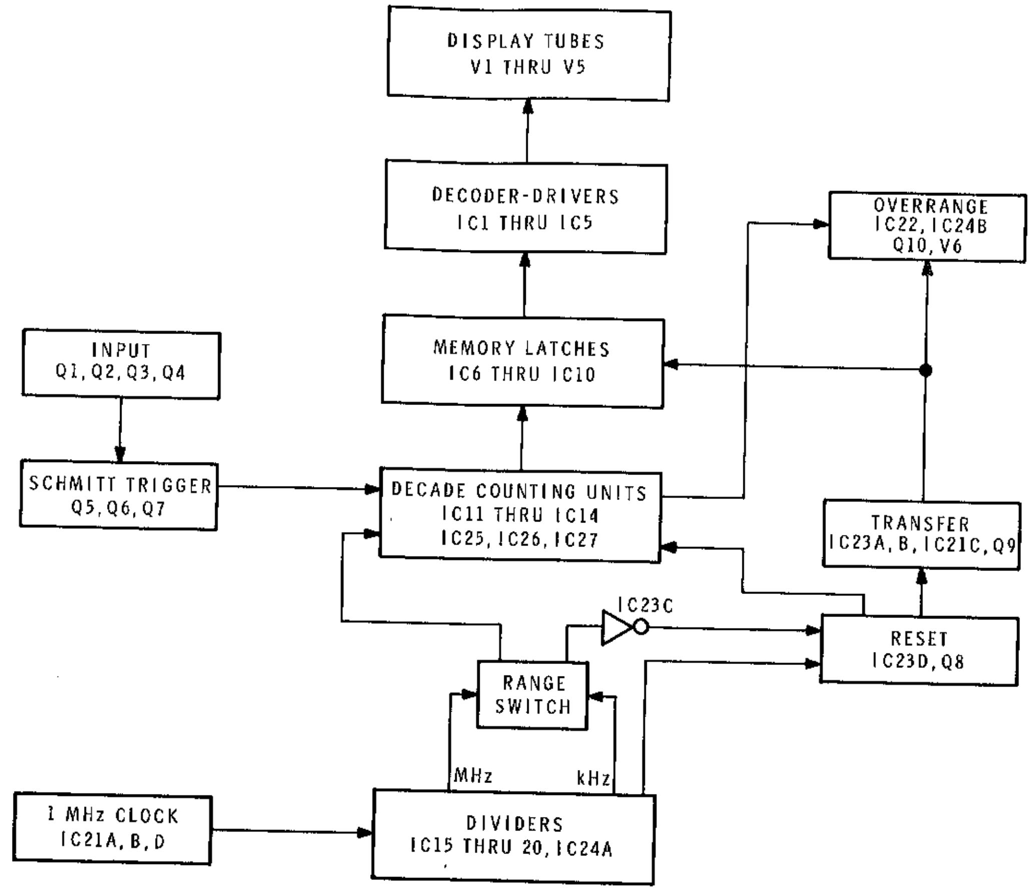
INPUT				LOW OUTPUT ON*
D	C	B	A	
L	L	L	L	0
L	L	L	H	1
L	L	H	L	2
L	L	H	H	3
L	H	L	L	4
L	H	L	H	5
L	H	H	L	6
L	H	H	H	7
H	L	L	L	8
H	L	L	H	9

H = high level, L = low level
*All other outputs are high (LOGIC 1).

Figure 4-4

POWER SUPPLY

The power transformer is used to operate two regulated and one unregulated dc power supplies. One of the regulated supplies provides +5 volts at 700 milliamperes, while the other one provides +15.5 volts at 70 milliamperes. The third, unregulated (half-wave) supply provides the high voltage (HV) necessary for the front panel readouts.



BLOCK DIAGRAM

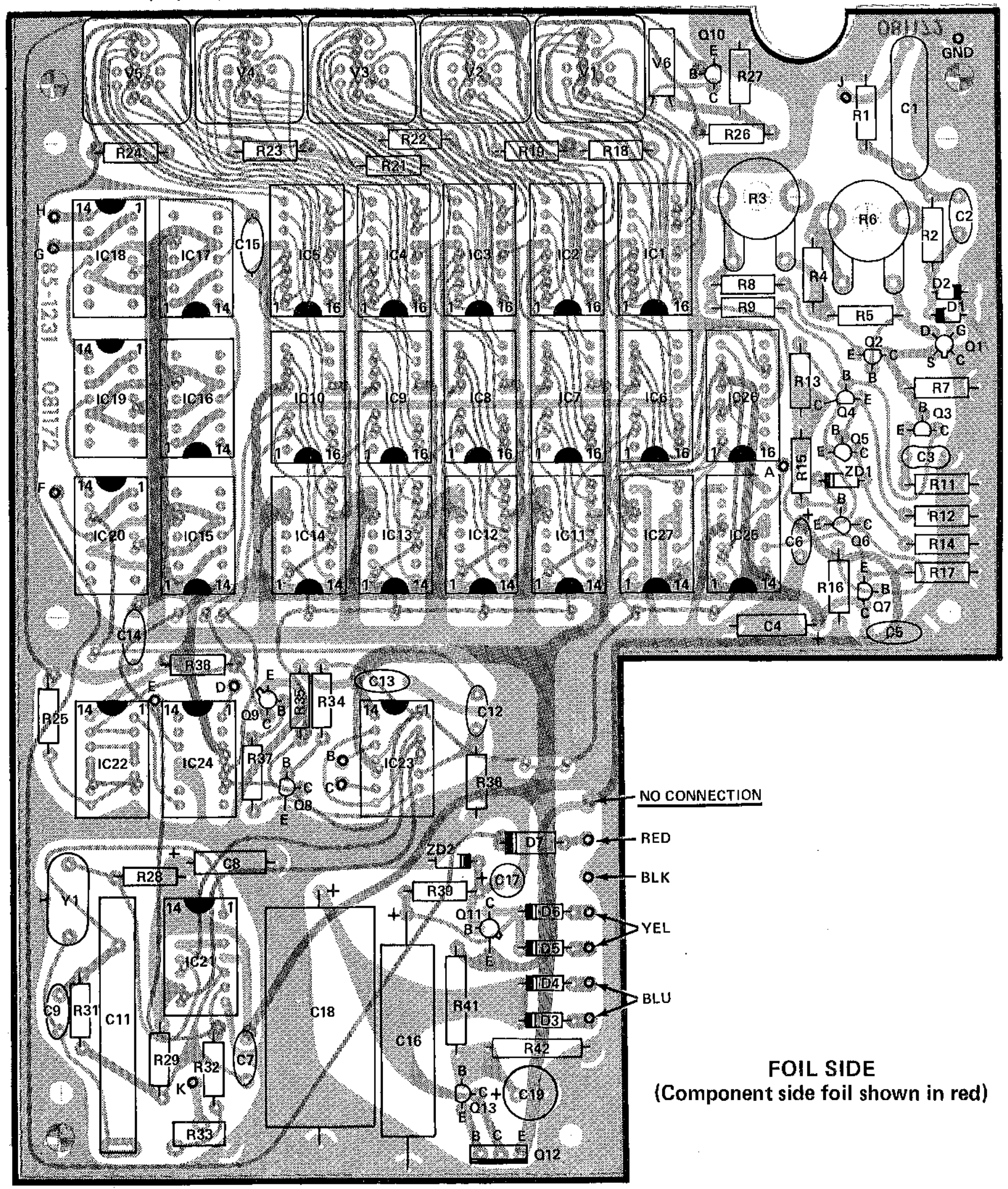
a pulse is
is spillover
he K input
uses the Q̄
e CP input
ion until a

used as an
:22 will be
vhen pin 2
inputs will
:ted to the
ange lamp
n pin 8 of
ER) that

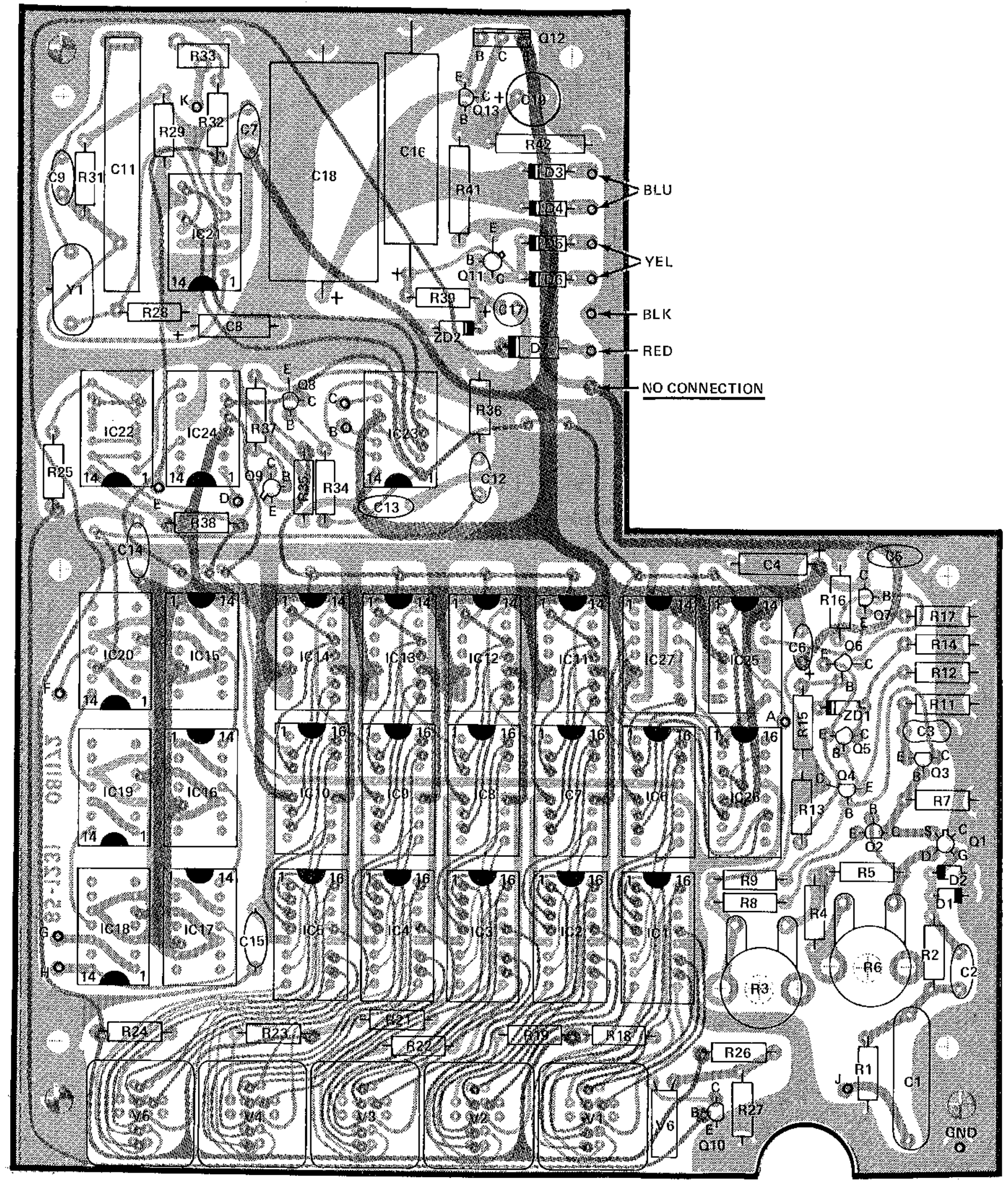
CIRCUIT BOARD X-RAY VIEWS

NOTE: To determine the value (22 Ω, 4 μF, etc.) of one of these parts, you may proceed in either of the following ways.

1. Refer to the place where the part is installed in the Step-by-Step Instructions.
2. Note the identification number of the part (R-number, C-number, etc.). Then locate the same identification number next to the part on the Schematic. The value, or "Description," of most parts will be near this number.



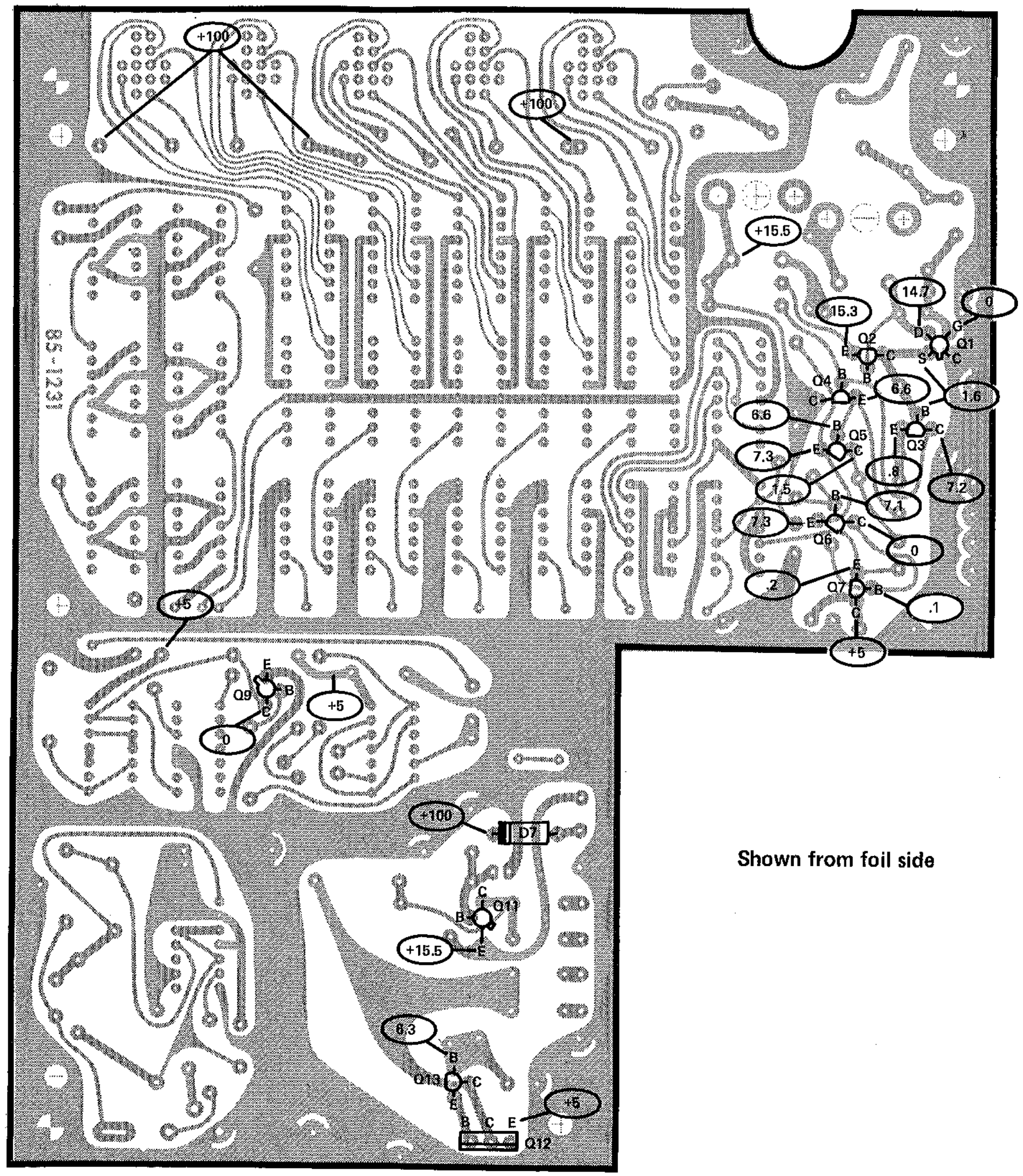
FOIL SIDE
(Component side foil shown in red)



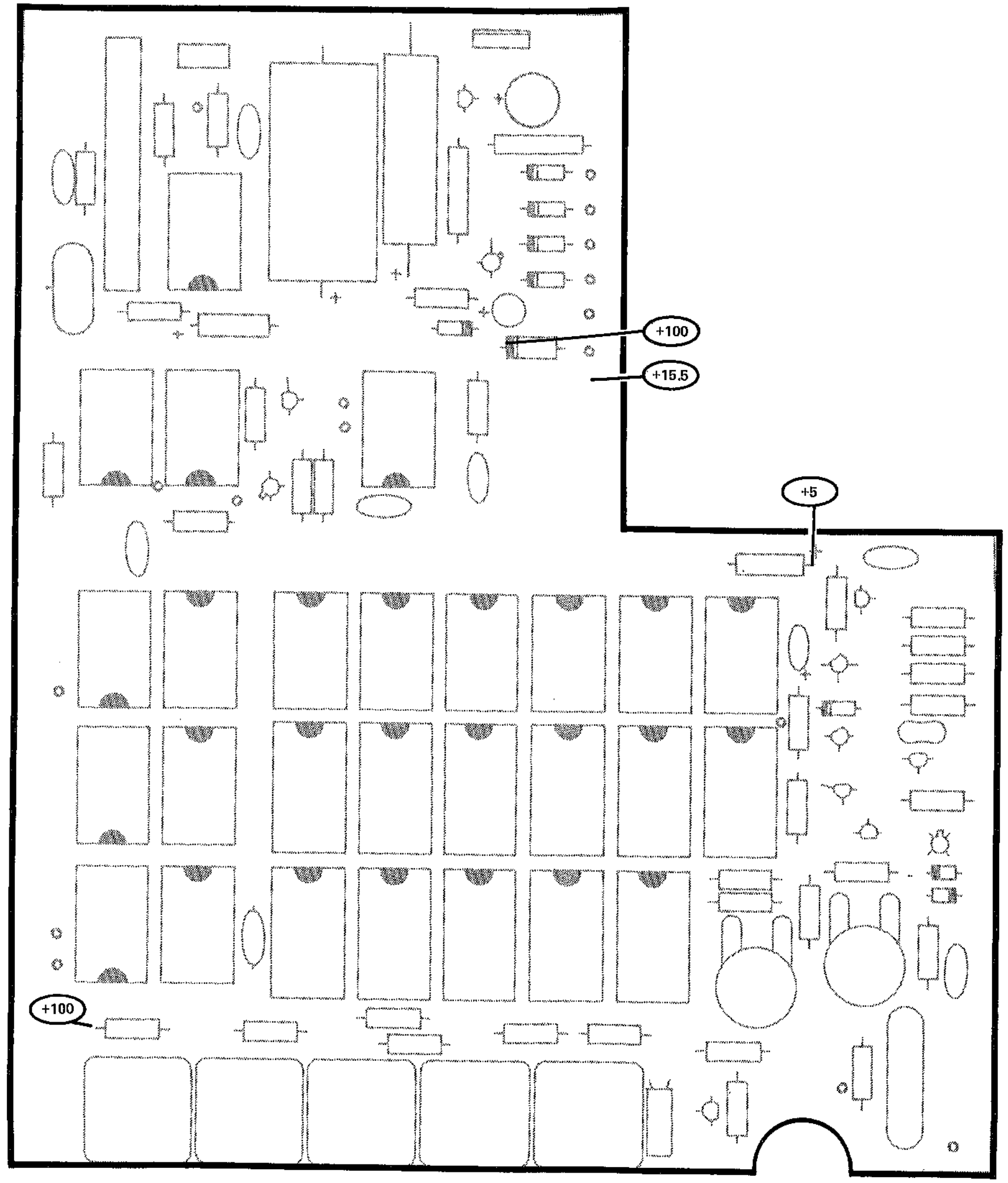
COMPONENT SIDE
(Component side foil shown in red)

CIRCUIT BOARD VOLTAGE CHARTS

NOTE: Indicated values are dc voltages taken with a high impedance input voltmeter from the point shown to chassis ground with no input signal to the Counter. Voltages may vary ±20%.

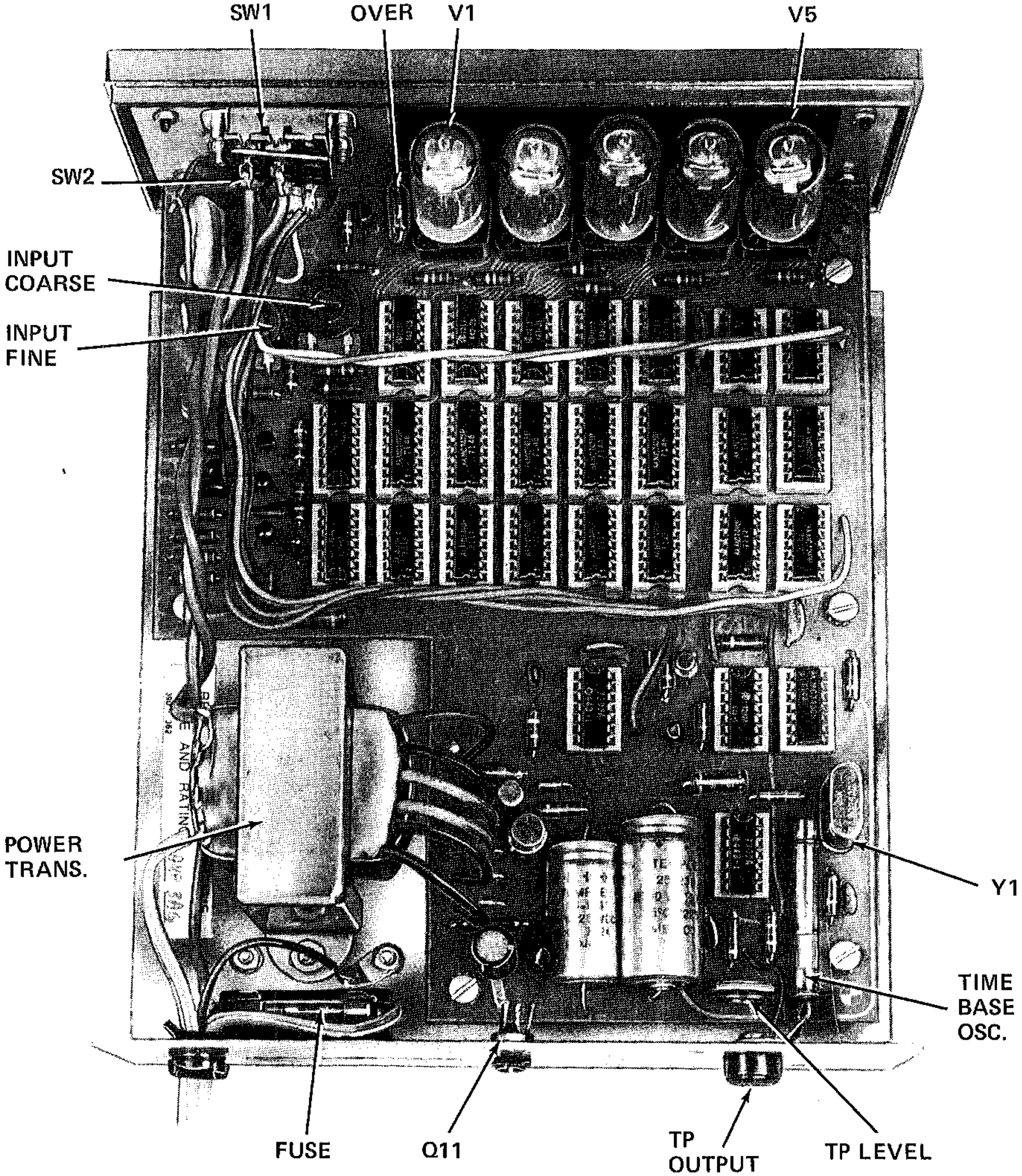


Shown from foil side

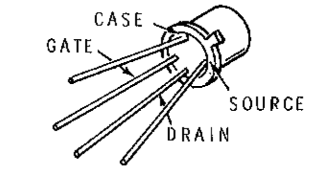
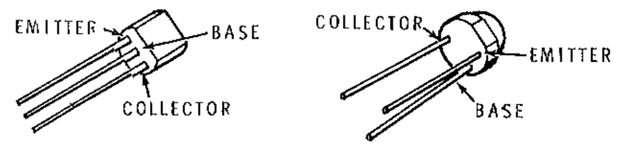
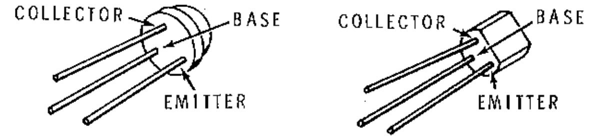
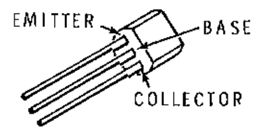
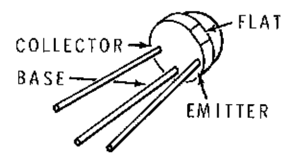
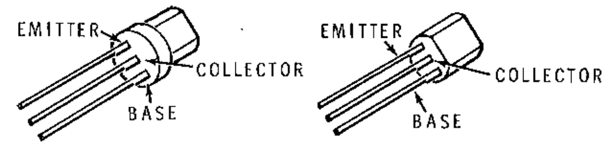
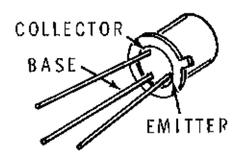
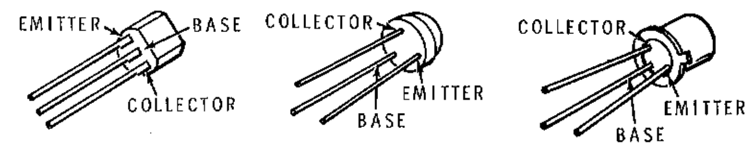
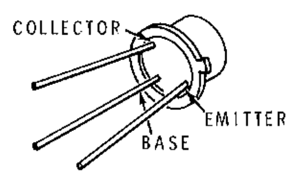


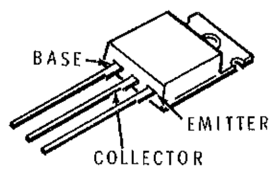
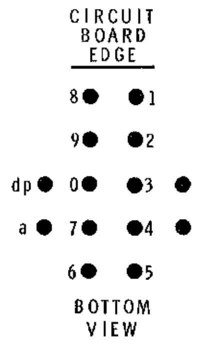
Shown from component side

CHASSIS PHOTOGRAPH



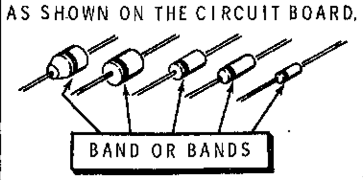
TUBE-TRANSISTOR IDENTIFICATION CHART

COMPONENT	HEATH PART NO.	REPLACEMENT TYPE & RATING	BASE VIEW
Q1	417-251	SFC2912	
Q2	417-235	2N4121	
Q3, Q7	417-125	2N3563	
Q4	417-134	MPS6520	
Q5, Q6	417-260	2N4258A	
Q8, Q13	417-118	2N3393	
Q9	417-154	2N2369	
Q10	417-173	ETS083	
Q11	417-269	SGC5282	

COMPONENT	HEATH PART NO.	REPLACEMENT TYPE & RATING	BASE VIEW
Q12	417-175	2N5294	
V6	412-15	NE2H	
V1-V5	411-284	AMPEREX ZM-1000	

PIN	CONNECTION
1	NUMERAL 1
2	NUMERAL 2
3	NUMERAL 3
4	NUMERAL 4
5	NUMERAL 5
6	NUMERAL 6
7	NUMERAL 7
8	NUMERAL 8
9	NUMERAL 9
0	NUMERAL 0
a	ANODE
dp	DECIMAL POINT

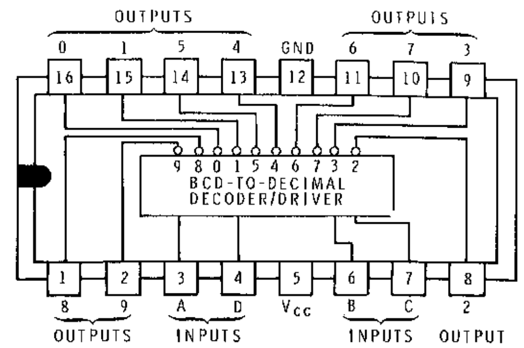
DIODE IDENTIFICATION CHART

COMPONENT	HEATH PART NO.	MAY BE REPLACED WITH	IDENTIFICATION
D1, D2	56-56	1N4149	HEATH PART NUMBERS ARE STAMPED ON MOST DIODES.
D3, D4, D5, D6	56-65	1N4002	NOTE: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES. ALWAYS POSITION THE BANDED END AS SHOWN ON THE CIRCUIT BOARD.
D7	57-27	1N2071	
ZD1	56-36	VR16.1G, 12mA 16.1 VOLT	
ZD2	56-63	MZ500-10, 5.6VOLT, 1mA ZENER	

INTEGRATED CIRCUIT BASE DIAGRAMS

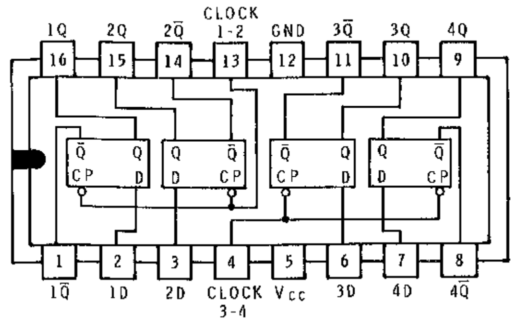
(All diagrams shown from top)

IC1
IC2
IC3
IC4
IC5



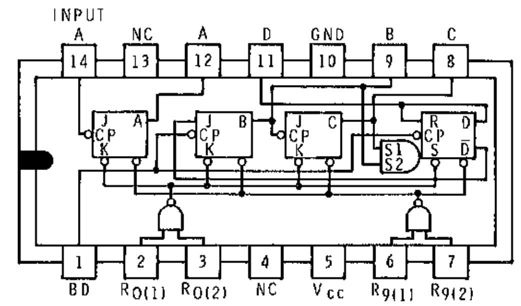
SN7441B BCD—TO—DECIMAL DECODER/DRIVER
#443—35

IC6
IC7
IC8
IC9
IC10



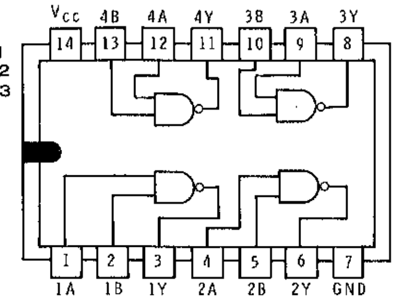
SN7475N 4—BIT BISTABLE LATCH
#443—13

IC11
IC12
IC13
IC14
IC15
IC16
IC17
IC18
IC19
IC20



SN7490N DECADE COUNTER
#443—7

IC21
IC22
IC23

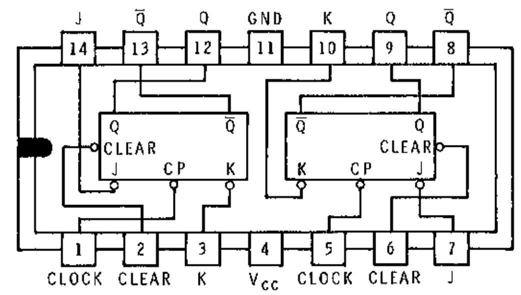


TRUTH TABLE (EACH GATE)

INPUTS A	INPUTS B	OUTPUT
0	0	1
0	1	1
1	0	1
1	1	0

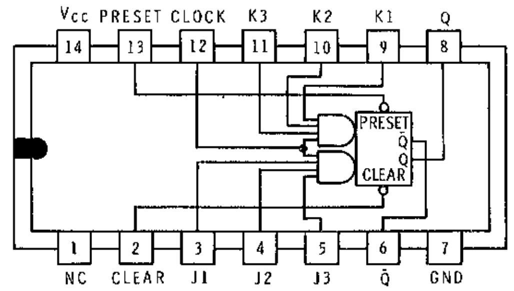
SN7400N QUADRUPLE 2—INPUT POSITIVE NAND GATE
#443—1

IC24



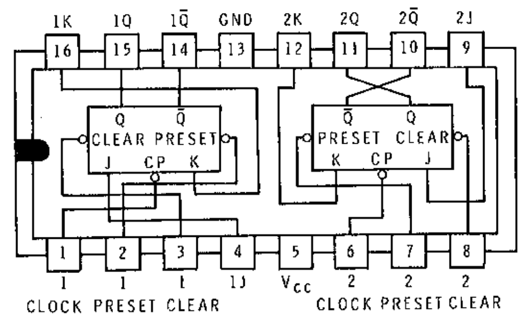
SN7473N DUAL J—K MASTER SLAVE FLIP—FLOP
#443—5

IC25



SN74H102N J—K EDGE TRIGGERED FLIP—FLOP
#443—43

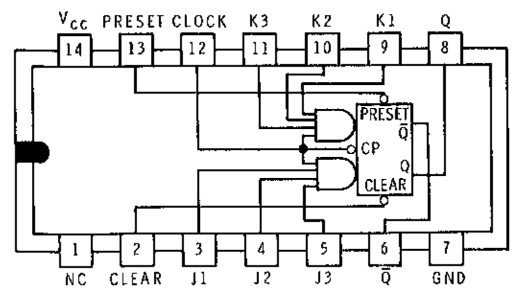
IC26



LOW INPUT TO PRESET SETS Q TO LOGICAL 1.
LOW INPUT TO CLEAR SETS Q TO LOGICAL 0.
CLEAR AND PRESET ARE INDEPENDENT OF CLOCK.

SN7476N DUAL J—K MASTER SLAVE FLIP—FLOP
#443—16

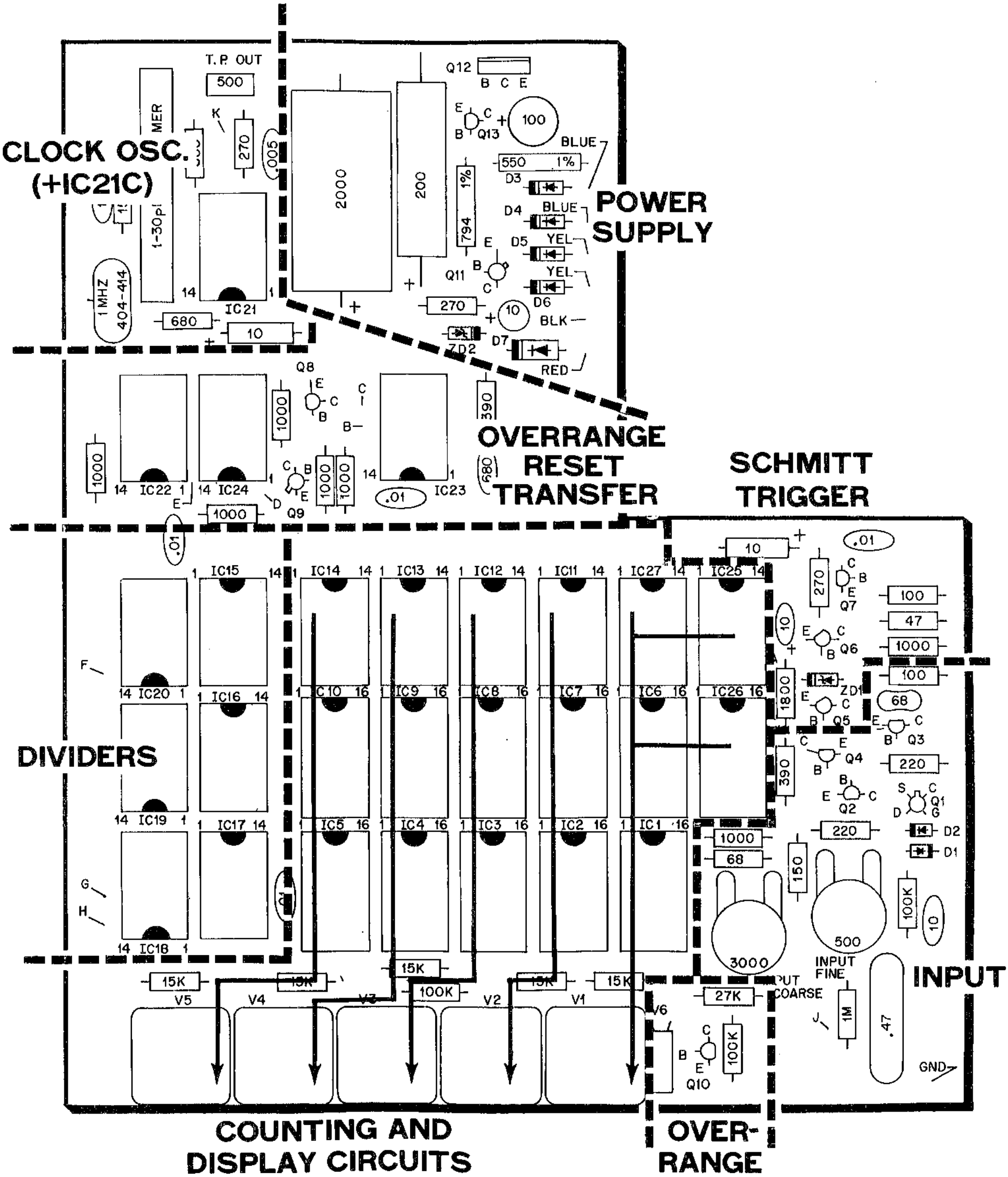
IC27

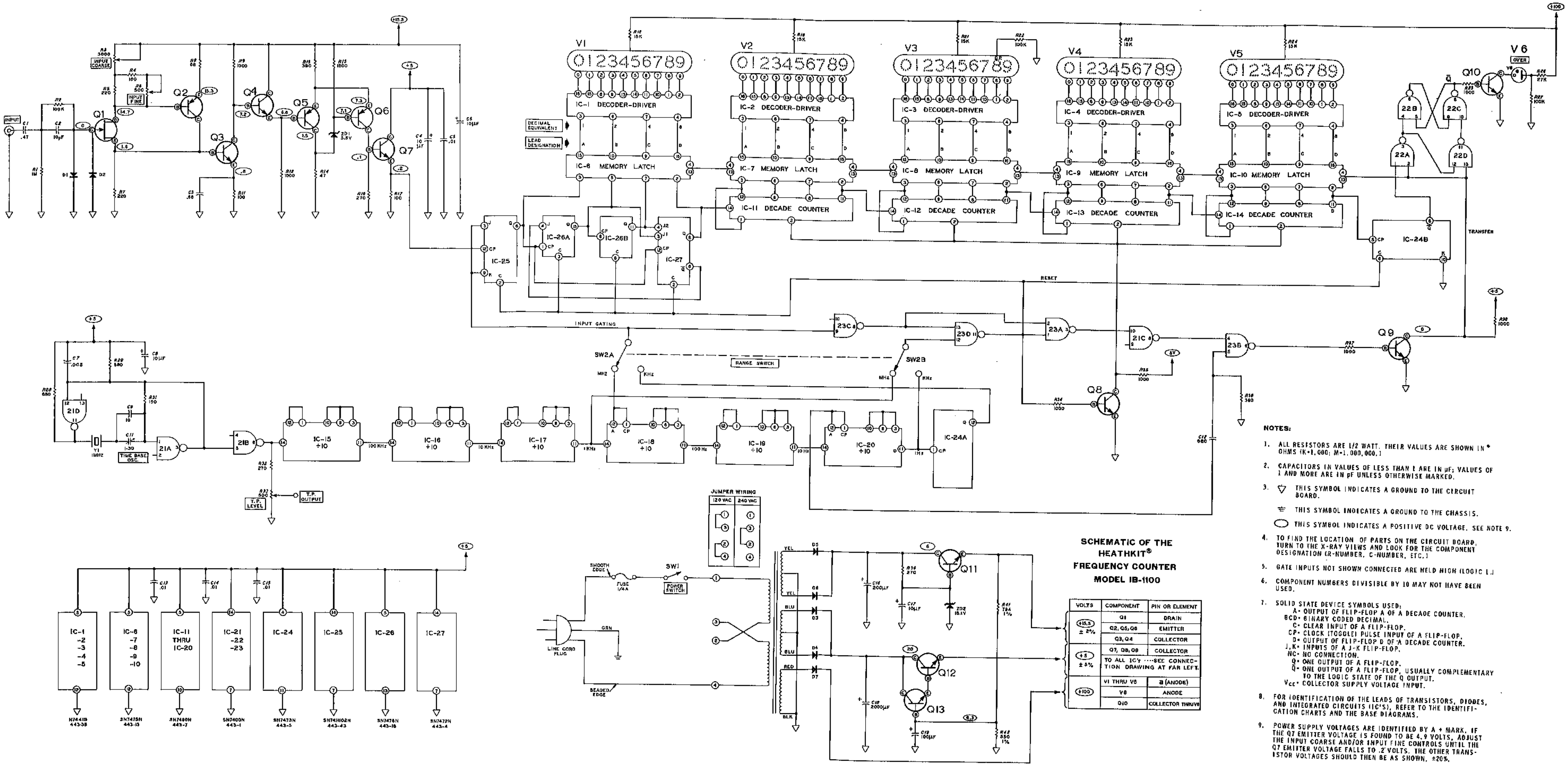


LOW INPUT TO PRESET SETS Q TO LOGICAL 1.
LOW INPUT TO CLEAR SETS Q TO LOGICAL 0.
PRESET AND CLEAR ARE INDEPENDENT OF CLOCK.

SN7472N J—K MASTER SLAVE FLIP—FLOP
#443—4

CIRCUIT BOARD FUNCTIONAL AREAS





SCHEMATIC OF THE HEATHKIT®
FREQUENCY COUNTER
MODEL IB-1100

VOLTS	COMPONENT	PIN OR ELEMENT
+15.5 ± 2%	Q1	DRAIN
	Q2, Q5, Q6	EMITTER
	Q3, Q4	COLLECTOR
+5 ± 5%	Q7, Q8, Q9	COLLECTOR
	TO ALL IC's ----SEE CONNECTION DRAWING AT FAR LEFT.	
+100	V1 THRU V5	a (ANODE)
	V6	ANODE
	Q10	COLLECTOR THRU V6

NOTES:

1. ALL RESISTORS ARE 1/2 WATT. THEIR VALUES ARE SHOWN IN OHMS (K=1,000; M=1,000,000.)
2. CAPACITORS IN VALUES OF LESS THAN 1 ARE IN μF; VALUES OF 1 AND MORE ARE IN pF UNLESS OTHERWISE MARKED.
3. ▽ THIS SYMBOL INDICATES A GROUND TO THE CIRCUIT BOARD.

   ⏚ THIS SYMBOL INDICATES A GROUND TO THE CHASSIS.

   ⬭ THIS SYMBOL INDICATES A POSITIVE DC VOLTAGE. SEE NOTE 9.
4. TO FIND THE LOCATION OF PARTS ON THE CIRCUIT BOARD, TURN TO THE X-RAY VIEWS AND LOOK FOR THE COMPONENT DESIGNATION (R-NUMBER, C-NUMBER, ETC.)
5. GATE INPUTS NOT SHOWN CONNECTED ARE HELD HIGH (LOGIC 1.)
6. COMPONENT NUMBERS DIVISIBLE BY 10 MAY NOT HAVE BEEN USED.
7. SOLID STATE DEVICE SYMBOLS USED:
   - A = OUTPUT OF FLIP-FLOP A OF A DECADE COUNTER.
   - BCD = BINARY CODED DECIMAL.
   - C = CLEAR INPUT OF A FLIP-FLOP.
   - CP = CLOCK (TOGGLE) PULSE INPUT OF A FLIP-FLOP.
   - D = OUTPUT OF FLIP-FLOP D OF A DECADE COUNTER.
   - J, K = INPUTS OF A J-K FLIP-FLOP.
   - NC = NO CONNECTION.
   - Q = ONE OUTPUT OF A FLIP-FLOP.
   - $\bar{Q}$ = ONE OUTPUT OF A FLIP-FLOP, USUALLY COMPLEMENTARY TO THE LOGIC STATE OF THE Q OUTPUT.
   - V_{cc} = COLLECTOR SUPPLY VOLTAGE INPUT.
8. FOR IDENTIFICATION OF THE LEADS OF TRANSISTORS, DIODES, AND INTEGRATED CIRCUITS (IC'S), REFER TO THE IDENTIFICATION CHARTS AND THE BASE DIAGRAMS.
9. POWER SUPPLY VOLTAGES ARE IDENTIFIED BY A + MARK. IF THE Q7 EMITTER VOLTAGE IS FOUND TO BE 4.9 VOLTS, ADJUST THE INPUT COARSE AND/OR INPUT FINE CONTROLS UNTIL THE Q7 EMITTER VOLTAGE FALLS TO .2 VOLTS. THE OTHER TRANSISTOR VOLTAGES SHOULD THEN BE AS SHOWN, ±20%.

HEATH
Schlumberger

HEATH COMPANY • BENTON HARBOR, MICHIGAN

THE WORLD'S FINEST ELECTRONIC EQUIPMENT IN KIT FORM

LITHO IN U.S.A.