FREQ.-COUNTER

SERIES
12630

HEATHKIT® MANUAL

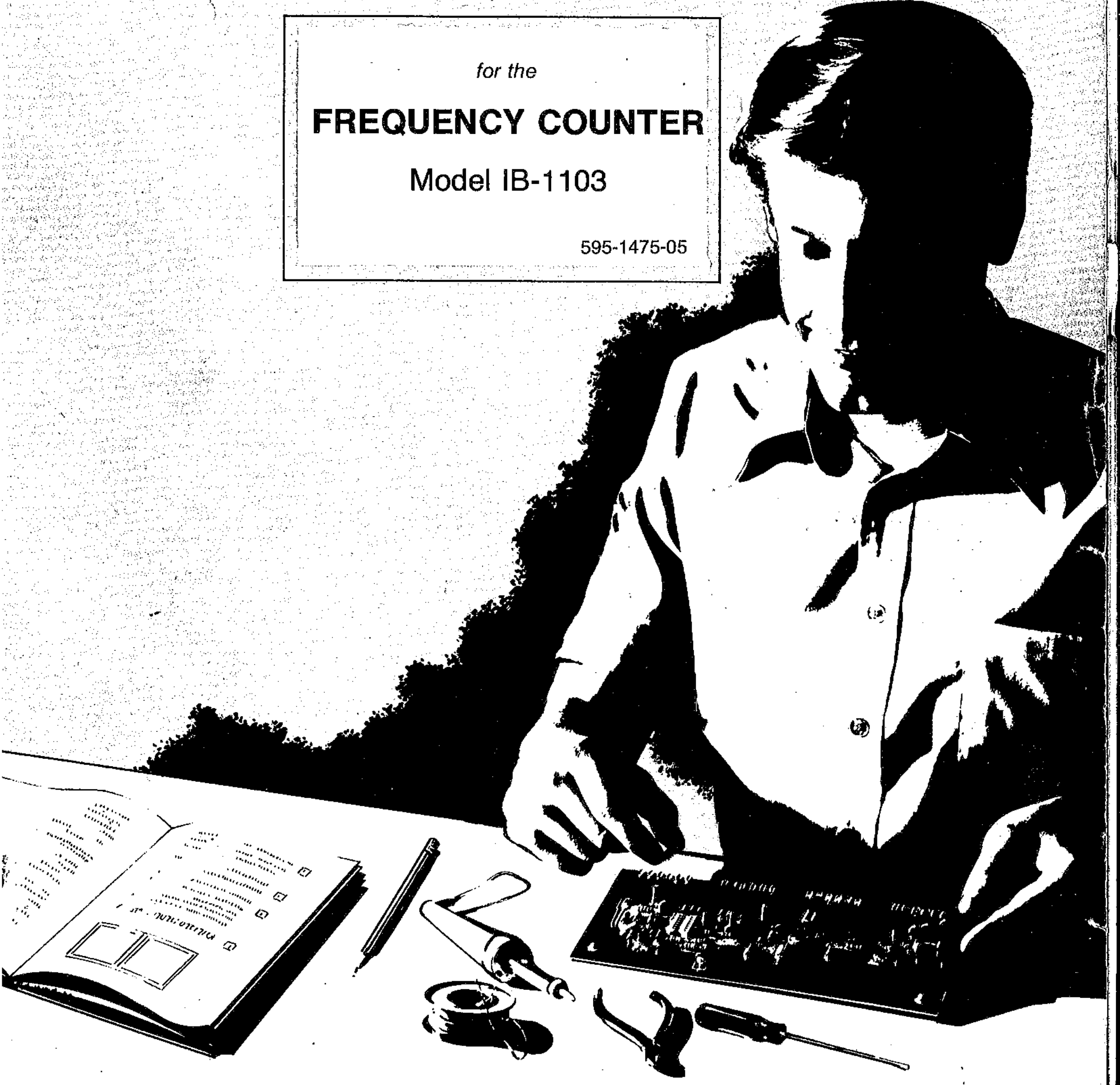
(IB-1103)

for the

FREQUENCY COUNTER

Model IB-1103

595-1475-05



HEATH COMPANY • BENTON HARBOR, MICHIGAN

Price $2.00

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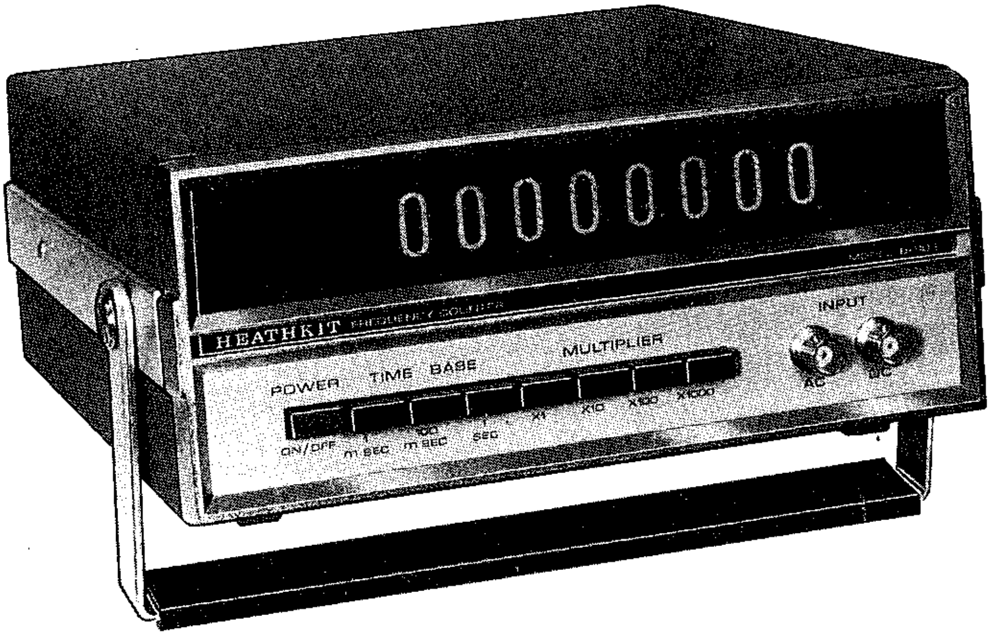

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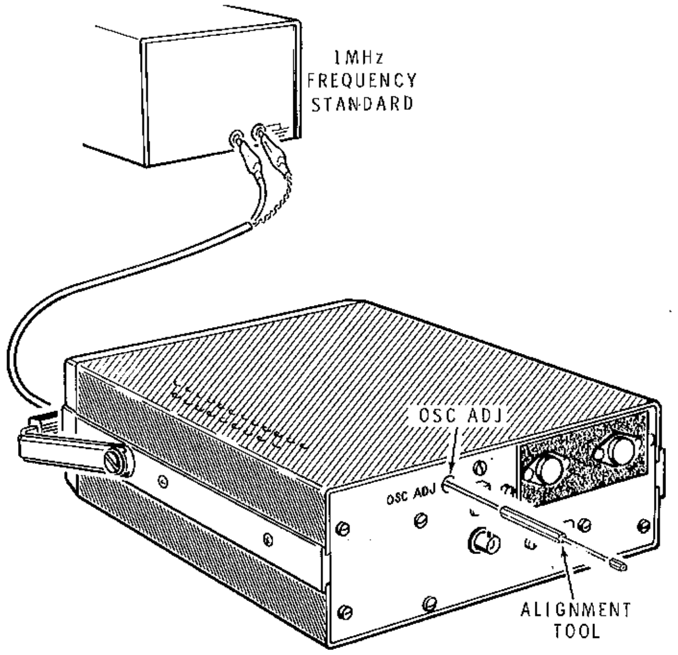


Figure 4

CALIBRATION

( ) With the cabinet shells installed, turn the Counter on and allow it to warm up for 30 minutes.

( ) Locate the alignment tool.

NOTE: If the rear panel on your Counter has a hole marked LEVEL ADJ, ignore this hole; it will not be used.

INPUT CIRCUIT

NOTE: The input circuit was calibrated during the "Initial Tests." If you wish to recalibrate the input circuit, remove the top cabinet shell and perform only the steps under "Input Calibration" on Page 76. Then replace the cabinet shell.

TCXO ADJUSTMENT

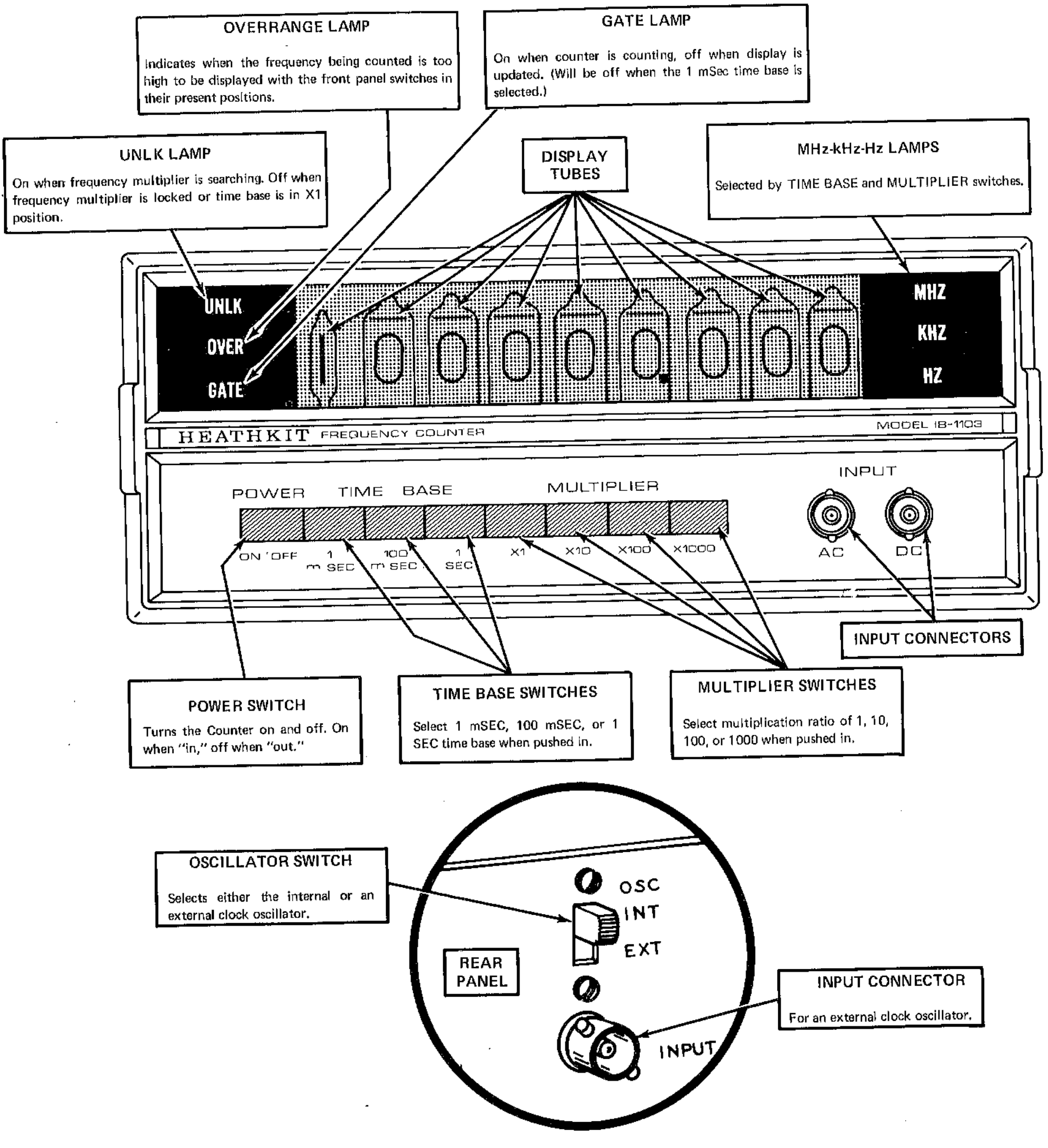
The TCXO (temperature compensated crystal oscillator) comes adjusted to the proper frequency within ±1 ppm. NOTE: Only perform the following steps if a frequency standard is available that has at least 10^{-8} accuracy.

( ) Refer to Figure 4 and connect a 1 MHz frequency signal to the input of the Counter.

( ) Adjust the OSC ADJ control of the TCXO, through the rear panel, until the readout of the frequency counter is exactly equal to the input frequency.

This completes the "Calibration."

NOTE: The IC's on the input circuit board will operate hotter than the IC's on the other circuit board. This is normal.



OVERRANGE LAMP

Indicates when the frequency being counted is too high to be displayed with the front panel switches in their present positions.

GATE LAMP

On when counter is counting, off when display is updated. (Will be off when the 1 mSec time base is selected.)

UNLK LAMP

On when frequency multiplier is searching. Off when frequency multiplier is locked or time base is in X1 position.

DISPLAY TUBES

MHz-kHz-Hz LAMPS

Selected by TIME BASE and MULTIPLIER switches.

INPUT CONNECTORS

POWER SWITCH

Turns the Counter on and off. On when "in," off when "out."

TIME BASE SWITCHES

Select 1 mSEC, 100 mSEC, or 1 SEC time base when pushed in.

MULTIPLIER SWITCHES

Select multiplication ratio of 1, 10, 100, or 1000 when pushed in.

OSCILLATOR SWITCH

Selects either the internal or an external clock oscillator.

INPUT CONNECTOR

For an external clock oscillator.

Figure 5

OPERATION AND APPLICATION

Refer to Figure 5 for a brief description of each control function.

DISPLAY UPDATING

When you use the one second time base, push the 1 SEC switch to the IN position and wait 3 seconds. Within 1.5 seconds a display will appear. However, this first display is inaccurate as it was probably counted in less than one counting period. The second display, which will appear 1.5 seconds after the first, will be counted over a full counting period and will therefore be accurate. The 3-second wait is not necessary in the other time bases, as the frequency display is updated sooner.

±1 COUNT

The clock of a digital counter is not synchronized with the incoming signal. That is, the 1-second standard in the Counter is started randomly with respect to the input signal. This makes it necessary to wait for 3 seconds when the TIME BASE switches are in the 1 sec position and causes a ±1 count error as shown in Figure 6. If the clock starts as clock A, the counter will count 10 pulses in that second. However, if the clock starts as clock B, the counter will count 11 pulses in that second. Hence, digital counters have an inherent error of ±1 in the least significant digit. The range does not matter. The right-hand digit is always ±1 count.

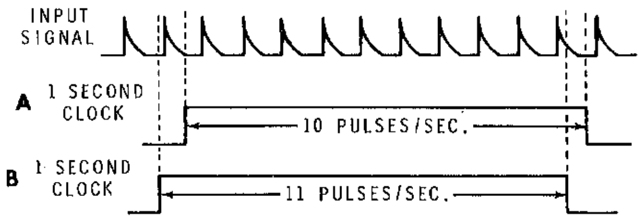


Figure 6

FREQUENCY MULTIPLIER

The frequency multiplier can be used to:

A. Increase the resolution of the Counter.

B. Quickly display low frequencies.

Increasing Counter Resolution

To increase the counter's resolution to 1/10 Hz, 1/100 Hz, or 1/1000 Hz, use the one second time base and the frequency multiplier. The readout stability is a function of the stability of the input signal –

1 Hz input drift X1000 = 1.000 Hz display drift

Example: Tune an organ.

Needed – a microphone with good sensitivity.

1. Hold the note long enough for the UNLK (unlock) lamp to turn off. When you tune the note, the multiplier will "track" the change and not unlock.
2. When you change notes, the multiplier will need to relock.

WARNING: When your line cord is connected to a 3-wire, polarized power line outlet, DO NOT use the common (negative) lead of this Counter when you measure power line frequency. This could short circuit the power line through the common lead, the chassis, and the green line cord wire.

Example: Monitor 60 Hz line frequency.

Needed – an isolation transformer.

1. Connect the test cable to the transformer and select the desired multiplication ratio.

Quick Display of Low Frequencies

To: A. Track an audio signal.

B. Adjust an audio generator in a minimum amount of time.

How: Use the frequency multiplier and a fast time base.

Example: Set an audio generator at 410.12 Hz.

1. Multiply the input signal by 1000 and use the 100 mSecond time base. Then adjust the generator to read 410 .12 Hz ±1 digit.
2. Switch to the 1 second time base and adjust the generator to read 410.120 Hz.

OPERATING RECOMMENDATIONS

1. Allow a warm-up time of 5 to 6 minutes before you do any accurate measurements.
2. Avoid overloading the input with signals that exceed the rated input capabilities. See the "Specifications" on Page 97.
3. Be sure the Counter is grounded, either through the line cord or a separate ground wire. At high frequencies, always ground the input cable as close to the signal source as possible.

WARNING: When your line cord is connected to a 3-wire, polarized power line outlet, DO NOT use the common (shield) lead of this Frequency Counter when you measure power line frequency. This could short circuit the power line through the common lead, the chassis, and the green line cord wire.

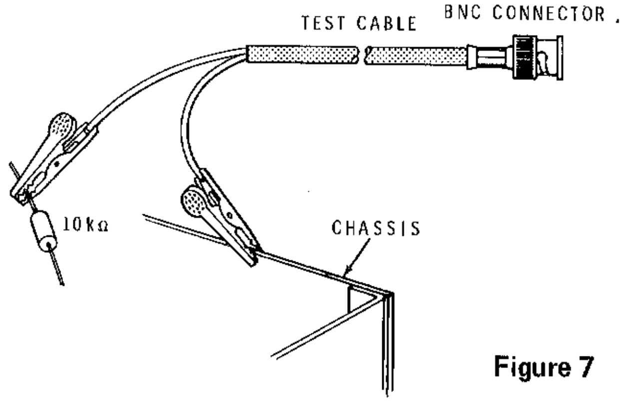


Figure 7

4. When you measure pulses of high amplitude and fast rise time (rise time $\geq$50 nanoseconds and amplitude $\geq$200 mV), put a 10 kΩ, 1/4-watt resistor in series with the test cable to eliminate any ringing in the test cable. See Figure 7.

Any cable will work with this Counter. Therefore, you can also use coaxial or other transmission line, terminated in its characteristic impedance, to eliminate serious reflections along the line which could otherwise damage the equipment under test. However, this will lower the impedance to the Counter, as the impedance will be the characteristic impedance of the transmission line.

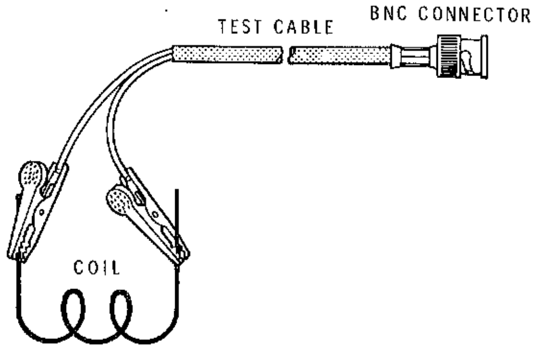


Figure 8

5. When you measure frequencies from a transmitter with a power greater than 1/2 watt, use a coupling coil in place of a direct connection. Three turns of a hook-up wire connected to the end of the test cable, as shown in Figure 8, will provide enough signal to trigger the counter. Place the coil just close enough to the signal source for the Counter to count. 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.
6. Do not use the 1 mSEC time base with the frequency multiplier because:
   - A. The short term stability of both the source and the Counter will cause a large change in the last digit or two.
   - B. There is no advantage to using the 1 mSEC time base over the 100 mSEC time base, since the hold-off time is so long compared to the count time.
   - C. The 1 SEC time base is the most accurate, since it averages out the short term instability.
7. Do not place the Counter on top of any heat generating device or test instrument, or the rated accuracy may be affected.

IN CASE OF DIFFICULTY

CONTENTS

Use the "Visual Tests" first to find a difficulty that shows up right after your kit is assembled. You can also use the "Troubleshooting Charts" right after your kit is assembled, or at some future time in case your Counter should ever begin to malfunction.

If the trouble is still not located after the "Visual Tests" are completed, and a voltmeter is available, check voltage readings against those shown on "Power Supply Check" (fold-out from Page 80). Read the "Precautions" on Page 88 before making any measurements. NOTE: All voltage readings were taken with a high input impedance voltmeter.

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.

NOTE: Refer to the "Circuit Board X-Ray Views" on Page 109 for the physical location of parts on the circuit boards.

VISUAL TESTS

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

2. About 90% of the kits that are returned to the Heath Company for repair do not function properly due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections to make sure that they are soldered as described in the "Soldering" section of the "Kit Builders Guide."

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

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

5. Check the values of the parts. Be sure in each step that the proper part has been wired into the circuit, as shown in the Pictorial diagrams. It would be easy, for example, to install a 680 Ω (blue-gray-brown) resistor where a 6800 Ω (blue-gray-red) resistor should have been installed.

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

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

TROUBLESHOOTING INFORMATION

PRECAUTIONS

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

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

EXTENDER CIRCUIT BOARD

If you troubleshoot either the input, time base, or frequency multiplier circuit boards, first install the extender circuit board as follows:

( ) Turn the Counter off.

( ) Remove the desired circuit board from the Counter, plug in the extender circuit board, and then plug the removed circuit board into the extender circuit board. See Figure 9.

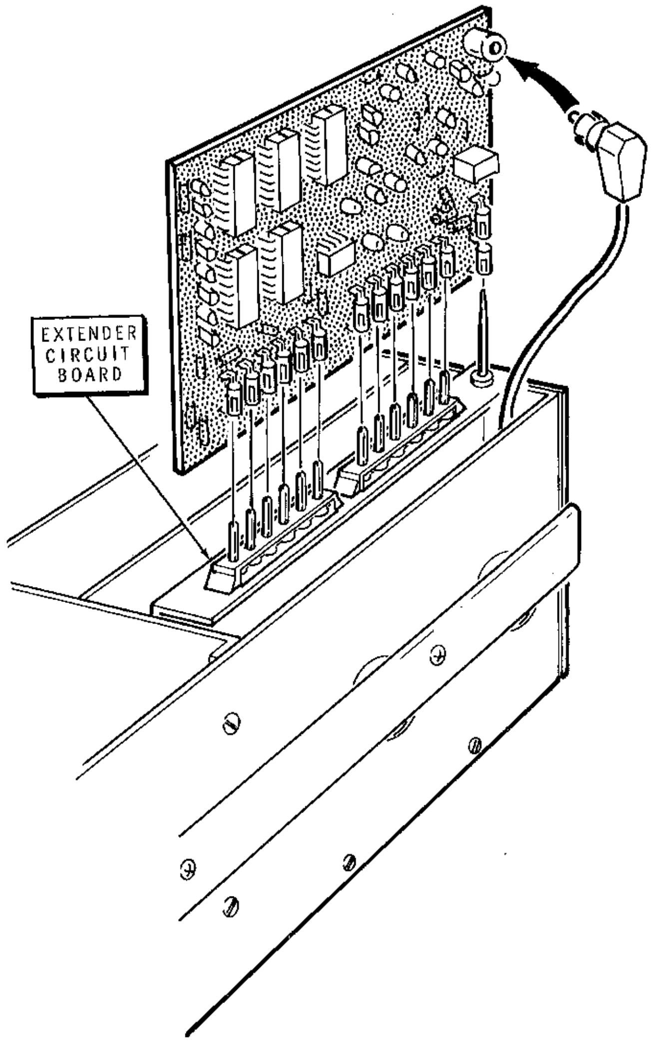


Figure 9

TROUBLESHOOTING CHARTS

GENERAL TROUBLESHOOTING

These Troubleshooting Charts include the "General Troubleshooting" chart below, and the "Frequency Multiplier" and "Time Base Charts" that follow. Refer to the "Sample Test Chart" information on Page 90 before you use the "Frequency Multiplier" or "Time Base Charts."

Check the "Condition" column of the following chart for the condition that fits your trouble. Then refer to the "Possible Cause" column and check the part or perform the indicated step.

NOTE: Interchange common types of IC's if you suspect one of being bad.

CONDITION	POSSIBLE CAUSE
Gate light does not flash in 1 mSEC time base.	1. This is normal.
Gate light does not flash (in 1 SEC or 100 mSEC time base), but all display tubes indicate zero. (The least significant digit tube may indicate zero or one.)	1. Time Base switches and their wiring. 2. Time base circuit board. Proceed to "Time Base Troubleshooting" on Page 94. 3. Input circuit board.
Gate light does not flash and all display tubes are not reset to zero except least significant digit tube.	1. Time base circuit board. Proceed to "Time Base Troubleshooting" on Page 94.
Gate light flashes, but all display tubes are not reset to zero (except least significant digit tube).	1. Transistor Q202 on time base circuit board. 2. Counter circuit board.
Gate light flashes and all display tubes are reset to zero except least significant digit tube. (Least significant digit tube OK if showing zero or one.)	1. Wiring between input circuit board and counter circuit board. 2. Input circuit board.
Counter counts; frequency multiplier is inoperative.	1. Frequency multiplier circuit board. Proceed to "Frequency Multiplier Troubleshooting" on Page 91. 2. Input circuit board.
All numbers in a display tube are turned on all at once, either continuously or intermittently.	1. Associated decoder/driver IC. 2. Short circuit on counter circuit board or at tube socket.
All numbers in all display tubes light.	1. 5-volt supply.
Cannot stop random count as described on Page 76, "Input Calibration."	1. Test cable is connected to Input. 2. Input circuit board. 3. Capacitor C1 defective.
IC's on input circuit board are hot to the touch.	1. This is normal.

SAMPLE TEST CHART

Learn how to use the following "Troubleshooting Charts," by referring to the Sample Test Chart below and reading through the following paragraphs. Do not actually perform the steps. The numbered paragraphs below are keyed to the circled numbers on the chart.

① Turn the Counter Off or On, as instructed here, with the On-Off switch. WARNING: Always turn the Counter Off when you remove or install IC's. When you remove or install any other component, always unplug the line cord, as line voltage is present at a number of points in the chassis as shown by the boxed-in areas in the "Chassis Photographs" on Page 107.

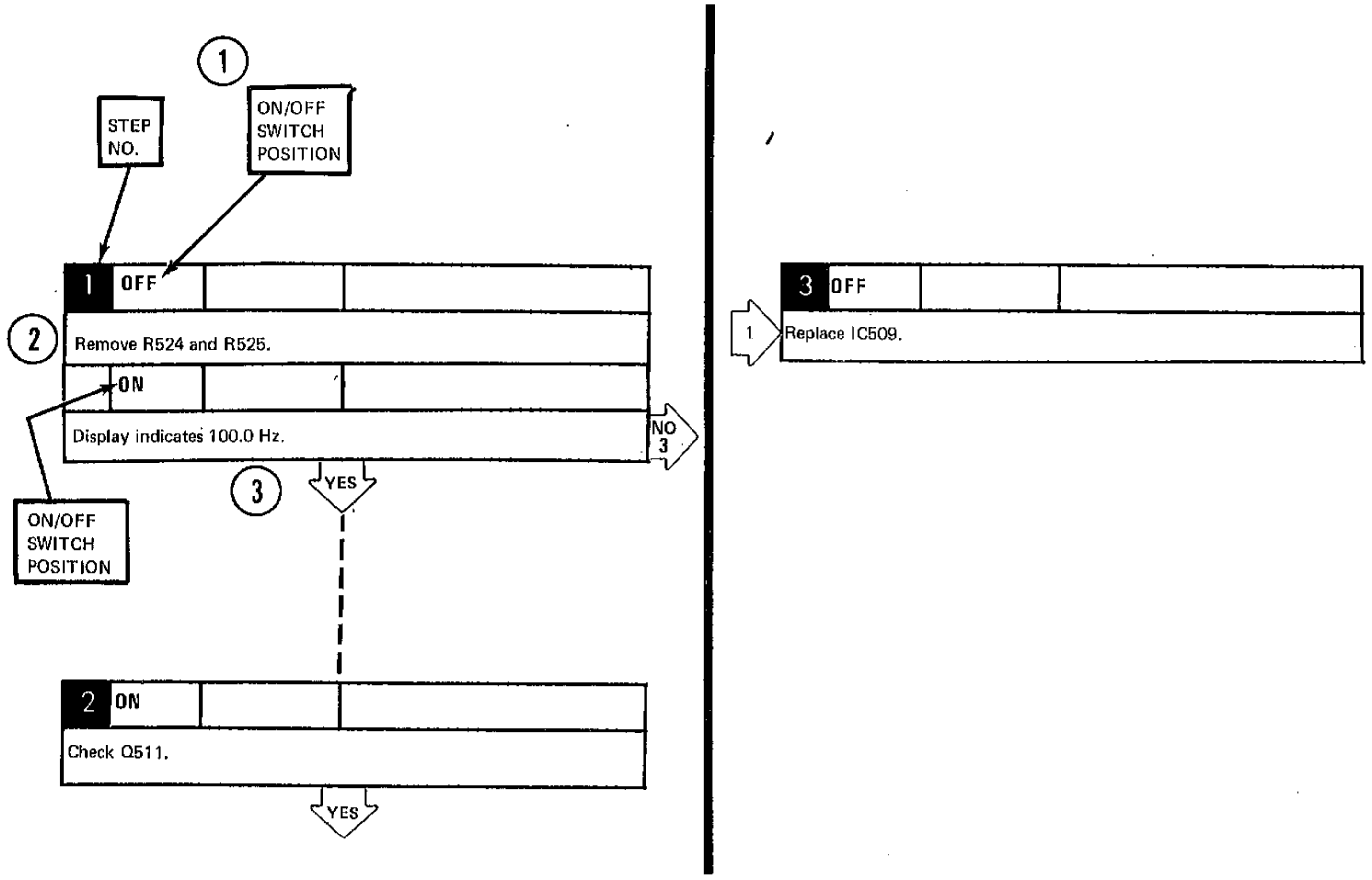
② Follow the instructions given here before you perform the test.

③ This is the test result.

As a step is performed, you will get a YES or NO result (or other instruction), which steers you to the next step. These steps will quickly bring you to a point where you are instructed to check a particular component. Check the component for proper installation. Replace the component if it is faulty.

After a repair has been made, check the Counter for proper operation, or follow the instructions in the step on the Chart where the fault first showed up. If the kit still does not perform properly, return to the beginning of the Chart and begin the tests again. Possibly there is more than one problem that must be corrected.

Do Not Use This Sample Test Chart for Any Tests



FREQUENCY MULTIPLIER TROUBLESHOOTING

( ) See the "Sample Test Chart" on Page 90 before proceeding.

( ) Apply a 100 Hz input signal to the input of the Counter.

( ) Position the front and rear panel switches as follows:

FRONT PANEL		REAR PANEL	
On/Off	IN	OSC	INT
1 SEC	IN		
X10	IN		

( ) Check the power supply voltages at J5. See "Power Supply Check" on the fold-out from Page 80.

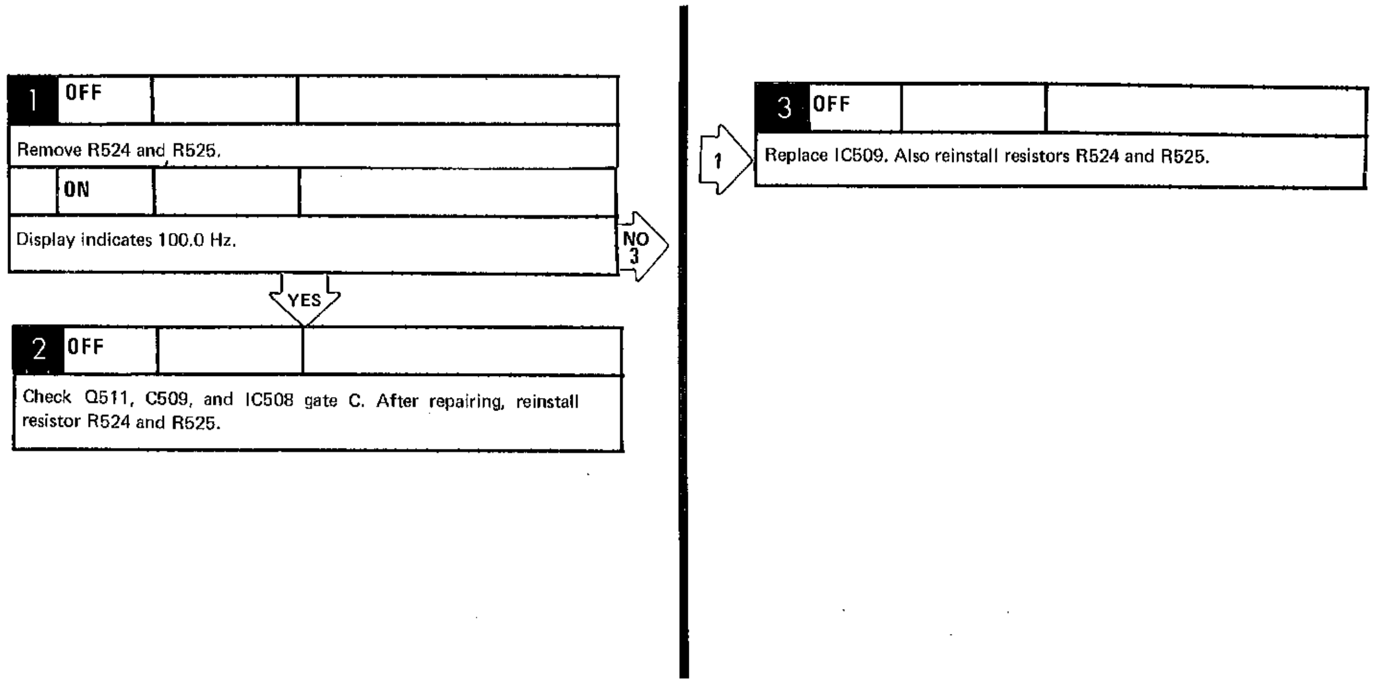
( ) Turn off the Counter and disconnect the input signal.

( ) Turn the Counter on and watch the UNLK lamp.

( ) Reconnect the 100 Hz input signal and watch the UNLK lamp.

( ) If the UNLK lamp is off but was on when there was no input signal, proceed to "Frequency Multiplier Chart #1." If the UNLK lamp is on and does not turn off, proceed to "Frequency Multiplier Chart #2."

Frequency Multiplier Chart #1



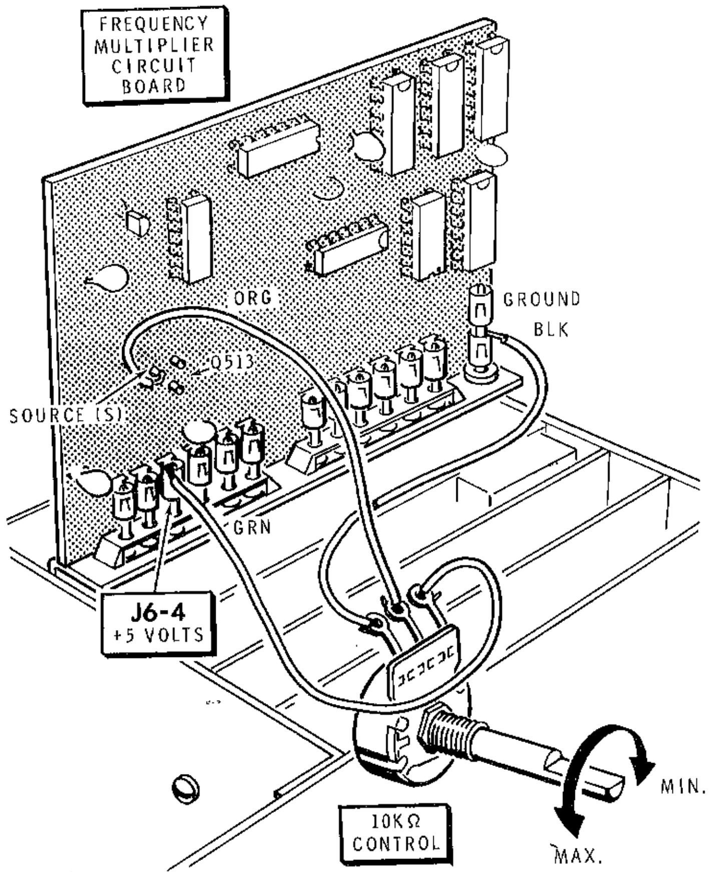


Figure 10

Frequency Multiplier Chart #2

1 OFF

Remove IC509. Connect wire from connector 2 to connector 6 as shown at top of next column.

ON

Counter displays unstable frequency.

NO 9

YES

2 OFF

Remove Q513. Connect 10 kΩ control (#10-308, supplied with your kit) between +5 volts and ground with center lug to source(s) of Q513 as shown in Figure 10.

ON

Vary control from minimum to maximum. Counter should display unstable frequencies from 100 Hz to 10 MHz.

NO 12

YES

3 OFF

Remove control and replace Q513.

4 OFF

Remove IC508. Connect wires from connectors 7 to 11 and 3 to 14.

ON

Measure voltage at collector of Q509. Should be approximately 7 volts.

NO 13

YES

5 OFF

Connect wires from connectors 7 to 3 and 11 to 14 at IC508.

ON

Measure voltage at collector of Q509. Should drift down to 1 volt or less.

NO 16

YES

6 OFF

Remove wires and replace IC508.

7 OFF

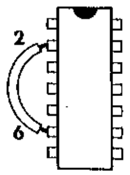
Remove IC503. Connect wire from connector 11 to connector 5 at IC503.

ON

Measure voltages at pins 13 and 2 of IC507. Both pins should be about +3 volts.

NO 17

YES



IC 509

8 ON

Measure voltages at pins 3 and 11 of IC508. If one is high and one is low, replace IC508. If both are low, check IC502, IC506, IC503, IC509, and transistors Q501 and Q502. Then remove wires and reinstall IC503.

1

9 OFF

Remove Q513, Q506, and Q505. Connect a VTVM to connector 2 at IC501.

ON

With a wire, short out capacitor C506 several times. VTVM should indicate 4 volts; then 3 volts as you short out the capacitor.

NO 11

YES

10 OFF

Replace Q505 or Q506. Then reinstall Q513.

9

11 OFF

Replace IC501 or Q504. Then reinstall Q513.

2

12 OFF

Replace ZD503, Q503, or Q504. Then remove the control and replace IC509.

4

13 ON

Measure voltage at collector of Q508. Should be ≤0.5 volt.

NO 15

YES

14 OFF

Replace Q510 or ZD601. Then remove wires and replace IC508.

13

15 OFF

Replace Q508. Then remove wires and replace IC508.

5

16 OFF

Replace Q509. Then remove wires and reinstall IC508.

7

17 OFF

Replace IC507. Then remove wires and reinstall IC503.

TIME BASE TROUBLESHOOTING

( ) Position the front and rear panel switches as follows:

FRONT PANEL

On/Off	IN
1 SEC	IN
X1	IN

REAR PANEL

OSC	INT

( ) Check the power supply voltages at J4-6. See "Power Supply Check" (fold-out from Page 80).

CONDITION	POSSIBLE CAUSE
Gate lamp does not flicker.	1. Check the Gate lamp and Q201. If OK, go to "Time Base Chart #2."
Gate lamp flashes, but at a rate different from the following: ON – 1 second OFF – 0.5 second	1. Proceed to "Time Base Chart #1."
Gate lamp flashes, but readout is locked.	1. Replace IC209.
Gate lamp flashes, but readout is reset to zero.	1. Input circuit board.
Gate lamp flashes, but readout is an attenuated count.	1. IC209.
Gate lamp flashes, but readout is an increasing up-count.	1. IC209.

Time Base Chart #1

(See the "Sample Test Chart" on Page 90 before proceeding.)

1 OFF

With VTVM, check voltage at pin 12 of IC210.

ON

If high* for 1 sec and low for 1.5 sec, replace IC207. If high for 1 sec and low for 1 sec, check IC210, IC208, R205 and C202.

Time Base Chart #2

(See the "Sample Test Chart" on Page 90 before proceeding.)

1 OFF

With VTVM, check voltage at pin 12 of IC210.

ON

If high,* go to step 5. If low, go to step 2.

2 OFF

Check voltage at pin 9 of IC210.

ON

If high,* go to step 6. If low, go to step 3.

3 OFF

Check voltage at pin 8 of IC208.

ON

If high,* go to step 7. If low, go to step 4.

*NOTE: High ≃ 3V, low ≃ 0.4V.

4 OFF

Check voltages at pins 11 and 12 of IC's 201, 202, 203, 204, 205, and 206.

ON

If all high, check IC211 and TCXO. If some are high and some are low, replace the decade with the low. If all low, replace IC208.

5 OFF

Check IC210. If OK, replace IC204.

6 OFF

Check IC209, IC207, IC211, and TCXO.

7 OFF

Check IC208, R205, and C202.

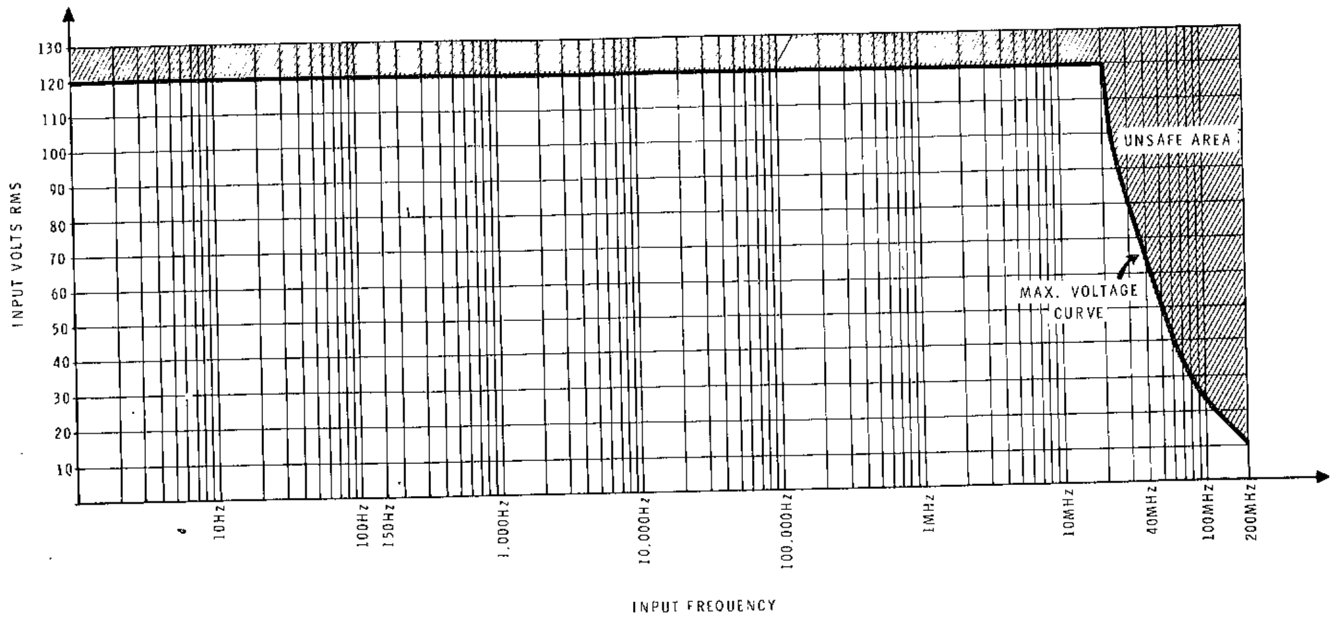
SPECIFICATIONS

FREQUENCY MEASUREMENTS

Range	1 Hz to 180 MHz.
Gate Time	1 millisecond, 100 milliseconds, or 1 second.
Accuracy	±1 count ± time base stability.
Readout	MHz, kHz, or Hz with positioned decimal point.

SIGNAL INPUT

Maximum Sensitivity	50 mV maximum, 25 mV typical, to 120 MHz. 100 mV to 180 MHz.
Coupling	AC and DC. (Two separate inputs.)
Impedance	1 MΩ in parallel with 35 pF.
Trigger Level	Automatic.



Overload	Diode-protected input circuit. See graph above.

TIME BASE

Crystal Frequency	4 MHz TCXO (Temperature Compensated Crystal Oscillator).
Stability	
Aging Rate	±1 ppm/year.
Short Term	Better than 0.5 ppm in 1 second.
Temperature	±1 ppm between 15°C to 40°C.
Line Voltage	0.5 ppm with ±10% voltage change.
Frequency Trimming	Accuracy: ±1 ppm. Range: ±10 ppm.
Sample Rate	≈ 500 milliseconds. (Time between two openings of counting gate.)

FREQUENCY MULTIPLIER

Ranges Versus Input Frequency	X1:	No multiplier used (1 Hz – 180 MHz).
	X10:	100 Hz to 300 kHz.
	X100:	10 Hz to 100 kHz.
	X1000:	10 Hz to 10 kHz.

Accuracy	X10:	±1 count ± time base accuracy.
	X100:	±1 count ± time base accuracy.
	X1000:	At <500 Hz, ±1 count ± time base stability. At>500 Hz, ±2 counts ± time base stability.
To Remain Locked		Frequency rate of change must not exceed 10 Hz.
Lock Time After Step Frequency Change	X10 and X100:	5 seconds for frequencies <500 Hz; 3 seconds for frequencies >500 Hz.
	X1000:	1.5 seconds for frequencies <500 Hz; 1 second for frequencies >500 Hz.
Lock Indicator		Front panel lamp; "Off" – locked, "On" – unlocked.

EXTERNAL TIME BASE INPUT

Frequency	1 MHz with stability $>10^{-7}$.
Input Impedance	1000 Ω.
Maximum Input	3 volts rms.

GENERAL

Display	8-1/2 digits plus overrange, gate, MHz, kHz, Hz and unlocked lamps.
Operating Temperature Range	Operating 10°C to 40°C.
Power Requirements	110-130 or 220-260 VAC, 50/60 Hz. 40 watts when not using frequency multiplier. 45 watts when using frequency multiplier.
Connectors	Three BNC's. Input (AC and DC) on front panel; external clock on rear panel.
Cabinet Dimensions	8-5/8" wide x 3-5/8" high x 9-1/4" deep.
Net Weight	9 lbs.

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

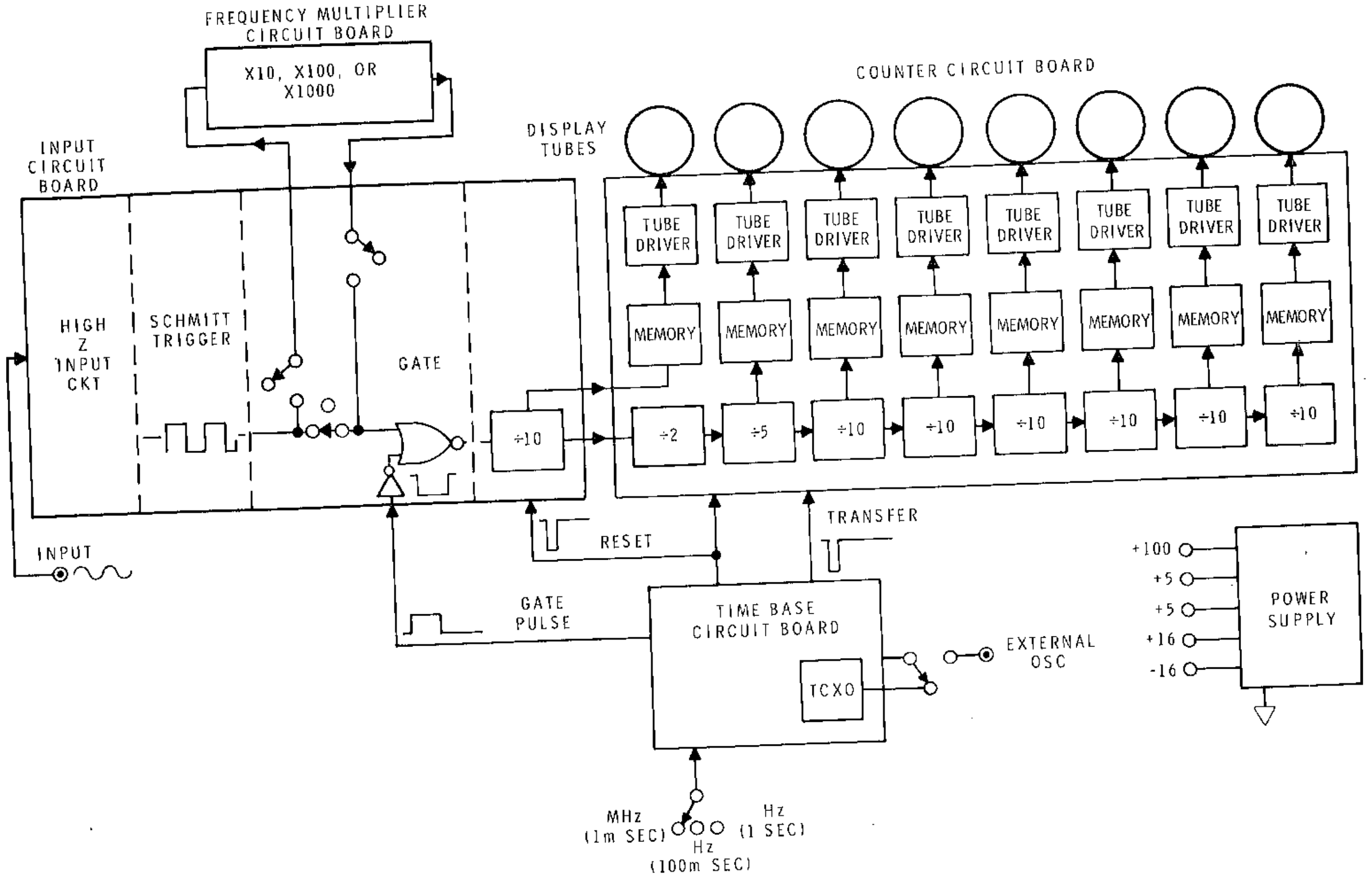
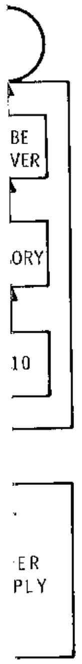


Figure 11
BLOCK DIAGRAM



CIRCUIT DESCRIPTION

Refer to the Schematic Diagram (fold-out from Page 125) and the Block Diagram (fold-out from Page 100) while you read this "Circuit Description."

The following "Theory of Operation" contains a general description of the circuits. The remaining sections describe each circuit in detail.

THEORY OF OPERATION

The signal to be counted is applied through the input connector and cable to the input circuit board. There it is "squared" by the Schmitt trigger and applied to the GATE or the frequency multiplier (depending on the positions of the front panel switches). If the signal goes to the frequency multiplier, it is multiplied by 10, 100, or 1000 before it is applied to the GATE.

During the time the pulse from the time base circuit board (GATE pulse) is present at the GATE, the GATE is open and the frequency is counted by the following decade counters. After the GATE is closed, at the end of the GATE pulse, the "count" in the decade counters is transferred to the memories by the transfer pulse. At this time, the tube drivers turn on the proper cathodes of the display tubes and the frequency is displayed. The reset pulse then clears the decade counters to be ready for the next time the GATE is open.

The duration of the GATE pulse is determined by the positions of the Time Base switches. The pulse is of one second duration in the 1 SEC position, 100 milliseconds in the 100 mSEC position, and of one millisecond duration in the 1 mSEC position.

INPUT CIRCUIT BOARD

The input signal is applied to impedance converter circuit transistors Q401 and Q402. This circuit has a high input impedance, a low output impedance, and a stage gain of less than one. The signal is then applied to the current amplifier, Q403. Q403 has a very low output impedance and, therefore, can drive the input capacitance of the following stage and maintain a very good bandwidth.

Differential amplifier transistors Q405 and Q406 further amplify the signal and then apply it to current amplifiers Q407 and Q408. Transistor Q404 serves as a constant current source for the differential amplifier.

Current amplifiers Q407 and Q408 have a relatively high input impedance and therefore do not load the differential amplifier. Q407 and Q408 also provide the low driving impedance necessary for the next stage; Q409, Q410, Q411, and Q412.

Transistors Q409, Q410, Q411, and Q412 make up a differential cascode amplifier. Transistors Q409 and Q410 provide current gain, and transistors Q411 and Q412 provide voltage gain. Control R418 adjusts the current through the differential cascode stage. By adjusting the current, the voltages at the collectors of transistors Q411 and Q412 are adjusted. When this voltage is changed, it changes the voltage on the emitters of transistors Q413 and Q414, and consequently the quiescent level at the inputs to the Schmitt trigger. Transistors Q413 and Q414 are current amplifiers and provide isolation between the amplifiers and the Schmitt trigger (IC402, FFA). The output from FFA of IC402 is at ECL (emitter coupled logic) levels with proper rise and fall times necessary to drive the following stages.

IC401 is an operational amplifier that senses the average voltages at the inputs to the Schmitt trigger. It then adjusts the bias on transistor Q406 to equalize the inputs to the Schmitt trigger.

The TTL (transistor transistor logic) GATE pulse from the time base circuit board is changed to ECL levels by resistors R434 and R435. Section C of IC403 and FFB of IC402 improve the rise and fall times and invert the GATE pulse. The inverted GATE pulse goes to the gated multiplexer and turns it on and off at the proper times.

There are two outputs from the Schmitt trigger (IC402). The Q output goes to Section A of IC403, which serves as a line driver to the frequency multiplier. The Q output of IC402, FFA, goes to Section A of IC404. If the multiplier circuit is activated, the multiplied output from IC509B comes into Section B of IC404. Section C of IC404 enables either Section A or Section B of IC404, depending on the status of the multiplexer control input (pin 9). The outputs of Sections A and B of IC404 of the gated multiplexer go to the first decade counter. The outputs of the first decade counter are then applied to differential level translators, which convert the ECL levels to TTL levels, to drive the following logic on the counter circuit board.

COUNTER CIRCUIT BOARD

The A, B, C, and D line signals, which represent 1-2-4-8 BCD (binary coded decimal), from the input circuit board are connected to IC102, a buffer/storage unit. During the transfer pulse from the time base circuit board, which is amplified by transistor Q101, the 1-2-4-8 information is stored in IC102. Then decoder/driver IC103 decodes the 1-2-4-8 into decimal and grounds the proper cathode of display tube V1. The cathode then glows and displays a number.

During the counting time, the signal to pin 2 of IC102 is also used as the carry and drives the next decade counter, IC101 and IC104. IC101 divides by two and IC104 is connected to divide by five. The following counters then each divide the carry signals they receive by 10. The buffer/storage, decoder/driver, and display tubes function as previously described. During the reset pulse, all the decade counters are returned to 0. The selected decimal point in the display tube is connected through the switching system to ground.

The last carry pulse is applied to the clock input of FFA of IC125, as shown in Figure 12. The flip-flop changes state and the Q output is applied to the clock input of FFB of IC125 and the D input of FFA of IC126. When the transfer pulse arrives at this clock input, the Q output goes high and turns on Q104 and the "I" lamp. However, if the input frequency is so high that another carry pulse arrives before the transfer pulse, the Q output of FFA of IC125 will go low and the Q output of FFB of IC125 will go high. In this condition, when the transfer pulse arrives only the "Over" lamp will be turned on. Then the reset pulse triggers Q102, and IC125 is cleared for the next count. The reset pulse also clears IC101.

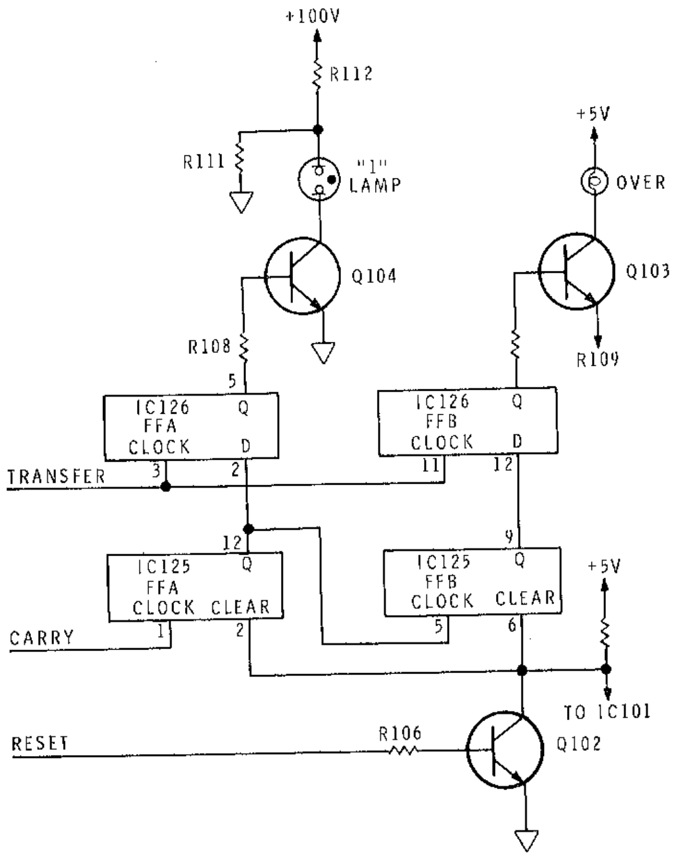


Figure 12

TIME BASE CIRCUIT BOARD

The 4 MHz clock signal is divided by 4 and applied to the INT–EXT switch on the rear panel. The selected clock signal is then divided by either one thousand, one hundred thousand, or one million by the following decade counters. If the division is by one million, the multiplexer (a digitally-programmable switch), IC207, is in the position shown. If the division is by one thousand or one hundred thousand, time base switches are in one of the other positions and decade counters IC201, IC202, and possibly IC203 are out of the circuit.

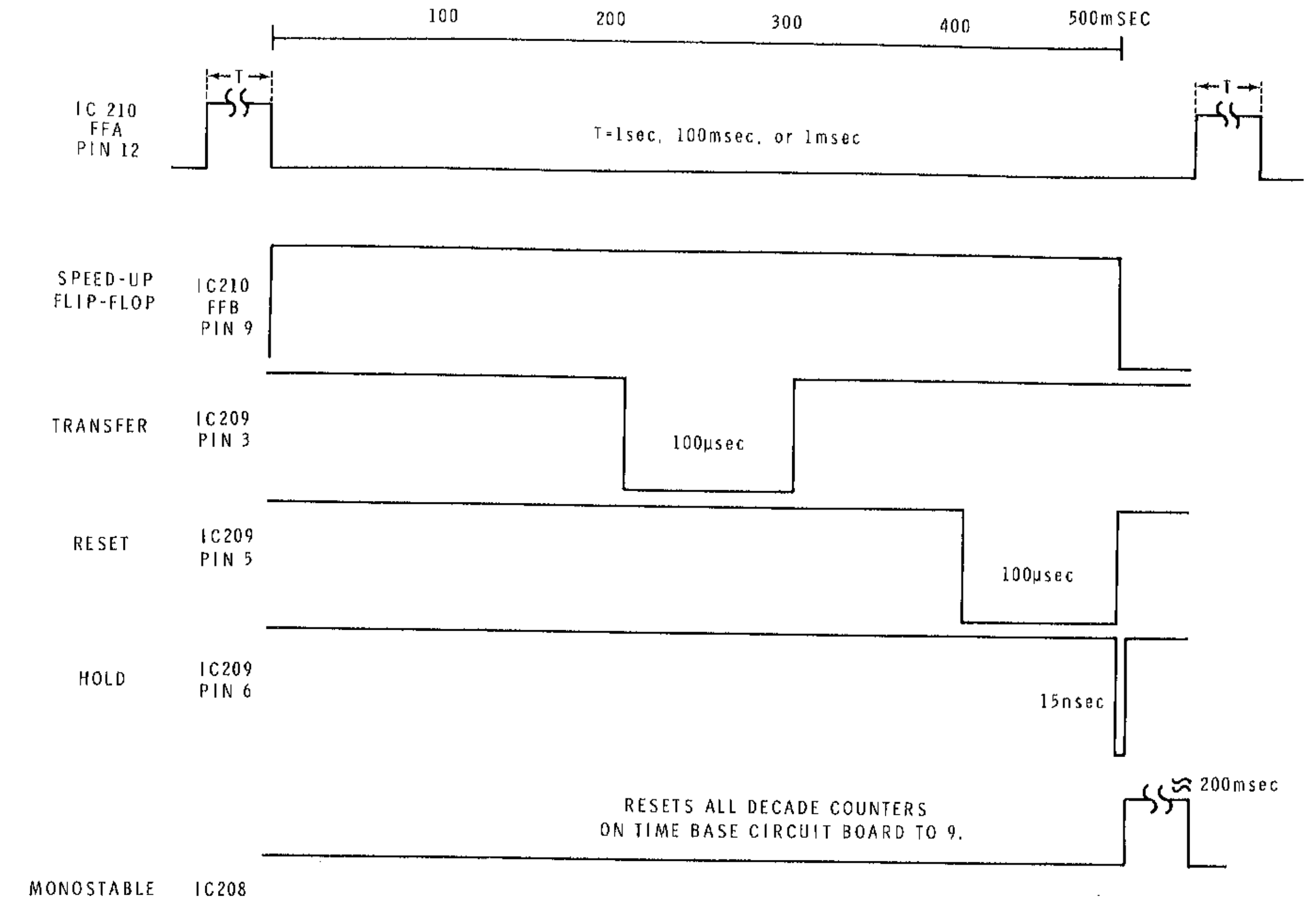


Figure 13

Consider the multiplexer to be in the 1 kHz position as shown in the Schematic. The D output from IC204 is then 1 Hz. FFA of IC210 then further divides this signal to produce a one-second pulse as shown in Figure 13. As the one-second pulse is completed, the trailing edge of the pulse triggers FFB of IC210, the speed-up flip-flop. The output of FFB reprograms the multiplexer (at input C) to the 1 MHz position and decade counters IC206 through IC204 divide the signal. Because the GATE pulse is now low, the decoder (IC209) is uninhibited and starts decoding its A, B, and C input lines. The result is first, a transfer pulse from pin 3; second, a reset pulse from pin 5; and third, a pulse from pin 6 that clears the speed-up flip-flop. As the speed-up flip-flop clears, the multiplexer is switched back to its original position and the monostable multivibrator (IC208) is started. This monostable sets the six decade counters to 9. At the end of the monostable pulse, the first pulse from the clock starts the one-second GATE pulse again.

Decoder

The decoder, IC209, requires a negative pulse at its D (pin 12) input before it will decode. Therefore, it is inhibited during the one second positive GATE pulse.

Multiplexer

The strobe input (pin 7) is always at ground. Because it is not used in switching, it will be ignored in the following description of an equivalent circuit.

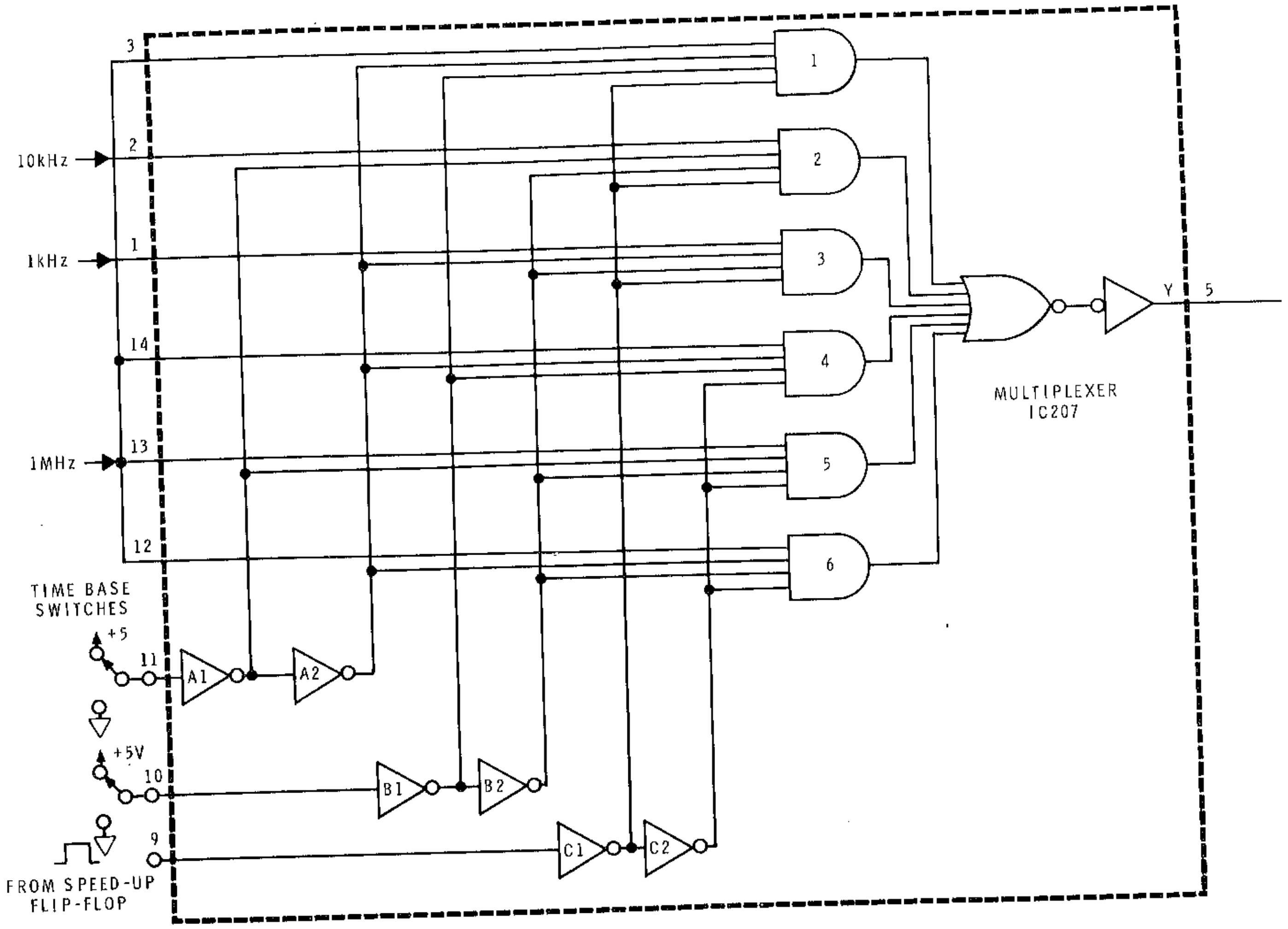


Figure 14

In the one-second time base, as shown in Figure 14, and with no input pulse from the speed-up flip-flop, the outputs from inverters A2, B2, and C1 are high and turn on AND gate 3. The 1 kHz signal is then coupled through the following gates to the output until the pulse arrives from the speed-up flip-flop. Then gate 3 is turned off and gate 6 is turned on for the time of the pulse. The 1 MHz signal is then coupled through.

When the time base is in the 1 mSEC position, the switch at pin 11 is grounded, gate 2 is turned on, and the 10 kHz signal is coupled to the output. Then when the speed-up pulse arrives, gate 2 turns off, gate 5 turns on, and 1 MHz is coupled through to the output.

When the time base switch is in the 1 mSEC position, the switch at pin 10 is grounded, gate 1 is turned on, and the 1 MHz signal is coupled to the output. Then when the speed-up pulse arrives, gate 1 turns off and gate 4 turns on. In this case, the signal coupled to the output is still the 1 MHz signal.

External Oscillator Input

An external 1 MHz signal, when connected to connector J11, is coupled through capacitor C201 to Schmitt trigger IC212. The resultant TTL square wave is then coupled through switch SW9 and controls the time base circuits as previously explained.

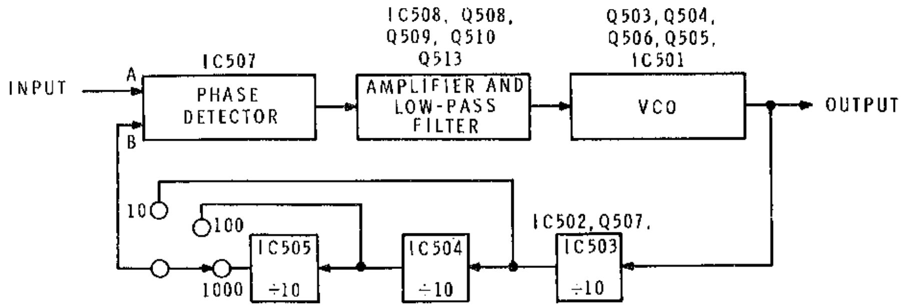


Figure 15

FREQUENCY MULTIPLIER CIRCUIT BOARD

As shown in Figure 15, the frequency multiplier basically consists of a phase detector, an amplifier and low-pass filter, a VCO (voltage controlled oscillator), and three decade counters to divide by 10, 100, or 1000.

The phase detector detects any difference in phase and frequency between the two signals at inputs A and B. The resulting frequencies are then amplified and filtered to drive the VCO until the input signals to the phase detector are in phase and are the same frequency. The VCO frequency is divided by 10, 100, or 1000 and applied to input B of the phase detector. Therefore, when the inputs to the phase detector are in phase and are the same frequency, the output from the VCO's frequency is exactly 10, 100, or 1000 times higher than the input frequency, and the phase detector is "locked." When the detector is not locked, the unlocked lamp is turned on and the output gate from the frequency multiplier is open so the erroneous frequency is not counted.

The output signal from gate A of IC509 is changed from ECL to TTL by transistors Q501 and Q502, and is applied to phase detector IC507. If the signal at pin 3 of the detector is higher in frequency than the signal at pin 1, the output signal at pin 13 will be high more of the time than the output signal at pin 2. Gate B of IC508 will turn off transistor Q508, which will turn off transistor Q510. Gate A will also turn on transistor Q509 and try to discharge capacitor C503. Since Q509 is on more of the time than Q510, capacitor C503 will discharge. This will cause the VCO to increase in frequency until the phase detector (IC507) locks

If the frequency at pin 3 is lower than pin 1, then the output at pin 2 is high more of the time than the output at pin 13. Therefore, transistor Q510 will be on more than transistor Q509 and capacitor C503, will charge. This causes the VCO frequency to decrease until the phase detector (IC507) locks.

When the inputs to the phase detector are in phase and at the same frequency, the detector outputs will both be locked high. The following gates and transistors will be turned off and the charge on capacitor C503 will remain constant and will continue to drive the VCO.

Transistor Q513 is connected as a source follower, has a very high input impedance, and controls transistor Q503 of the VCO.

Capacitor C506 charges through transistor Q503 and zener diode ZD503 to produce a ramp. Transistor Q504 isolates the capacitor from the following Schmitt trigger, IC501. V_{BB} is a voltage reference for comparator gates B and C of IC501. As the ramp reaches a certain positive value, the output of gate C of IC501 is driven to ground and drives the inverted output of gate B (pin 1) high and the noninverted output (pin 2) low. This turns on transistors Q505 and Q506 and discharges capacitor C506. Then the Schmitt trigger resets and another ramp begins.

Because of the narrow pulses produced, an ECL flip-flop (IC502) is used to divide the frequency by two. Transistor Q507 changes the flip-flop output to TTL levels to drive the following decade counters. IC503 is connected to divide by five while the remaining two counters each divide by ten. IC506, the multiplexer, switches to the desired division ratio and applies the signal to the phase detector. (For a description of a multiplexer, see "Multiplexer" in the "Time Base Circuit Board" description.)

When the phase detector is unlocked, the detector's output pulses are combined in gate D of IC508. These pulses turn transistor Q512 on and off, which turns the UNLK (unlocked) lamp on and off. The lamp, however, appears to be steadily on. Also, the pulses from gate D of IC508 are inverted by gate C. However, they do not turn on transistor Q511 because of the RC time of resistor R526 and capacitor C509. Therefore, the 5-volt source, which is coupled through resistor R524, holds gate B of IC509 closed.

When the phase detector locks, the output of gate D goes low. This turns off transistor Q512 and the UNLK lamp, and drives the output of gate C of IC508 high. Transistor Q511 then turns on and presents a low to gate B of IC509 and opens the gate so the VCO frequency can be counted by the following circuitry.

POWER SUPPLY CIRCUIT BOARD

Dual-primary transformer T1 can be wired to operate from either 120 VAC or 240 VAC. Three secondary output windings furnish the AC voltage for the +100-volt, +16-volt, −16-volt, and +5-volt power supplies.

+100-Volt Power Supply

Capacitor C301 couples the voltage to the half-wave rectifier, diode D306. The resulting +100 volts rms is used to light the display tubes on the counter circuit board.

+16 and −16-Volt Power Supply

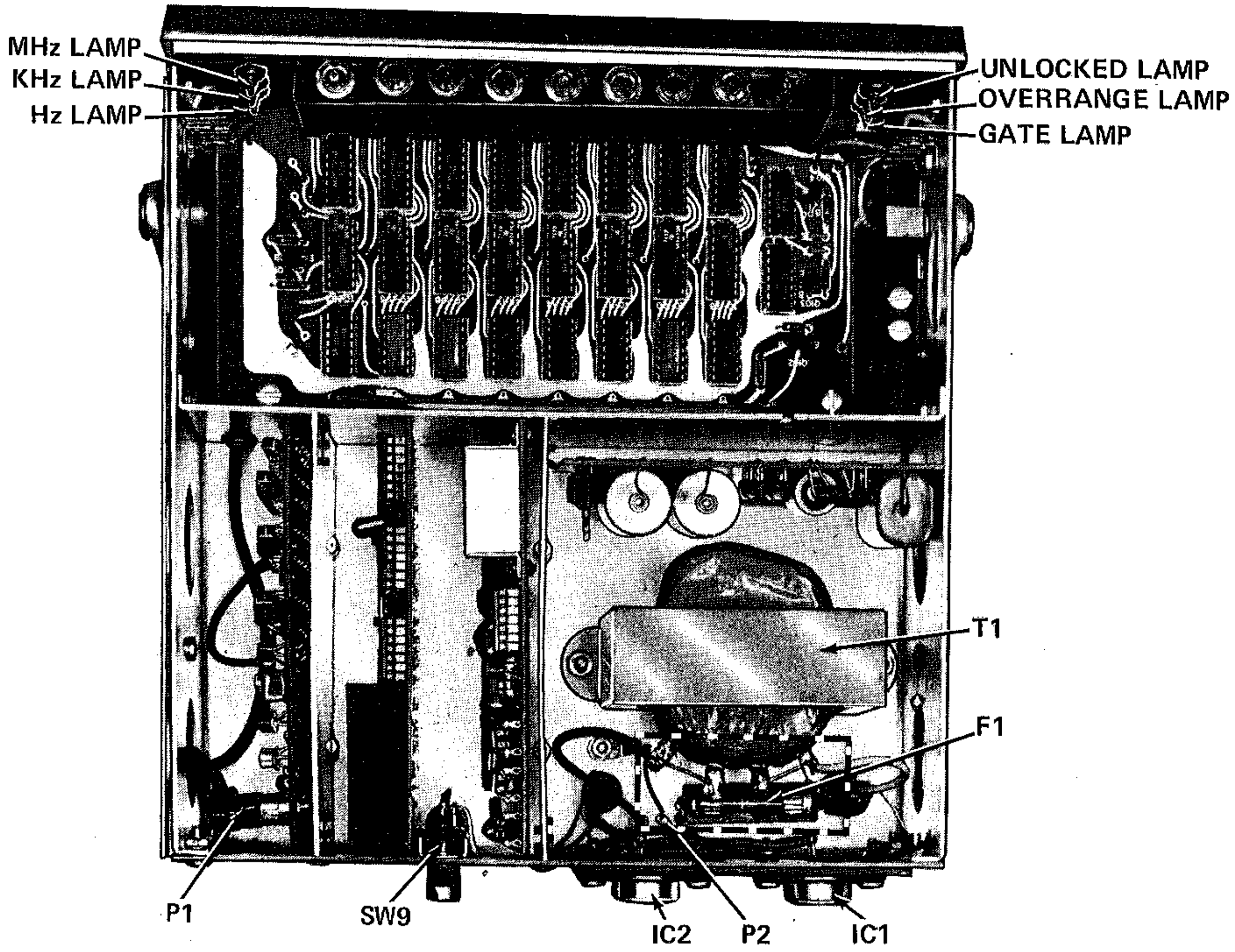
Diodes D302 through D305 form a full-wave bridge rectifier. Zener diode ZD302 establishes the minus supply at -16 volts, and zener diode ZD301 establishes the positive supply at +16 volts. Capacitor C302 filters the AC and transistors Q301 and Q302 provide current limiting. Transistor Q302 senses the voltage drop across R302. If the load is increased above a safe limit, the voltage across R302 increases to a point where it begins to forward bias the base-emitter junction of Q302. Transistor Q302 then begins to conduct and lowers the base-emitter voltage on Q301 and starts to turn off Q301. This then shuts down the +16 volt output to a safe amount of current.

+5-Volt Power Supply

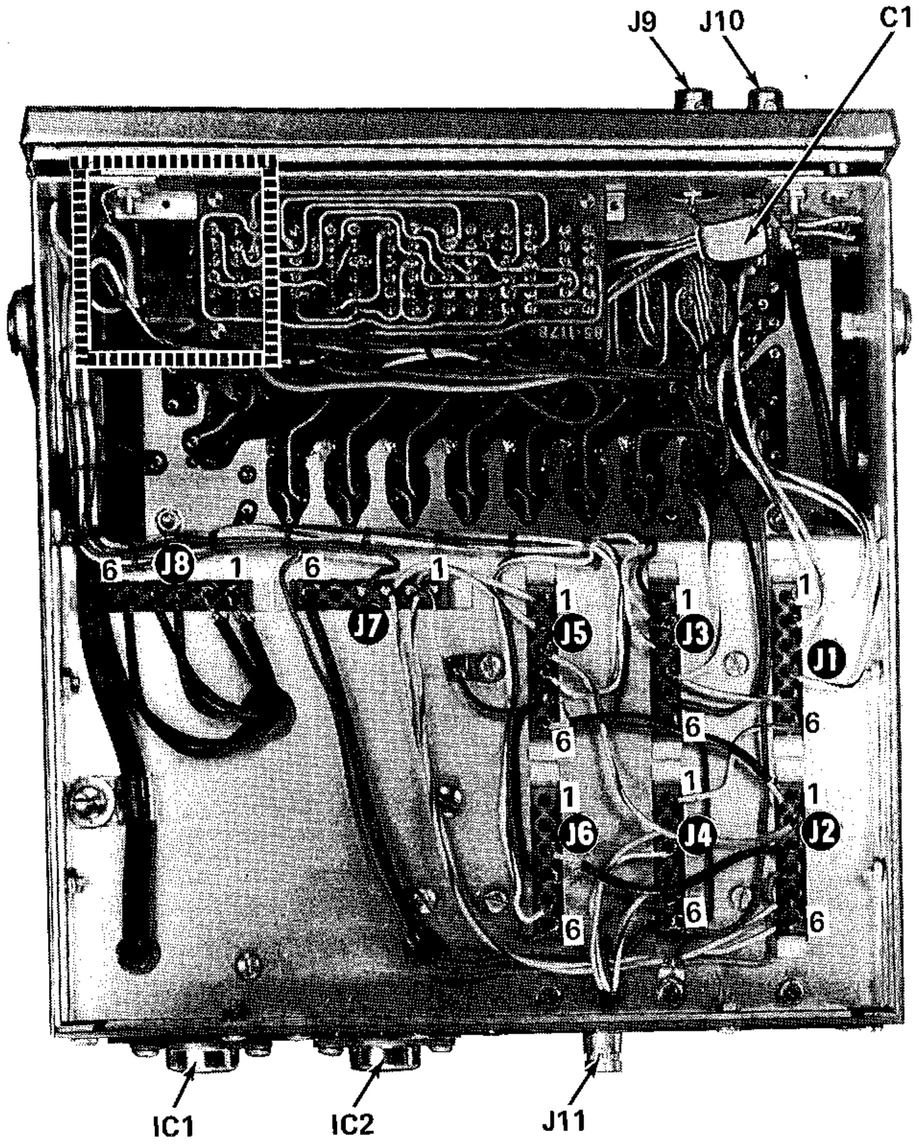
Diodes D307 and D310 form a full-wave bridge rectifier. Capacitors C303 and C304 filter the pulsating DC, and IC's IC1 and IC2 are integrated circuits that regulate the DC, making two +5-volt regulated power supplies.

CHASSIS PHOTOGRAPHS

WARNING: Boxed-in areas indicate hazardous voltage locations.



WARNING: Boxed-in areas indicate hazardous voltage locations.

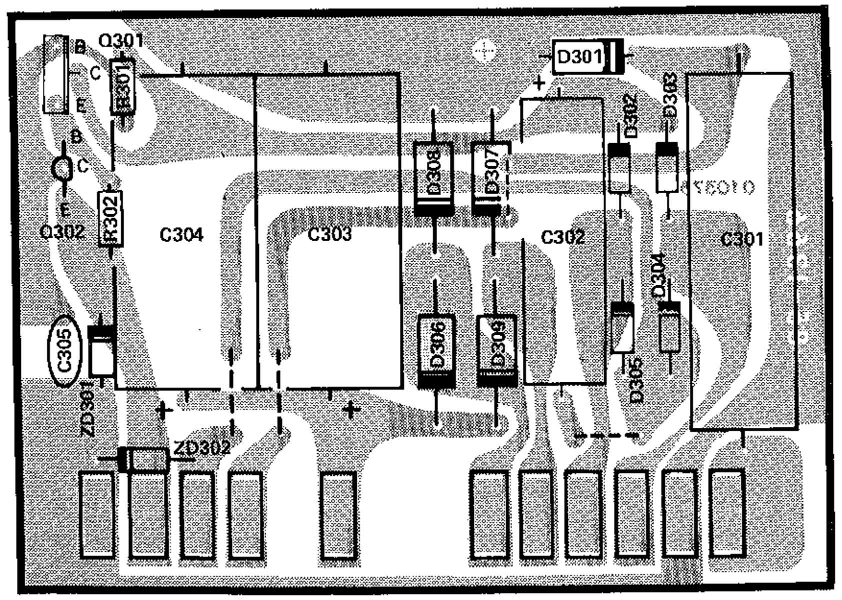


CIRCUIT BOARD X-RAY VIEWS

NOTE: To identify a part shown in one of these Views, so you can order a replacement, proceed as follows:

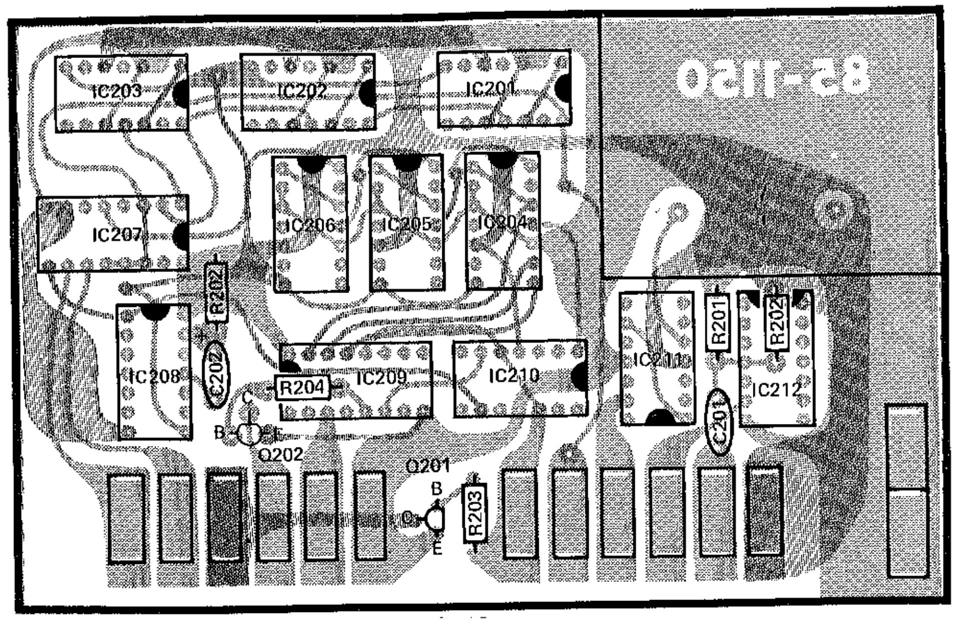
1. Note the identification number of the part (R-number, C-number, etc.).
2. Locate the same identification number (next to the part) on the Schematic. The "Description" of the part (for example – 22 kΩ, .05 μF, or 2N2712) will also appear near the part.
3. Lock up the Description in the Parts List.

POWER SUPPLY CIRCUIT BOARD

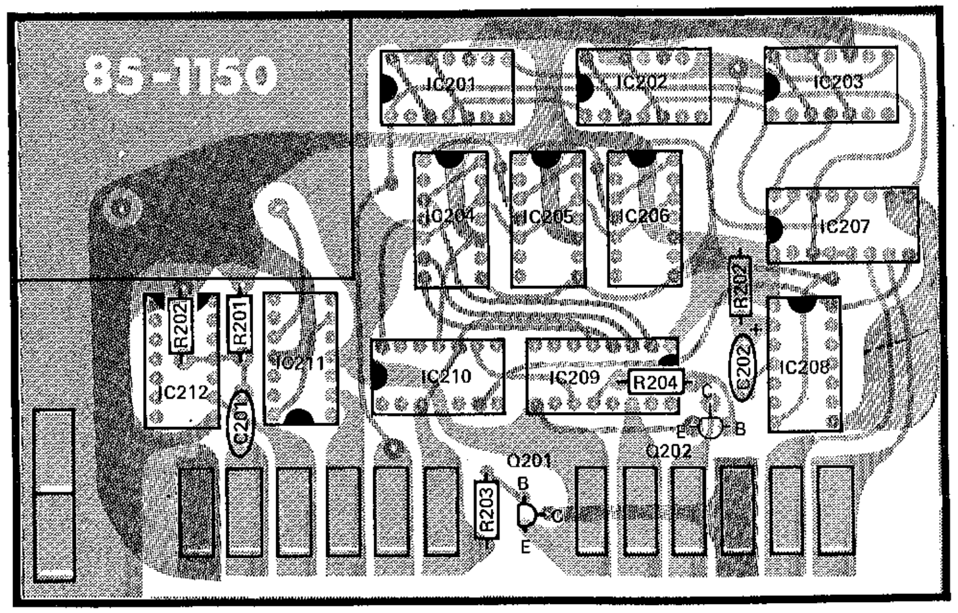


(COMPONENT SIDE VIEW)

TIME BASE CIRCUIT BOARD

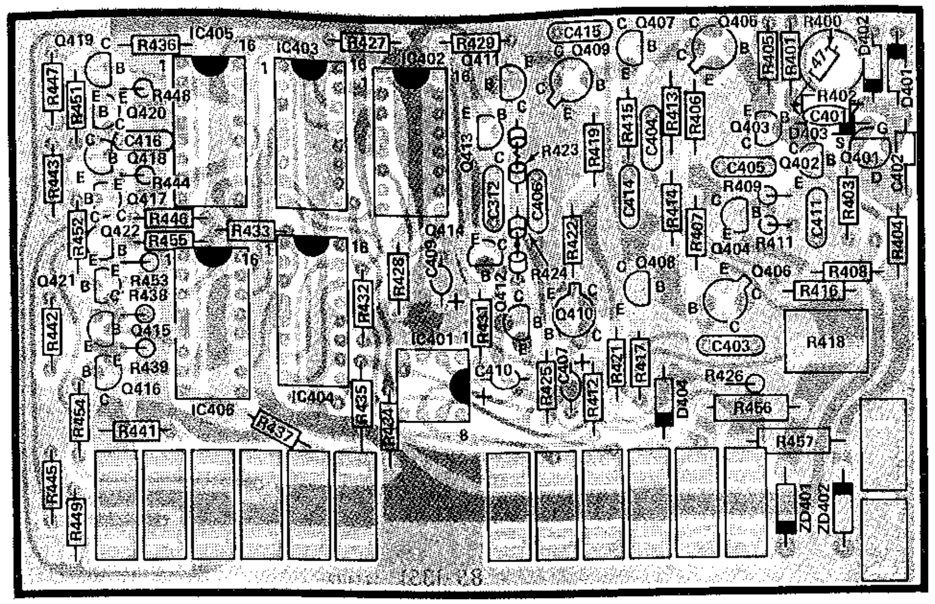


COMPONENT SIDE VIEW
(Component side foil in red)

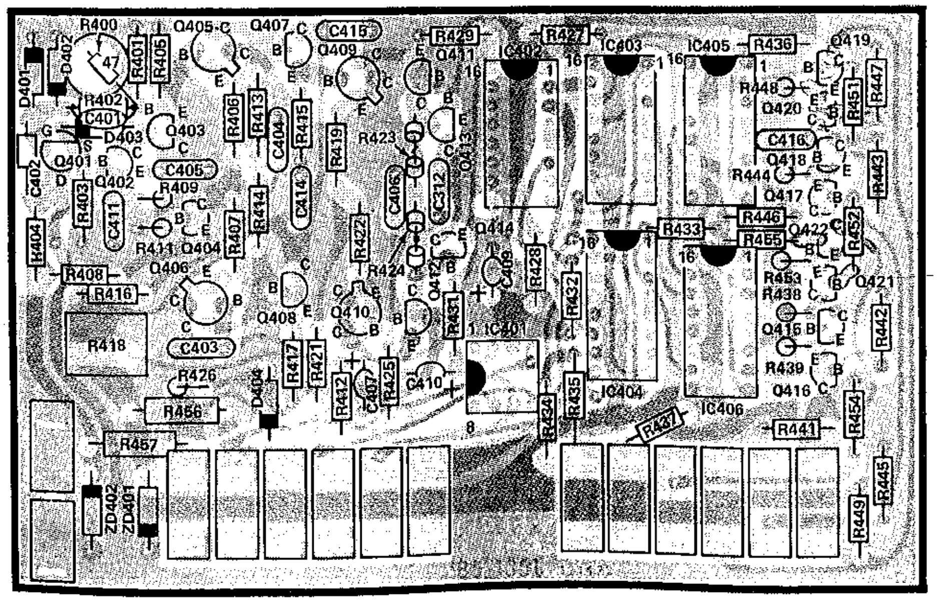


FOIL SIDE VIEW
(Component side foil in red)

INPUT CIRCUIT BOARD

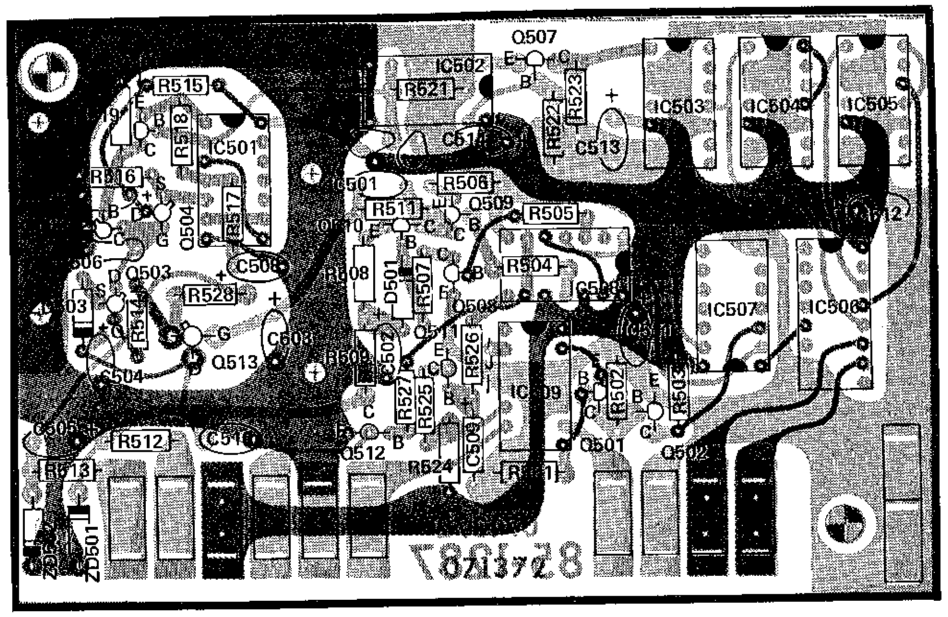


COMPONENT SIDE VIEW
(Component side foil in red)

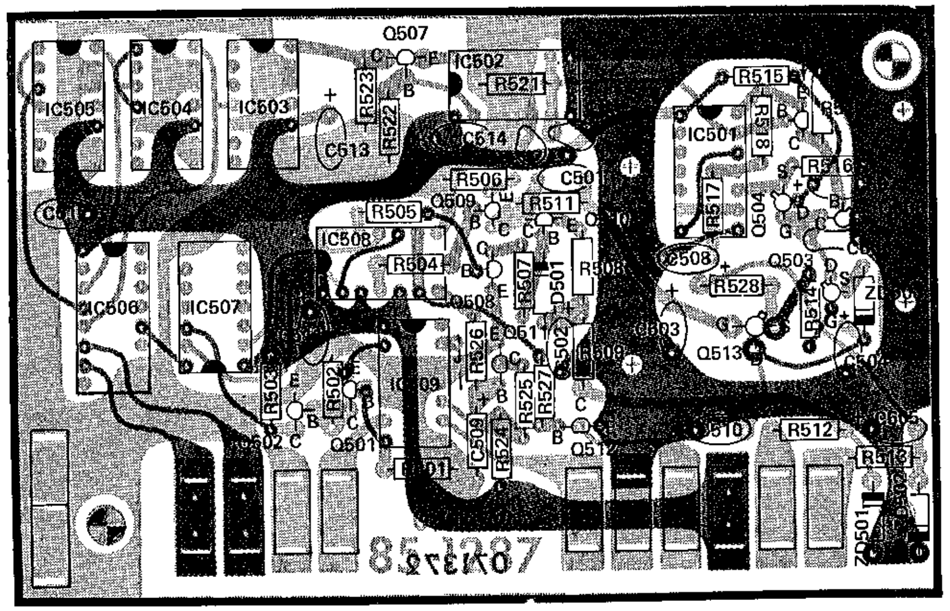


FOIL SIDE VIEW
(Component side foil in red)

FREQUENCY MULTIPLIER CIRCUIT BOARD

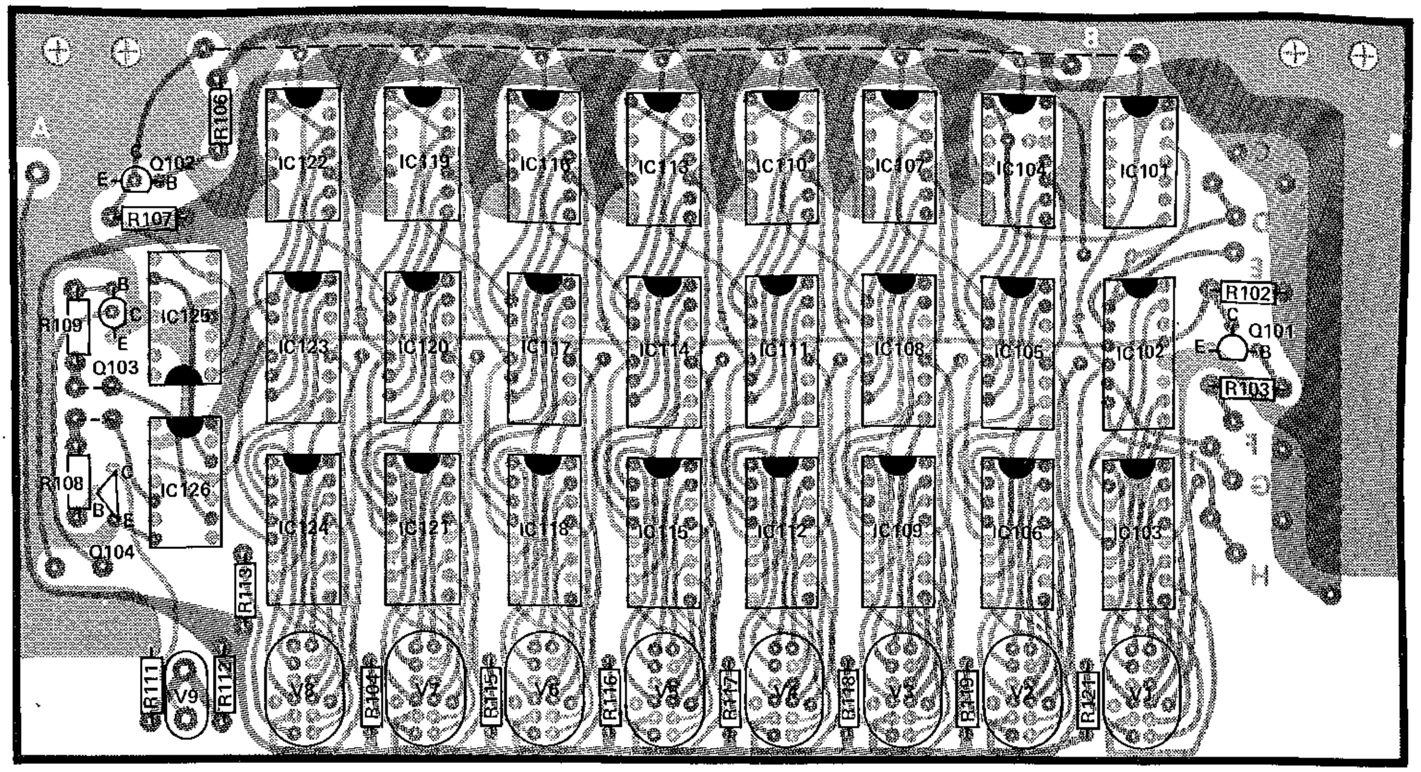


COMPONENT SIDE VIEW
(Component side foil in red)

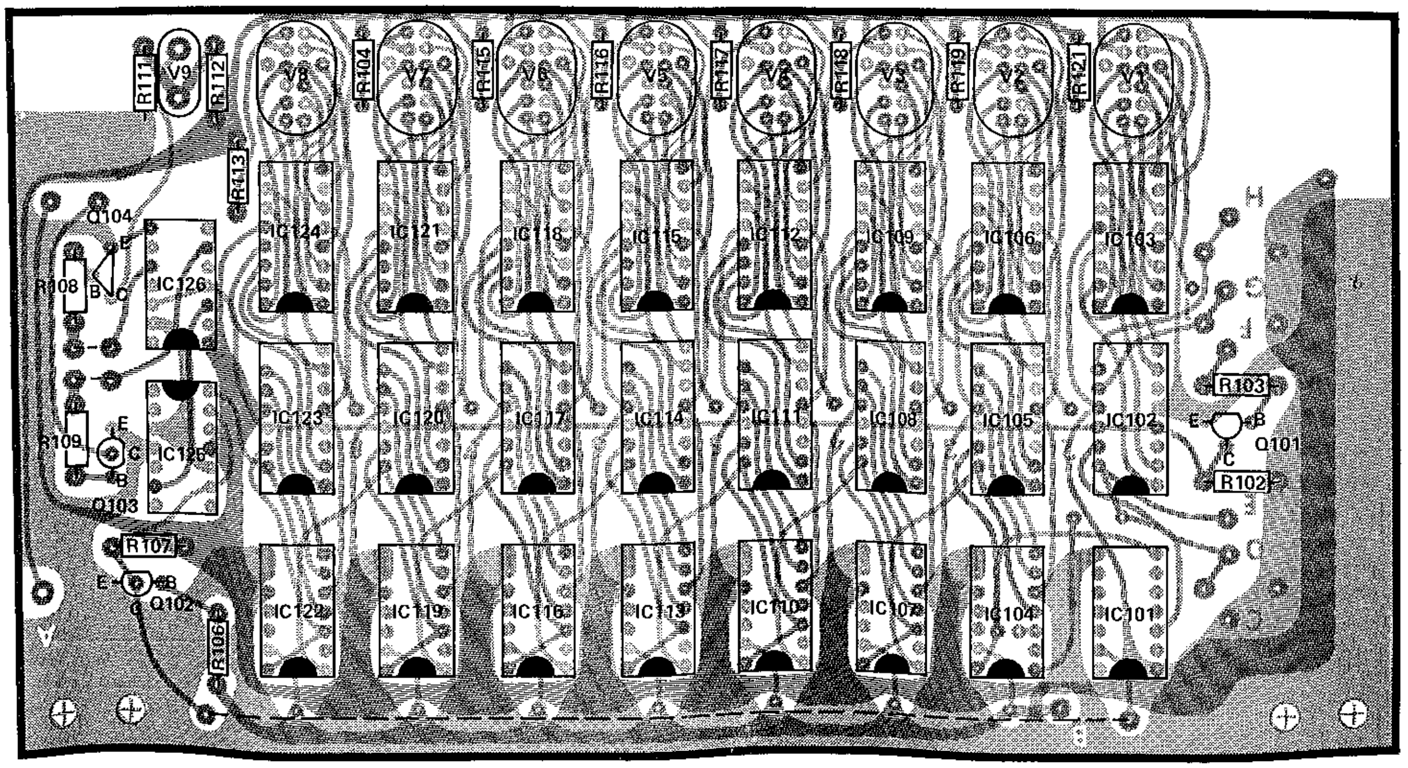


FOIL SIDE VIEW
(Component side foil in red)

COUNTER CIRCUIT BOARD

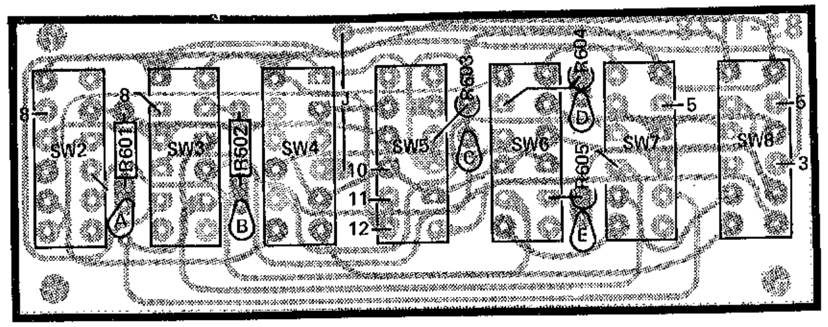


COMPONENT SIDE VIEW
(Component side foil in red)

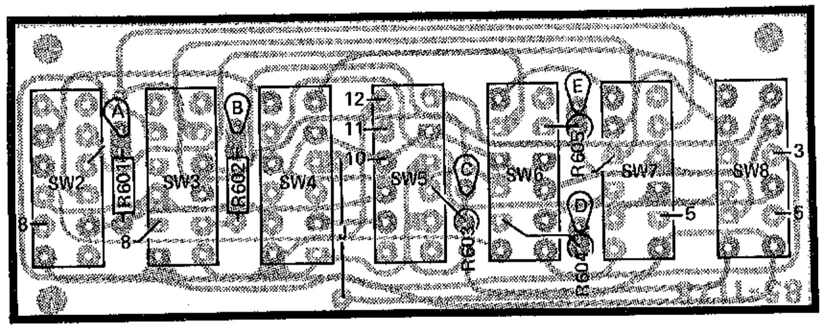


FOIL SIDE VIEW
(Component side foil in red)

SWITCH CIRCUIT BOARD



COMPONENT SIDE VIEW
(Component side foil in red)

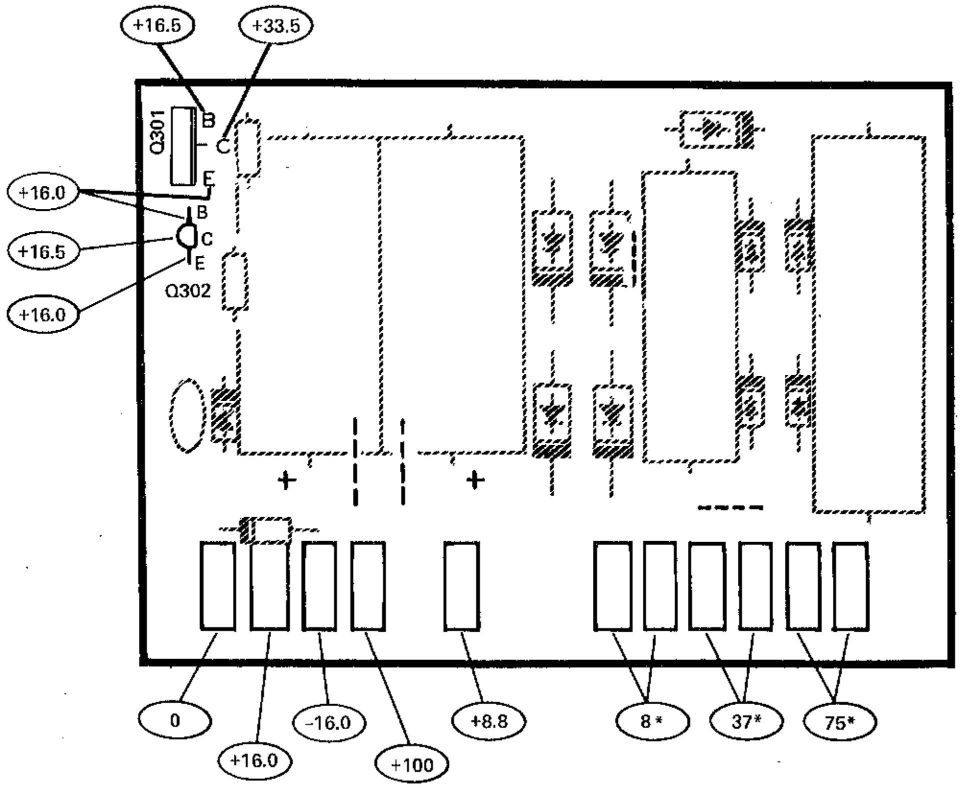


FOIL SIDE VIEW
(Component side foil in red)

CIRCUIT BOARD VOLTAGE CHARTS

POWER SUPPLY CIRCUIT BOARD

1. All voltages (except those marked *) are DC and taken with a 10 megohm impedance voltmeter from the point indicated to chassis ground. Voltages may vary ±10%.
2. Voltages marked with an asterisk (*) are AC and are taken with a high impedance voltmeter between the two points indicated.

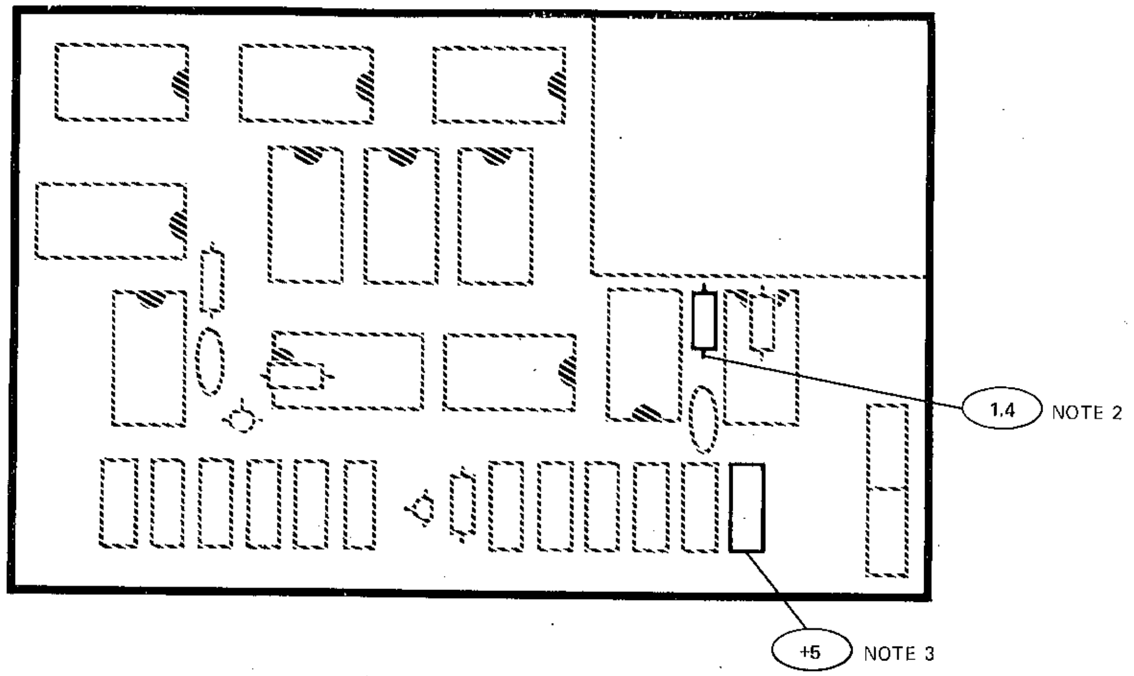


(Viewed from component side)

TIME BASE CIRCUIT BOARD

NOTES:

1. All voltages shown are DC and taken with a 10 megohm impedance voltmeter from the point indicated to chassis ground with no input signal.
2. Voltage may vary ±10%.
3. Voltage may vary ±5%.
4. IC voltages are TTL logic levels of 0.4 V to 3.0 V ±20%.

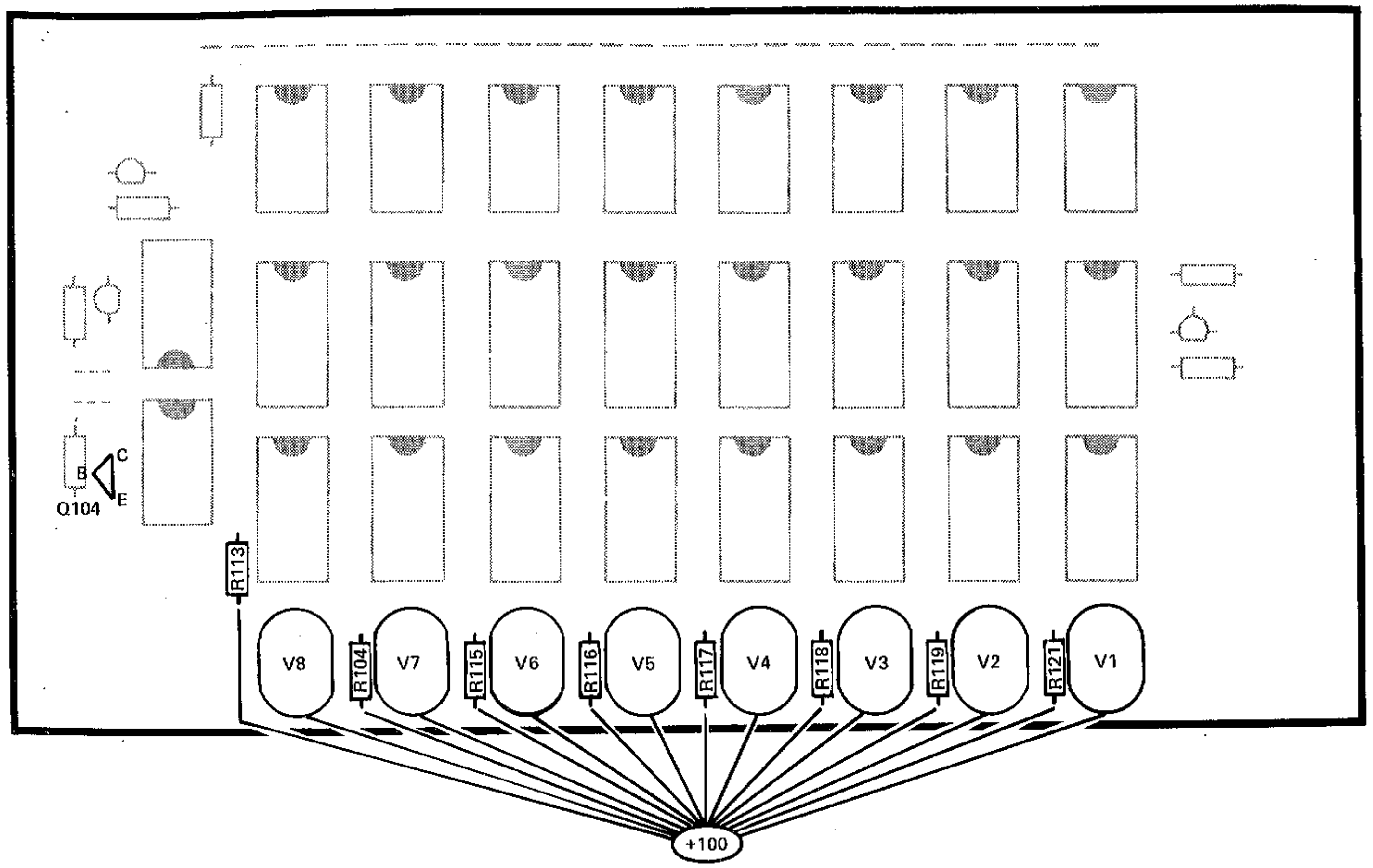


(Viewed from component side)

COUNTER CIRCUIT BOARD

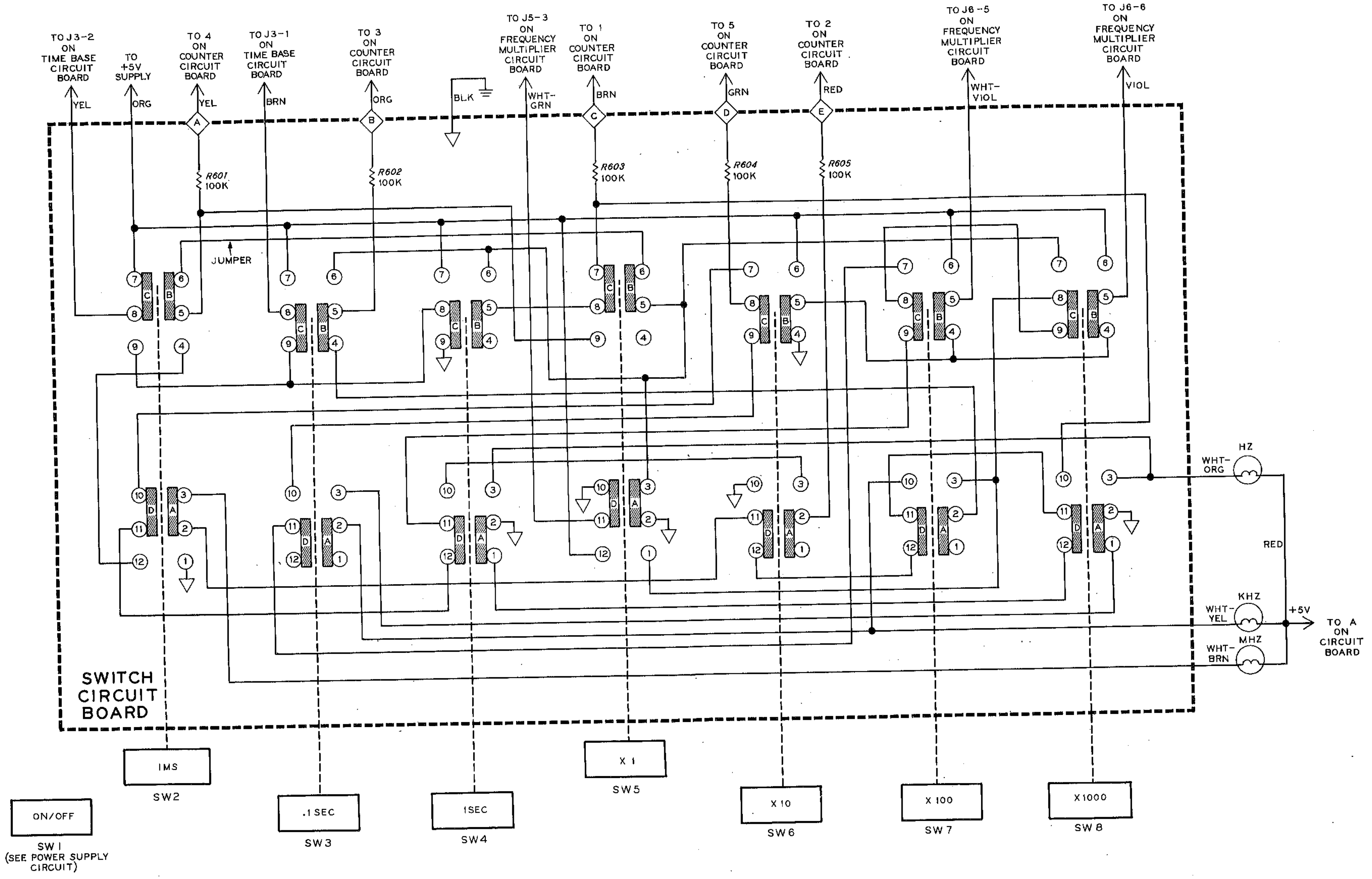
NOTES:

1. All voltages shown are DC and taken with a 10 megohm impedance voltmeter from the point indicated to chassis ground with no input signal. Voltages may vary ±10%.
2. IC voltages are TTL logic levels of 0.4 V to 3.0 V ±20%.



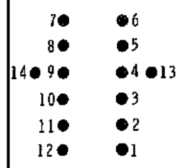
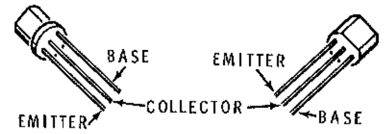
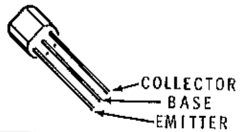
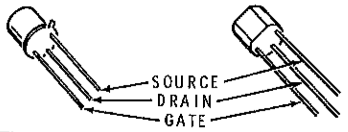
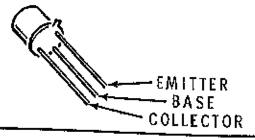
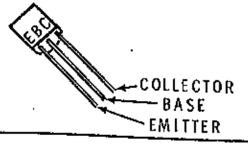
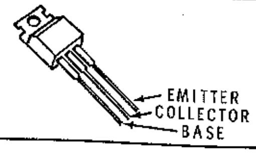
(Viewed from component side)

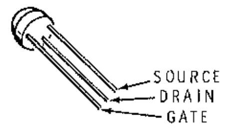
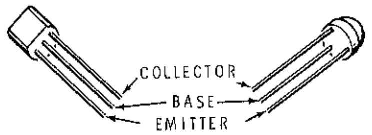
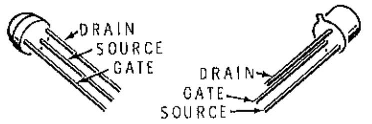
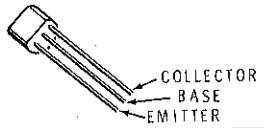
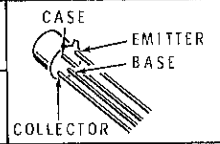
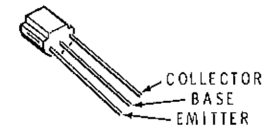
SWITCH SUPPLEMENT



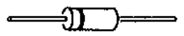
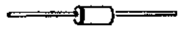
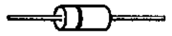
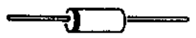
IDENTIFICATION CHART

TRANSISTORS

COMPONENT	HEATH PART NUMBER	MAY BE REPLACED WITH	BASE DIAGRAM (BOTTOM VIEW)
V1, V2, V3, V4, V5, V6, V7, V8,	411-264	NATIONAL ELECTRONICS NL950S OR BURROUGHS B-5859S	VIEW  PIN CONNECTION 1 NUMERAL 1 2 NUMERAL 2 3 NUMERAL 3 4 NUMERAL 4 5 NUMERAL 5 6 NUMERAL 6 7* ANODE 8 NUMERAL 7 9 NUMERAL 8 10* ANODE 11 NUMERAL 9 12 NUMERAL 0 13 RT. DEC. PT. 14 LFT. DEC. PT. *CONNECTED INTERNALLY
Q101, Q102, Q103, Q201, Q202, Q302, Q511, Q512,	417-118	2N3393 R.S. 2009	
Q509	417-134	MPS 6520	
Q504, Q513	417-140	2N4304 R.S.- 2028	
Q506	417-154	2N2369 R.S. - 2009	
Q104	417-294	MPSA42	
Q301	417-203	TA7311	

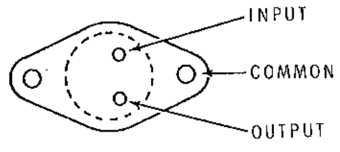
COMPONENT	HEATH PART NUMBER	MAY BE REPLACED WITH	BASE DIAGRAM (BOTTOM VIEW)
Q401	417-828	E304 (SELECTED)	
Q504	417-802	E304	
Q404, Q415, Q416, Q417, Q418, Q419, Q420, Q501, Q505, Q507, Q510	417-235	2N4121 R.S. - 2032	
Q503	417-820	2N4342 (SELECTED)	
Q502, Q508	417-267	MPS6560	
Q409, Q410	417-290	MRF-502	
Q405, Q406	417-813	2N4959 GET- 2905 RS - 2039	
Q402, Q407, Q408, Q421, Q422	417-292	2N5771 R.S. 2021.	
Q403, Q411, Q412, Q413, Q414	417-293	2N5770 R.S. - 2038	

DIODES

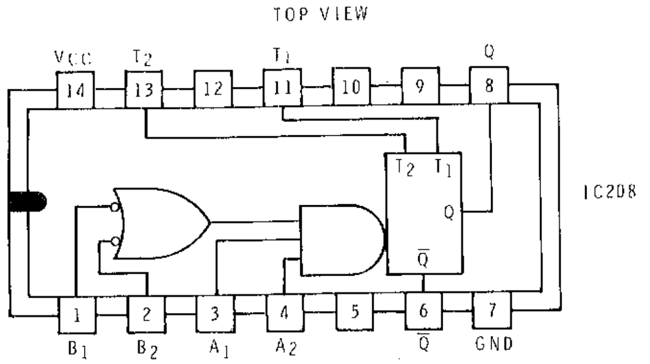
COMPONENT	HEATH PART NUMBER	MAY BE REPLACED WITH	LEAD DIAGRAM (BOTTOM VIEW)
ZD302	56-36	VR-16.1G 16.1 VOLT, 12mA ZENER	
D502	56-56	IN4149	
D403, D404 D501	56-61	GESTB-620 1.3 VOLT, 1mA STABISTOR	
ZD503	56-615	LNA 356 (SELECTED) 5.6 VOLT, ZENER	
ZD401, ZD402, ZD501, ZD502	56-67	VR-10A 10VOLT, 12mA ZENER	
D401, D402	56-86	FD777	
D301	57-27	1N2071	
D307, D308, D309, D306	57-42	3A1	
D302, D303, D304, D305	57-65	1N4002	
ZD301	56-606	1N5353B	

gy

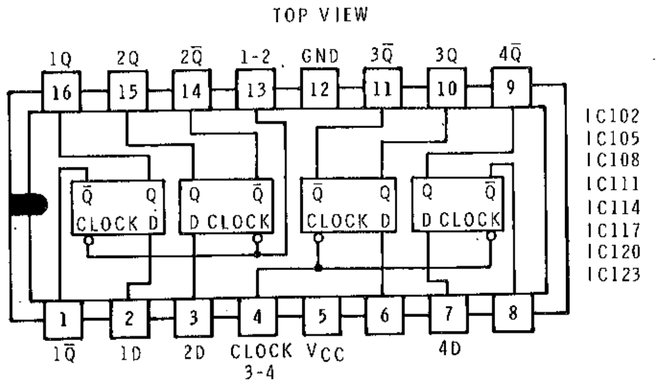
INTEGRATED CIRCUITS



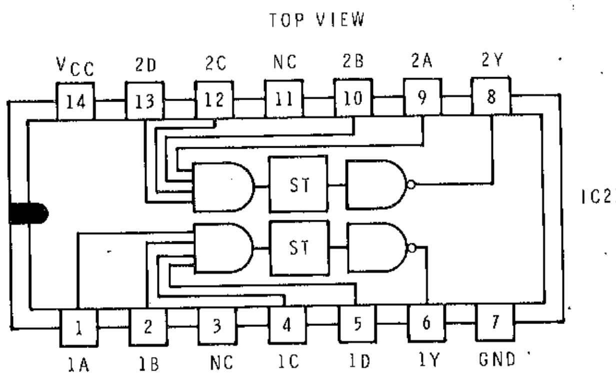
IC1-IC2
μA309K
5-VOLT REGULATOR
#442-30



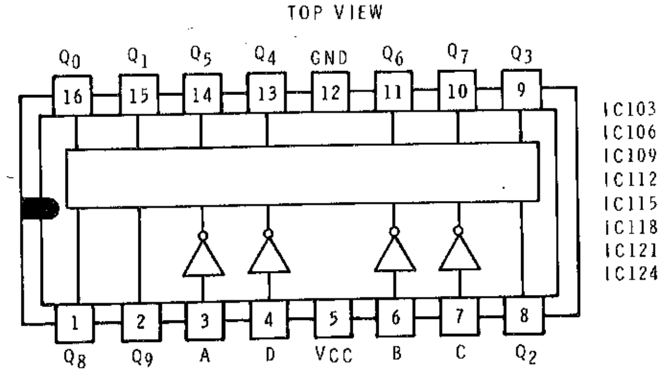
SN74122N RETRIGGERABLE
MONOSTABLE MULTIVIBRAT
#443-23



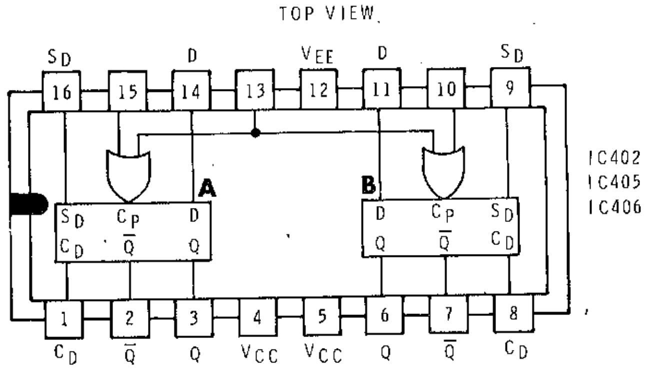
SN7475N 4-BIT
BISTABLE LATCH
#443-13



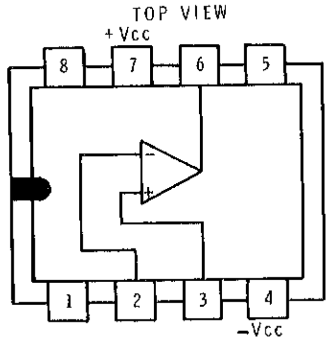
SN7413N DUAL NAND
SCHMITT TRIGGER
#443-44



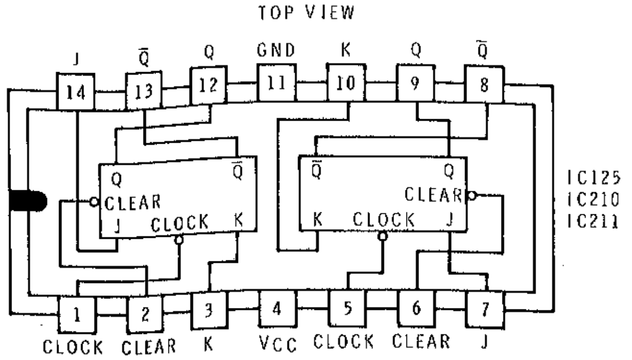
N7441B BCD-TO-DECIMAL
DECODER/DRIVER
#443-35



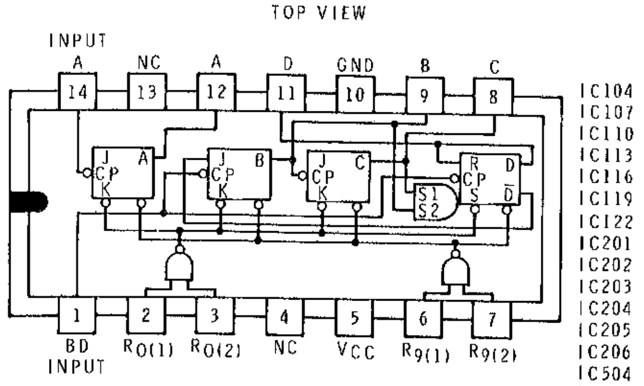
95H2859 DUAL D-TYPE
180MHZ FLIP-FLOP
#443-83



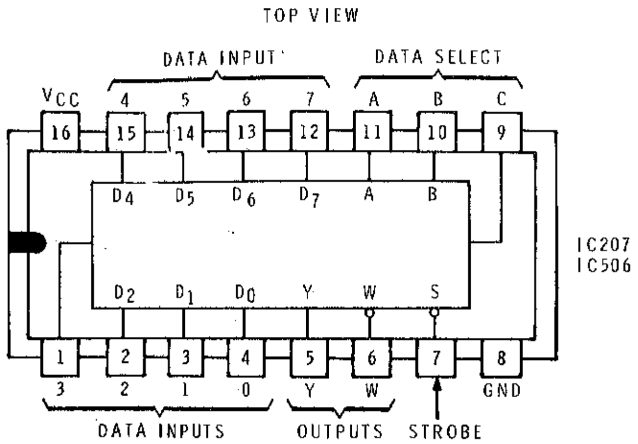
IC401
N5741V
OPERATIONAL
AMPLIFIER
#442-22



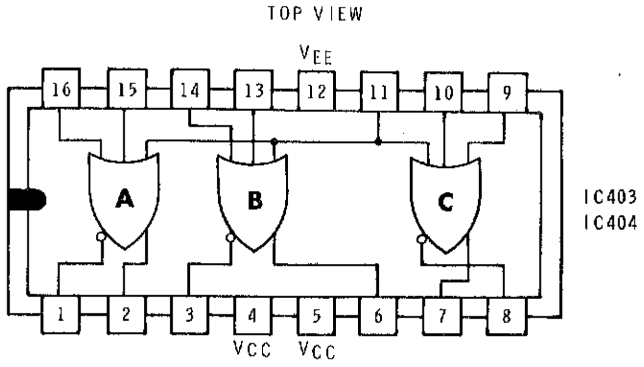
SN7473N DUAL J-K
MASTER-SLAVE FLIP-FLOP
#443-5



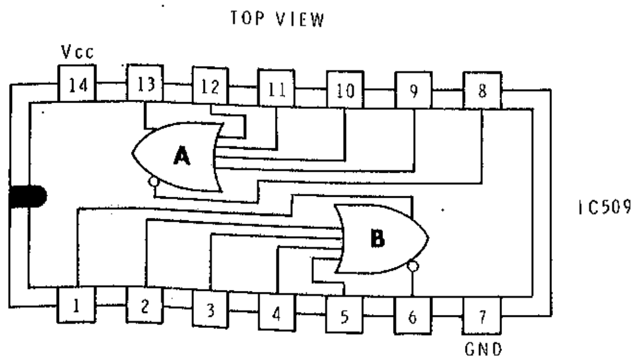
SN7490N HIGH SPEED
BCD DECADE COUNTER
#443-7
SN7490A, 443-629, USED AT IC503



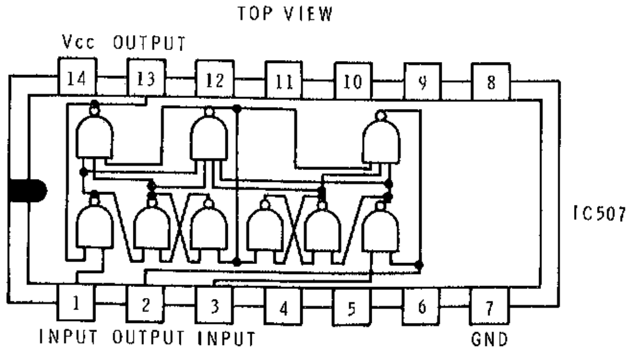
SN7415N MULTIPLEXER
#443-25



95H0359 TRIPLE 2
OR/NOR GATE
#443-79

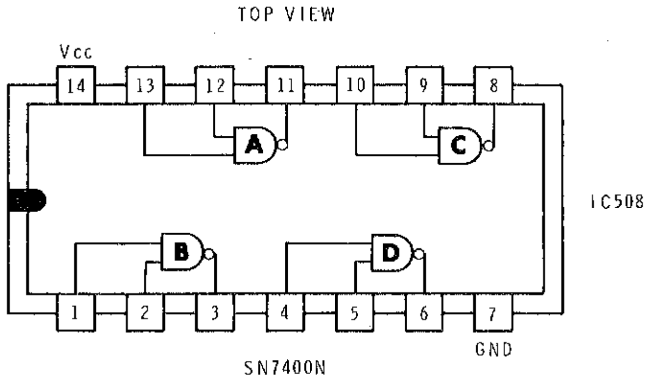


MC1023P
DUAL 4-INPUT GATE
#443-624

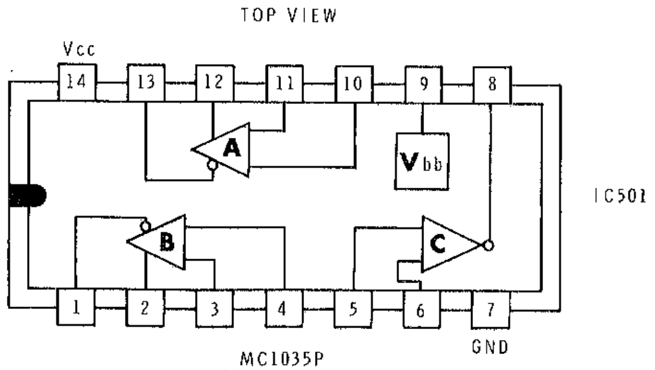


MC4044P
PHASE DETECTOR
#443-62

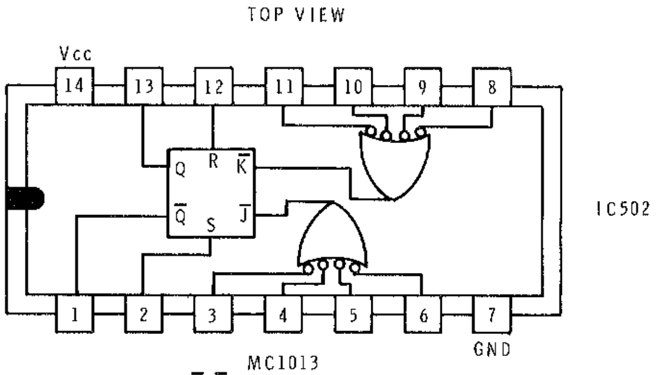
NOTE:
PORTIONS OF THIS IC
ARE NOT SHOWN.



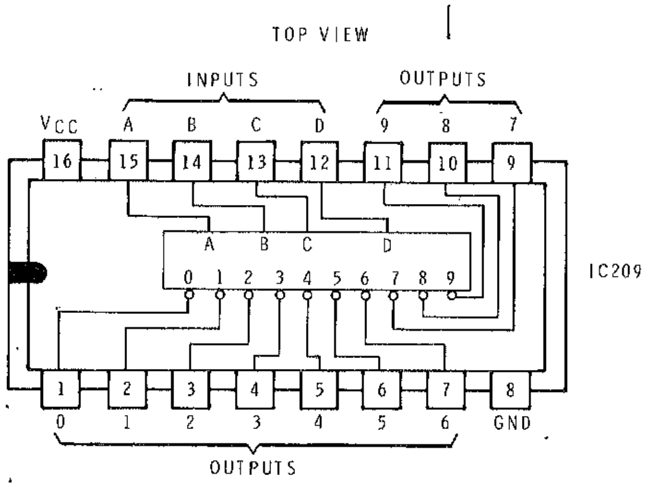
SN7400N
QUAD 2-INPUT GATE
#443-1



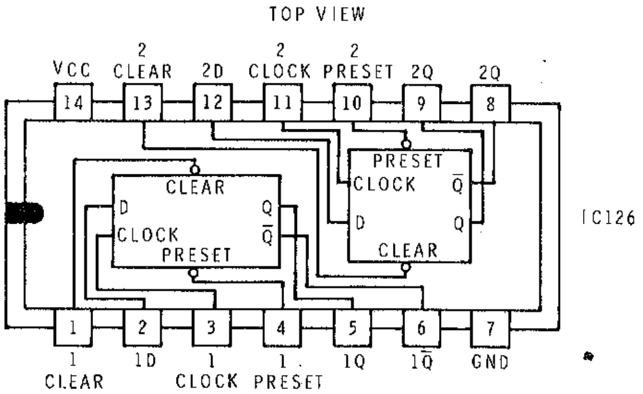
MC1035P
TRIPLE DIFFERENTIAL AMPLIFIER
#443-80



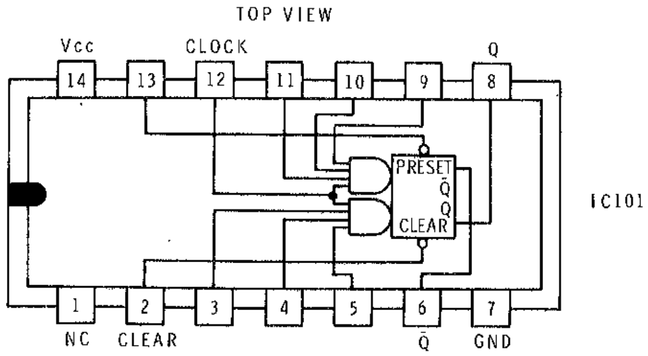
MC1013
$\overline{J}$-$\overline{K}$ FLIP-FLOP
#443-40



SN7442N 4-TO-10 LINE
DECODER
#443-53



SN7474N DUAL D-TYPE
EDGE-TRIGGERED FLIP-FLOP
#443-6

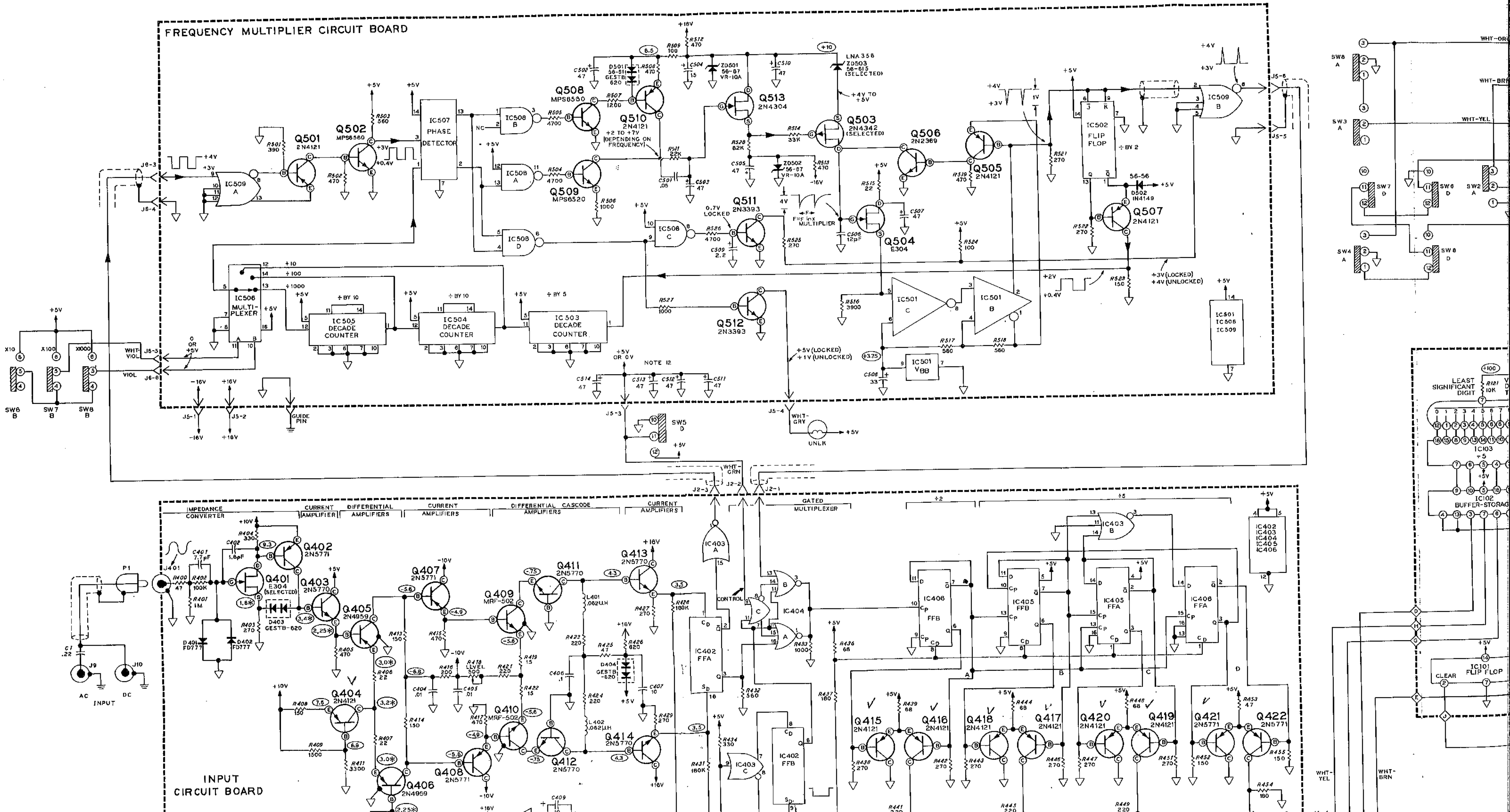


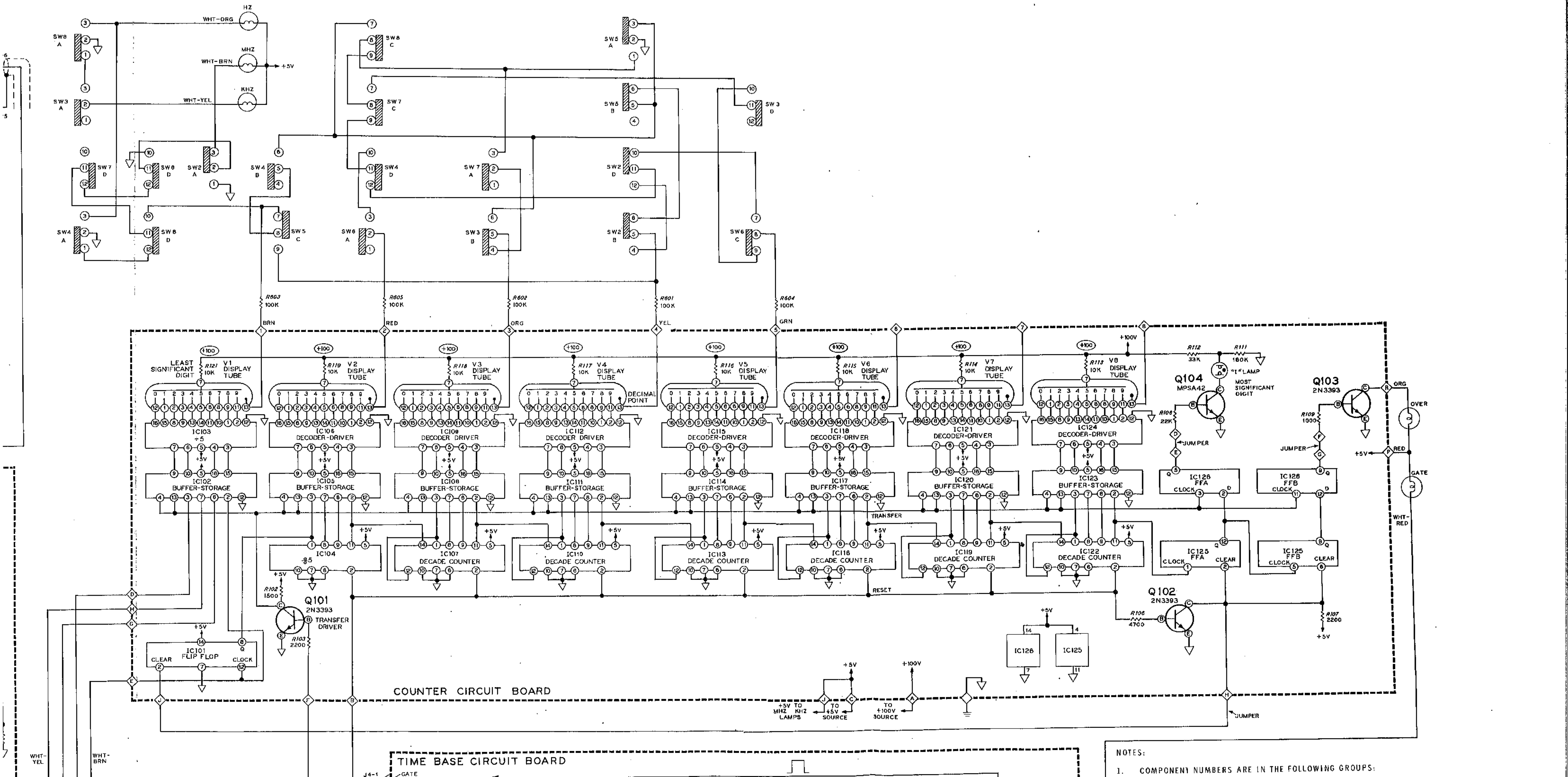
SN74H102N
J-K EDGE-TRIGGERED FLIP-FLOP
#443-43

HEATH
Schlumberger

HEATH COMPANY • BENTON HARBOR, MICHIGAN
THE WORLD'S FINEST ELECTRONIC EQUIPMENT IN KI RM

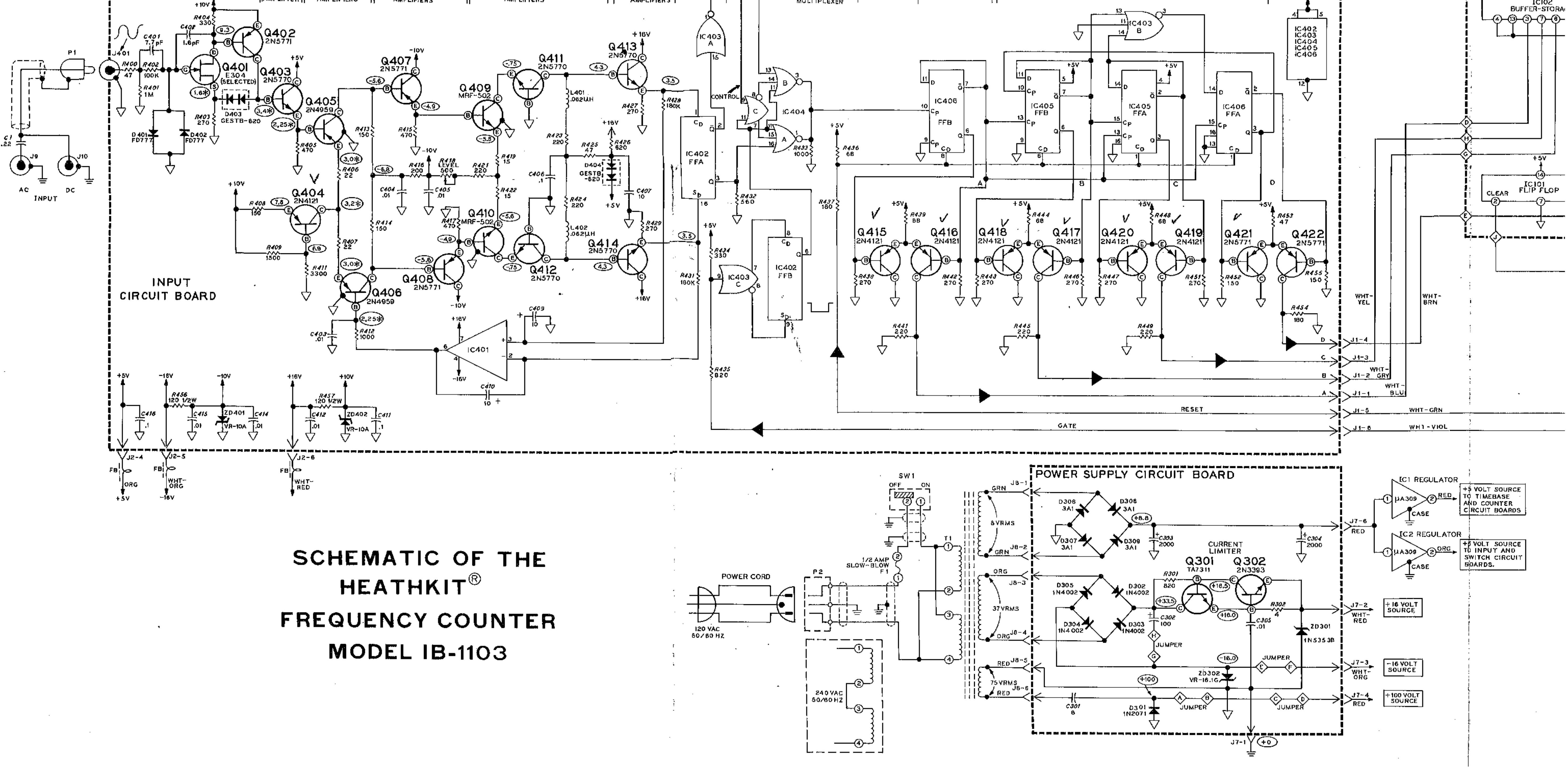
LITHO IN U.S.A.


FREQUENCY MULTIPLIER CIRCUIT BOARD
INPUT CIRCUIT BOARD
Q501 2N4121
Q502 MPS6560
IC507 PHASE DETECTOR
IC508 B
IC508 A
IC508 D
IC508 C
Q508 MPS6560
Q509 MPS6520
Q510 2N4121
Q513 2N4304
Q503 2N4342 (SELECTED)
Q506 2N2369
Q505 2N4121
Q507 2N4121
Q511 2N3393
Q512 2N3393
Q504 E304
IC509 A
IC509 B
IC502 FLIP FLOP ÷ BY 2
IC506 MULTI-PLEXER
IC505 DECADE COUNTER
IC504 DECADE COUNTER
IC503 DECADE COUNTER
IC501 C
IC501 B
IC501 VBB
+3V (LOCKED)
+4V (UNLOCKED)
+5V (LOCKED)
+1V (UNLOCKED)
0.7V LOCKED
F=F in x MULTIPLIER
+2 TO +7V (DEPENDING ON FREQUENCY)
NOTE 12
GUIDE PIN
UNLK
SW5 D
SW6 B
SW7 B
SW8 B
X10
X100
X1000
IMPEDANCE CONVERTER
CURRENT AMPLIFIER
DIFFERENTIAL AMPLIFIERS
CURRENT AMPLIFIERS
DIFFERENTIAL CASCODE AMPLIFIERS
CURRENT AMPLIFIERS
GATED MULTIPLEXER
÷2
÷5
Q401 E304 (SELECTED)
Q402 2N5771
Q403 2N5770
Q404 2N4121
Q405 2N4959
Q406 2N4959
Q407 2N5771
Q408 2N5771
Q409 MRF-502
Q410 MRF-502
Q411 2N5770
Q412 2N5770
Q413 2N5770
Q414 2N5770
IC403 A
IC403 B
IC403 C
IC404
IC402 FFA
IC402 FFB
IC406 FFB
IC405 FFB
IC405 FFA
IC406 FFA
Q415 2N4121
Q416 2N4121
Q418 2N4121
Q417 2N4121
Q420 2N4121
Q419 2N4121
Q421 2N5771
Q422 2N5771
R418 LEVEL 500
CONTROL
INPUT
AC
DC
J9
J10
P1
J401
LEAST SIGNIFICANT DIGIT
IC103 ÷5
IC102 BUFFER-STORAGE
IC101 FLIP FLOP
CLEAR
WHT-ORG
WHT-BRN
WHT-YEL
WHT-GRY
WHT-GRN
WHT-VIOL
VIOL
SW8 A
SW3 A
SW7 D
SW6 D
SW2 A
SW4 A
SW8 D

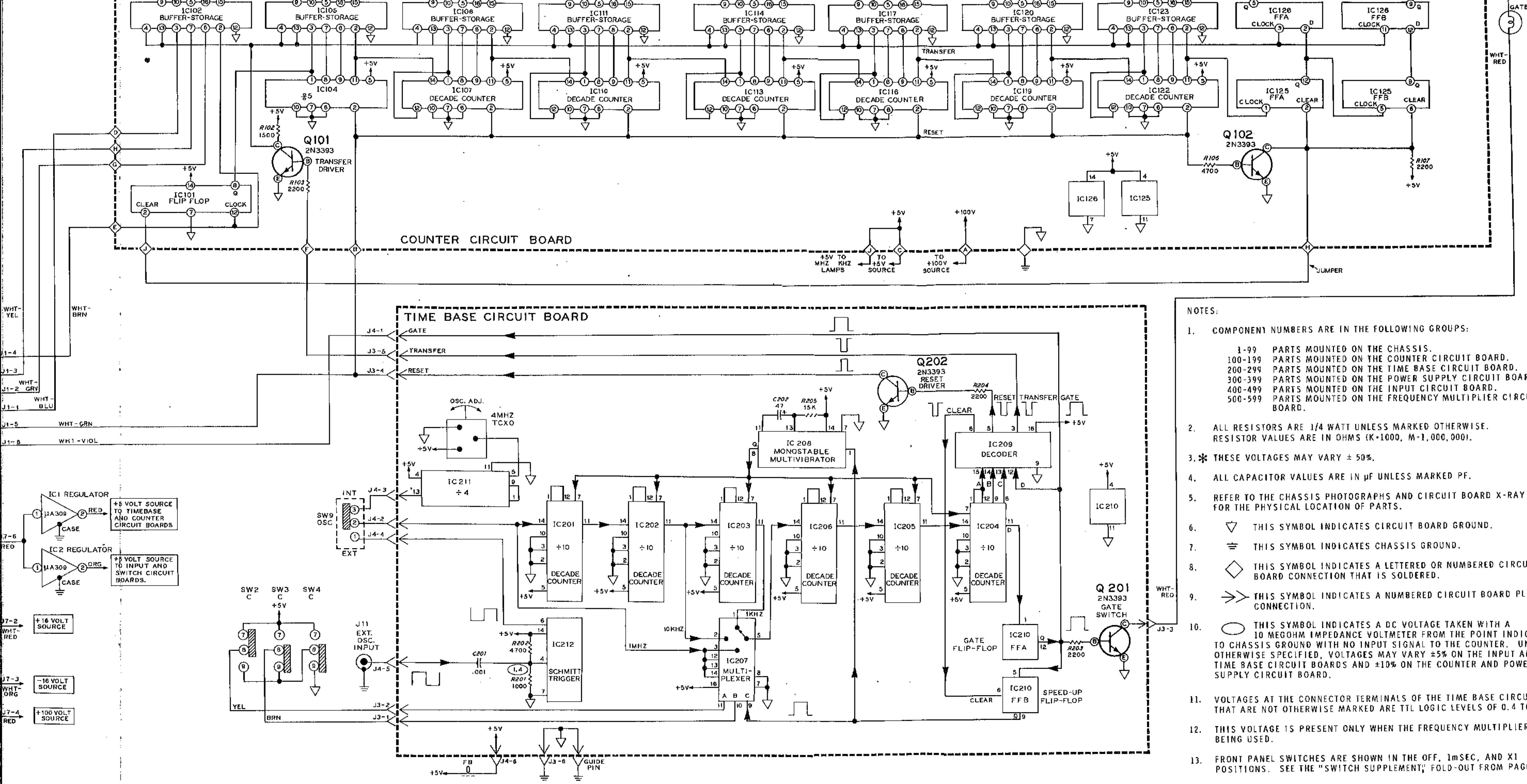


NOTES:

1. COMPONENT NUMBERS ARE IN THE FOLLOWING GROUPS:



SCHEMATIC OF THE HEATHKIT®
FREQUENCY COUNTER
MODEL IB-1103



NOTES:

1. COMPONENT NUMBERS ARE IN THE FOLLOWING GROUPS:

1-99	PARTS MOUNTED ON THE CHASSIS.
100-199	PARTS MOUNTED ON THE COUNTER CIRCUIT BOARD.
200-299	PARTS MOUNTED ON THE TIME BASE CIRCUIT BOARD.
300-399	PARTS MOUNTED ON THE POWER SUPPLY CIRCUIT BOARD.
400-499	PARTS MOUNTED ON THE INPUT CIRCUIT BOARD.
500-599	PARTS MOUNTED ON THE FREQUENCY MULTIPLIER CIRCUIT BOARD.

2. ALL RESISTORS ARE 1/4 WATT UNLESS MARKED OTHERWISE. RESISTOR VALUES ARE IN OHMS (K=1000, M=1,000,000).

3. ✻ THESE VOLTAGES MAY VARY ± 50%.

4. ALL CAPACITOR VALUES ARE IN µF UNLESS MARKED PF.

5. REFER TO THE CHASSIS PHOTOGRAPHS AND CIRCUIT BOARD X-RAY VIEWS FOR THE PHYSICAL LOCATION OF PARTS.

6. ▽ THIS SYMBOL INDICATES CIRCUIT BOARD GROUND.

7. ⏚ THIS SYMBOL INDICATES CHASSIS GROUND.

8. ◇ THIS SYMBOL INDICATES A LETTERED OR NUMBERED CIRCUIT BOARD CONNECTION THAT IS SOLDERED.

9. →> THIS SYMBOL INDICATES A NUMBERED CIRCUIT BOARD PLUG CONNECTION.

10. ⬭ THIS SYMBOL INDICATES A DC VOLTAGE TAKEN WITH A 10 MEGOHM IMPEDANCE VOLTMETER FROM THE POINT INDICATED TO CHASSIS GROUND WITH NO INPUT SIGNAL TO THE COUNTER. UNLESS OTHERWISE SPECIFIED, VOLTAGES MAY VARY ±5% ON THE INPUT AND TIME BASE CIRCUIT BOARDS AND ±10% ON THE COUNTER AND POWER SUPPLY CIRCUIT BOARD.

11. VOLTAGES AT THE CONNECTOR TERMINALS OF THE TIME BASE CIRCUIT BOARD THAT ARE NOT OTHERWISE MARKED ARE TTL LOGIC LEVELS OF 0.4 TO 3.0V ±20%.

12. THIS VOLTAGE IS PRESENT ONLY WHEN THE FREQUENCY MULTIPLIER IS BEING USED.

13. FRONT PANEL SWITCHES ARE SHOWN IN THE OFF, 1mSEC, AND X1 POSITIONS. SEE THE "SWITCH SUPPLEMENT," FOLD-OUT FROM PAGE 120.