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HEWLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

114BR 150 -

TIME COMPARATOR

hp 114BR

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OPERATING AND SERVICE MANUAL

MODEL 114BR

SERIALS PREFIXED: 150 -

TIME COMPARATOR

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This manual has been carefully prepared to help you operate and maintain your equipment. Technical content follows the requirements of most military specifications including MIL-H-7960 and MIL-M-9848; typography generally conforms to MIL-M-5474 and MIL-M-4410. We welcome suggestions for additions and corrections. Please address your comments to Publications Supervisor, Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, California.

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Table 1-1. Specifications

Sweep Delay Range:

0-999 milliseconds in 1 millisecond steps with direct reading, in-line front panel switches

Sweep Output:

- From HORIZ. AXIS. BNC connector on front panel.
- Duration: 1000, 100, 10, or 1 millisecond as selected by front panel SWEEP TIME switch.
- Amplitude: 1 volt peak-to-peak; dc coupled.
- Position Control: front panel HORIZ. POS. VERNIER control provides fine adjustment of dc level of sweep voltage.
- Recommended Display Unit: Model 120A/AR.

WWV Tick Output:

WWV Tick, gated at 1-second intervals to provide stable base line for intensity markers between ticks, appears at VERT. AXIS. BNC connector on front panel.

Z-axis Output: (MS 3102R-14S-7S Connector on Rear)

Intensity Markers:

- Intervals automatically adjusted to 1/10 of the sweep duration.
- Length automatically adjusted with SWEEP TIME.
- Intensity markers may be switched on or off by MARKERS switch.

Unblanking Voltage:

50 kc unblanking square wave synchronized with standard frequency for interpolation to 10 μ sec or better. Amplitude 40 volts peak-to-peak.

Input Requirements:

- 1 kc positive pulses from Model 113BR, BNC connector on rear.
- 1 pps positive pulses from Model 113BR, BNC connector on rear.
- WWV tick, 0.1-10 volts peak-to-peak, BNC connector on rear.

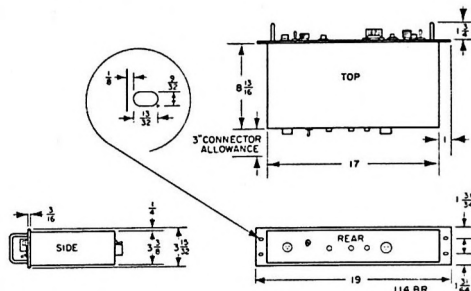
Self Check:

Each digit of the delay setting may be checked by means of front panel CHECK pushbutton.

Power Requirements:

115/230 volts $\pm 10\%$, 50-1000 cps; approximately 7 watts. AN3102A-10SL-3P connector at rear.

Dimensions: (Rack Mount)



Weight:

Net, approximately 11 lbs.

Accessories Furnished:

Model 114BR-16A power cable, 6 feet long, with NEMA line plug and MS3106A-10SL-3S plug for chassis power connector.

Model 114BR-16B Z-axis cable, 3 feet long, with MS3106E-14S-7P plug for chassis connector.

Model 114BR-16C horizontal axis output cable, 6-1/2 inches long, BNC to banana plug connector.

Model 114BR-16D vertical axis output cable, 10 inches long, BNC to banana plug connector.

Complementary Equipment:

- Model 103AR Quartz Oscillator
- Model 113BR Frequency Divider and Clock
- Model 724B Standby Power Supply, 20 ampere-hour standby capacity
- Model 120AR Oscilloscope

SECTION I GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This manual provides complete instructions on installation, operation, and maintenance of the Hewlett-Packard Model 114BR Time Comparator (figure 1-1) hereinafter referred to as the "comparator." This manual applies directly to all instruments with serial numbers prefixed 150-. The serial number of each comparator is stamped on a tag at the rear of the chassis.

1-3. DESCRIPTION.

1-4. The comparator is a component instrument in the frequency and time standard system (see paragraph 1-8). Instrument specifications are listed in table 1-1. The comparator is used in making comparisons against the 1-second timing pulses (ticks) from radio station WWV, WWVH, or a similar source of master timing signals. The instrument, which permits the addition of a controlled delay to the 1-pps local clock tick from the time standard system, provides a simple means of measuring the time difference between the 1-pps local clock ticks and the master ticks (WWV) without requiring phase adjustment of the 1-pps local clock ticks.

1-5. The 1-second timing pulses (ticks) transmitted by station WWV normally consist of a 5-millisecond pulse of a 1000-cps sine wave (WWVH, 1200-cps), with exact time represented by the leading edge of the pulse. This signal is displayed on the oscilloscope using a sweep generated in the comparator. This sweep is initiated after a selectable time delayed interval from the occurrence of the local 1-pps clock pulse. By adjusting the time delay and the sweep speed, the WWV tick can be displayed in expanded form.

1-6. The comparator introduces precise time delays in multiples of 1-millisecond up to 1000-milliseconds. The four sweep times available are: 1000, 100, 10, and 1 millisecond. Any one cycle of the WWV tick can be displayed on the oscilloscope screen when the fastest sweep speed is used. Ten intensity markers are available on each sweep speed to aid in time calibration. On the fastest sweep range the markers occur at 100-microsecond intervals and the WWV tick waveform is modulated by a synchronized 50-kilocycle square wave which produces a dashed trace with each dash and space equal to 10 microseconds. The time interval between the clock tick and a selected reference point on the WWV tick can therefore be obtained to the nearest millisecond from the comparator front panel settings, and to the nearest 10 microseconds from oscilloscope interpolation.

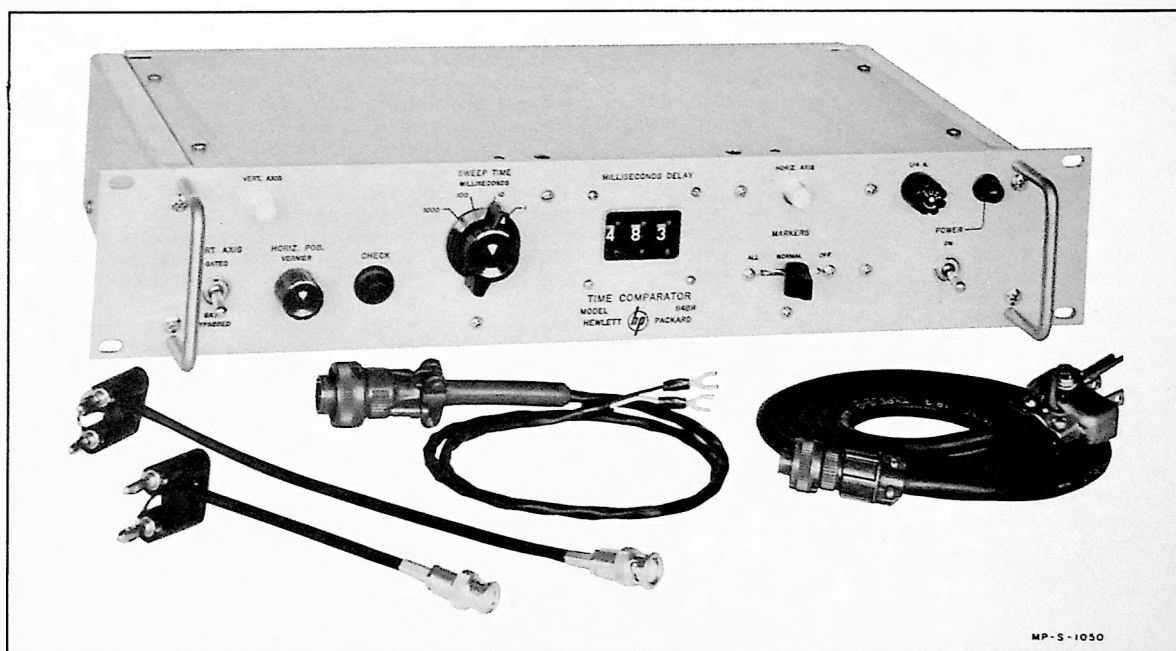


Figure 1-1. Model 114BR Time Comparator

1-7. The comparator is composed of eight printed circuit plug-in assembly boards mounted on the chassis (refer to figures 5-5 through 5-10). Each plug-in board has a special function, and interconnections are made through contact strips at the board base. In addition to the assembly boards, the switches, transformers, variable controls, indicators, and receptacles are mounted directly on the chassis. Transistors are used in all circuits, including the power supply.

1-8. SYSTEM CONCEPT.

1-9. The comparator is normally used in a system (figure 1-2) consisting of a precision oscillator such as the  Model 103AR Quartz Oscillator, a clock such as the  Model 113BR Frequency Divider and Clock, and an oscilloscope such as the  Model 120A/AR. Adjustment of the comparator will not effect operation of the frequency or time standard in any way.

1-10. The clock keeps correct time indefinitely, if the precision oscillator driving it maintains its exact nominal value. With the comparator in the system, fast and accurate time checks can be made daily. Time error is recorded in the system log and serves as the correction figure to bring the clock tick into coincidence or near coincidence with the WWV tick. The data thus accumulated over a period of weeks and months may be used to determine the long term drift of the precision oscillator.

1-11. Refer to Hewlett-Packard Application Note 52 "Frequency and Time Standards" for a discussion of system operation and detailed instruction on methods of frequency and time control.

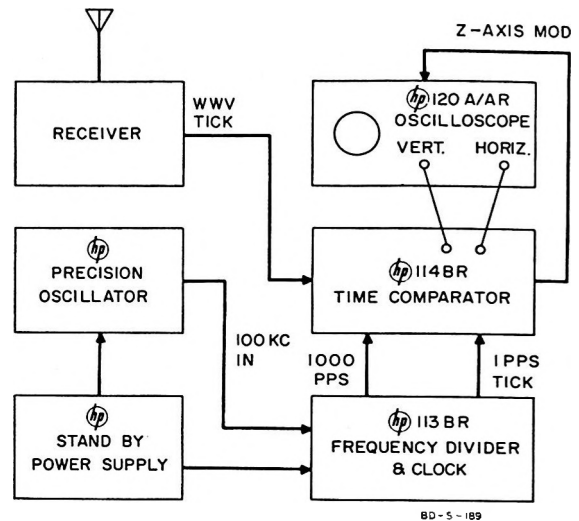


Figure 1-2. Relationship to Frequency and Time Standard System

SECTION II INSTALLATION

2-1. UNPACKING AND MECHANICAL INSPECTION.

2-2. Inspect instrument for shipping damage as soon as it is unpacked. If reshipment is expected, save all packing materials to simplify repackaging. Check for broken knobs or connectors and inspect painted surfaces for scratches or abraded areas. If the instrument is damaged in any way, notify the carrier immediately; see warranty sheet for additional instructions.

2-3. PACKING FOR STORAGE OR RESHIPMENT.

2-4. To properly protect valuable electronic equipment during storage or shipment, always use the best packaging methods available. Your representative can provide packing material such as that used in original factory packaging. Contract packaging companies can provide dependable custom packaging on short notice. The following alternative packaging methods are recommended:

a. ORIGINAL. Place instrument in original container. Replace all packing pads and fillers in the exact position they originally occupied.

b. RUBBERIZED HAIR. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument securely in strong corrugated container (350 lb/sq. in. bursting test) with 2-inch rubberized hair pads placed along all surfaces of the instrument. Insert fillers between pads and container to ensure a snug fit on all surfaces of the instrument.

c. EXCELSIOR. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument in strong corrugated container (350 lb/sq. in. bursting test) with a layer of 6-inch excelsior packed firmly against all surfaces of the instrument.

2-5. Environmental conditions during storage and shipment should normally be limited as follows:

- a. Maximum altitude 10,000 feet.
- b. Minimum temperature -40°F (-40°C).
- c. Maximum temperature 167°F ($+75^{\circ}\text{C}$).

2-6. MOUNTING.

2-7. Mount the comparator in a standard rack. Normally the comparator is placed in the system rack above the clock and below the oscilloscope. Ambient temperature in the rack during operation must not exceed a maximum of 122°F (50°C) or a minimum of 32°F (0°C).

2-8. POWER CORD.

2-9. The three-conductor power cable supplied with the instrument is terminated in a polarized three-prong male connection recommended by the National Electrical Manufacturers' Association. The third contact is an offset round pin added to a standard two-blade, a-c plug. The pin grounds the instrument chassis when used with an appropriate receptacle. To use this plug in a standard two-contact outlet, an adapter should be used to connect the NEMA plug to the two-contact system. When the adapter is used, the ground connection becomes a short lead from the adapter which can be connected to a suitable ground for the protection of operating personnel.

2-10. ELECTRICAL CONNECTIONS.

2-11. Proceed as follows to connect the comparator for operation:

a. Connect 3-wire power cable (supplied) between POWER jack on rear of comparator (figure 3-1) and suitable 115-volt, 50 to 1000-cps power source.

b. Connect BNC-to-BNC cable between CLOCK 1KC jack on rear panel of comparator and 1 KC OUTPUT jack on rear panel of clock.

c. Connect BNC-to-BNC cable between CLOCK TICK jack on rear of comparator and TICK OUTPUT jack on clock.

NOTE

A positive clock tick pulse is required for comparator operation. Clock Models 113X and 113BR provide a positive tick at the chassis rear. Model 113AR normally provides a negative tick; minor internal circuit modification, therefore, is required on the standard Model 113AR to invert polarity of the tick output. The clock tick output must be coincident with one positive 1-kc pip or measurement errors as large as a 0.5 millisecond may result.

During operation when using the Model 113AR, slight non-unblanking of the first 200 microseconds of any sweep may occur. To remedy this, increase the 1-pps clock tick width by reducing the value of R80 (normally 82 ohms) in the Model 113AR.

d. Connect cable between MASTER TICK jack on rear of comparator and audio output connector on radio receiver (or other source of master time signals).

e. Connect AN-connector-to-spade-lug cable (supplied) between Z - AXIS jack on rear of comparator chassis and X-axis terminals at rear of oscilloscope.

f. Connect BNC - to - dual-banana-plug cable (supplied) between VERT. AXIS jack on front panel of comparator and vertical input of oscilloscope.

g. Connect BNC - to - dual-banana-plug cable (supplied) between HORIZ. AXIS jack on front panel of comparator and horizontal input of oscilloscope.

2-12. CONNECTION FOR 230-VOLT POWER.

2-13. The comparator is normally shipped from the factory with the dual primary windings of the power

transformer connected in parallel for 115-volt, a-c input lines. The windings can be easily connected in series for a 230-volt, a-c input. To connect the windings in series, remove the jumpers between pins 1-2 and 3-4 (figure 5-18) and connect a jumper between pins 2 and 3.

2-14. CONNECTION FOR LONG-PERSISTENCE CRT.

2-15. When a long-persistence oscilloscope is used in the system, marker brightness can be lowered by reducing marker duty-cycle on the 100 and 10-millisecond sweep times (see paragraph 4-17). Connect jumpers across terminal pins E1-E2 and E3-E4. Refer to figure 5-3 for location of terminal pins.

SECTION III

OPERATION INSTRUCTION

3-1. INTRODUCTION.

3-2. The operator uses the comparator to determine the difference in time between the local clock tick and a master timing tick. The master (WWV) tick is displayed on the oscilloscope while the comparator controls adjust oscilloscope sweep time and the delay between the occurrence of the local clock tick and the start of the oscilloscope sweep. The interval between the clock tick and a selected reference point on the master tick is equal to the delay indicated on the MILLISECONDS DELAY switches plus the time between the start of the oscilloscope sweep and the reference point on the WWV tick.

3-3. A quick operational check can be performed on the comparator by using its self-check circuit. The self-check circuit guarantees a positive confirmation of all the three digits of the delay setting, assuring correct operation of all delay circuitry. It is recommended that the self-check procedure given in paragraph 5-19 be performed before each time comparison or when a malfunction is suspected.

3-4. RADIO RECEPTION.

3-5. Accuracy of measurements using high-frequency timing signals (WWV, WWVH) can be improved by observing a few precautions to lessen the effects of variations in propagation delay.

a. Schedule all WWV comparisons observations for an all-daylight or all-night transmission path between transmitter and receiver. Avoid twilight hours in the transmission path.

b. Choose the highest WWV transmission frequency which provides consistent reception.

c. Observe WWV tick transmission for a few minutes to get the "feel" of propagation conditions. The best measurements are made on days when signals show little jitter or fading. If reception conditions are erratic, as indicated by considerable jitter in tick timing and signal fading, postpone the measurement. (Ionospheric disturbances causing erratic reception sometimes last less than an hour but may last several days.)

d. Make time-comparison measurements using the ticks which appear to have the earliest consistent arrival time (i.e. those which tend to group to the left on the oscilloscope trace).

3-6. FUNCTION OF CONTROLS.

3-7. Front and rear panel controls and receptacles are illustrated in figure 3-1 and their functions are given in table 3-1. Index numbers allow cross reference between figure and table.

3-8. TIME COMPARISON PROCEDURE.

3-9. USING 1-PPS TICKS. Perform the following steps when comparing time between local clock tick (1 pps) and master tick (1 pps).

a. Perform electrical connections given in paragraph 2-10.

b. Set MARKERS switch to NORMAL.

c. Turn on receiver, oscilloscope, and comparator. Allow warmup time of 5 minutes.

d. Adjust receiver for clear reception of WWV signal.

e. Set horizontal input switch on oscilloscope to HOR SENS 0.1 VOLTS/CM.

f. Set oscilloscope VERT SENSITIVITY switch to 1 VOLT/CM.

g. Set oscilloscope input switches on both horizontal and vertical channels for DC coupling.

h. Adjust oscilloscope controls for best presentation with trace centered vertically and horizontally.

i. Set VERT. AXIS switch to GATED.

j. Set SWEEP TIME switch to 1000 MILLISECONDS.

k. Adjust receiver gain for WWV tick height of 2 to 4 centimeters (peak-to-peak) on the oscilloscope.

m. Position the WWV tick between the two intensity markers (100-millisecond spacing) at the left end of the oscilloscope sweep using the MILLISECONDS DELAY hundreds switch (S3).

n. Set the SWEEP TIME switch to 100 MILLISECONDS.

o. Position the WWV tick between the two intensity markers (10-millisecond spacing) at the left end of the oscilloscope sweep using the MILLISECONDS DELAY tens switch.

p. Set SWEEP TIME switch to 10 MILLISECONDS.

q. Set the MILLISECONDS DELAY units switch to permit convenient viewing of the WWV ticks. Select an easily identified portion of the tick for a reference point such as the zero-crossing point of the second cycle of the tick. Note the selected reference point in the system log so that the same point can be used for future measurements.

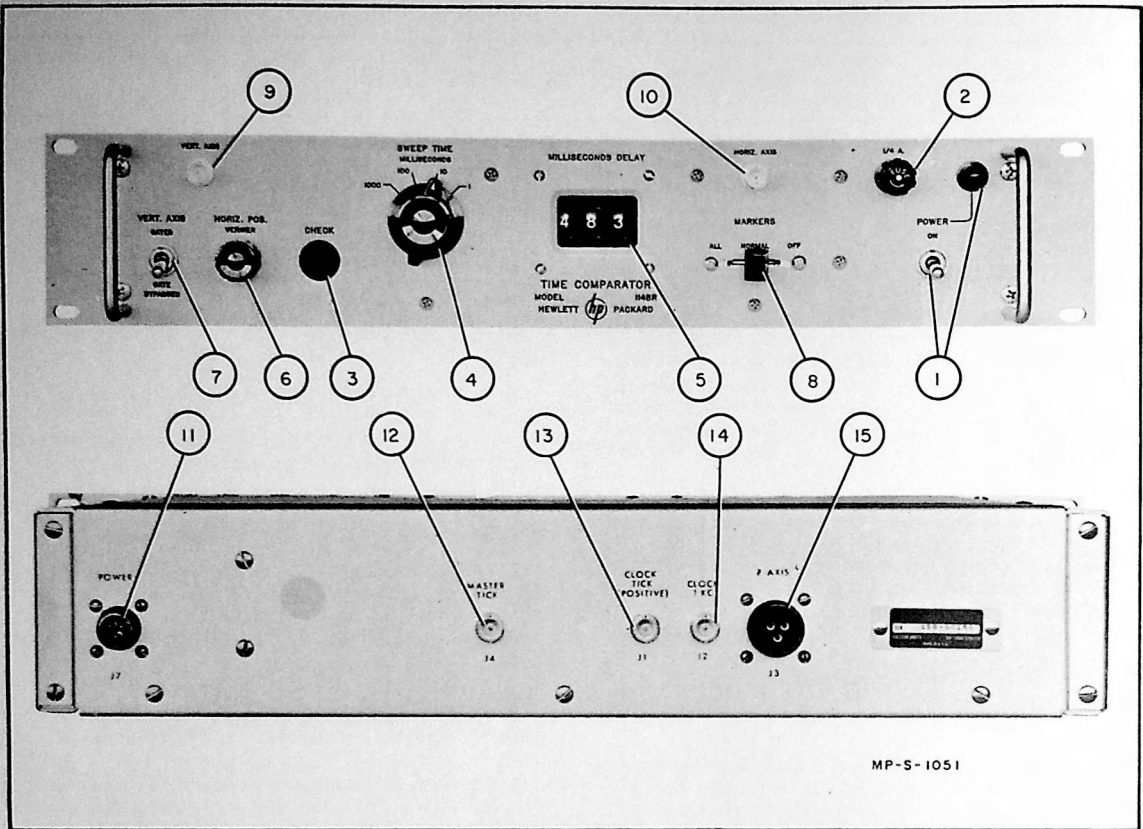
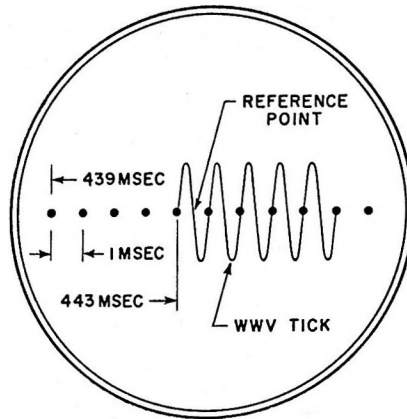


Figure 3-1. Operating Controls and Receptacles

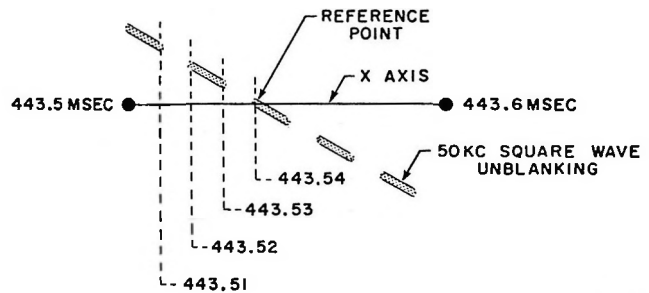
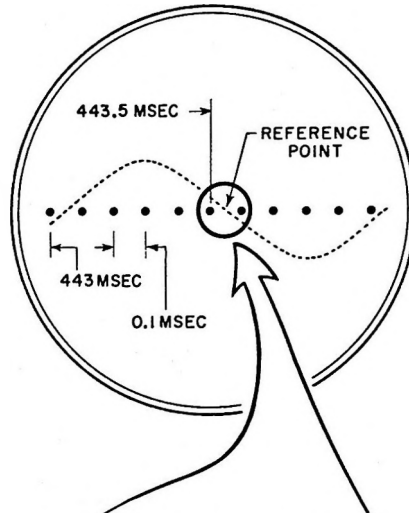
Table 3-1. Operating Controls and Receptacles

Figure 3-1 Index No.	Control	Ref. Desig.	Function
1	POWER ON	S8	Controls line power to instrument; lamp (DS1) indicates power is on.
2	1/4A FUSE	F1	Overload protection device for comparator.
3	CHECK	S6	Allows check of MILLISECONDS DELAY switches (all settings), thus assuring correct operation of all delay circuits.
4	SWEEP TIME MILLISECONDS	S4	Permits selection of desired oscilloscope sweep time.
5	MILLISECONDS DELAY	S1, S2, S3	Indicate preset delay between time of local clock tick and start of oscilloscope sweep.
6	HORIZ. POS. VERNIER	R9	Provides horizontal positioning adjustment of oscilloscope trace.
7	VERT. AXIS GATED-GATE BYPASSED	S5	In GATED position vertical axis information is applied to oscilloscope at a 1-cps rate. When in GATE BYPASSED, vertical axis information applied to oscilloscope all times.
8	MARKERS NORMAL-OFF- ALL	S7	Controls application of markers. In NORMAL position, markers are displayed in the three fastest sweep times. In OFF, no markers are displayed. In ALL, markers displayed on all speeds, but no vertical deflection can occur on oscilloscope.
9	VERT. AXIS	J5	Supplies gated master timing tick (WWV) to vertical channel of oscilloscope.
10	HORIZ. AXIS	J6	Supplies sweep sawtooth to horizontal channel of oscilloscope.
11	POWER	J1	Receives input line power to instrument.
12	MASTER TICK	J4	Accepts input master tick from master timing source.
13	CLOCK TICK	J1	Accepts input clock tick from local timing source.
14	CLOCK 1KC	J2	Accepts input 1-kc pulse train from local timing source.
15	Z-AXIS	J3	Supplies unblanking signal (50-kc) to oscilloscope X-axis input.

A
SWEEP TIME SWITCH: 10MSEC
MILLISECONDS DELAY SWITCHES: 439MSEC



B
SWEEP TIME SWITCH: 1MSEC
MILLISECONDS DELAY SWITCHES: 443MSEC



LD-L-353

Figure 3-2. Waveform Interpretation

r. The time difference between the clock tick output (i. e. the Model 113 AR/BR TIME REFERENCE reading) and the start of the oscilloscope sweep (left end) can now be read directly off the MILLISECONDS DELAY switches on the comparator. The intensity markers are spaced at intervals of 1 millisecond to permit accurate measurement to the reference point on the WWV tick. See figure 3-2.

s. If the WWV tick appears to be relatively free of jitter, a more accurate reading can be made by switching the SWEEP TIME control to 1 MILLISECOND. With this sweep time, one cycle of the WWV tick appears on the oscilloscope. As shown in figure 3-2, intensity markers occur at intervals of 100 microseconds along the base line of the sweep with the left-hand marker occurring at the time indicated by the MILLISECONDS DELAY switches. The 10-microsecond dashes on the waveform start at even 10-microsecond intervals, and the spaces start at odd 10-microsecond intervals.

NOTE

To compensate for inherent comparator circuit delays when making measurements using the waveform dashes, add exactly 10 microseconds to the reading taken from the comparator dials and oscilloscope trace.

t. Record the time comparison reading in the system log. Note any unusual circumstances which could affect the validity of the reading.

3-10. USING 100 PPS TIMING CODE. A binary-coded-decimal (BCD) time-of-year signal is broadcast by WWV for 1-minute periods starting at minutes 7, 12, 17, 22, 27, 32, 37, 42, 52, and 57. A four-pulse 1-2-4-8 BCD group is used. The binary "0" is represented by a 2-millisecond pulse (2 cycles of a 1000-cps sine wave), and the binary "1" is represented by a 6-millisecond pulse (6 cycles of a 1000-cps sine wave). All BCD information pulses maintain 10-millisecond spacing.

3-11. Accurate time comparison measurements can be made using the time-of-year signal during periods of erratic radio reception. The same operation procedure is used in making time comparison as for 1-pps ticks, except that the VERT. AXIS is placed in GATE BYPASSED position. When using the 10-millisecond sweep speed, 2- and 6- cycle waveforms are displayed on the system oscilloscope continuously for one minute in the regular 1-pps tick location.

3-12. USING VLF TRANSMISSIONS. VLF transmissions are broadcast by the Naval Radio Station, NBA, at Summit, Panama and station GBR, at Rugby, United Kingdom. In this discussion reference is made to NBA which transmits a carrier of 18 KC. The carrier of NBA is keyed at a 1-pps repetition rate with a 30% duty cycle. That is, the carrier is on for 0.3 second and off for 0.7 second. Frequency comparison measurements in this case can be made only during the "on" time of the carrier.

3-13. A special wide-band VLF receiver must be used to receive time signals transmitted by NBA. The VLF signal (tick) from the receiver is connected to the comparator MASTER TICK jack. The time comparison operation procedure is generally the same as that given in paragraph 3-9, except that the waveform presented on the system oscilloscope will be similar to that shown in figure 3-3. The waveform reference point is estimated as shown in the figure. For a detailed discussion of VLF time signals, refer to R. R. Stone, Jr., W. Markowitz, and R. G. Hall. "Time and Frequency Synchronization of Navy VLF Transmissions"; IRE Transactions on Instrumentation, September, 1960.

3-14. INTERCOMPARISON OF TWO OSCILLATOR-CLOCK SYSTEMS.

3-15. The comparator monitors the drift of other clocks by measuring time intervals between a reference (or master) clock tick and the 1-pps tick of one or more local clocks. The clock tick output from the reference clock is connected to the comparator MASTER TICK (WWV) jack. Local clock 1-pps and 1000-pps outputs are connected to the comparator CLOCK TICK and CLOCK 1 KC jacks, respectively. The time comparison procedure is generally the same as that given in paragraph 3-9, except that a pulse will be viewed on the system oscilloscope instead of a WWV 5-cycle waveform. The leading edge of the pulse should be selected as the reference point to which time interval is measured.

SWEEP TIME SWITCH: 10 MSEC

MILLISECONDS DELAY SWITCHES: 439 MSEC

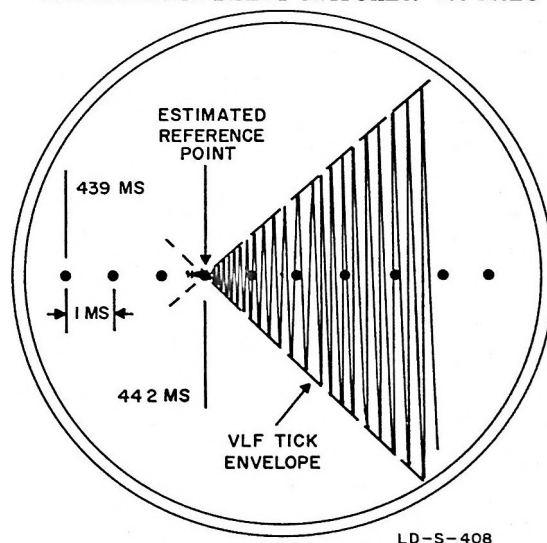


Figure 3-3. VLF Waveform Interpretation

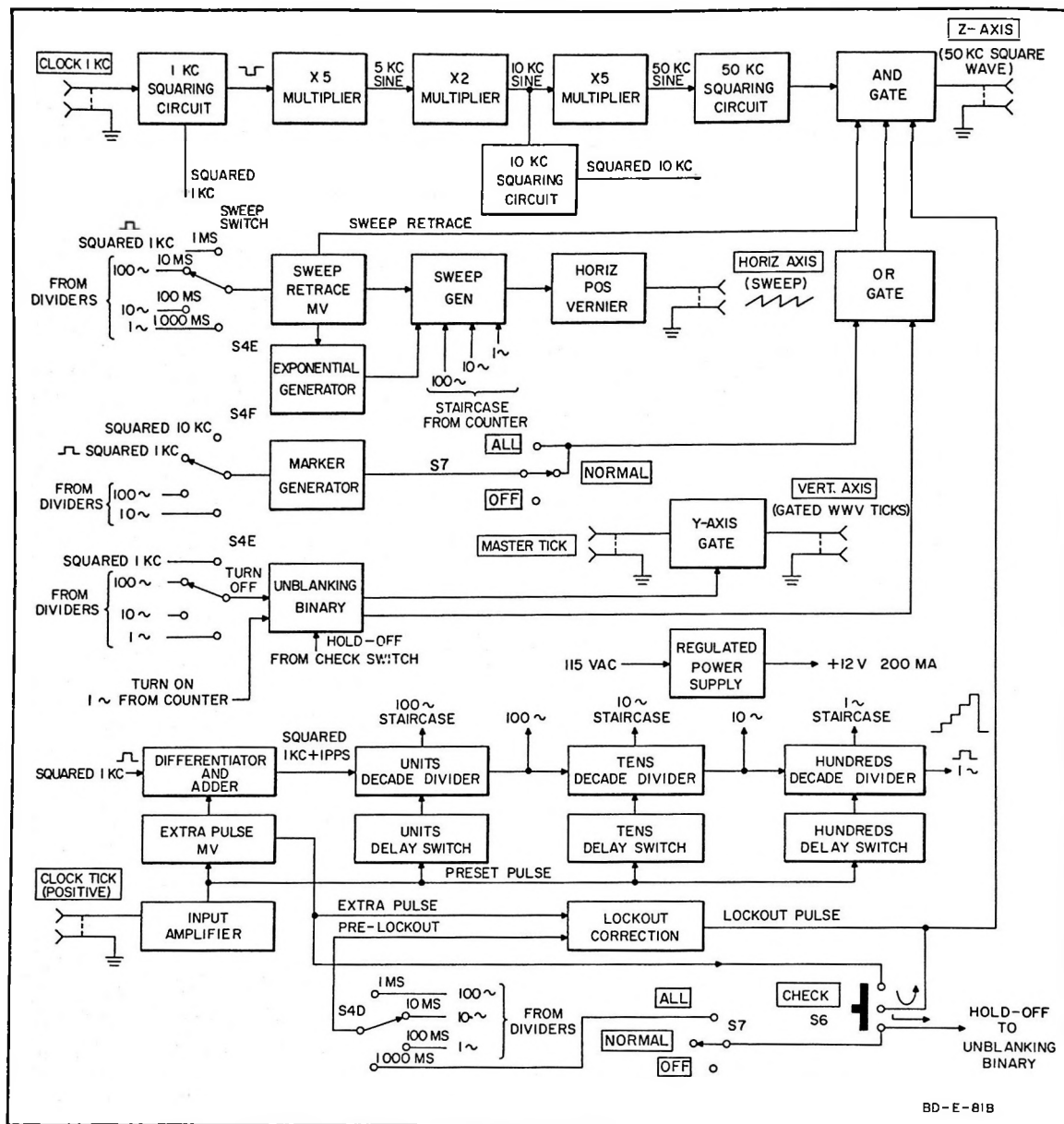


Figure 4-1. Block Diagram

SECTION IV

PRINCIPLES OF OPERATION

4-1. BASIC OPERATION.

4-2. The comparator measures the time interval between a 1-pps master tick from a master timing source and a 1-pps tick from a local clock. Basically, the comparator consists of a preset counter, sweep generator, gate control, Y-axis gate, Z-axis gate, and a multiplier circuit. An external oscilloscope serves as an indicator. The sweep generator provides a continuous sweep sawtooth voltage to the oscilloscope X-axis. An input 1-kc pulse train to the comparator is multiplied to 50-kc; the 50-kc signal, controlled by the Z-axis gate, serves as the oscilloscope unblanking signal. The Y-axis gate controls the application of the master tick to oscilloscope vertical axis. The local clock tick is delayed by the preset counter, whose output triggers the gate control at a 1-pps rate. When the Y- and Z- axis gates are opened by the gate control the sweep trace is unblanked, thus allowing presentation of the master tick. By adjusting the time delay and sweep speed, the master tick can be displayed in expanded form. Ten intensity markers are available on each sweep speed to aid in time calibration. The time interval between the occurrence of the master and local clock ticks is equal to the delay time inserted by the preset counter plus the time between the start of the oscilloscope sweep and a reference point on the master tick.

4-3. BLOCK DIAGRAM DISCUSSION.

4-4. The comparator operates in frequency or time standard systems that provide a positive 1-pps tick and a 1-kc pulse train. It is necessary that there be coincidence between these two pulse rates, otherwise measurement error will result. To ensure accurate waveform timing, the input 1-kc pulse train (applied to CLOCK 1 KC jack) from the local clock is routed through the 1-kc squaring circuit to produce a waveform with a fast transition (refer to figure 4-1). The input clock (1-pps) tick (applied to CLOCK TICK jack) is differentiated; the trailing edge is amplified and called the preset pulse.

4-5. Three decade divider boards form a preset counter. The preset pulse sets the counter to the 999-complement of the number selected on the front panel MILLISECONDS DELAY switches. (The 999 complement of a number is 999 minus the number.) The preset pulse also triggers a 200-microsecond one-shot multivibrator to produce an extra pulse. The output from the extra-pulse multivibrator is differentiated and the trailing edge is added into the positive 1-kc square wave pulse train from the 1-kc squaring circuit. The extra pulse, in effect, converts the 999-complement counter to a 1000-complement counter to permit direct reading of the delay dials. Basically, the output pulse from the hundreds decade divider represents the input clock tick delayed by the amount shown on the MILLISECONDS DELAY switches. The delayed pulse

turns on the unblanking binary that causes trace unblanking via the Z-axis AND gate and opens the Y-axis gate to allow presentation of the master tick (WWV) on the oscilloscope screen. The master tick (applied at MASTER TICK jack) is obtained from a primary or master timing source, such as WWV transmissions.

4-6. Staircase waveforms from the decade dividers serve as the linearizing voltage for the three slowest sweeps. An exponential sweep correction waveform is generated for the fastest sweep (1 ms). The sweep applied to the oscilloscope horizontal axis is continuous and accurately synchronized with the decade divider outputs, so that the unblanking interval exactly coincides with a single sweep. A single trace thus occurs once per second at some preselected time interval after the application of the preset pulse to the counter. The remaining sweeps are unblanked only during marker pulses.

4-7. Marker generator input trigger frequency is ten times the sweep repetition rate in order to produce 10 markers on each sweep range. During the unblanking binary off interval, the Y-axis input to the oscilloscope is grounded to provide a steady base line for markers. To reduce the intensity of the marker dots at high sweep speeds a marker lockout circuit is incorporated to reduce the marker duty cycle. The decade dividers provide the pre-lockout signal for the lockout circuit. The extra pulse multivibrator provides the correction signal for the lockout correction circuit.

4-8. The negative 1-kc square wave pulses from the 1-kc squaring circuit drive a series of frequency multipliers, which generate 10-kc marker pulses for the fastest sweep speed and a 50-kc square-wave for Z-axis modulation. Three multiplier stages X5, X2, X5 produce 5-kc, 10-kc and 50-kc sine waves, respectively. The 10-kc and 50-kc sine wave outputs are shaped by squaring circuits before being used to drive the marker and Z-axis circuitry. The positive 1-kc square wave pulses drive the preset counter, sweep generator and marker generator.

4-9. A self-check circuit is incorporated to ensure correct operation of all delay circuits. Extra pulse multivibrator provides the self check signal.

4-10. PRESET COUNTER LOGIC.

4-11. The comparator measures the delay in time between the clock tick and master (WWV) tick. When the two ticks are not in coincidence the clock tick is always considered to be leading the master tick. The clock provides a 1-kilocycle positive pulse train to drive the three decade dividers; one of the pulses will be in coincidence with the clock tick. To generate the desired delay the 999-complement of the number of milliseconds delay selected with the MILLISECONDS DELAY

switches is set into the counter. The counter continuously counts the 1-kilocycle pulse train, so that the last (hundreds) divider produces a pulse when the count reaches 1000 milliseconds. The start of the hundreds-divider output pulse is coincident with the start of the unblanking sweep.

4-12. When the counter is set by the preset pulse (clock tick trailing edge), an extra pulse is generated and added into the 1-kilocycle pulse train. In effect, 1001 pulses are being fed into the counter.

4-13. During zero delay (000) the counter is preset to 999. The leading edge of the counter output pulse is coincident (desired condition) with the reset pulse. Approximately 200 microseconds after the reset pulse the extra pulse triggers the counter into the 000 state, thus producing a second counter output. Integration of the two output pulses by stretcher circuits in the decade dividers prevents double triggering of the succeeding comparator circuitry.

4-14. INPUT CIRCUIT.

4-15. The input clock tick (1 pps) is differentiated and the negative-going trailing edge is amplified by amplifier Q1. (Refer to figure 5-14.) The delay between the leading edges of the clock tick and the amplifier output pulse (preset pulse) is determined by the width of the clock tick. Normal clock tick width from the model 113BR clock is 20 microseconds minimum. A feature of the comparator is that it will operate satisfactory with a clock tick up to 100-microseconds in width. The preset pulse sets the 999-complement counter and triggers the extra pulse multivibrator (Q2-Q3). Extra-pulse multivibrator output pulse is differentiated, and the resulting positive spike (trailing edge) is added to the 1-kc square wave pulses in a diode adder circuit. The extra pulse is also used in the self-check (refer to paragraph 4-47) and lockout correction circuits.

4-16. The 1-kc squaring multivibrator (figure 5-14) converts the 1-kc pulse train from the clock into square waves having fast transition. The 1-kc squaring multivibrator is basically a one-shot, whose output is a 40-microsecond pulse with a risetime of approximately 0.5 microseconds. The positive output pulses drive the decade dividers, sweep generator, and marker generator; the negative pulses drive the frequency multipliers.

4-17. Marker lockout circuit (figure 4-2) is employed to reduce the marker duty cycle and is available on the three fastest sweep speeds. The negative going output pulses from each of the decade dividers serve as the pre-lockout signal to be selected by S4D. Lockout signal is connected (at factory) for lockout operation on the fastest sweep (1 ms) only. By connecting jumpers across the terminal pins E1-E2 and E3-E4, reduced marker duty cycle is available on the 10 and 100 millisecond sweeps.

4-18. In all cases, the lockout signal consists of a +11-volt level on 80 percent of the time and a +1-volt level on 20 percent of the time. The Z-axis gate control is disabled during the duration of the +11-volt

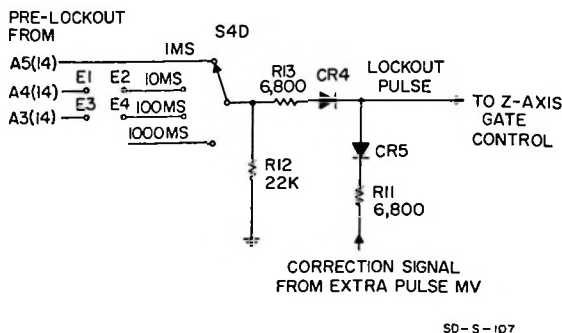


Figure 4-2. Lockout Correction

level. An unwanted 200-microsecond pulse occurs in the lockout signal during the extra-pulse multivibrator interval for some settings of the delay switches. For a delay setting of 000, this pulse occurs approximately 10 microseconds after the unblanking binary has been turned on, and would blank the first 200 microseconds of the oscilloscope trace if it were allowed to disable the Z-axis gate control. A correction signal from the extra pulse multivibrator causes CR5 to conduct, thus cancelling the effect of the unwanted signal.

4-19. PRESET COUNTER.

4-20. Three identical plug-in dividers, each containing four binary circuits, comprise the preset counter (figures 5-12 and 4-3). Each divider is basically a scale-of-16 binary counter modified by feedback to provide decimal counting. Counting logic is 1, -2, -4, 8. The dividers count in a standard binary fashion until immediately after the tenth input pulse, when a positive feedback pulse from binary D (collector Q8) reverses binaries B and C, and advances the count by 6; thus, the divider recycles at pulse 10 instead of 16. A count is set into each divider by the preset pulse from the associated MILLISECONDS DELAY switch. The number inserted is always the nine's-complement of that number as shown on the MILLISECONDS DELAY switch.

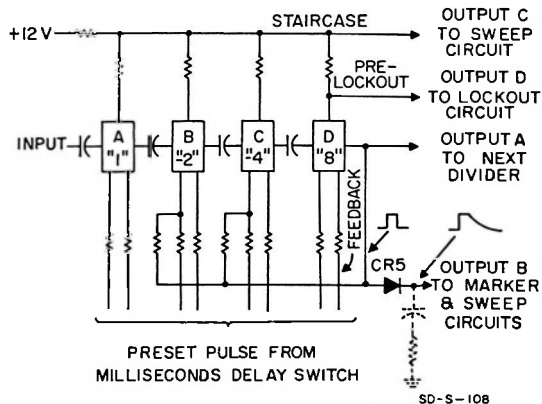


Figure 4-3. Decade Divider

4-21. Three separate output signals are taken from binary D of each decade divider (figure 5-15). A positive 9-volt transition (output A) taken off Q8 collector serves as the input trigger for the next divider. During the negative transition of this output signal, diode CR5 is reverse biased. Capacitive loading of the output signal forms a unidirectional integrator (stretcher circuit). The stretcher circuit stretches the negative-going trailing edge by several milliseconds. This prevents double triggering of the sweep and marker generators by a divider which is preset from "0" to "9" or from "2" to "1". The pre-lockout signal (output D) from each decade divider is routed to section D of SWEEP TIME switch (S4).

4-22. A five-resistor combination provides a 1.5-volt staircase waveform riding on a 9-volt baseline level. The staircase amplitude at any instant is proportional to the count in the decade divider at that instant. Staircases are used to linearize the three slowest sweeps.

4-23. FREQUENCY MULTIPLIERS.

4-24. The three multiplier circuits (figure 5-13) provide 5-kc, 10-kc and 50-kc sine waves from the input 1-kc pulse train. Each of the multiplier circuits consists of a normally cutoff current source with a double-tuned and over-coupled tank circuit. The transistors conduct during a small portion of the input cycle, and sustain a ringing waveform voltage in their respective resonant circuits. A fixed 90-degree leading phase shift is introduced in the output frequency of each multiplying stage.

4-25. 10-KC SQUARING CIRCUIT.

4-26. The output from the 10-kc squaring circuit (figure 5-13) is used to produce 100-microsecond markers on the 1-millisecond sweep range. The squaring circuit produces a positive pulse whose leading edge is in coincidence with the negative going zero crossing of the input 10-kc sine wave. An additional 90-degree lagging phase shift (25 microseconds) at 10-kc is required to align the output 10-kc square wave with the 1-kc square wave reference pulses entering the first multiplier stage (Q1). The 25-microsecond delay is obtained by feeding the 10-kc sine wave through L1, into a low resistance load consisting of a saturated transistor (Q8) base and diode CR3. The sine-wave current is amplified and clipped by Q8 whose output is used to trigger a conventional Schmitt trigger circuit (Q9-Q10).

4-27. 50-KC SQUARING CIRCUIT.

4-28. The output from the 50-kc squaring circuit (figure 5-13) is used to intensity modulate the Z-axis of the oscilloscope, thus producing well defined dashes and spaces on the oscilloscope trace. The input emitter follower Q4 (normally cut-off) is biased to clip the positive half cycle of the input 50-kc sine wave. Squaring amplifier Q5 (normally conducting) completes the squaring operation and drives the complementary symmetry circuit Q6-Q7 with a 0 to +12-volt, 50-kc square wave signal. The gate reference voltage at terminal 1 (T4) is +6 volts. The Z-axis gate control is connected

to the return lead of the T4 primary to provide 50-kc gating.

4-29. UNBLANKING BINARY.

4-30. The 50-kc unblanking signal is gated to the oscilloscope during one sweep interval each second. Unblanking binary Q1-Q2 (figure 5-16) controls the Z-axis unblanking gate. This binary is turned on by the positive going 1-pps output of the hundreds-decade divider A3 and turned off by the sweep trigger that is selected by the SWEEP TIME switch (S4E). The differentiating time constant of the turn-on input is made relatively long to turn on and hold the binary circuit even though other pulses may be occurring at the binary-off input. During the binary-on interval a negative signal from the collector of Q1 is sent to the Z-axis gate control to unblank the trace and a positive pulse level is sent to the Y-axis gate (Switch, Q3) to open the gate.

4-31. For viewing of the 1000-millisecond sweep speed markers the unblanking binary must be turned off. By operating the MARKERS switch (S7) to ALL, the hold-off signal (ground through a 22K resistor) is applied to the binary. When this condition exists, it is not possible to have a WWV tick presentation since the Y-axis gate is held closed by the unblanking binary circuit.

4-32. Z-AXIS GATE CONTROL.

4-33. The Z-axis gate control (figure 5-16) supplies the necessary gate (referenced to +6V) that controls the 50-kc unblanking signal. As shown in figure 4-4, the gate consists of a two-input "OR" gate, a three-input "AND" gate, gated amplifier Q4, emitter follower Q5, and a-c switch Q6. Unblanking occurs during either an unblanking binary pulse or a marker pulse, provided that no retrace blanking pulse is present. When the lockout signal is applied, the gate is held closed for its duration, regardless of any signals from the marker generator or the unblanking binary circuit.

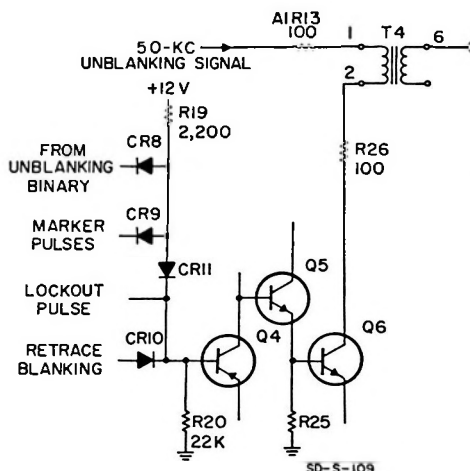


Figure 4-4. Z-axis Gate Control

4-34. Normally, when Q4 is conducting, the gate is open. Thus a negative 6- to 9-volt pulse at the base of Q4 drives Q5, which, in turn, drives Q6 into saturation. This action closes the primary circuit of T4 allowing the 50-kc unblanking signal to pass through to the oscilloscope Z-axis. Damping resistors R26 and A1R13 reduce overshoot caused by T4 leakage inductance.

4-35. SWEEP GENERATOR.

4-36. The sweep generator circuit (figure 5-17) produces a positive-going linear sawtooth which is made available at HORIZ. AXIS jack J6. This circuit consists of sweep-retrace multivibrator Q1-Q2, switch Q3, an RC sweep circuit, and exponential generator Q4.

4-37. The staircase waveforms generated by the decade counters serve as the linearizing voltages for the RC sweep circuit. The linearization voltage for the 1-millisecond sweep range is not available in staircase form. Generator Q4 provides the exponential sweep correction voltage for linearization of this sweep. Selection of the appropriate charging capacitors and resistors for the various sweep ranges is accomplished by sections A and B of the SWEEP TIME switch (S4). Each sweep range is individually calibrated with potentiometers R12 through R15. By splitting the sweep charge currents through the HORIZ. POS VERNIER (R9) and the calibration potentiometers the same d-c level is maintained for the four sweep outputs.

4-38. The sweep timing capacitors are discharged through CR1 and Q3, when the switch (Q3) is closed by the negative retrace pulse from the sweep-retrace multivibrator. The sweep is reset at approximately +0.6 volts (determined by the forward drop in diode CR1). During discharge time (retrace), CR1 conducts heavily; however, toward the end of the retrace time the resistance of CR1 increases, and the discharge time-constant lengthens. Adjustment of the retrace pulse width, for each sweep range, ensures that all sweeps will return to the same d-c point. The sweep trigger for the sweep-retrace multivibrator is selected from the decade counter outputs by switch (S4E).

4-39. The retrace (blanking) pulse is also used for blanking the oscilloscope during sweep retrace. The retrace time on the 100-millisecond sweep range must be less than the duration of a WWV tick to ensure that the tick remains visible. This sweep circuit retraces the beam in 0.5 millisecond on the 1000-millisecond range, although blanking lasts for 1.5 milliseconds.

4-40. MARKER GENERATOR.

4-41. The marker generator (figure 5-17) is basically a one-shot multivibrator circuit, formed by transistors Q5 and Q6. The selected input triggers (by S4F) are of a frequency ten times that of the sweep repetition rate which produces ten markers (0 through 9) on each sweep range. The width of the marker pulse changes for each sweep range. The reason is that the retrace blanking pulse occurs simultaneously with the first marker and blanks a portion of the marker. Since the retrace blanking pulse width varies with sweep speed, the marker width is made to vary correspondingly in

order to remain visible and to maintain a uniform marker-dot brightness on the screen. The first marker on the oscilloscope screen always represents zero time delay from the beginning of the sweep.

4-42. Y-AXIS GATE.

4-43. The WWV tick from the receiver enters the comparator (J4, BNC) and passes through R18, C4, C6, and R7 to the oscilloscope Y-axis (figure 5-16). Switch transistor Q3 allows the Y-axis signal to pass to the oscilloscope when gated off by a positive pulse from the unblanking binary circuit. Normally Q3 shunts the Y-axis signal to ground. Breakdown diode CR3 provides +7 volts at the Q3 collector. Resistor R16 is shunted across the collector-emitter to ensure that the collector d-c voltage does not shift during the off interval.

4-44. The VERT. AXIS switch (S5) allows by-passing of the Y-axis gate when the comparator is used with time standards that provide time references or marks more frequently than once per second, such as the WWV time-coded signal. When S5 is in the GATED position, the Y-axis gate opens once per second for a period of time determined by the sweep time setting, thus providing vertical axis information to the oscilloscope for the duration of a single sweep. With S5 in GATE BYPASSED, vertical axis information is supplied to the oscilloscope at all times, enabling 10-pps, 100-pps, or 1000-pps marks to be viewed. VERT. AXIS switch holds the Y-axis gate open by reverse biasing the emitter-base junction of Q3.

4-45. POWER SUPPLY.

4-46. The power supply (figure 5-18) provides +12 volts at 200 milliamperes to the comparator circuitry. Load voltage is maintained relatively constant during normal line-voltage fluctuations. A feedback loop series-regulator type regulation system is employed. The loop consists of a current amplifier (Q2) driving an emitter follower (driver Q1), which furnishes the additional current gain needed to drive the series regulator transistor. Any change in the Q2 base current is coupled to Q1. The high voltage winding output of transformer T5 (approximately 100 volts) is half wave rectified (by CR1) and regulated to 25 volts by CR2. Diode CR3 provides a reference voltage for Q2 base. Potentiometer R16 provides output voltage adjustment. The series regulator transistor is connected as a grounded emitter amplifier and functions the same as the series tube in a conventional vacuum-tube regulator.

4-47. SELF-CHECK CIRCUIT.

4-48. The self-check circuit consists of the CHECK pushbutton (S6), which controls the application of the negative-going extra pulse to the unblanking binary and Z-axis gate control (figure 5-12). The unblanking binary is held off (which in turn holds off the Y-axis gate) during check to prevent Y-axis deflection. Z-axis gate control is open during the presence of the 200-microsecond extra pulse. This results in a single intensity-modulated dot appearing on the oscilloscope screen, the position of which corresponds to 1000

milliseconds from the initial clock tick. This intensity-modulated dot can be shifted in time throughout the range of the comparator.

4-49. Note that pressing the CHECK button introduces additional loading on the extra-pulse multivibrator, and reduces the amplitude of the extra pulse as seen at the input to the decade dividers. This introduces a safety factor, so that if the response of the decades to the extra pulse is marginal, a 1-millisecond self-check error will occur (paragraph 5-19).

4-50. PROTECTION FEATURES.

4-51. Protection features incorporated in the comparator enable the unit to withstand accidental appli-

cation of external voltages. Most of the protection circuits are in the form of breakdown diode and resistor combinations at the inputs and outputs of the comparator (figures 5-13, 5-14, 5-16, and 5-17).

4-52. In the event that the 50-kc squaring circuit output line is shorted to either ground or +12 volts, damping resistors A1R13 and A6R26 (figure 4-4) limit the short-circuit current to 120 milliamperes.

NOTE

A summary of key time relationships is given in the timing chart, figure 5-11.

SECTION V MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains instructions for servicing, troubleshooting, and adjusting the comparator. Waveforms, schematics and component location diagrams are included at the rear of this section.

5-3. SERVICING.

5-4. GENERAL. It is assumed that the maintenance specialists have been thoroughly trained in maintenance practices and have had previous experience on similar types of equipment. The following materials, or their equivalents, are used for maintenance:

Lintless cloth

Stiff (non-metallic) bristle brush

Solvent (Trichloroethane, Federal Specification O-T-620)

Compressed air (filtered, moisture- and oil-free, 30 psi maximum)

60/40 Solder (Military Specification MIL-S-6872)

5-5. CLEANING. Clean the equipment by brushing, wiping with a lintless cloth, vacuuming, or by blowing with compressed air. Solvents may be used when specified for additional cleaning action. Use brush or cloth moistened with solvent to clean dirty portions of the instrument.

WARNING

When using solvents provide adequate ventilation and skin protection.

CAUTION

Solvents may damage paint and identification marks.

5-6. INSPECTION, REPAIR, AND REPLACEMENT. Visually inspect the chassis and assembly boards for missing or damaged parts. Instructions for the removal and replacement of parts mounted on printed circuit assembly boards are given in paragraphs 5-7 and 5-8.

CAUTION

The cases of power supply filter capacitors C33 and C34 are coated with a plastic compound to insulate them from the chassis. Do not puncture this insulation or permit shorting between the capacitor case and chassis.

5-7. REMOVAL OF PARTS FROM BOARDS. The procedure for removal of lead-mounted parts from boards is as follows:

CAUTION

Excess heat will damage printed cards. Use 40-watt soldering iron with 1/8 inch tip at temperature not greater than 550 degrees F. Do not apply soldering iron for more than five seconds to any one area. Protect heat-sensitive parts with heat sink between part and solder point.

- a. Cut component lead at point A, figure 5-1.
- b. Apply soldering iron to lead stub.
- c. Remove lead from card in the direction shown in figure 5-1.

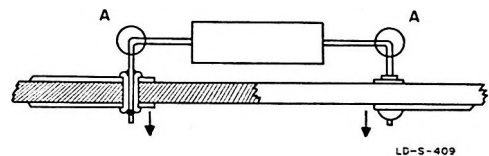


Figure 5-1. Removal of Part from Printed Circuit Assembly Board

5-8. REMOUNTING PARTS ON BOARD. Replace parts on the assembly board in accordance with the following procedure:

- a. Assure minimum clearance of 1/32 inch between part and board.
- b. Allow minimum of 1/8 inch between lead bend and body of part.
- c. Adjust clearance between part and printed board with a spacer.
- d. Crimp protruding part leads prior to soldering.
- e. Solder with small-diameter, 60/40, rosin-core solder.
- f. Apply minimum heat that allows free flow of solder.

5-9. TROUBLESHOOTING.

5-10. In general, the following approach is recommended to locate circuit failures in the comparator:

a. Sectionalize trouble by substituting assembly boards (paragraph 5-11) and performance of operational check procedures (paragraph 5-17).

b. Localize trouble, using symptom-to-cause table (table 5-2) and waveform timing chart (figure 5-11).

c. Check for failure of individual components by substitution, resistance measurements, etc.

5-11. Recommended spare assembly boards to be kept on hand:

Multiplier Assembly
Input Assembly
Divider Assembly
Gating and Unblanking Assembly
Sweep and Marker Generator Assembly

An extender board is supplied to facilitate circuit troubleshooting. The extender board is fastened to the top chassis cover (inside) by two wing nuts.

5-12. TEST EQUIPMENT. Recommended test equipment for complete maintenance of the comparator is listed in table 5-1.

Table 5-1. Recommended Test Equipment

Type	Application	Recommended Instruments	
		Commercial	Military
Electronic Voltmeter	General troubleshooting	Ⓢ Models 410B, 412A	AN/PRM-16 TS-375A/U AN/USM-34 TS-487/U ME-25A/U TS-505/U ME-26/U TS-520/U
Test Oscilloscope (dual channel preferred)	General troubleshooting; multiplier alignment; operational checks.	Ⓢ Models 122A, 150A with 152B Plug-in	AN/USM-24 AN/USM-25
Test Oscillator (1 kc to 100 kc range)	General troubleshooting; alignment of multipliers; operational checks.	Ⓢ Models 200CD, 200T	AN/USM-30 SG-83(XC)/U TS-382E/U
Electronic Counter (to 100 kc)	Monitoring test oscillator output during multiplier alignment.	Ⓢ Models 522B, 523B/C/D, 524B/C/D	AN/FRM-3 AN/USM-29 AN/URM-18 FR-4/U AN/URM-79 FR-5/U AN/URM-80 FR-38/U AN/USM-26 FR-47/U
Capacitor Substitution Box	Multiplier alignment	Cornell-Dubilier Model CDA-5	none

Table 5-2. Symptom-to-Cause

No.	Symptom	Cause
1	Instrument dead	Fuse
2	All sweep signals are reduced or increased by the same magnitude.	Check oscilloscope calibration; check +12 volt adjustment.
3	Rapid horizontal jitter in all markers	Poor regulation (A8, figure 5-18)
4	No sweep output on any sweep speed	Retrace circuit (A7)
5	Markers not available on any sweep	Marker generator (A7)
6	Self-check dot not available on any sweep speed.	Extra pulse mv (A2)

Table 5-2. Symptom-to-Cause (Continued)

No.	Symptom	Cause
7	Delay decreases by 1 ms each second (self-check dot moves to the right 1 cm/sec on the 10 ms sweep speed); decades not resetting; extra pulse multivibrator functioning.	Input amplifier (A2)
8	Delay 1 ms too long, but self-check dot is available.	Diode adder. Insufficient output of the extra pulse multivibrator (A2).
9	With a delay setting of 000, the first two cm of the 1 ms sweep are blanked.	Lockout circuit (A2)
10	50 kc unblanking square wave distorted or not present. No markers available on 1 ms sweep speed.	1 kc squaring circuit (A2); first and second multipliers (A1). Misalignment of multipliers.
11	Same as 10, except markers available on 1 ms sweep speed.	Third multipliers and/or 50 kc squaring circuit (A1).
12	No markers on 1 ms sweep speed.	10 kc squaring circuit (A1)
13	No sweep output on 10, 100, or 1000 ms sweep speeds.	Diode adder (A2), 1-kc squaring (A2) circuit, units decade divider (A5)
14	X-axis gate held closed or open on all sweeps; once/second Z-axis unblanking signal not present (or always present). Sweep outputs are correct.	Unblanking binary (A6)
15	Y-axis gate held closed or open on all sweeps; Z-axis signal correct.	Y-axis gate (A6)
16	Y-axis gate held closed on all sweeps; once/second Z-axis unblanking signal not present; no sweep output on 1000 ms sweep speed.	No output from hundreds decade divider (A3)
17	Z-axis unblanking signal occurs more frequently than once/second; 1000 ms sweep signal too short in duration.	Hundreds decade divider (A3) not dividing properly.
18	Same as 16, except there is no sweep output on 100 or 1000 ms speeds.	No output from tens decade divider (A4).
19	Same as 17, except that 1000 and 100 ms sweeps are both too short in duration	Tens decade not dividing properly (A4).
20	Same as 16, except there is no sweep output on 1000, 100, or 10 ms speeds.	No output from units decade (A5).
21	Same as 17, except 1000, 100, and 10 ms sweeps all too short in duration.	Units decade not dividing properly.
22	1 ms sweep output nonlinear	Exponential generator (A7)

u. Adjust C5 until the positive leading edge of the 10-kc pulse occurs 10-microseconds after the positive leading edge of the 1-kc pulse (refer to waveforms 36 and 38).

v. With the test oscilloscope synchronized on the 1 kc as in step t, monitor the Z-axis output (T4, pin 4) with a sweep of 10 μ sec/cm. Adjust C18 until the first visible negative Z-axis pulse (50 kc) begins 10-microseconds after the positive leading edge of the 1-kc pulse (refer to waveforms 36 and 40).

5-16. CALIBRATION OF SWEEP SPEEDS.

a. Perform electrical connections per paragraph 2-10. Set MARKERS switch (S7) to ALL.

b. Adjust the system oscilloscope (@120A/AR) HOR. SENS. control to .1 VOLTS/CM, horizontal VERNIER to CAL., VERT. SENSITIVITY to 100 MILLIVOLTS/CM, and INTENSITY control fully counter-clockwise.

c. Observe the system oscilloscope trace for proper presentation on each of the comparator's four sweep speeds. Proper presentation consists of ten marker dots across the oscilloscope face; markers will be over-ridden by a once-per-second trace on all but the 1000-millisecond sweep.

d. With the SWEEP TIME switch set to 1, adjust R12 so that each marker dot exactly coincides with an intersection on the oscilloscope graticule, the distance between adjacent markers is exactly 1 centimeter. There should not be a marker to the right of the tenth centimeter. Tighten lock nut and recheck marker spacing.

e. With the SWEEP TIME switch set to 10, adjust R13 to position the markers as in d above.

f. With the SWEEP TIME switch set to 100, adjust R14 to position the markers as in d above.

g. With the SWEEP TIME switch set to 1000, adjust R15 to position the markers as in d above.

5-17. OPERATIONAL CHECKS.

5-18. The operational checks should be performed: when instrument malfunctions are suspected, when troubleshooting, and after the performance of alignment or calibration procedures. Connect instrument per instructions in paragraph 2-10.

5-19. SELF-CHECK.

a. With the MILLISECONDS DELAY switches set to 000 and the SWEEP TIME switch at 10, press the CHECK button. A single once-per-second dot should appear instead of the marker on the left edge of the system oscilloscope. Change the delay switch to 009; this should move the dot one centimeter to the right. Repeat for settings of 008, 007, 006, through 001; each successive setting should move the dot one centimeter to the right, until at the setting, 001, the dot should appear instead of the marker on the right edge.

b. Repeat step a, with the SWEEP TIME switch set at 100, and the delay setting changes of 000, 090, 080, through 010; the dot appears and moves in the same manner as previously described.

c. Repeat step a, with the SWEEP TIME switch set at 1000, and delay settings of 000, 900, 800 through 100; the dot must appear as in a above, except for the setting of 000. For this setting, the dot should not appear.

5-20. MARKER CHECK.

a. Set MARKERS switch to ALL, the markers should be present at all four comparator sweep speeds. When in the OFF position, the markers should not be visible on the sweeps. In the NORMAL position, markers are provided only at the three fastest sweep speeds.

b. Place the MARKERS switch in NORMAL position, and the SWEEP TIME switch to 1; remove assembly board A5 from the instrument. The markers presented on the system oscilloscope screen should become brighter (increase in duty cycle). Replace assembly board.

c. With the SWEEP TIME switch set to 10, short the terminal pins E1 and E2 (figure 5-3). The marker intensity should be reduced. Remove the short.

d. With the SWEEP TIME switch set at 100, short the terminal pins E3 and E4. The marker intensity should be reduced. Remove the short.

e. Synchronize the test oscilloscope on the positive leading edge of the tick from the Hewlett-Packard Model 113BR clock. Set the SWEEP TIME switch to 1, the MILLISECONDS DELAY switches to 000, and the MARKERS switch to OFF. Monitor the Z-axis unblanking signal (T4, terminal 4); observe a 1-millisecond burst of the 50-kc square wave of at least 35 volts peak-to-peak. When the duration of the burst is less than 1-millisecond there is a malfunction in the marker lockout circuit.

5-21. RETRACING BLANKING CHECK.

a. Monitor the Z-axis unblanking signal, as in paragraph 5-20 e, except that the SWEEP TIME switch is set to 100. The unblanking signal should be delayed 150-microseconds $\pm$ 20 percent from the start of the test oscilloscope sweep.

b. Repeat step a above with the SWEEP TIME switch set to 1000. The unblanking signal should be delayed 1.5-milliseconds $\pm$ 20 percent from the start of the test oscilloscope sweep.

5-22. HORIZ. POS VERNIER CHECK. With markers presented on the system oscilloscope screen, rotate the HORIZ. POS VERNIER control in a clockwise direction; the presentation on the system oscilloscope should move to the right. The control should provide

approximately two centimeters of adjustment on the system oscilloscope when rotated from full clockwise to full counterclockwise position.

5-23. Y-AXIS GATE CHECK.

a. Set the MARKERS switch to OFF, the VERT. AXIS switch to GATED, and the SWEEP TIME switch to 1000. Set the vertical sensitivity on the system oscilloscope to 1 volt/cm. Connect a 4.5-kc signal from the test oscillator to the comparator MASTER TICK receptacle, and adjust the test oscillator amplitude control for two centimeters vertical deflection on the system oscilloscope. The 4.5-kc signal must appear once per second on the oscilloscope for each position of the SWEEP TIME switch.

b. Set the VERT. AXIS switch to GATE BYPASSED position. When the oscilloscope intensity is increased,

the 4.5-KC signal must appear uninterrupted on all four comparator sweep speeds.

c. Return the VERT. AXIS switch to GATED position, set MARKERS switch to NORMAL, and set the system oscilloscope vertical sensitivity control to 10 mv/cm. Observe the markers with the SWEEP TIME switch in the 100, 10 and 1 MILLISECONDS positions; there should not be a d-c displacement of the markers. It should not be necessary to readjust the vertical control on the system oscilloscope. The vertical smear of the markers should not be greater than 1.5 cm.

d. Disconnect the 4.5-kc signal and set the vertical sensitivity control of the system oscilloscope to 100 mv/cm. The markers and the once-per-second trace should appear at exactly the same vertical level (the trace should bisect the markers).

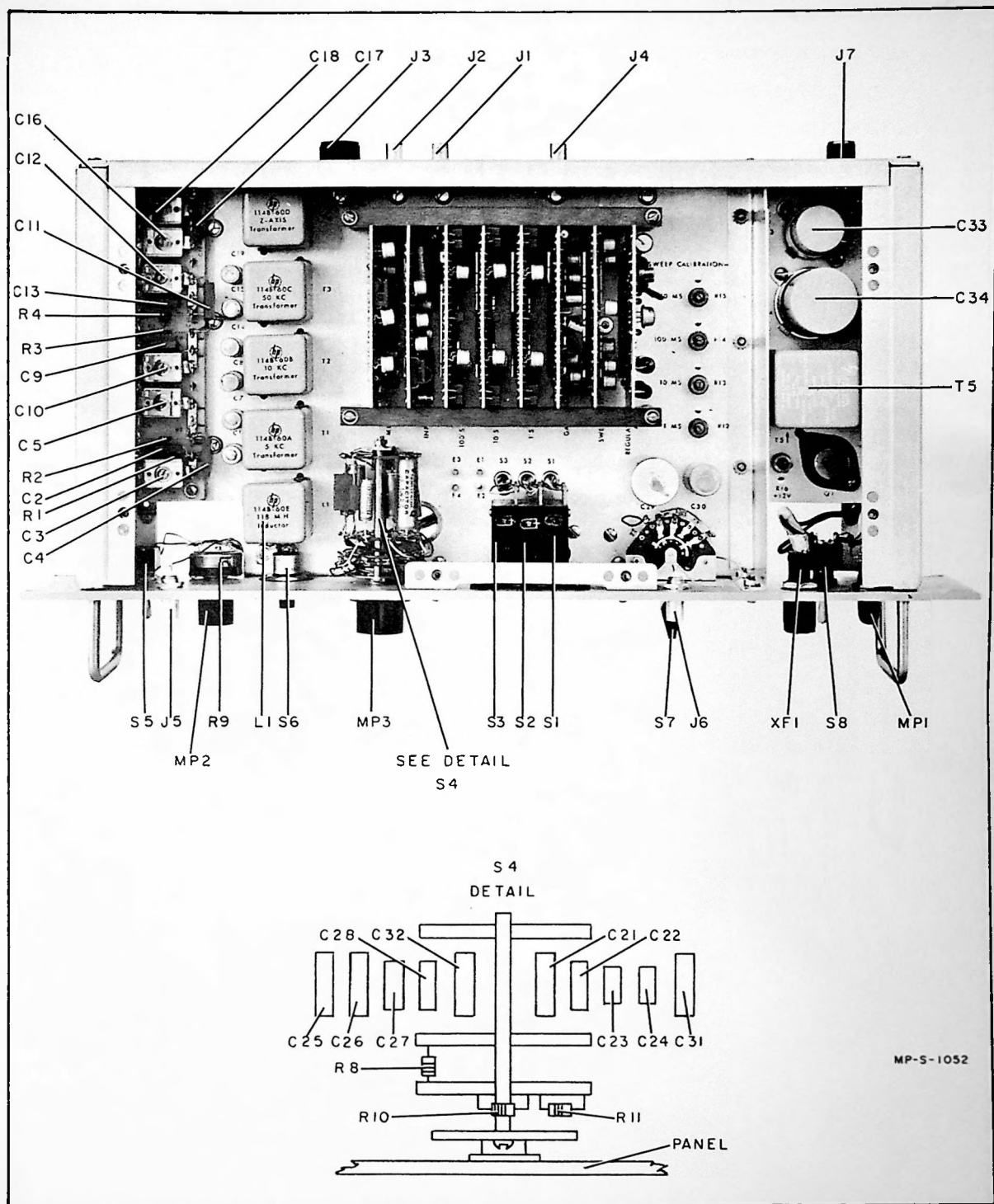


Figure 5-3. Comparator Top View, Component Location

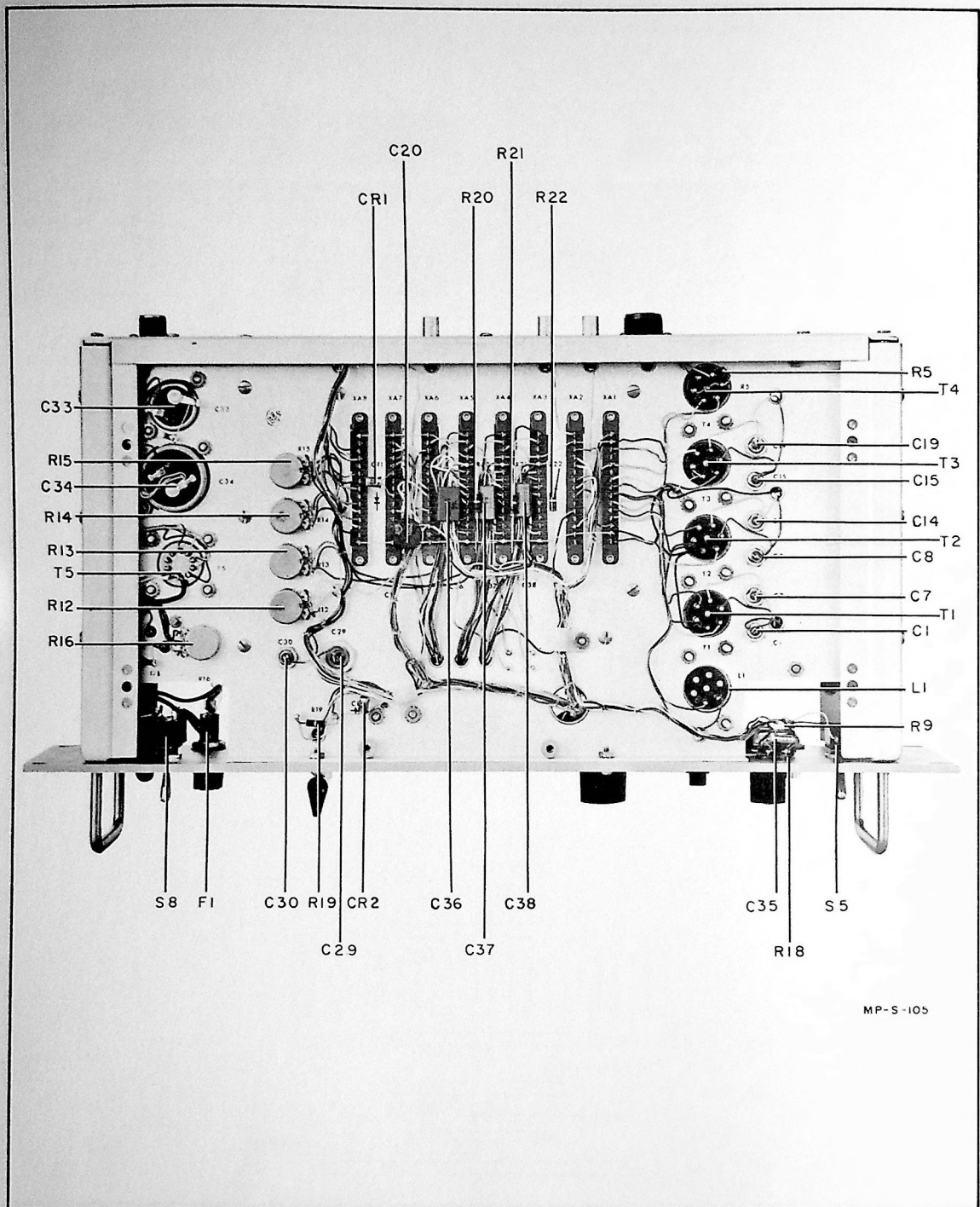
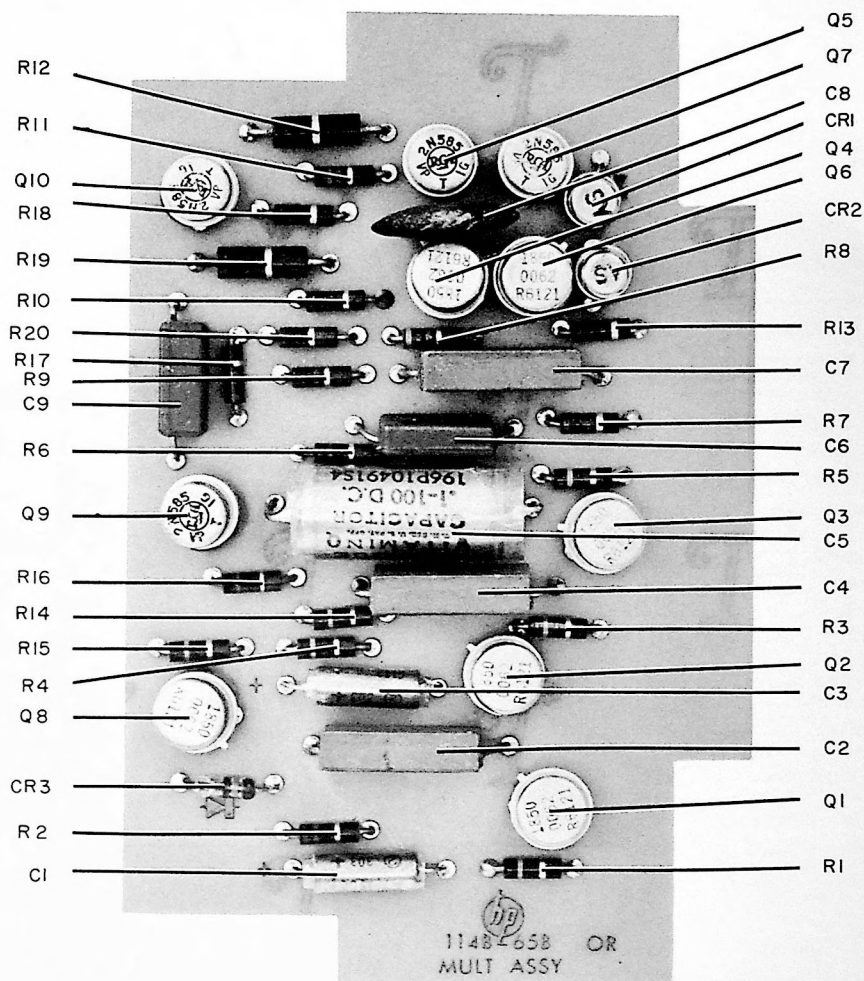
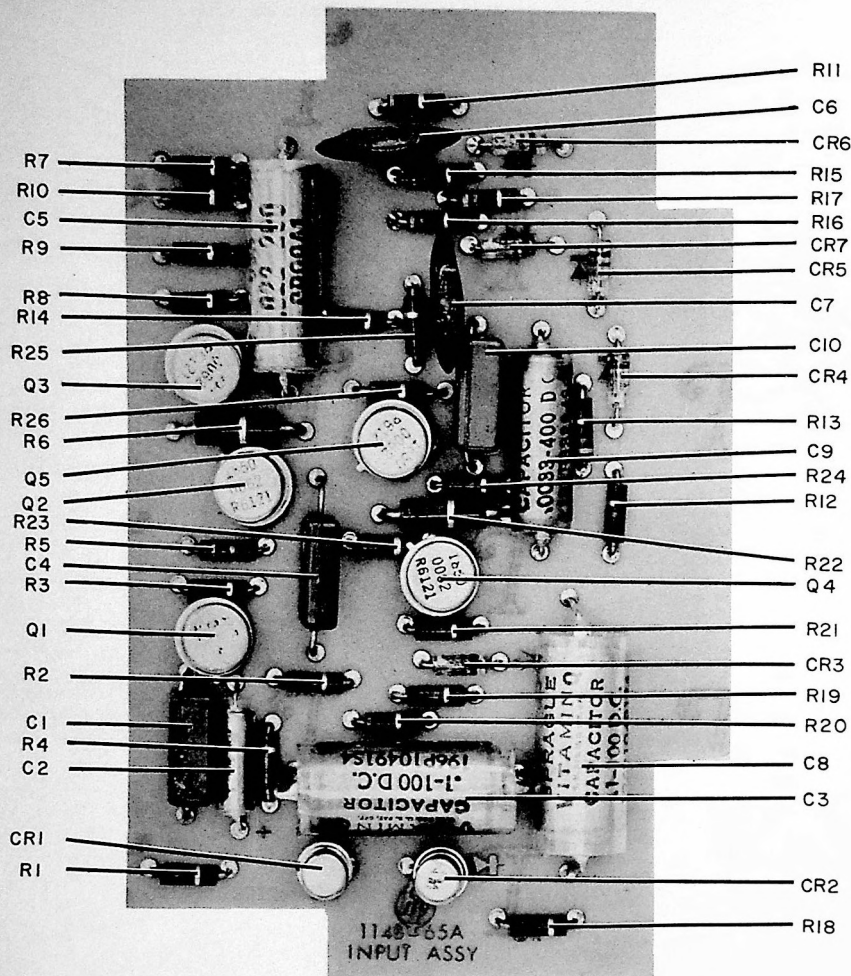


Figure 5-4. Comparator Bottom View, Component Location



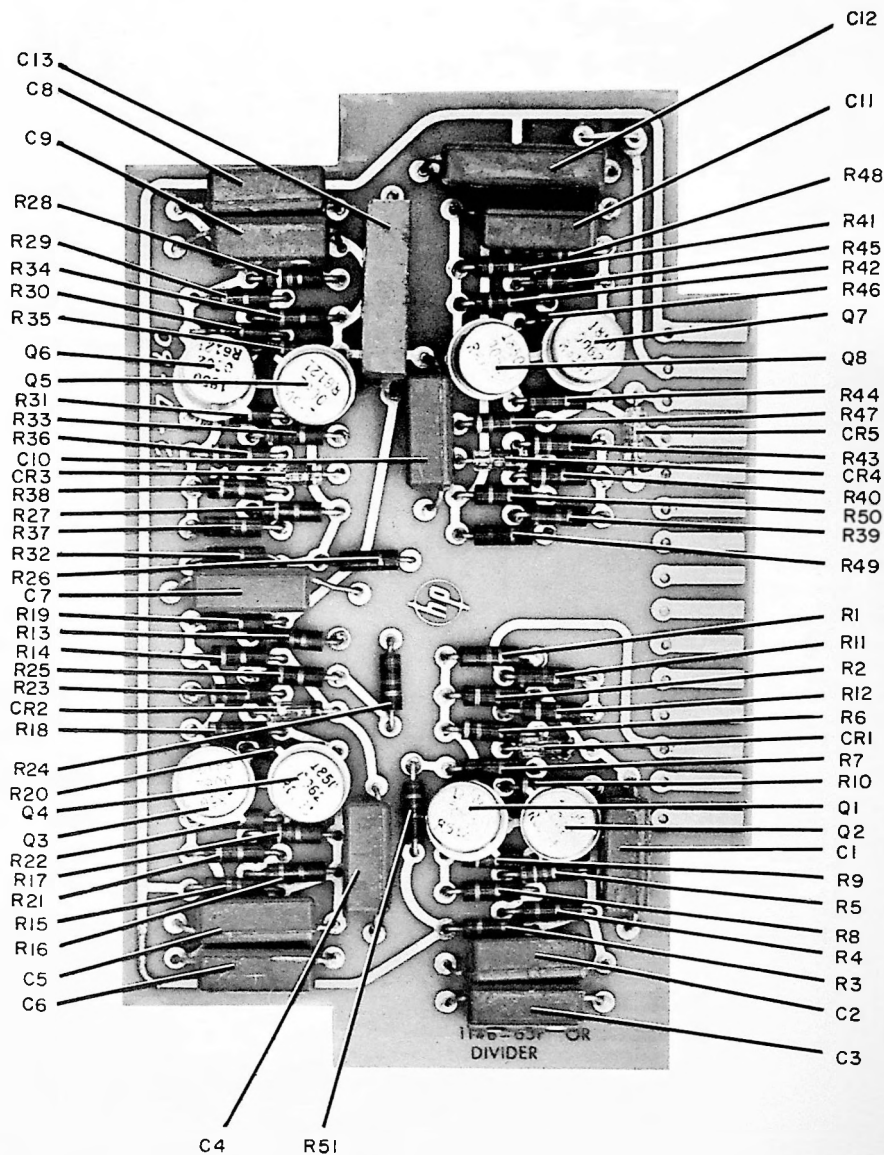
MP-S-876

Figure 5-5. Multiplier Assembly A1, Component Location



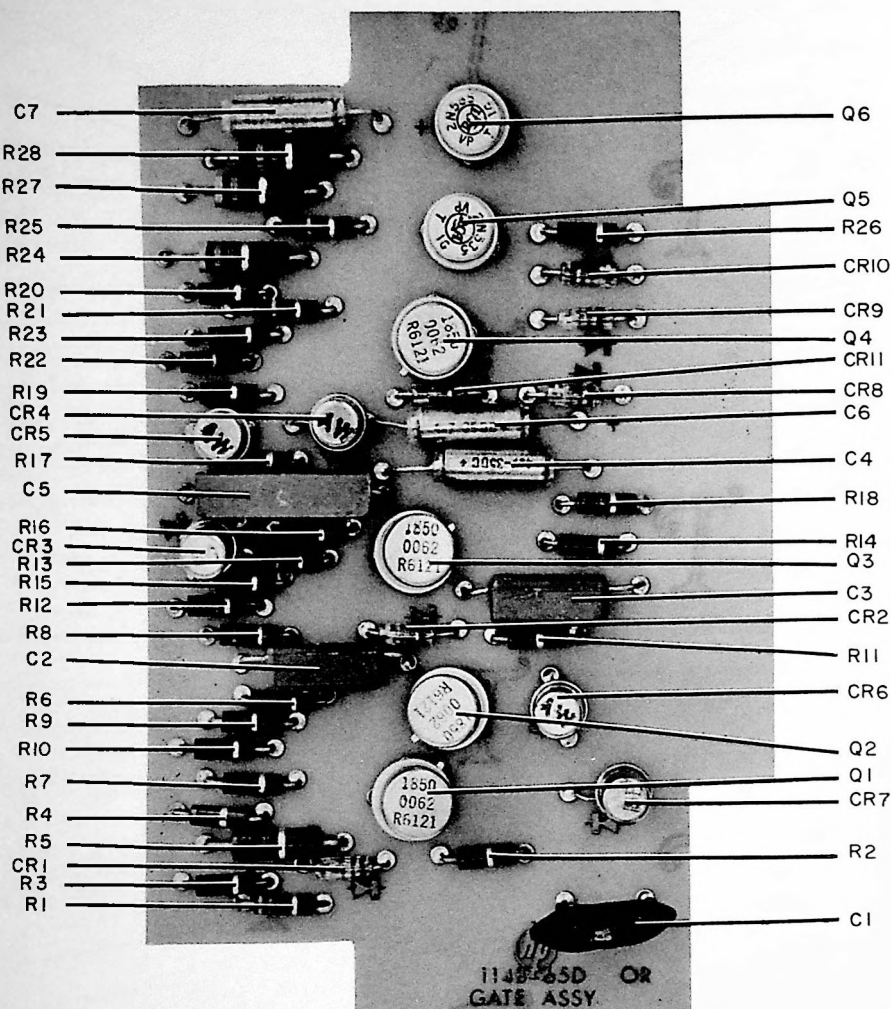
MP-S-867

Figure 5-6. Input Assembly A2, Component Location



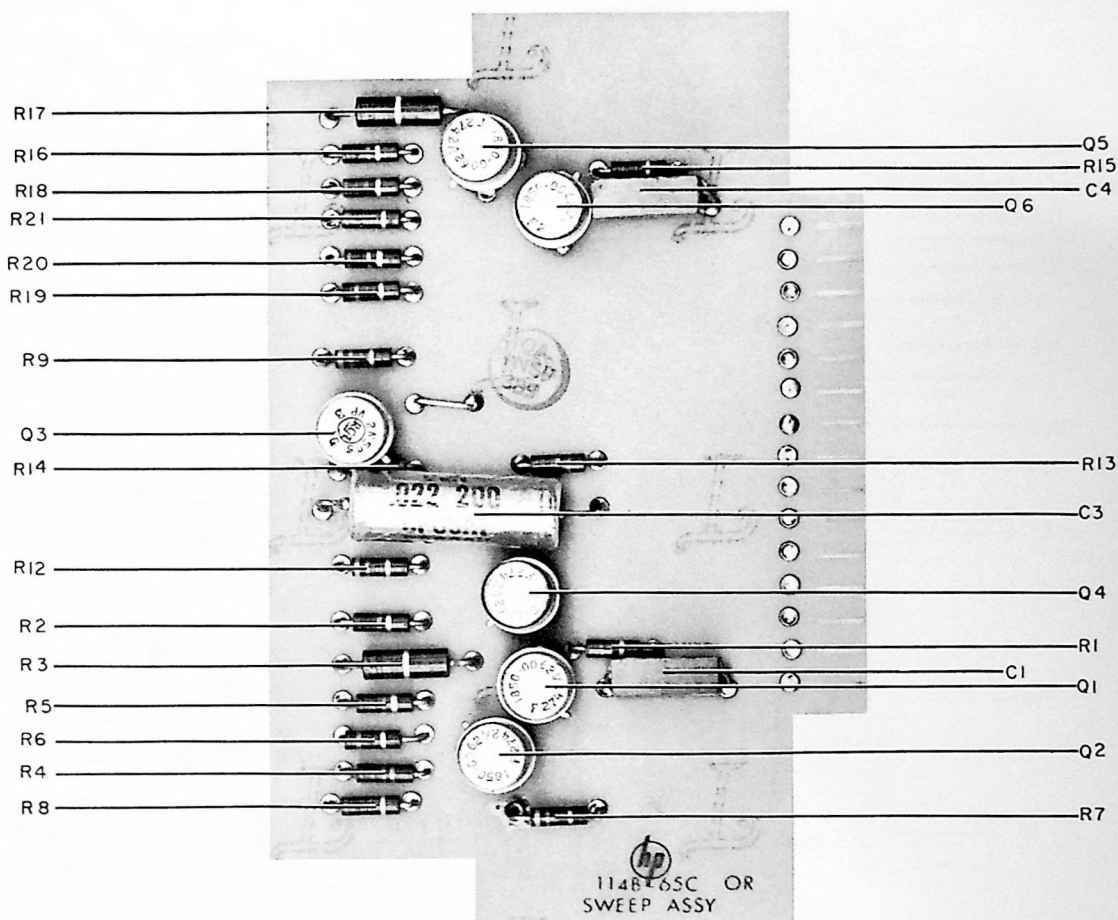
MP-S-874

Figure 5-7. Divider Assembly A3, A4, A5, Component Location



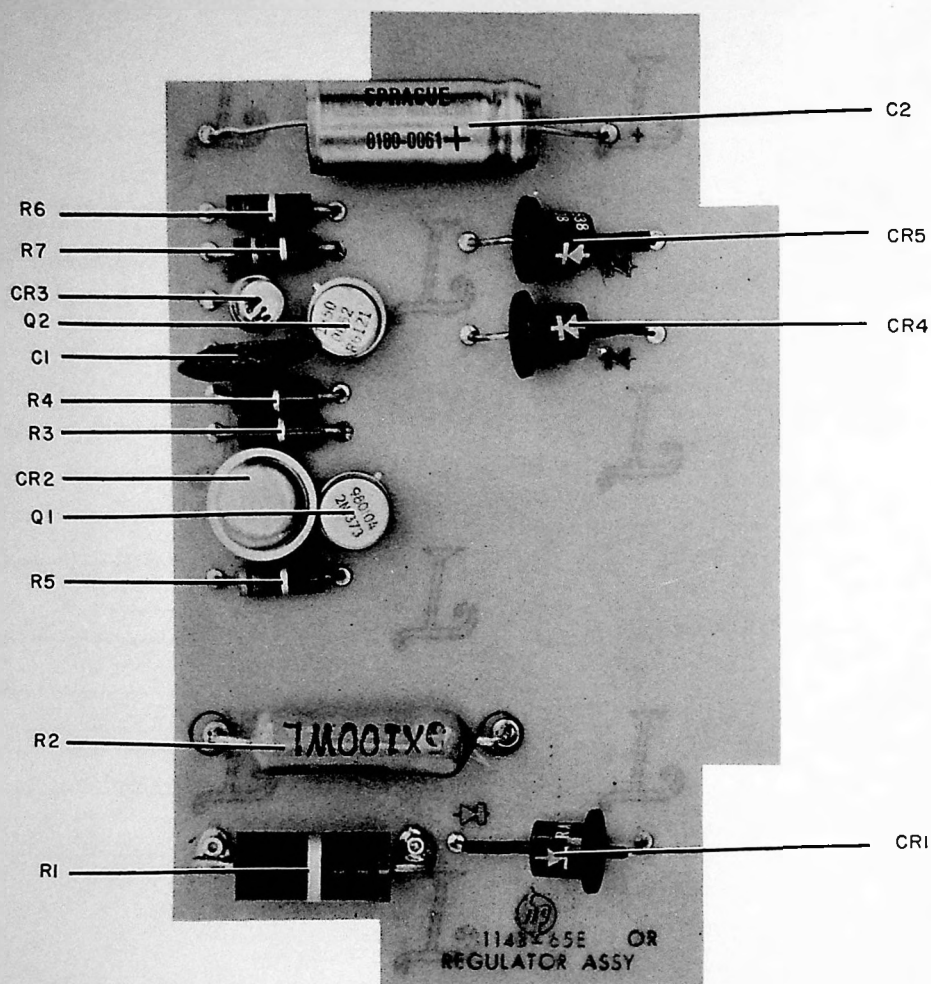
MP-S-877

Figure 5-8. Gating and Unblanking Assembly A6, Component Location



MP-S-1054

Figure 5-9. Sweep and Marker Assembly A7, Component Location



MP-S-868

Figure 5-10. Regulator Assembly A8, Component Location

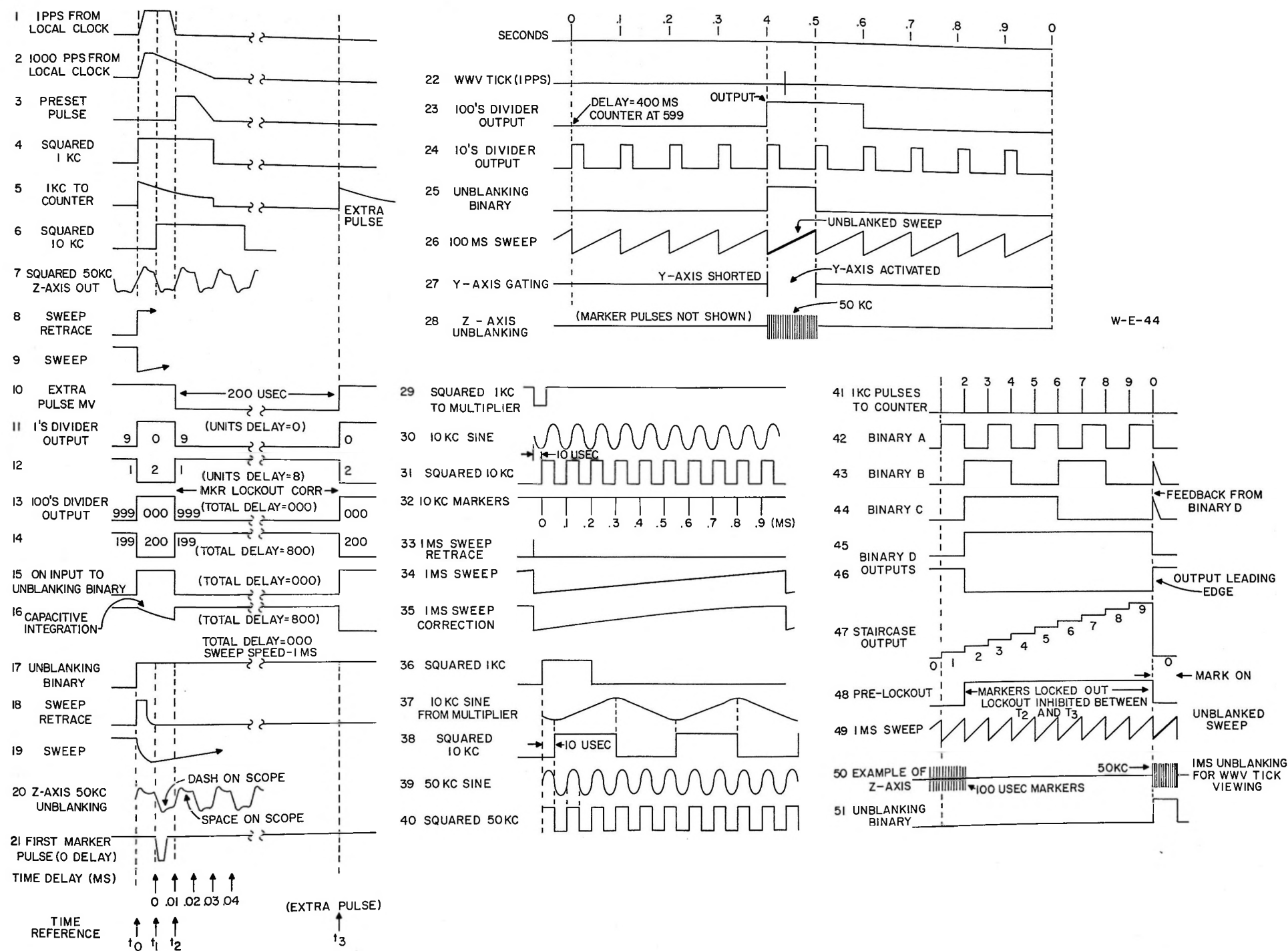


Figure 5-11. Timing Chart
5-15/5-16

NOTES

1. UNLESS OTHERWISE INDICATED:
RESISTANCE IN OHMS;
CAPACITANCE IN PICOFARADS
2. CONNECT E1 TO E2 AND E3 TO E4
TO SHORTEN MARKER DUTY CYCLE
ON 10m SEC AND 1m SEC SWEEP TIMES
3. ASTERISK (*) INDICATES SELECTED
VALUE; C2, C6, C9 AND C13 ARE
CHOSEN TO TUNE T1 AND T2 TO
RESONANCE WHEN C3, C5, C10 AND C12
ARE NEAR MID-POSITION

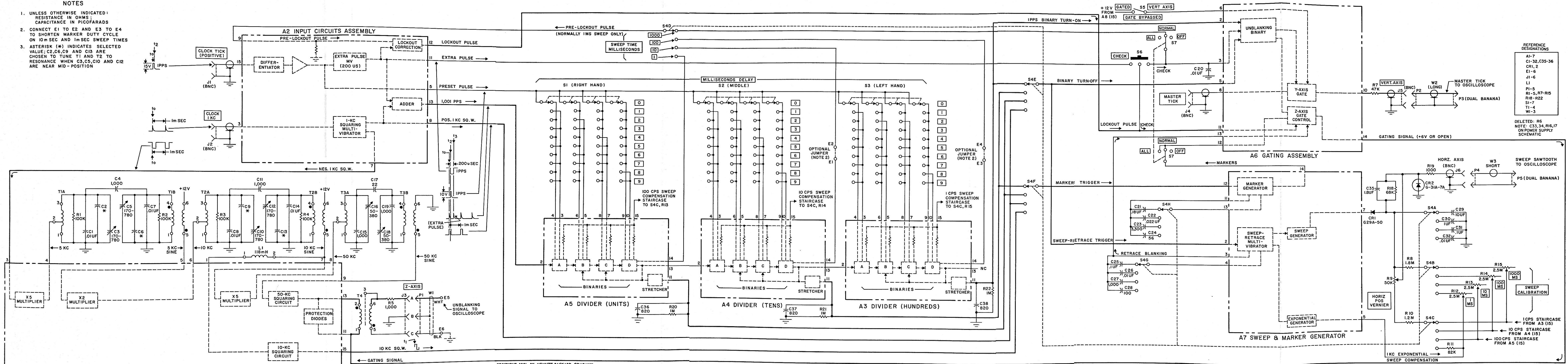
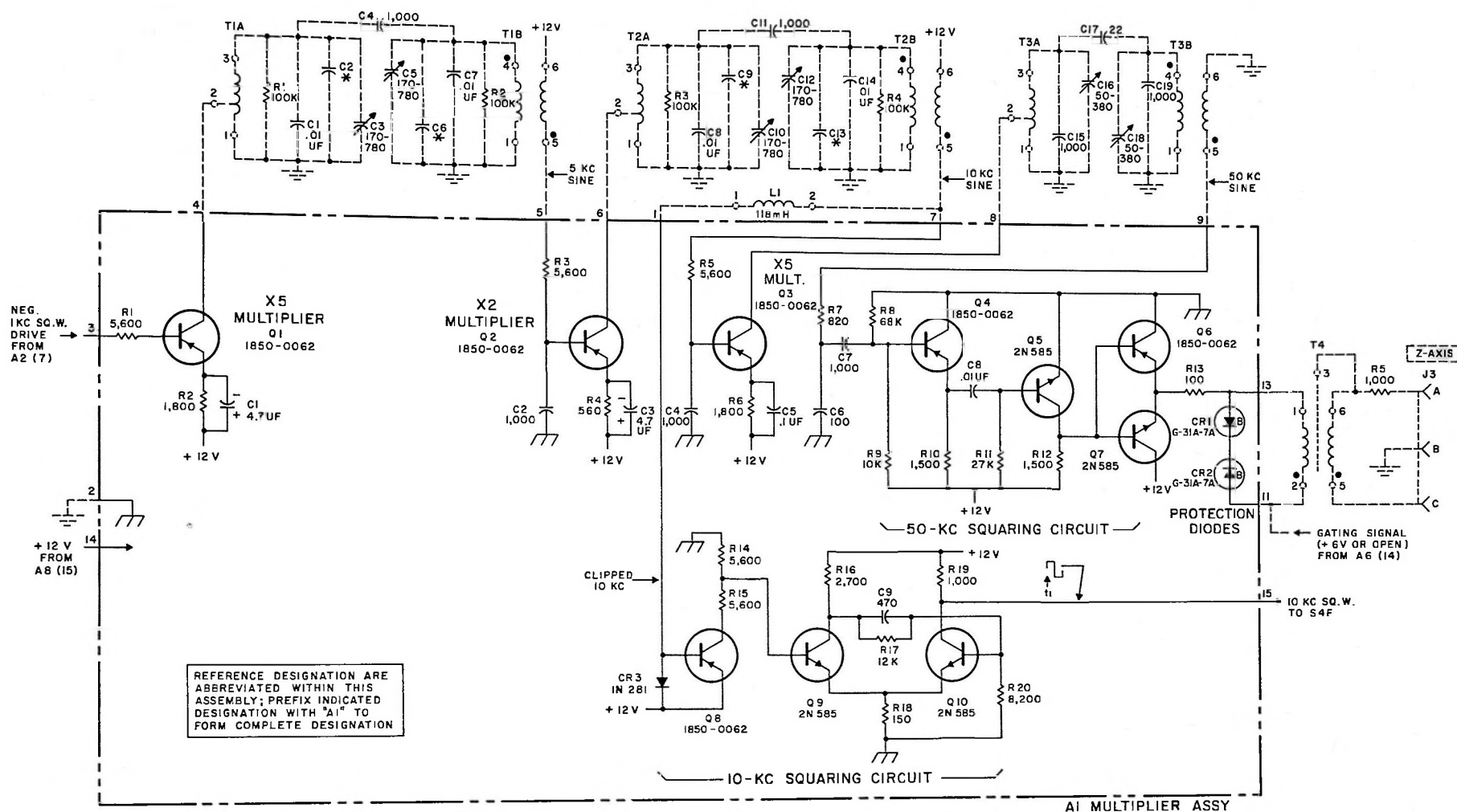


Figure 5-12. Overall Schematic

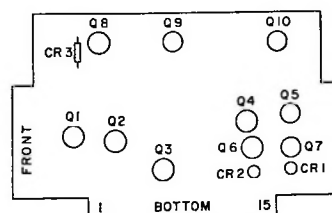


REFERENCE DESIGNATIONS

PREFIX REQ'D	AI
CI - 9	CR1 - 3
Q1 - 10	RI - 20
PREFIX NOT REQ'D	AI
CI - 19	J3
LI	RI - 5

NOTES

1. UNLESS OTHERWISE INDICATED:
RESISTANCE IN OHMS;
CAPACITANCE IN PICOFARADS



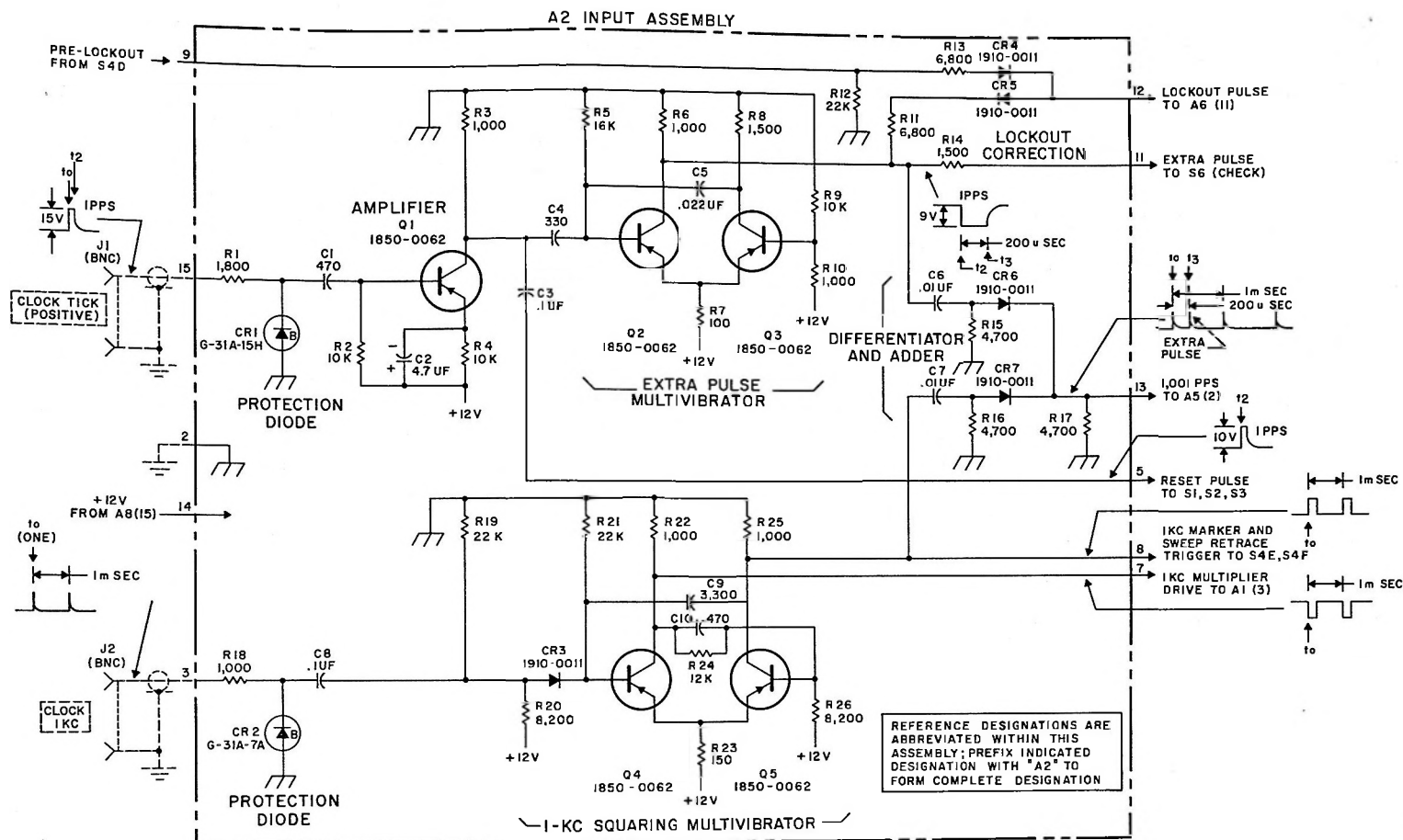
SEMICONDUCTOR LOCATION

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114BR - MULTIPLIER - T150A

Figure 5-13. Multiplier Assembly A1

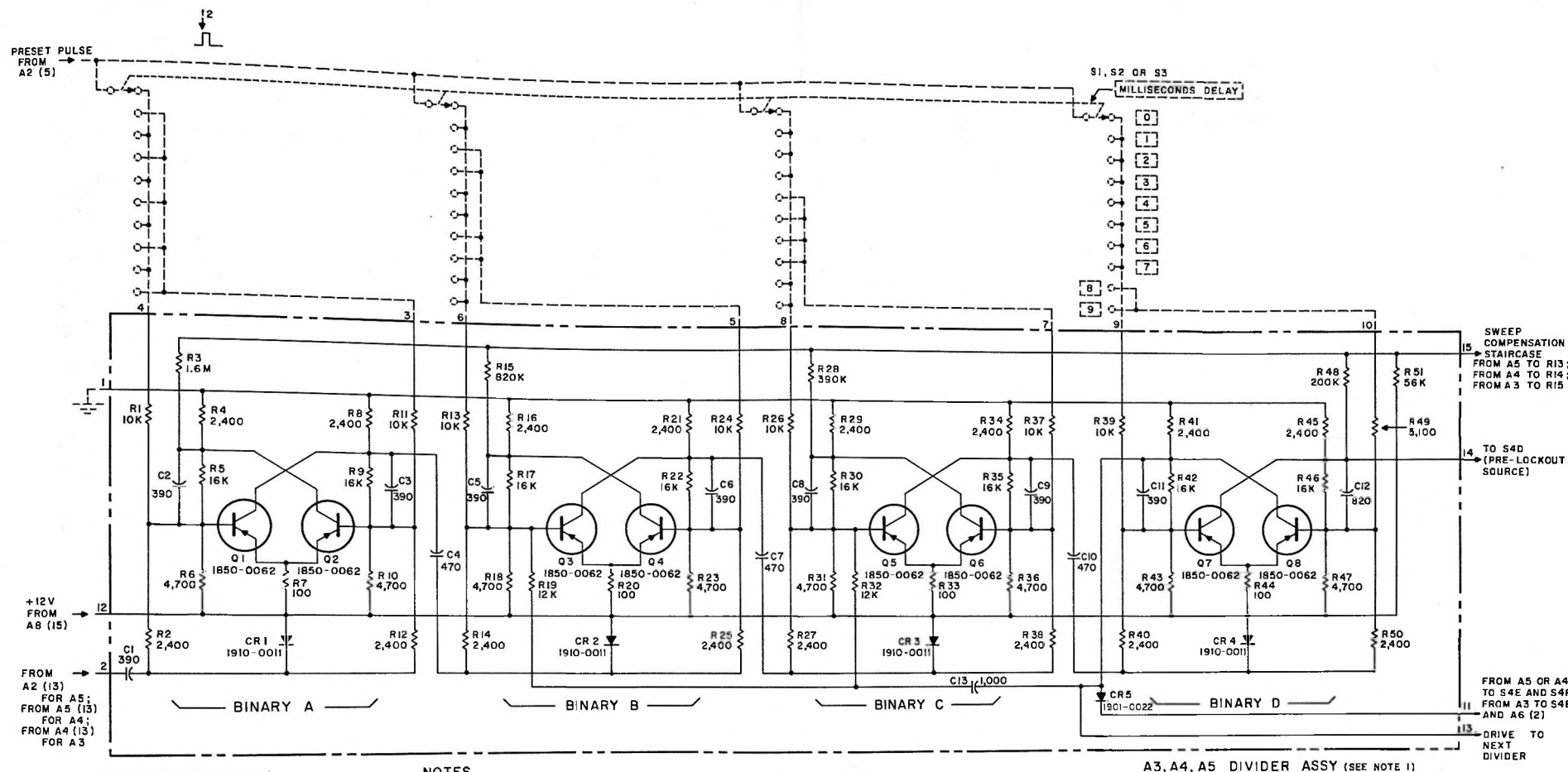


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114BR - INPUT - T150A

Figure 5-14. Input Assembly A2



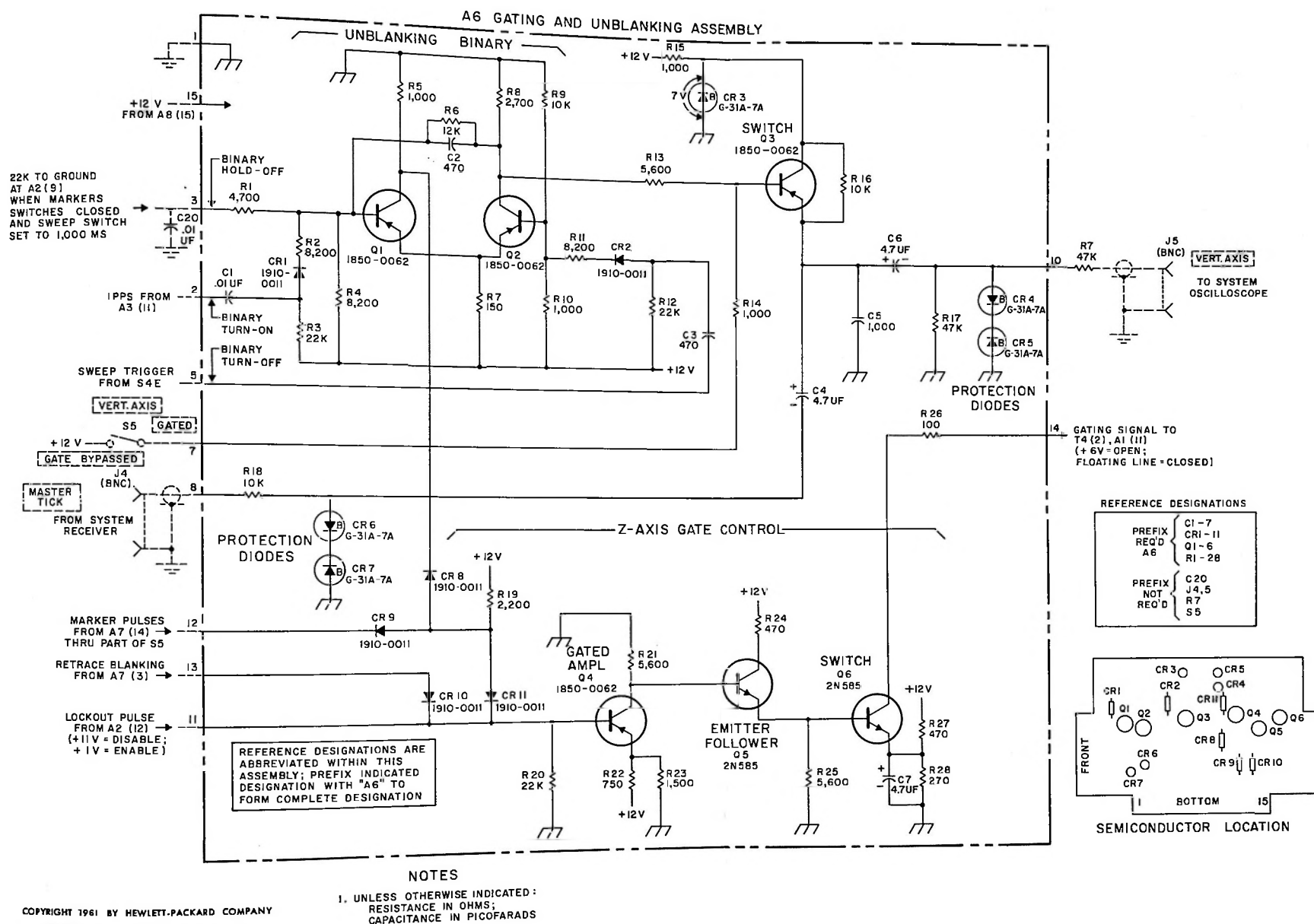
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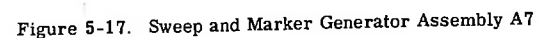
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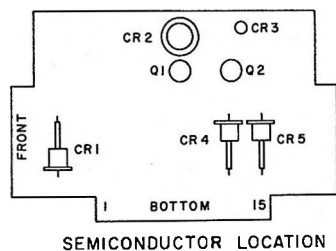
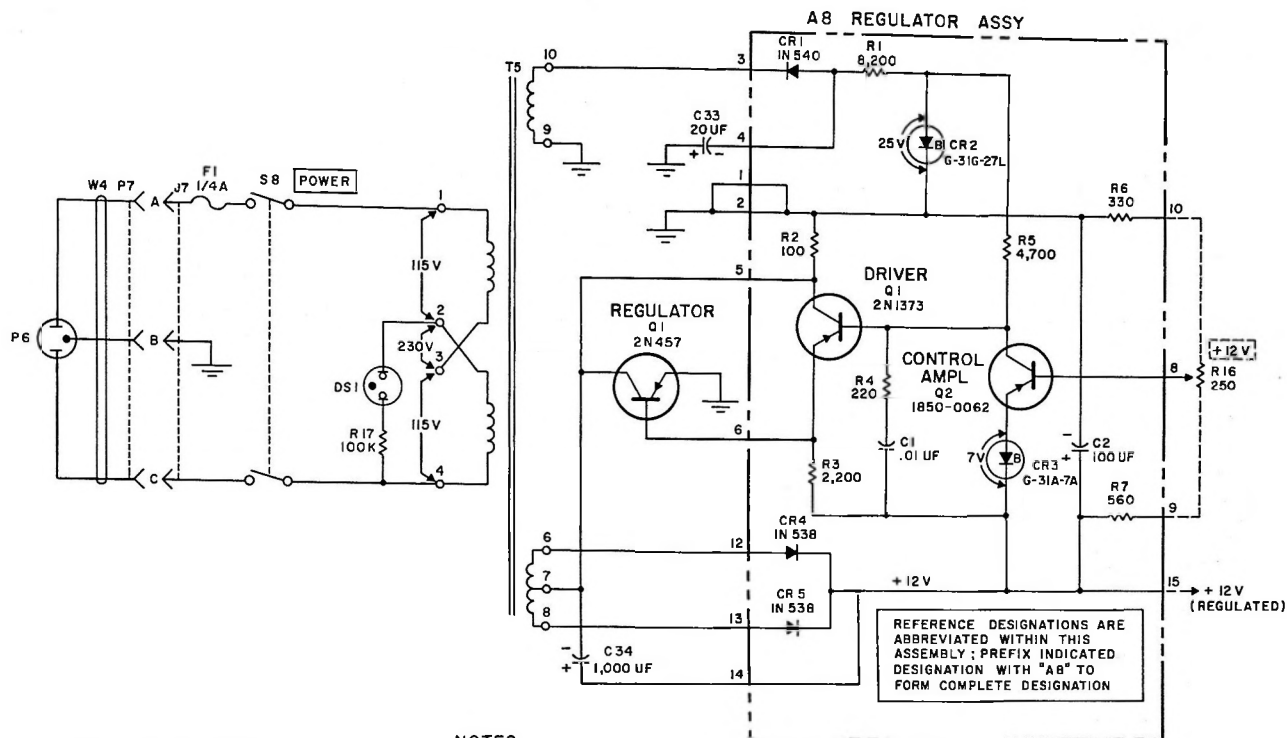
114 BR - DIVIDER - T150A

Figure 5-15. Divider Assembly A3, A4, A5

5-23/5-24







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H4BR - REGULATOR - T112A

Figure 5-18. Power Supply (Regulator Assembly A8)

SECTION VI REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alpha-numerical order of their reference designators and indicates the description and stock number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their stock numbers and provides the following information on each part:

- a. Description of the part (see list of abbreviations below).
- b. Manufacturer of the part in a five-digit code; see list of manufacturers in appendix.
- c. Typical manufacturer's stock number.
- d. Total quantity used in the instrument (TQ column).
- e. Recommended spare part quantity for complete maintenance during one year of isolated service (RS column).

6-3. DESCRIPTION ONLY. Several cables (W1, W2, W3, W4) do not have stock numbers and must be ordered by description. Table 6-3 lists these cables by reference designation and gives the necessary word description for ordering.

6-4. ORDERING INFORMATION.

6-5. To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales representative or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California,

or, in Western Europe, to

Hewlett-Packard S. A.
Rue du Vieux Billard No. 1
Geneva, Switzerland.

6-6. Specify the following information for each part:

- a. Model and complete serial number of instrument.
- b. Hewlett-Packard stock number.
- c. Circuit reference designator.
- d. Description.

6-7. To order a part not listed in table 6-1, give a complete description of the part and include its function and location.

REFERENCE DESIGNATORS

A = assembly	F = fuse	P = plug	V = vacuum tube, neon bulb, photocell, etc.
B = motor	FL = filter	Q = transistor	W = cable
C = capacitor	J = jack	R = resistor	X = socket
CR = diode	K = relay	RT = thermistor	XF = fuseholder
DL = delay line	L = inductor	S = switch	XV = tube socket
DS = device signaling (lamp)	M = meter	T = transformer	XDS = lampholder
E = misc electronic part			

ABBREVIATIONS

bp = bandpass	elect = electrolytic	mtg = mounting	rot = rotary
bwo = backward wave oscillator	encap = encapsulated	my = mylar	rms = root-mean-square
c = carbon	f = farads	NC = normally closed	rmo = rack mount only
cer = ceramic	fxd = fixed	Ne = neon	s-b = slow-blow
cmo = cabinet mount only	Ge = germanium	NO = normally open	Se = selenium
coef = coefficient	grd = ground (ed)	NPO = negative positive zero-zero temperature coefficient	sect = section(s)
com = common	h = henries	nsr = not separately replaceable	Si = silicon
comp = composition	Hg = mercury	obd = order by description	sl = slide
conn = connection	impg = impregnated	p = peak	td = time delay
crt = cathode-ray tube	incd = incandescent	pc = printed circuit board	TiO ₂ = titanium dioxide
dep = deposited	ins = insulation (ed)	pf = picofarads = 10 ⁻¹² farads	tog = toggle
det = detector	K = kilo	pp = peak-to-peak	tol = tolerance
EIA = Tubes and transistors selected for best performance will be supplied if ordered by stock numbers; tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications	lin = linear taper	piv = peak inverse voltage	trim = trimmer
	log = logarithmic taper	pos = position(s)	tw = traveling wave tube
	m = milli = 10 ⁻³	pot = potentiometer	var = variable
	M = megohms	rect = rectifier	w/ = with
	ma = milliamperes		W = watts
	minat = miniature		ww = wirewound
	mfg = metal film on glass		w/o = without
	mfr = manufacturer		* = optimum value selected at factory, average value shown (part may be omitted)

Table 6-1. Reference Designation Index

Circuit Reference	Ⓢ Stock No.	Description #	Note
A1	114B-65B	Assy, Multiplier (includes all components prefixed A1)	
A1C1	0180-0100	C: fxd, elect, 4.7 uf ± 20%, 35 vdcw	
A1C2	0140-0018	C: fxd, mica, 1000 pf ± 5%, 500 vdcw	
A1C3	0180-0100	C: fxd, elect, 4.7 uf ± 20%, 35 vdcw	
A1C4	0140-0018	C: fxd, mica, 1000 pf ± 5%, 500 vdcw	
A1C5	0160-0076	C: fxd, paper, 0.1 uf ± 10%, 100 vdcw	
A1C6	0140-0041	C: fxd, mica, 100 pf ± 5%, 500 vdcw	
A1C7	0140-0018	C: fxd, mica, 1000 pf ± 5%, 500 vdcw	
A1C8	0150-0081	C: fxd, cer, 0.01 uf +80% -20%, 500 vdcw	
A1C9	0140-0167	C: fxd, mica, 470 pf ± 5%, 300 vdcw	
A1CR1	G-31A-7A	Diode, si	
A1CR2	G-31A-7A	Diode, si	
A1CR3	1910-0007	Diode, ge: 1N281	
A1Q1	1850-0062	Transistor: Ⓢ type 1850-0062	
A1Q2	1850-0062	Transistor: Ⓢ type 1850-0062	
A1Q3	1850-0062	Transistor: Ⓢ type 1850-0062	
A1Q4	1850-0062	Transistor: Ⓢ type 1850-0062	
A1Q5	1851-0018	Transistor: 2N585	
A1Q6	1850-0062	Transistor: Ⓢ type 1850-0062	
A1Q7	1851-0018	Transistor: 2N585	
A1Q8	1850-0062	Transistor: Ⓢ type 1850-0062	
A1Q9	1851-0018	Transistor: 2N585	
A1Q10	1851-0018	Transistor: 2N585	
A1R1	0684-5621	R: fixed, comp, 5.6K ohms ± 10%, 1/4W	
A1R2	0684-1821	R: fixed, comp, 1.8K ohms ± 10%, 1/4W	
A1R3	0684-5621	R: fxd, comp, 5.6K ohms ± 10%, 1/4W	
A1R4	0684-5611	R: fxd, comp, 560 ohms ± 10%, 1/4W	
A1R5	0684-5621	R: fxd, comp, 5.6K ohms ± 10%, 1/4W	
A1R6	0684-1821	R: fxd, comp, 1.8K ohms ± 10%, 1/4W	
A1R7	0684-8211	R: fxd, comp, 820 ohms ± 10%, 1/4W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓢ Stock No.	Description #	Note
A1R8	0684-6831	R: fxd, comp, 68K ohms $\pm$ 10%, 1/4W	
A1R9	0684-1031	R: fxd, comp, 10K ohms $\pm$ 10%, 1/4W	
A1R10	0684-1521	R: fxd, comp, 1.5K ohms $\pm$ 10%, 1/4W	
A1R11	0684-2731	R: fxd, comp, 27K ohms $\pm$ 10%, 1/4W	
A1R12	0687-1521	R: fxd, comp, 1.5K ohms $\pm$ 10%, 1/2W	
A1R13	0684-1011	R; fxd, comp, 100 ohms $\pm$ 10%, 1/4W	
A1R14	0684-5621	R: fxd, comp, 5.6K ohms $\pm$ 10%, 1/4W	
A1R15	0684-5621	R: fxd, comp, 5.6K ohms $\pm$ 10%, 1/4W	
A1R16	0684-2721	R: fxd, comp, 2.7K ohms $\pm$ 10%, 1/4W	
A1R17	0684-1231	R: fxd, comp, 12K ohms $\pm$ 10%, 1/4W	
A1R18	0684-1511	R: fxd, comp, 150 ohms $\pm$ 10%, 1/4W	
A1R19	0687-1021	R: fxd, comp, 1K ohms $\pm$ 10%, 1/2W	
A1R20	0684-8221	R: fxd, comp, 8.2K ohms $\pm$ 10%, 1/4W	
A2	114B-65A	Assy, input circuit (incl all components prefixed A2)	
A2C1	0140-0167	C: fxd, mica, 470 pf $\pm$ 5%, 300 vdcw	
A2C2	0180-0100	C: fxd, elect, 4.7 uf $\pm$ 10%, 35 vdcw	
A2C3	0160-0076	C: fxd, paper, 0.1 uf $\pm$ 10%, 100 vdcw	
A2C4	0140-0168	C: fxd, mica, 330 pf $\pm$ 5%, 300 vdcw	
A2C5	0160-0114	C: fxd, paper, 0.022 uf $\pm$ 10%, 200 vdcw	
A2C6	0150-0081	C: fxd, cer, 0.01 uf +80%, -20%, 500 vdcw	
A2C7	0150-0081	C: fxd, cer, 0.01 uf +80% -20%, 500 vdcw	
A2C8	0160-0076	C: fxd, paper, 0.1 uf $\pm$ 10%, 100 vdcw	
A2C9	0160-0112	C: fxd, paper, 3300 pf $\pm$ 10%, 400 vdcw	
A2C10	0140-0167	C: fxd, mica, 470 pf $\pm$ 5%, 300 vdcw	
A2CR1	G-31A-15H	Diode, si	
A2CR2	G-31A-7A	Diode, si	
A2CR3	1910-0011	Diode, ge: Type HD-2135A-5	
A2CR4	1910-0011	Diode, ge: Type HD-2135A-5	
A2CR5	1910-0011	Diode, ge: Type HD-2135A-5	
A2CR6	1910-0011	Diode, ge: Type HD-2135A-5	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓢ Stock No.	Description#	Note
A2CR7	1910-0011	Diode, ge: Type HD-2135A-5	
A2Q1	1850-0062	Transistor: Ⓢ type 1850-0062	
A2Q2	1850-0062	Transistor: Ⓢ type 1850-0062	
A2Q3	1850-0062	Transistor: Ⓢ type 1850-0062	
A2Q4	1850-0062	Transistor: Ⓢ type 1850-0062	
A2Q5	1850-0062	Transistor: Ⓢ type 1850-0062	
A2R1	0684-1821	R: fxd, comp, 1.8K ohms $\pm 10\%$, 1/4W	
A2R2	0684-1031	R: fxd, comp, 10K ohms $\pm 10\%$, 1/4W	
A2R3	0684-1021	R: fxd, comp, 1K ohms $\pm 10\%$, 1/4W	
A2R4	0684-1031	R: fxd, comp, 10K ohms $\pm 10\%$, 1/4W	
A2R5	0683-1635	R: fxd, comp, 16K ohms $\pm 5\%$, 1/4W	
A2R6	0687-1021	R: fxd, comp, 1K ohms $\pm 10\%$, 1/2W	
A2RT	0684-1011	R: fxd, comp, 100 ohms $\pm 10\%$, 1/4W	
A2R8	0684-1521	R: fxd, comp, 1.5K ohms $\pm 10\%$, 1/4W	
A2R9	0684-1031	R: fxd, comp, 10K ohms $\pm 10\%$, 1/4W	
A2R10	0684-1021	R: fxd, comp, 1K ohms $\pm 10\%$, 1/4W	
A2R11	0684-6821	R: fxd, comp, 6.8K ohms $\pm 10\%$, 1/4W	
A2R12	0684-2231	R: fxd, comp, 22K ohms $\pm 10\%$, 1/4W	
A2RB	0684-6821	R: fxd, comp, 6.8K ohms $\pm 10\%$, 1/4W	
A2R14	0684-1521	R: fxd, comp, 1.5K ohms $\pm 10\%$, 1/4W	
A2R15	0684-4721	R: fxd, comp, 4.7K ohms $\pm 10\%$, 1/4W	
A2R16	0684-4721	R: fxd, comp, 4.7K ohms $\pm 10\%$, 1/4W	
A2R17	0684-4721	R: fxd, comp, 4.7K ohms $\pm 10\%$, 1/4W	
A2R18	0684-1021	R: fxd, comp, 1K ohms $\pm 10\%$, 1/4W	
A2R19	0684-2231	R: fxd, comp, 22K ohms $\pm 10\%$, 1/4W	
A2R20	0684-8221	R: fxd, comp, 8.2K ohms $\pm 10\%$, 1/4W	
A2R21	0684-2231	R: fxd, comp, 22K ohms $\pm 10\%$, 1/4W	
A2R22	0687-1021	R: fxd, comp, 1K ohms $\pm 10\%$, 1/2W	
A2R23	0684-1511	R: fxd, comp, 150 ohms $\pm 10\%$, 1/4W	
A2R24	0684-1231	R: fxd, comp, 12K ohms $\pm 10\%$, 1/4W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓢ Stock No.	Description #	Note
A2R25	0684-1021	R: fxd, comp, 1K ohms $\pm$ 10%, 1/4W	
A2R26	0684-8221	R: fxd, comp, 8.2K ohms $\pm$ 10%, 1/4W	
A3	114B-65F	Assy, divider (includes all components prefixed A3, A4 and A5)	
A3C1	0140-0037	C: fxd, mica, 390 pf $\pm$ 5%, 500 vdcw	
A3C2	0140-0037	C: fxd, mica, 390 pf $\pm$ 5%, 500 vdcw	
A3C3	0140-0037	C: fxd, mica, 390 pf $\pm$ 5%, 500 vdcw	
A3C4	0140-0167	C: fxd, mica, 470 pf $\pm$ 5%, 300 vdcw	
A3C5	0140-0037	C: fxd, mica, 390 pf $\pm$ 5%, 500 vdcw	
A3C6	0140-0037	C: fxd, mica, 390 pf $\pm$ 5%, 500 vdcw	
A3C7	0140-0167	C: fxd, mica, 470 pf $\pm$ 5%, 300 vdcw	
A3C8	0140-0037	C: fxd, mica, 390 pf $\pm$ 5%, 500 vdcw	
A3C9	0140-0037	C: fxd, mica, 390 pf $\pm$ 5%, 500 vdcw	
A3C10	0140-0167	C: fxd, mica, 470 pf $\pm$ 5%, 300 vdcw	
A3C11	0140-0037	C: fxd, mica, 390 pf $\pm$ 5%, 500 vdcw	
A3C12	0140-0091	C: fxd, mica, 820 pf $\pm$ 5%, 500 vdcw	
A3C13	0140-0018	C: fxd, mica, 1000 pf $\pm$ 5%, 500 vdcw	
A3CR1	1910-0011	Diode, ge: Type HD-2135A-5	
A3CR2	1910-0011	Diode, ge: Type HD-2135A-5	
A3CR3	1910-0011	Diode, ge: Type HD-2135A-5	
A3CR4	1910-0011	Diode, ge: Type HD-2135A-5	
A3CR5	1901-0022	Diode, si	
A3Q1	1850-0062	Transistor: Ⓢ type 1850-0062	
A3Q2	1850-0062	Transistor: Ⓢ type 1850-0062	
A3Q3	1850-0062	Transistor: Ⓢ type 1850-0062	
A3Q4	1850-0062	Transistor: Ⓢ type 1850-0062	
A3Q5	1850-0062	Transistor: Ⓢ type 1850-0062	
A3Q6	1850-0062	Transistor: Ⓢ type 1850-0062	
A3Q7	1850-0062	Transistor: Ⓢ type 1850-0062	
A3Q8	1850-0062	Transistor: Ⓢ type 1850-0062	
A3R1	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description #	Note
A3R2	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A3R3	0683-1655	R: fxd, comp, 1.6M $\pm$ 5%, 1/4W	
A3R4	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A3R5	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A3R6	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	
A3R7	0683-1015	R: fxd, comp, 100 ohms $\pm$ 5%, 1/4W	
A3R8	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A3R9	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A3R10	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	
A3R11	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A3R12	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A3R13	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A3R14	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A3R15	0683-8245	R: fxd, comp, 820K ohms $\pm$ 5%, 1/4W	
A3R16	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A3R17	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A3R18	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	
A3R19	0683-1235	R: fxd, comp, 12K ohms $\pm$ 5%, 1/4W	
A3R20	0683-1015	R: fxd, comp, 100 ohms $\pm$ 5%, 1/4W	
A3R21	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A3R22	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A3R23	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	
A3R24	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A3R25	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A3R26	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A3R27	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A3R28	0683-3945	R: fxd, comp, 390K ohms $\pm$ 5%, 1/4W	
A3R29	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A3R30	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A3R31	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓢ Stock No.	Description #	Note
A3R32	0683-1235	R: fxd, comp, 12K ohms $\pm 5\%$, 1/4W	
A3R33	0683-1015	R: fxd, comp, 100 ohms $\pm 5\%$, 1/4W	
A3R34	0683-2425	R: fxd, comp, 2.4K ohms $\pm 5\%$, 1/4W	
A3R35	0683-1635	R: fxd, comp, 16K ohms $\pm 5\%$, 1/4W	
A3R36	0683-4725	R: fxd, comp 4.7K ohms $\pm 5\%$, 1/4W	
A3R37	0683-1035	R: fxd, comp, 10K ohms $\pm 5\%$, 1/4W	
A3R38	0683-2425	R: fxd, comp, 2.4K ohms $\pm 5\%$, 1/4W	
A3R39	0683-1035	R: fxd, comp, 10K ohms $\pm 5\%$, 1/4W	
A3R40	0683-2425	R: fxd, comp, 2.4K ohms $\pm 5\%$, 1/4W	
A3R41	0683-2425	R: fxd, comp, 2.4K ohms $\pm 5\%$, 1/4W	
A3R42	0683-1635	R: fxd, comp, 16K ohms $\pm 5\%$, 1/4W	
A3R43	0683-4725	R: fxd, comp, 4.7K ohms $\pm 5\%$, 1/4W	
A3R44	0683-1015	R: fxd, comp, 100 ohms $\pm 5\%$, 1/4W	
A3R45	0683-2425	R: fxd, comp, 2.4K ohms $\pm 5\%$, 1/4W	
A3R46	0683-1635	R: fxd, comp, 16K ohms $\pm 5\%$, 1/4W	
A3R47	0683-4725	R: fxd, comp, 4.7K ohms $\pm 5\%$, 1/4W	
A3R48	0683-2045	R: fxd, comp, 200K ohms $\pm 5\%$, 1/4W	
A3R49	0683-5125	R: fxd, comp, 51K ohms $\pm 5\%$, 1/4W	
A3R50	0683-2425	R: fxd, comp, 2.4K ohms $\pm 5\%$, 1/4W	
A3R51	0683-5635	R: fxd, comp, 56K ohms $\pm 5\%$, 1/4W	
A4	114B-65F	Assy, divider (includes all componets prefixed A3, A4, and A5)	
A4C1	0140-0037	C: fxd, mica, 390 pf $\pm 5\%$, 500 vdcw	
A4C2	0140-0037	C: fxd, mica, 390 pf $\pm 5\%$, 500 vdcw	
A4C3	0140-0037	C: fxd, mica, 390 pf $\pm 5\%$, 500 vdcw	
A4C4	0140-0167	C: fxd, mica, 470 pf $\pm 5\%$, 300 vdcw	
A4C5	0140-0037	C: fxd, mica, 390 pf $\pm 5\%$, 500 vdcw	
A4C6	0140-0037	C: fxd, mica, 390 pf $\pm 5\%$, 500 vdcw	
A4C7	0140-0167	C: fxd, mica, 470 pf $\pm 5\%$, 300 vdcw	
A4C8	0140-0037	C: fxd, mica, 390 pf $\pm 5\%$, 500 vdcw	
A4C9	0140-0037	C: fxd, mica, 390 pf $\pm 5\%$, 500 vdcw	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓢ Stock No.	Description #	Note
A4C10	0140-0167	C: fxd, mica, 470 pf $\pm$ 5%, 300 vdcw	
A4C11	0140-0037	C: fxd, mica, 390 pf $\pm$ 5%, 500 vdcw	
A4C12	0140-0091	C: fxd, mica, 820 pf $\pm$ 5%, 500 vdcw	
A4C13	0140-0018	C: fxd, mica, 1000 pf $\pm$ 5%, 500 vdcw	
A4CR1	1910-0011	Diode, ge: Type HD-2135A-5	
A4CR2	1910-0011	Diode, ge: Type HD-2135A-5	
A4CR3	1910-0011	Diode, ge: Type HD-2135A-5	
A4CR4	1910-0011	Diode, ge: Type HD-2135A-5	
A4CR5	1901-0022	Diode, si: G-129	
A4Q1	1850-0062	Transistor: Ⓢ type 1850-0062	
A4Q2	1850-0062	Transistor: Ⓢ type 1850-0062	
A4Q3	1850-0062	Transistor: Ⓢ type 1850-0062	
A4Q4	1850-0062	Transistor: Ⓢ type 1850-0062	
A4Q5	1850-0062	Transistor: Ⓢ type 1850-0062	
A4Q6	1850-0062	Transistor: Ⓢ type 1850-0062	
A4Q7	1850-0062	Transistor: Ⓢ type 1850-0062	
A4Q8	1850-0062	Transistor: Ⓢ type 1850-0062	
A4R1	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A4R2	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A4R3	0683-1655	R: fxd, comp, 1.6 M $\pm$ 5%, 1/4W	
A4R4	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A4R5	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A4R6	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	
A4R7	0683-1015	R: fxd, comp, 100 ohms $\pm$ 5%, 1/4W	
A4R8	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A4R9	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A4R10	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	
A4R11	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A4R12	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A4R13	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓢ Stock No.	Description #	Note
A4R14	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A4R15	0683-8245	R: fxd, comp, 820K ohms $\pm$ 5%, 1/4W	
A4R16	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A4R17	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A4R18	0683-4725	R: fxd, comp, 4.7K ohms, $\pm$ 5%, 1/4W	
A4R19	0683-1235	R: fxd, comp, 12K ohms $\pm$ 5%, 1/4W	
A4R20	0683-1015	R: fxd, comp, 100 ohms $\pm$ 5%, 1/4W	
A4R21	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A4R22	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A4R23	0683-4725	R: fxd, comp, 4.7K ohms, $\pm$ 5%, 1/4W	
A4R24	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A4R25	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A4R26	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A4R27	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A4R28	0683-3945	R: fxd, comp, 390K ohms $\pm$ 5%, 1/4W	
A4R29	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A4R30	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A4R31	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	
A4R32	0683-1235	R: fxd, comp, 12K ohms $\pm$ 5%, 1/4W	
A4R33	0683-1015	R: fxd, comp, 100 ohms $\pm$ 5%, 1/4W	
A4R34	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A4R35	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A4R36	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	
A4R37	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A4R38	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A4R39	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A4R40	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A4R41	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A4R42	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A4R43	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓢ Stock No.	Description #	Note
A4R44	0683-1015	R: fxd, comp, 100 ohms, $\pm 5\%$, 1/4W	
A4R45	0683-2425	R: fxd, comp, 2.4K ohms $\pm 5\%$, 1/4W	
A4R46	0683-1635	R: fxd, comp, 16K ohms $\pm 5\%$, 1/4W	
A4R47	0683-4725	R: fxd, comp, 4.7K ohms $\pm 5\%$, 1/4W	
A4R48	0683-2045	R: fxd, comp, 200K ohms $\pm 5\%$, 1/4W	
A4R49	0683-5125	R: fxd, comp, 5.1K ohms $\pm 5\%$, 1/4W	
A4R50	0683-2425	R: fxd, comp, 2.4K ohms $\pm 5\%$, 1/4W	
A4R51	0683-5635	R: fxd, comp, 56K ohms $\pm 5\%$, 1/4W	
A5	114B-65F	Assy, divider (includes all components prefixed A3, A4 and A5)	
A5C1	0140-0037	C: fxd, mica, 390 pf $\pm 5\%$, 500 vdcw	
A5C2	0140-0037	C: fxd, mica, 390 pf $\pm 5\%$, 500 vdcw	
A5C3	0140-0037	C: fxd, mica, 390 pf $\pm 5\%$, 500 vdcw	
A5C4	0140-0167	C: fxd, mica, 470 pf $\pm 5\%$, 300 vdcw	
A5C5	0140-0037	C: fxd, mica, 390 pf $\pm 5\%$, 500 vdcw	
A5C6	0140-0037	C: fxd, mica, 390 pf $\pm 5\%$, 500 vdcw	
A5C7	0140-0167	C: fxd, mica, 470 pf $\pm 5\%$, 300 vdcw	
A5C8	0140-0037	C: fxd, mica, 390 pf $\pm 5\%$, 500 vdcw	
A5C9	0140-0037	C: fxd, mica, 390 pf $\pm 5\%$, 500 vdcw	
A5C10	0140-0167	C: fxd, mica, 470 pf $\pm 5\%$, 300 vdcw	
A5C11	0140-0037	C: fxd, mica, 390 pf $\pm 5\%$, 500 vdcw	
A5C12	0140-0091	C: fxd, mica, 820 pf $\pm 5\%$, 500 vdcw	
A5C13	0140-0018	C: fxd, mica, 1000 pf $\pm 5\%$, 500 vdcw	
A5CR1	1910-0011	Diode, ge: Type HD-2135A-5	
A5CR2	1910-0011	Diode, ge: Type HD-2135A-5	
A5CR3	1910-0011	Diode, ge: Type HD-2135A-5	
A5CR4	1910-0011	Diode, ge: Type HD-2135A-5	
A5CR5	1901-0022	Diode, si: G-129	
A5Q1	1850-0062	Transistor: Ⓢ type 1850-0062	
A5Q2	1850-0062	Transistor: Ⓢ type 1850-0062	
A5Q3	1850-0062	Transistor: Ⓢ type 1850-0062	

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Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓢ Stock No.	Description #	Note
A5Q4	1850-0062	Transistor: Ⓢ type 1850-0062	
A5Q5	1850-0062	Transistor: Ⓢ type 1850-0062	
A5Q6	1850-0062	Transistor: Ⓢ type 1850-0062	
A5Q7	1850-0062	Transistor: Ⓢ type 1850-0062	
A5Q8	1850-0062	Transistor: Ⓢ type 1850-0062	
A5R1	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A5R2	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A5R3	0683-1655	R: fxd, comp, 1.6M ohms $\pm$ 5%, 1/4W	
A5R4	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A5R5	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A5R6	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	
A5R7	0683-1015	R: fxd, comp, 100 ohms $\pm$ 5%, 1/4W	
A5R8	0683-2435	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A5R9	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A5R10	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	
A5R11	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A5R12	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A5R13	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A5R14	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A5R15	0683-8245	R: fxd, comp, 820 K ohms $\pm$ 5%, 1/4W	
A5R16	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A5R17	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A5R18	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	
A5R19	0683-1235	R: fxd, comp, 12K ohms $\pm$ 5%, 1/4W	
A5R20	0683-1015	R: fxd, comp, 100 ohms $\pm$ 5%, 1/4W	
A5R21	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A5R22	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A5R23	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	
A5R24	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A5R25	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	

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Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓢ Stock No.	Description#	Note
A5R26	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A5R27	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A5R28	0683-3945	R: fxd, comp, 390K ohms $\pm$ 5%, 1/4W	
A5R29	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A5R30	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A5R31	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	
A5R32	0683-1235	R: fxd, comp, 12K ohms $\pm$ 5%, 1/4W	
A5R33	0683-1015	R: fxd, comp, 100 ohms $\pm$ 5%, 1/4W	
A5R34	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A5R35	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A5R36	0683-4725	R: fxd, comp, 4.7 K ohms $\pm$ 5%, 1/4W	
A5R37	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A5R38	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A5R39	0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4W	
A5R40	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A5R41	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A5R42	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A5R43	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	
A5R44	0683-1015	R: fxd, comp, 100 ohms $\pm$ 5%, 1/4W	
A5R45	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A5R46	0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	
A5R47	0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	
A5R48	0683-2045	R: fxd, comp, 200K ohms $\pm$ 5%, 1/4W	
A5R49	0683-5125	R: fxd, comp, 5.1K ohms $\pm$ 5%, 1/4W	
A5R50	0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	
A5R51	0683-5635	R: fxd, comp, 56K ohms $\pm$ 5%, 1/4W	
A6	114B-65D	Assy, gating and unblanking (includes all components prefixed A6)	
A6C1	0150-0081	C: fxd, cer, 0.01 μ f +80% -20%, 200 vdcw	
A6C2	0140-0167	C: fxd, mica, 470 pf $\pm$ 5%, 300 vdcw	
A6C3	0140-0167	C: fxd, mica, 470 pf $\pm$ 5%, 300 vdcw	

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Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓢ Stock No.	Description#	Note
A6C4	0180-0100	C: fxd, elect, 4.7 μ f $\pm$ 10%, 35 vdcw	
A6C5	0140-0018	C: fxd, mica, 1000 pf $\pm$ 5%, 500 vdcw	
A6C6	0180-0100	C: fxd, elect, 4.7 μ f $\pm$ 10%, 35 vdcw	
A6C7	0180-0100	C: fxd, elect, 4.7 μ f $\pm$ 10%, 35 vdcw	
A6CR1	1910-0011	Diode, ge: Type HD-2135A-5	
A6CR2	1910-0011	Diode, ge: Type HD-2135A-5	
A6CR3	G-31A-7A	Diode, si	
A6CR4	G-31A-7A	Diode, si	
A6CR5	G-31A-7A	Diode, si	
A6CR6	G-31A-7A	Diode, si	
A6CR7	G-31A-7A	Diode, si	
A6CR8	1910-0011	Diode, ge: Type HD-2135A-5	
A6CR9	1910-0011	Diode, ge: Type HD-2135A-5	
A6CR10	1910-0011	Diode, ge: Type HD-2135A-5	
A6CR11	1910-0011	Diode, ge: Type HD-2135A-5	
A6Q1	1850-0062	Transistor: Ⓢ type 1850-0062	
A6Q2	1850-0062	Transistor: Ⓢ type 1850-0062	
A6Q3	1850-0062	Transistor: Ⓢ type 1850-0062	
A6Q4	1850-0062	Transistor: Ⓢ type 1850-0062	
A6Q5	1851-0018	Transistor: 2N585	
A6Q6	1851-0018	Transistor: 2N585	
A6R1	0684-4721	R: fxd, comp, 4.7K ohms $\pm$ 10%, 1/4W	
A6R2	0684-8221	R: fxd, comp, 8.2K ohms $\pm$ 10%, 1/4W	
A6R3	0684-2231	R: fxd, comp, 22K ohms $\pm$ 10%, 1/4W	
A6R4	0684-8221	R: fxd, comp, 8.2K ohms $\pm$ 10%, 1/4W	
A6R5	0684-1021	R: fxd, comp, 1K ohms $\pm$ 10%, 1/4W	
A6R6	0684-1231	R: fxd, comp, 12K ohms $\pm$ 10%, 1/4W	
A6R7	0684-1511	R: fxd, comp, 150 ohms $\pm$ 10%, 1/4W	
A6R8	0684-2721	R: fxd, comp, 2.7K ohms $\pm$ 10%, 1/4W	
A6R9	0684-1031	R: fxd, comp, 10K ohms $\pm$ 10%, 1/4W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓢ Stock No.	Description	Note
A6R10	0684-1021	R: fxd, comp, 1K ohms $\pm 10\%$, 1/4W	
A6R11	0684-8221	R: fxd, comp, 8.2K ohms $\pm 10\%$, 1/4W	
A6R12	0684-2231	R: fxd, comp, 22K ohms $\pm 10\%$, 1/4W	
A6R13	0684-5621	R: fxd, comp, 5.6K ohms $\pm 10\%$, 1/4W	
A6R14	0684-1021	R: fxd, comp, 1K ohms $\pm 10\%$, 1/4W	
A6R15	0684-1021	R: fxd, comp, 1K ohms $\pm 10\%$, 1/4W	
A6R16	0684-1031	R: fxd, comp, 10K ohms $\pm 10\%$, 1/4W	
A6R17	0684-4731	R: fxd, comp, 47K ohms $\pm 10\%$, 1/4W	
A6R18	0684-1031	R: fxd, comp, 10K ohms $\pm 10\%$, 1/4W	
A6R19	0684-2221	R: fxd, comp, 2.2K ohms $\pm 10\%$, 1/4W	
A6R20	0684-2231	R: fxd, comp, 22K ohms $\pm 10\%$, 1/4W	
A6R21	0684-5621	R: fxd, comp, 5.6K ohms $\pm 10\%$, 1/4W	
A6R22	0683-7515	R: fxd, comp, 750 ohms $\pm 5\%$, 1/4W	
A6R23	0684-1521	R: fxd, comp, 1.5K ohms $\pm 10\%$, 1/4W	
A6R24	0687-4711	R: fxd, comp, 470 ohms $\pm 10\%$, 1/2W	
A6R25	0684-5621	R: fxd, comp, 5.6K ohms $\pm 10\%$, 1/4W	
A6R26	0684-1011	R: fxd, comp, 100 ohms $\pm 10\%$, 1/4W	
A6R27	0687-4711	R: fxd, comp, 470 ohms $\pm 10\%$, 1/4W	
A6R28	0687-2711	R: fxd, comp, 270 ohms $\pm 10\%$, 1/4W	
A7	114B-65C	Assy, sweep and marker generator (includes all components prefixed A7)	
A7C1	0140-0083	C: fxd, mica, 220 pf $\pm 5\%$, 500 vdcw	
A7C2		Not assigned	
A7C3	0160-0114	C: fxd, paper, 0.022 μ f $\pm 10\%$, 200 vdcw	
A7C4	0140-0083	C: fxd, mica, 220 pf $\pm 5\%$, 500 vdcw	
A7Q1	1850-0062	Transistor: Ⓢ type 1850-0062	
A7Q2	1850-0062	Transistor: Ⓢ type 1850-0062	
A7Q3	1851-0018	Transistor: 2N585	
A7Q4	1850-0062	Transistor: Ⓢ type 1850-0062	
A7Q5	1850-0062	Transistor: Ⓢ type 1850-0062	
A7Q6	1850-0062	Transistor: Ⓢ type 1850-0062	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓒ Stock No.	Description #	Note
A7R1	0684-2221	R: fxd, comp, 2.2K ohms $\pm 10\%$, 1/4W	
A7R2	0684-2231	R: fxd, comp, 22K ohms $\pm 10\%$, 1/4W	
A7R3	0687-1021	R: fxd, comp, 1K ohms $\pm 10\%$, 1/2W	
A7R4	0684-2211	R: fxd, comp, 220 ohms $\pm 10\%$, 1/4W	
A7R5	0684-2211	R: fxd, comp, 220 ohms $\pm 10\%$, 1/4W	
A7R6	0684-2721	R: fxd, comp, 2.7K ohms $\pm 10\%$, 1/4W	
A7R7	0684-4721	R: fxd, comp, 4.7K ohms $\pm 10\%$, 1/4W	
A7R8	0684-1021	R: fxd, comp, 1K ohms $\pm 10\%$, 1/4W	
A7R9	0684-4721	R: fxd, comp, 4.7K ohms $\pm 10\%$, 1/4W	
A7R10		Not assigned	
A7R11		Not assigned	
A7R12	0684-4701	R: fxd, comp, 47 ohms $\pm 10\%$, 1/4W	
A7R13	0683-2035	R: fxd, comp, 20K ohms $\pm 5\%$, 1/4W	
A7R14	0684-4721	R: fxd, comp, 4.7K ohms $\pm 10\%$, 1/4W	
A7R15	0684-2221	R: fxd, comp, 2.2K ohms $\pm 10\%$, 1/4W	
A7R16	0684-2231	R: fxd, comp, 22K ohms $\pm 10\%$, 1/4W	
A7R17	0687-1021	R: fxd, comp, 1K ohms $\pm 10\%$, 1/2W	
A7R18	0684-1511	R: fxd, comp, 150 ohms $\pm 10\%$, 1/4W	
A7R19	0684-2721	R: fxd, comp, 2.7K ohms $\pm 10\%$, 1/4W	
A7R20	0684-1031	R: fxd, comp, 10K ohms $\pm 10\%$, 1/4W	
A7R21	0684-1021	R: fxd, comp, 1K ohms $\pm 10\%$, 1/4W	
A8	114B-65E	Assy, regulator (includes all components prefixed A8)	
A8C1	0150-0081	C: fxd, cer, 0.01 μ f $+80\%$ -20% , 500 vdcw	
A8C2	0180-0061	C: fxd, elect, 100 μ f $+100\%$ -10% , 15 vdcw	
A8CR1	1901-0010	Diode, si: 1N540	
A8CR2	G-31G-27L	Diode, si	
A8CR3	G-31A-7A	Diode, si	
A8CR4	1901-0021	Diode, si: 1N538	
A8CR5	1901-0021	Diode, si: 1N538	
A8Q1	1850-0070	Transistor: 2N1373	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓢ Stock No.	Description	Note
A8Q2	1850-0062	Transistor: hp type 1850-0062	
A8R1	0693-8221	R: fxd, comp, 8.2K ohms $\pm 10\%$, 2W	
A8R2	0813-0018	R: fxd, ww, 2.8K ohms $\pm 10\%$, 5W	
A8R3	0687-2221	R: fxd, comp, 2.2K ohms $\pm 10\%$, 1/2W	
A8R4	0687-2211	R: fxd, comp, 220 ohms $\pm 10\%$, 1/2W	
A8R5	0687-4721	R: fxd, comp, 4.7K ohms $\pm 10\%$, 1/2W	
A8R6	0687-3311	R: fxd, comp, 330 ohms $\pm 10\%$, 1/2W	
A8R7	0687-5611	R: fxd, comp, 560 ohms $\pm 10\%$, 1/2W	
A9	114B-16A	Assy, power cable (includes P6, P7, W4)	
A10	114B-16B	Assy, Z-axis cable (includes E1 thru E6, P1, W1)	
A11	114B-16C	Assy, horizontal axis cables, short BNC to banana (includes P2, P3, W2)	
A12	114B-16D	Assy, vertical axis cable, long BNC to banana (includes P4, P5, W3)	
A13	114B-19A	Assy, sweep switch (includes C21 thru C28, C31, C32, R8, R10, R11, S4)	
C1	0170-0058	C: fxd, poly, 0.01 $\mu f \pm 10\%$, 200 vdcw	
C2			a
C3	0131-0003	C: var, mica, 170-780 pf, 175 vdcw	
C4	0140-0018	C: fxd, mica, 1000 pf $\pm 5\%$, 500 vdcw	
C5	0131-0003	C: var, mica, 170-780 pf, 175 vdcw	
C6			a
C7	0170-0058	C: fxd, poly, 0.01 $\mu f \pm 10\%$, 200 vdcw	
C8	0170-0058	C: fxd, poly, 0.01 $\mu f \pm 10\%$, 200 vdcw	
C9			a
C10	0131-0003	C; var, mica, 170-780 pf, 175 vdcw	
C11	0140-0018	C: var, mica, 1000 pf $\pm 5\%$, 500 vdcw	
C12	0131-0003	C: var, mica, 170-780 pf, 175 vdcw	
C13			a
C14	0170-0058	C: fxd, poly, 0.01 $\mu f \pm 10\%$, 200 vdcw	
C15	0170-0068	C: fxd, poly, 0.001 $\mu f \pm 10\%$, 200 vdcw	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description#	Note
C16	0131-0001	C: var, mica, 50-380 pf, 175 vdcw	
C17	0140-0034	C: fxd, mica, 22 pf $\pm$ 5%, 500 vdcw	
C18	0131-0001	C: var, mica, 50-380 pf, 175 vdcw	
C19	0170-0068	C: fxd, poly, 0.001 uf $\pm$ 10%, 200 vdcw	
C20	0150-0081	C: fxd, cer, 0.01 μ f +80%, -20%, 500 vdcw	
C21	0160-0115	C: fxd, paper, 0.18 μ f $\pm$ 10%, 100 vdcw	
C22	0160-0114	C: fxd, paper, 0.022 μ f $\pm$ 10%, 200 vdcw	
C23	0160-0112	C: fxd, paper, 3300 pf $\pm$ 10%, 400 vdcw	
C24	0140-0081	C: fxd, mica, 56 pf $\pm$ 10%, 500 vdcw	
C25	0160-0076	C: fxd, paper, 0.0 μ f $\pm$ 10%, 100 vdcw	
C26	0160-0113	C: fxd, paper, 0.01 μ f $\pm$ 10%, 100 vdcw	
C27	0140-0018	C: fxd, mica, 1000 pf $\pm$ 5%, 500 vdcw	
C28	0140-0041	C: fxd, mica, 100 pf $\pm$ 5%, 500 vdcw	
C29	0160-0117	C: fxd, paper, 10 μ f $\pm$ 10%, 200 vdcw	
C30	0160-0116	C: fxd, paper, 1.0 μ f $\pm$ 10%, 100 vdcw	
C31	0160-0076	C: fxd, paper, 0.1 μ f $\pm$ 10%, 100 vdcw	
C32	0160-0113	C: fxd, paper, 0.01 μ f $\pm$ 10%, 100 vdcw	
C33	0180-0102	C: fxd, elect, 20 μ f, 200 vdcw	
C34	0180-0103	C: fxd, elect, 1000 μ f, 50 vdcw	
C35	0180-0101	C: fxd, elect, 1.8 μ f $\pm$ 10%, 35 vdcw	
C36	0140-0091	C: fxd, mica, 820 pf $\pm$ 5%, 500 vdcw	
C37	0140-0091	C: fxd, mica, 820 pf $\pm$ 5%, 500 vdcw	
C38	0140-0091	C: fxd, mica, 820 pf $\pm$ 5%, 500 vdcw	
DS1	2140-0017	Lamp, Ne: Type NE2D	c
E1	0340-0011	Insulator bushing	
	0340-0015	Terminal post	
E2	0340-0011	Insulator bushing	
	0340-0015	Terminal post	
E3	0340-0011	Insulator bushing	
	0340-0015	Terminal post	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	⊗ Stock No.	Description #	Note
E4	0340-0011	Insulator bushing	
	0340-0015	Terminal post	
E5		Part of A10; nsr	
E6		Part of A10; nsr	
F1	2110-0004	Fuse, cartridge: 1/4 amp	
J1	1250-0083	Connector, female: BNC, UG 1094/U	
J2	1250-0083	Connector, female: BNC, UG1094/U	
J3	1251-0147	Connector, female: 3 pin	
J4	1250-0083	Connector, female: BNC, UG 1094/U	
J5	1250-0118	Connector, female: BNC, UG1094/U	
J6	1250-0118	Connector, female: BND, UG1094/U	
J7	1251-0039	Connector, male: 3 pin	
L1	114B-60E	Inductor, fxd: 118 mh	
MP1	1450-0034	Jewel, red: pilot light	
MP2	G-74C	Knob, round: black, 3/4"	
MP3	G-74N	Knob, bar w/2 arrows: black, 1"	
P1	1251-0154	Bushing, telescoping	
	1251-0155	Connector, male: 3 pin	
P2	1250-0049	Nut, clamp: for BNC	
	1250-0052	Connector, plug: BNC	
	1250-0089	Connector, male: BNC, center pin	
P3	1251-0005	Connector, banana plug	
P4	1250-0049	Nut, clamp: for BNC	
	1250-0052	Connector, plug, BNC	
	1250-0089	Connector, male: BNC, center pin	
P5	1251-0005	Connector, banana plug	
P6	1251-0037	Connector, power, male: 3 pin	
P7	1251-0038	Connector, female: 3 pin	
Q1	1850-0050	Transistor: 2N457A	
R1	0684-1041	R: fxd, comp, 100K ohms $\pm$ 10%, 1/4W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓢ Stock No.	Description #	Note
R2	0684-1041	R: fxd, comp, 100K ohms $\pm$ 10%, 1/4W	d
R3	0684-1041	R: fxd, comp, 100K ohms $\pm$ 10%, 1/4W	
R4	0684-1041	R: fxd, comp, 100K ohms $\pm$ 10%, 1/4W	
R5	0684-1021	R: fxd, comp, 1K ohms $\pm$ 10%, 1/4W	
R6		Not assigned	
R7	0684-4731	R: fxd, comp, 47K ohms $\pm$ 10%, 1/4W	
R8	0683-1855	R: fxd, comp, 1.8M $\pm$ 5%, 1/4W	
R9	2100-0044	R: var, comp, lin, 50K ohms $\pm$ 10%	
R10	0683-1255	R: fxd, comp, 1.2M $\pm$ 5%, 1/4W	
R11	0683-8235	R: fxd, comp, 82K ohms $\pm$ 5%, 1/4W	
R12	2100-0269	R: var, comp, lin, 2.5 M $\pm$ 20%	
R13	2100-0269	R: var, comp, lin, 2.5M $\pm$ 20%	
R14	2100-0269	R: var, comp, lin, 2.5M $\pm$ 20%	
R15	2100-0269	R: var, comp, lin, 2.5M $\pm$ 20%	
R16	2100-0268	R: var, comp, lin, 250 ohms $\pm$ 10%	
R17	0687-1041	R: fxd, comp, 100K ohms $\pm$ 10%, 1/2W	
R18	0684-6831	R: fxd, comp, 68K ohms $\pm$ 10%, 1/4W	
R19	0687-1021	R: fxd, comp, 1K ohms $\pm$ 10%, 1/4W	
R20	0687-1051	R: fxd, comp, 1M $\pm$ 10%, 1/2W	
R21	0687-1051	R: fxd, comp, 1M $\pm$ 10%, 1/2W	
R22	0687-1051	R: fxd, comp, 1M $\pm$ 10%, 1/2W	
S1	3100-0266	Switch thumbwheel: three 10-pos modular	
S2	3100-0266	Switch, thumbwheel: three 10-pos modular	
S3	3100-0266	Switch, thumbwheel: three 10-pos modular	
S4		Part of A13; nsr; see MP3 for knob	
S5	3101-0001	Switch, tog: SPST	
S6	3101-0035	Switch, push: momentary snap action	
S7	3100-0147	Switch, lever : 3 pos	
S8	3101-0003	Switch, tog: DPST	
T1	114B-60A	Transformer, 5 kc	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description #	Note
E4	0340-0011	Insulator bushing	
	0340-0015	Terminal post	
E5		Part of A10; nsr	
E6		Part of A10; nsr	
F1	2110-0004	Fuse, cartridge: 1/4 amp	
J1	1250-0083	Connector, female: BNC, UG 1094/U	
J2	1250-0083	Connector, female: BNC, UG1094/U	
J3	1251-0147	Connector, female: 3 pin	
J4	1250-0083	Connector, female: BNC, UG 1094/U	
J5	1250-0118	Connector, female: BNC, UG1094/U	
J6	1250-0118	Connector, female: BND, UG1094/U	
J7	1251-0039	Connector, male: 3 pin	
L1	114B-60E	Inductor, fxd: 118 mh	
MP1	1450-0034	Jewel, red: pilot light	
MP2	G-74C	Knob, round: black, 3/4"	
MP3	G-74N	Knob, bar w/2 arrows: black, 1"	
P1	1251-0154	Bushing, telescoping	
	1251-0155	Connector, male: 3 pin	
P2	1250-0049	Nut, clamp: for BNC	
	1250-0052	Connector, plug: BNC	
	1250-0089	Connector, male: BNC, center pin	
P3	1251-0005	Connector, banana plug	
P4	1250-0049	Nut, clamp: for BNC	
	1250-0052	Connector, plug, BNC	
	1250-0089	Connector, male: BNC, center pin	
P5	1251-0005	Connector, banana plug	
P6	1251-0037	Connector, power, male: 3 pin	
P7	1251-0038	Connector, female: 3 pin	
Q1	1850-0050	Transistor: 2N457A	
R1	0684-1041	R: fxd, comp, 100K ohms $\pm 10\%$, 1/4W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description #	Note
R2	0684-1041	R: fxd, comp, 100K ohms $\pm 10\%$, 1/4W	d
R3	0684-1041	R: fxd, comp, 100K ohms $\pm 10\%$, 1/4W	
R4	0684-1041	R: fxd, comp, 100K ohms $\pm 10\%$, 1/4W	
R5	0684-1021	R: fxd, comp, 1K ohms $\pm 10\%$, 1/4W	
R6		Not assigned	
R7	0684-4731	R: fxd, comp, 47K ohms $\pm 10\%$, 1/4W	
R8	0683-1855	R: fxd, comp, 1.8M $\pm 5\%$, 1/4W	
R9	2100-0044	R: var, comp, lin, 50K ohms $\pm 10\%$	
R10	0683-1255	R: fxd, comp, 1.2M $\pm 5\%$, 1/4W	
R11	0683-8235	R: fxd, comp, 82K ohms $\pm 5\%$, 1/4W	
R12	2100-0269	R: var, comp, lin, 2.5 M $\pm 20\%$	
R13	2100-0269	R: var, comp, lin, 2.5M $\pm 20\%$	
R14	2100-0269	R: var, comp, lin, 2.5M $\pm 20\%$	
R15	2100-0269	R: var, comp, lin, 2.5M $\pm 20\%$	
R16	2100-0268	R: var, comp, lin, 250 ohms $\pm 10\%$	
R17	0687-1041	R: fxd, comp, 100K ohms $\pm 10\%$, 1/2W	
R18	0684-6831	R: fxd, comp, 68K ohms $\pm 10\%$, 1/4W	
R19	0687-1021	R: fxd, comp, 1K ohms $\pm 10\%$, 1/4W	
R20	0687-1051	R: fxd, comp, 1M $\pm 10\%$, 1/2W	
R21	0687-1051	R: fxd, comp, 1M $\pm 10\%$, 1/2W	
R22	0687-1051	R: fxd, comp, 1M $\pm 10\%$, 1/2W	
S1	3100-0266	Switch thumbwheel: three 10-pos modular	
S2	3100-0266	Switch, thumbwheel: three 10-pos modular	
S3	3100-0266	Switch, thumbwheel: three 10-pos modular	
S4		Part of A13; nsr; see MP3 for knob	
S5	3101-0001	Switch, tog: SPST	
S6	3101-0035	Switch, push: momentary snap action	
S7	3100-0147	Switch, lever : 3 pos	
S8	3101-0003	Switch, tog: DPST	
T1	114B-60A	Transformer, 5 kc	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓢ Stock No.	Description #	Note
T2	114B-60B	Transformer, 10 kc	
T2	114B-60C	Transformer, 50 kc	
T4	114B-60D	Transformer, Z-axis	
T5	9100-0136	Transformer, power	
W1			b
W2			b
W3			b
W4			b
W5	M-65A	Circuit board extender	
XA1	1251-0135	Connector, printed circuit: 15 pin	
XA2	1251-0135	Connector, printed circuit: 15 pin	
XA3	1251-0135	Connector, printed circuit: 15 pin	
XA4	1251-0135	Connector, printed circuit: 15 pin	
XA5	1251-0135	Connector, printed circuit: 15 pin	
XA6	1251-0135	Connector, printed circuit: 15 pin	
XA7	1251-0135	Connector, printed circuit: 15 pin	
XA8	1251-0135	Connector, printed circuit: 15 pin	
XDS1	1450-0032	Lampholder: for 2-pin base	c
XF1	1400-0085	Fuseholder	
Notes: a = Mica capacitor: selected at factory; value varies from 0 to 1000 pf. b = Order by description; see table 6-3. c = See MP1 for jewel d = See MP2 for knob e = part of A13			

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Table 6-2. Replaceable Parts

Stock No.	Description	Mfr.	Mfr. Part No.	TQ	RS		
G-29A-50	Diode, si	28480	G-29A-50	1	1		
G-31A-7A	Diode, si	28480	G-31A-7A	10	10		
G-31A-15H	Diode, si	28480	G-31A-15H	1	1		
G-31G-27L	Diode, si	28480	G-31G-27L	1	1		
G-74C	Knob, round: black, 3/4"	28480	G-74C	1	0		
G-74N	Knob, bar w/2 arrows: black, 1"	28480	G-74N	1	0		
M-65A	Circuit board extender	28480	M-65A	1	0		
114B-16A	Assy, power cable (includes P6, P7, W4)	28480	114B-16A	1	1		
114B-16B	Assy, Z-axis cable (includes E5 and E6, P1, W1)	28480	114B-16B	1	0		
114B-16C	Assy, horiz axis cable; short BNC to banana (includes P2, P3, W2)	28480	114B-16C	1	0		
114B-16D	Assy, ver axis cable, long BNC to banana (includes P4, P5, W3)	28480	114B-16D	1	0		
114B-19A	Assy, sweep switch (includes C21 thru C28; C31, C32, R8, R10, R11, S4)	28480	114B-19A	1	1		
114B-60A	Transformer, 5 kc	28480	114B-60A	1	1		
114B-60B	Transformer, 10 kc	28480	114B-60B	1	1		
114B-60C	Transformer, 50 kc	28480	114B-60C	1	1		
114B-60D	Transformer, 50 kc	28480	114B-60D	1	1		
114B-60E	Inductor, fxd: 118 mh	28480	114B-60E	1	1		
114B-65A	Assy, input circuit (includes all components prefixed A2)	28480	114B-65A	1	1		
114B-65B	Assy, multiplier (includes all components prefixed A1)	28480	114B-65B	1	1		
114B-65C	Assy, sweep and marker generator (includes all components prefixed A7)	28480	114B-65C	1	1		
114B-65D	Assy, gating and unblanking (includes all components prefixed A6)	28480	114B-65D	1	1		
114B-65E	Assy, regulator (includes all components prefixed A8)	28480	114B-65E	1	1		
114B-65F	Assy, divider (includes all components prefixed A3, A4, A5)	28480	114B-65F	3	1		
0131-0001	C: var, mica, 50-380 pf, 175 vdcw	72136	obd#	2	1		
0131-0003	C: var, mica, 170-780 pf, 175 vdcw	72136	T52910	4	1		

See introduction to this section

Table 6-2 . Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0140-0018	C: fxd, mica, 1000 pf $\pm$ 5%, 500 vdcw	76433	RCM2CE102J	10	3		
0140-0034	C: fxd, mica, 22 pf $\pm$ 5%, 500 vdcw	76433	RCM15E220J	1	1		
0140-0037	C: fxd, mica, 390 pf $\pm$ 5%, 500 vdcw	76433	RCM15E391J	24	5		
0140-0041	C: fxd, mica, 100 pf $\pm$ 5%, 500 vdcw	76433	RCM15E101J	2	1		
0140-0081	C: fxd, mica, 56 pf $\pm$ 1%, 500 vdcw	11711	CM15E560G	1	1		
0140-0083	C: fxd, mica, 220 pf $\pm$ 5%, 500 vdcw	76433	RCM15E221J	2	1		
0140-0091	C: fxd, mica, 820 pf $\pm$ 5%, 500 vdcw	72136	CM20E821J	6	1		
0140-0167	C: fxd, mica, 470 pf $\pm$ 5%, 300 vdcw	72136	CM15D471J	17	4		
0140-0168	C: fxd, mica, 330 pf $\pm$ 5%, 300 vdcw	72136	CM15D331JN3	1	1		
0150-0081	C: fxd, cer, 0.01 μ f $\pm$ 80%, -20%, 500 vdcw	72982	CK63AW103X	6	2		
0160-0076	C: fxd, paper, 0.1 μ f $\pm$ 10%, 100 vdcw	56289	196P10491 S4	5	2		
0160-0112	C: fxd, paper, 3300 pf $\pm$ 10%, 400 vdcw	56289	191P33294S4	2	1		
0160-0113	C: fxd, paper, 0.01 μ f $\pm$ 10%, 100 vdcw	56289	191-10391-S4	2	1		
0160-0114	C: fxd, paper, 0.022 μ f $\pm$ 10%, 200 vdcw	56289	191P-22392-S4	3	1		
0160-0115	C: fxd, paper, 0.18 μ f $\pm$ 10%, 100 vdcw	56289	191P-18491-S4	1	1		
0160-0116	C: fxd, paper, 1.0 μ f $\pm$ 10%, 100 vdcw	56289	181P-10591-T15	1	1		
0160-0117	C: fxd, paper, 10 μ f $\pm$ 10%, 200 vdcw	56289	118P-10692-T25	1	1		
0170-0058	C: fxd, poly, 0.01 μ f $\pm$ 10%, 200 vdcw	56289	114P-10392-T15	4	1		
0170-0068	C: fxd, poly, 0.001 μ f $\pm$ 10%, 200 vdcw	56289	114P-10292-T15	2	1		
0180-0061	C: fxd, elect, 100 μ f $\pm$ 100% -10%, 15 vdcw	56289	30D172A1	1	1		
0180-0100	C: fxd, elect, 4.7 μ f $\pm$ 10%, 35 vdcw	56289	150D475X9035B2	6	2		
0180-0101	C: fxd, elect, 1.8 μ f $\pm$ 10%, 35 vdcw	56289	150D185X9035B2	1	1		
0180-0102	C: fxd, elect, 20 μ f, 200 vdcw	56289	SP-CE31B200K	1	1		
0180-0103	C: fxd, elect, 1000 μ f, 50 vdcw	56289	Sample #91093	1	1		
0340-0011	Insulator bushing	08145	421373	4	1		
0340-0015	Terminal post	08145	420969	4	1		
0683-1015	R: fxd, comp, 100 ohms, $\pm$ 5%, 1/4W	01121	CB1015	12	3		
0683-1035	R: fxd, comp, 10K ohms $\pm$ 5%, 1/4 W	01121	CB1035	21	5		
0683-1235	R: fxd, comp, 12K ohms, $\pm$ 5%, 1/4W	01121	CB1235	6	2		
0683-1255	R: fxd, comp, 1.2 megohms $\pm$ 5%, 1/4W	01121	CB1255	1	1		

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0683-1635	R: fxd, comp, 16K ohms $\pm$ 5%, 1/4W	01121	CB1635	25	6		
0683-1655	R: fxd, comp, 1.6M $\pm$ 5%, 1/4W	01121	CB1655	3	1		
0683-1855	R: fxd, comp, 1.8K ohms $\pm$ 5%, 1/4W	01121	CB1855	1	1		
0683-2035	R: fxd, comp, 20 K ohms $\pm$ 5%, 1/4W	01121	CB2035	1	1		
0683-2045	R: fxd, comp, 200K ohms $\pm$ 5%, 1/4W	01121	CB2045	3	1		
0683-2425	R: fxd, comp, 2.4K ohms $\pm$ 5%, 1/4W	01121	CB2425	48	10		
0683-3945	R: fxd, comp, 390K ohms $\pm$ 5%, 1/4W	01121	CB3945	3	1		
0683-4725	R: fxd, comp, 4.7K ohms $\pm$ 5%, 1/4W	01121	CB4725	24	5		
0683-5125	R: fxd, comp, 5.1K ohms $\pm$ 5%, 1/4W	01121	CB5125	3	1		
0683-5635	R: fxd, comp, 56. K ohms $\pm$ 5%, 1/4W	01121	CB5635	3	1		
0683-7515	R: fxd, comp, 750 ohms $\pm$ 5%, 1/4W	01121	CB7515	1	1		
0683-8235	R: fxd, comp, 82K ohms $\pm$ 5%, 1/4W	01121	CB8235	1	1		
0683-8245	R: fxd, comp, 820K ohms $\pm$ 5%, 1/4W	01121	CB8245	3	1		
0684-1011	R: fxd, comp, 100 ohms $\pm$ 10%, 1/4W	01121	CB1011	3	1		
0684-1021	R: fxd, comp, 1K ohms $\pm$ 10%, 1/4W	01121	CB1021	12	3		
0684-1031	R: fxd, comp, 10K ohms $\pm$ 10%, 1/4W	01121	CB1031	8	2		
0684-1041	R: fxd, comp, 100K ohms $\pm$ 10%, 1/4W	01121	CB1041	4	1		
0684-1231	R: fxd, comp, 12K ohms $\pm$ 10%, 1/4W	01121	CB1231	3	1		
0684-1511	R: fxd, comp, 150 ohms $\pm$ 10%, 1/4W	01121	CB1511	4	2		
0684-1521	R: fxd, comp, 1.5K ohms $\pm$ 10%, 1/4W	01121	CB1521	4	1		
0684-1821	R: fxd, comp, 1.8K ohms $\pm$ 10%, 1/4W	01121	CB1821	3	1		
0684-2211	R: fxd, comp, 220 ohms $\pm$ 10%, 1/4W	01121	CB2211	1	1		
0684-2221	R: fxd, comp, 2.3K ohms $\pm$ 10%, 1/4W	01121	CB2221	3	1		
0684-2231	R: fxd, comp, 22K ohms $\pm$ 10%, 1/4W	01121	CB2231	8	2		
0684-2721	R: fxd, comp, 2.7K ohms $\pm$ 10%, 1/4W	01121	CB2721	4	1		
0684-2731	R: fxd, comp, 27K ohms $\pm$ 10%, 1/4W	01121	CB2731	1	1		
0684-4701	R: fxd, comp, 47 ohms $\pm$ 10%, 1/4W	01121	CB4701	1	1		
0684-4721	R: fxd, comp, 4.7K ohms $\pm$ 10%, 1/4W	01121	CB4721	7	2		
0684-4731	R: fxd, comp, 47K ohms $\pm$ 10%, 1/4W	01121	CB4731	2	1		
0684-5611	R: fxd, comp, 560 ohms $\pm$ 10%, 1/4W	01121	CB5611	1	1		

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0684-5621	R: fxd, comp, 5.6K ohms $\pm$ 10%, 1/4W	01121	CB5621	8	2		
0684-6821	R: fxd, comp, 6.8K ohms $\pm$ 10%, 1/4W	01121	CB6821	2	1		
0684-6831	R: fxd, comp, 68K ohms $\pm$ 10%, 1/4W	01121	CB6831	2	1		
0684-8211	R: fxd, comp, 820 ohms $\pm$ 10%, 1/4W	01121	CB8211	1	1		
0684-8221	R: fxd, comp, 8.2K ohms $\pm$ 10%, 1/4W	01121	CB8221	6	2		
0687-1021	R: fxd, comp. 1K ohms $\pm$ 10%, 1/2W	01121	EB1021	6	2		
0687-1041	R: fxd, comp, 100K ohms $\pm$ 10%, 1/2W	01121	EB1041	1	1		
0687-1051	R: fxd, comp, 1M $\pm$ 10%, 1/2 W	01121	EB1051	3	3		
0687-1521	R: fxd, comp, 1.5K ohms $\pm$ 10%, 1/2W	01121	EB1521	1	1		
0687-2211	R: fxd, comp, 220 ohms $\pm$ 10%, 1/2W	01121	EB2211	1	1		
0687-2221	R: fxd, comp, 2.2K ohms $\pm$ 10%, 1/2W	01121	EB2221	1	1		
0687-2711	R: fxd, comp, 270 ohms $\pm$ 10%, 1/2W	01121	EB2711	1	1		
0687-3311	R: fxd, comp, 330 ohms $\pm$ 10%, 1/2W	01121	EB3311	1	1		
0687-4711	R: fxd, comp, 470 ohms $\pm$ 10%, 1/2 W	01121	EB4711	2	1		
0687-4721	R: fxd, comp, 4.7K ohms $\pm$ 10%, 1/2W	01121	EB4721	1	1		
0687-5611	R: fxd, comp, 560 ohms $\pm$ 10%, 1/2W	01121	EB5611	1	1		
0693-8221	R: fxd, comp, 8.2K ohms $\pm$ 10%, 2W	01121	HB8221	1	1		
0813-0018	R: fxd, ww, 2.8K ohms $\pm$ 10%, 5 W	35434	C-5-2800	1	1		
1250-0049	Nut, clamp: for BNC	91737	7013-2	2	1		
1250-0052	Connector: plug: BNC	91737	7010	2	1		
1250-0083	Connector , female: BNC, UG 1094/U	91737	UG1094/U	3	1		
1250-0089	Connector, male: BNC, center pin	91737	7000-19	3	1		
1250-0118	Connector, female: BNC, UG1094A/U	91737	8427	2	1		
1251-0005	Connector, banana plug	24655	Type 274-MB	2	1		
1251-0037	Connector, power, male: 3 pin	97539	N-UP121M	1	1		
1251-0038	Connector, female: 3 pin	02660	MS-3106A-10SL-3S	1	1		
1251-0039	Connector, male: 3 pin	02660	MS-3102A-10SL-3P	1	1		
1251-0135	Connector, printed circuit: 15 pin	95354	SD-615UR spec	8	2		
1251-0147	Connector, female: 3 pin	71468	MS3102R10SL-3P	1	1		
1251-0154	Bushing, telescoping	71468	18220-4	1	1		

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
1251-0155	Connector, male: 3 pin	71468	MS3106E14S-1P	1	1		
1400-0085	Fuseholder	75915	342004	1	1		
1450-0032	Lampholder: for 2 pin base	72619	137-8536-9				
1450-0034	Jewel, red: pilot light	72619	obd#	1	0		
1850-0050	Transistor: 2N457A	01295	2N457A	1	1		
1850-0062	Transistor: hp Type 1850-0062	49956	T51602	45	45		
1850-0070	Transistor: 2N1373	01295	2N1373	1	1		
1851-0018	Transistor: 2N585	02735	2N585	7	7		
1901-0010	Diode, si: 1N540	04713	1N540	1	1		
1901-0021	Diode, si: 1N538	03508	1N538	2	2		
1901-0022	Diode, si: G-129	82647	G-129	3	3		
1910-0007	Diode, ge: 1N281	93332	1N281	1	1		
1910-0011	Diode, ge: Type HD-2135A-5	73292	HD-2135A-5	23	23		
2100-0044	R: var, comp, lin, 50K ohms $\pm$ 10%	01121	JA1N056S503UA	1	1		
2100-0268	R: var, comp, lin, 250 ohms $\pm$ 10%	11237	RV5LAYSB251A	1	1		
2100-0269	R: var, comp, lin, 2.5M $\pm$ 20%	11237	RV5LAYSB255B	1	1		
2100-0004	Fuse cartridge: 1/4 amp	75915	3AG/Cat #312.250	1	10		
2140-0017	Lamp, Ne: Type NE2D	24455	GET-2NE2D	1	1		
3100-0147	Switch, lever: 3 pos	71590	PA220-290	1	1		
3100-0266	Switch, thumbwheel: three 10-pos modules	07126	Type 7310.3	3	1		
3101-0001	Switch, tog: SPST	04009	80994-H	1	1		
3101-0003	Switch, tog: DPST	88140	obd#	1	1		
3101-0035	Switch, push: momentary snap action	99707	W104UB6	1	1		
9100-0136	Transformer, power	28480	9974	1	1		

See introduction to this section

Table 6-3. Description

Reference Designation	Description	Mfr*	TQ*	RS*
	ORDER BY DESCRIPTION			
W1	Cable, shielded, 2 conductor (part of A10, not recommended for field replacement)	28480		
W2	Cable: 7-15/16 inch length of Ⓢ Stock No. 8120-0017, RG58A/U	28480	1	1
W3	Cable: 11-7/16 inch length of Ⓢ Stock No. 8120-0017, RG58A/U	28480	1	1
W4	Cable, 3 conductor: consists of 70-1/2 inch length of Ⓢ Stock No. 8120-0022	28480	1	1

*See Introduction to this section.

APPENDIX

CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

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

CODE NO.	MANUFACTURER	ADDRESS	CODE NO.	MANUFACTURER	ADDRESS	CODE NO.	MANUFACTURER	ADDRESS
00334	Humidical Co.	Colton, Calif.	07137	Transistor Electronics Corp.	Minneapolis, Minn.	42190	Muter Co.	Chicago, Ill.
00335	Westrex Corp.	New York, N.Y.	07138	Westinghouse Electric Corp.	Elmira, N.Y.	43990	C. A. Norgren Co.	Englewood, Colo.
00373	Garlock Packing Co.	Camden, N.J.	07261	Avnet Corp.	Los Angeles, Calif.	44655	Ohmrite Mfg. Co.	Skokie, Ill.
00656	Aerovox Corp.	New Bedford, Mass.	07263	Fairchild Semiconductor Corp.	Mountain View, Calif.	47904	Polaroid Corp.	Cambridge, Mass.
00779	Amp, Inc.	Harrisburg, Pa.	07910	Continental Device Corp.	Hawthorne, Calif.	48820	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.	07933	Rheem Semiconductor Corp.	Mountain View, Calif.	49956	Raytheon Company	Lexington, Mass.
00853	Sangamo Electric Company, Orville Division (Capacitors)	Marion, Ill.	07980	Boonton Radio Corp.	Boonton, N.J.	54294	Shallcross Mfg. Co.	Selma, N.C.
00866	Goe Engineering Co.	Los Angeles, Calif.	08145	U.S. Engineering Co.	Los Angeles, Calif.	55026	Simpson Electric Co.	Chicago, Ill.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.	08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada	55933	Sonolone Corp.	Elmsford, N.Y.
01121	Allen Bradley Co.	Milwaukee, Wis.	08717	Sloan Company	Burbank, Calif.	55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
01255	Liton Industries, Inc.	Beverly Hills, Calif.	08718	Cannon Electric Co.	Phoenix, Ariz.	56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.	08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.	56289	Sprague Electric Co.	North Adams, Mass.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas	09026	Babcock Relays, Inc.	Costa Mesa, Calif.	59446	Telex, Inc.	St. Paul, Minn.
01349	The Alliance Mfg. Co.	Alliance, Ohio	09134	Texas Capacitor Corp.	Houston, Texas	61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
01561	Chassi-Trak Corp.	Indianapolis, Ind.	09250	Electro Assemblies, Inc.	Chicago, Ill.	62119	Universal Electric Co.	Owosso, Mich.
01589	Pacific Relays, Inc.	Van Nuys, Calif.	09549	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada	64959	Western Electric Co., Inc.	New York, N.Y.
01930	Amerock Corp.	Rockford, Ill.	10214	General Transistor Western Corp.	Los Angeles, Calif.	65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
01961	Pulse Engineering Co.	Santa Clara, Calif.	10411	Ti-Tal, Inc.	Berkeley, Calif.	66346	Wollensak Optical Co.	Rochester, N.Y.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.	10646	Carborundum Co.	Niagara Falls, N.Y.	70276	Allen Mfg. Co.	Hartford, Conn.
02286	Cole Mfg. Co.	Palo Alto, Calif.	11236	CTS of Berna, Inc.	Berna, Ind.	70309	Allied Control Co., Inc.	New York, N.Y.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.	11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.	70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.	11312	Microwave Electronics Corp.	Palo Alto, Calif.	70563	Amperite Co., Inc.	New York, N.Y.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.	11711	General Instrument Corporation Semiconductor Division	Newark, N.J.	70903	Beiden Mfg. Co.	Chicago, Ill.
02777	Hopkins Engineering Co.	San Fernando, Calif.	11717	Imperial Electronics, Inc.	Buena Park, Calif.	70998	Bird Electronic Corp.	Cleveland, Ohio
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.	11870	Melabs, Inc.	Palo Alto, Calif.	71002	Birnbach Radio Co.	New York, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio	12697	Claroast Mfg. Co.	Dover, N.H.	71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
03797	Eldema Corp.	El Monte, Calif.	14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.	71218	Bud Radio Inc.	Cleveland, Ohio
03877	Transitron Electronic Corp.	Wakefield, Mass.	15909	The Daven Co.	Livingston, N.J.	71286	Camloc Fastener Corp.	Paramus, N.J.
03888	Pyrilum Resistor Co.	Morrisstown, N.J.	16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.	71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.	16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.	71400	Buamann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.	18873	E. I. DuPont and Co., Inc.	Wilmington, Del.	71450	CTS Corp.	Elkhart, Ind.
04062	Elmenco Products Co.	New York, N.Y.	19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.	71468	Cannon Electric Co.	Los Angeles, Calif.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.	19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.	71471	Cinema Engineering Co.	Burbank, Calif.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.	19701	Electra Manufacturing Co.	Kansas City, Mo.	71482	C. P. Clare & Co.	Chicago, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.	20183	Electronic Tube Corp.	Philadelphia, Pa.	71528	Standard-Thomson Corp., Clifford Mfg. Co. Div.	Waltham, Mass.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.	21520	Fanstee Metallurgical Corp.	No. Chicago, Ill.	71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona	21335	The Fafnir Bearing Co.	New Britain, Conn.	71700	The Cornish Wire Co.	New York, N.Y.
04732	Filtron Co., Inc., Western Division	Culver City, Calif.	21964	Fed. Telephone and Radio Corp.	Clifton, N.J.	71744	Chicago Miniature Lamp Works	Chicago, Ill.
04773	Automatic Electric Co.	Northlake, Ill.	24446	General Electric Co. Lamp Division	Nela Park, Cleveland, Ohio	71785	Cinch Mfg. Corp.	West Orange, N.J.
04870	P. M. Motor Co.	Chicago, Ill.	24655	General Radio Co.	West Concord, Mass.	71984	Dow Corning Corp.	Midland, Mich.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.	24662	Grobet File Co. of America, Inc.	Carlstadt, N.J.	72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.	26992	Hamilton Watch Co.	Lancaster, Pa.	72354	John E. Fast & Co.	Chicago, Ill.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.	28480	Hewlett-Packard Co.	Palo Alto, Calif.	72419	Dialight Corp.	Chicago, Ill.
05624	Barber Colman Co.	Rockford, Ill.	33173	G.E. Receiving Tube Dept.	Owensboro, Ky.	72456	General Ceramics Corp.	Brooklyn, N.Y.
05729	Metropolitan Telecommunications Corp., Metro Cap. Div.	Brooklyn, N.Y.	35434	Lectrohm Inc.	Chicago, Ill.	72758	Girard-Hopkins	Kearney, N.J.
05783	Stewart Engineering Co.	Santa Cruz, Calif.	37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.	72765	Drake Mfg. Co.	Chicago, Ill.
06004	The Bassick Co.	Bridgeport, Conn.	39543	Mechanical Industries Prod. Co.	Akron, Ohio	72825	Hugh H. Eby Inc.	Philadelphia, Pa.
06555	Beebe Electrical Instrument Co., Inc.	Penacook, N.H.	40920	Miniature Precision Bearings, Inc.	Keene, N.H.	72928	Gudeman Co.	Chicago, Ill.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.				72982	Erie Resistor Corp.	Erie, Pa.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.				73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
07126	Digitran Co.	Pasadena, Calif.				73138	Heliplot Div. of Beckman Instruments, Inc.	Fullerton, Calif.

From: F.S.C. Handbook Supplements
H4-1 Dated November 1961
H4-2 Dated November 1961

00015-20
Revised: 23 January 1962

APPENDIX **CODE LIST OF MANUFACTURERS (Sheet 2 of 2)**

CODE NO.	MANUFACTURER	ADDRESS	CODE NO.	MANUFACTURER	ADDRESS	CODE NO.	MANUFACTURER	ADDRESS
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio	82447	Metals and Controls, Inc.	Div. of	95264	Larco Electronics, Inc.	Burbank, Calif.
73793	The General Industries Co.	Elyria, Ohio		Texas Instruments, Inc.	Arlleboro, Mass.	95265	National Coil Co.	Sheridan, Wyo.
73905	Jennings Radio Mfg. Co.	San Jose, Calif.		Spencer Prods.	Madison, Wis.	95275	Vitramon, Inc.	Bridgeport, Conn.
74455	J. H. Wynn and Sons	Winchester, Mass.	82866	Research Products Corp.		95354	Method Mfg. Co.	Chicago, Ill.
74861	Industrial Condenser Corp.	Chicago, Ill.	82877	Roltron Manufacturing Co., Inc.	Woodstock, N.Y.	95987	Wackesser Co.	Chicago, Ill.
74868	R.F. Products Division of Amphel-Borg Electronics Corp.	Danbury, Conn.			Glendale, Calif.	96067	Huggins Laboratories	Sunnyvale, Calif.
74970	E. F. Johnson Co.	Waseca, Minn.	83058	Carr Fastener Co.	Cambridge, Mass.	96095	Hi-Q Division of Aerovox	Olean, N.Y.
75042	International Resistance Co.	Philadelphia, Pa.	83125	Pyramid Electric Co.	Darlington, S.C.	96256	Thordarson-Meisner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.	83148	Electro Cordis Co.	Los Angeles, Calif.	96296	Solar Manufacturing Co.	Los Angeles, Calif.
75378	James Knights Co.	Sandwich, Ill.	83186	Victory Engineering Corp.	Union, N.J.	96330	Carlton Screw Co.	Chicago, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.	83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.	96341	Microwave Associates, Inc.	Burlington, Mass.
75818	Lent Electric Mfg. Co.	Chicago, Ill.	83330	Smith, Herman H., Inc.	Brooklyn, N.Y.	96501	Excel Transformer Co.	Oakland, Calif.
75915	Littelfuse Inc.	Des Plaines, Ill.	83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.	97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
76005	Lord Mfg. Co.	Erie, Pa.	83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.	97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
76210	C. W. Marwedel	San Francisco, Calif.	83777	Model Eng. and Mfg., Inc.	Huntington, Ind.	98141	Axel Brothers Inc.	Jamaica, N.Y.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.			Festus, Mo.	98220	Francis L. Mosley	Pasadena, Calif.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.	83821	Loyd Scruggs Co.	New York, N.Y.	98278	Microdot, Inc.	So. Pasadena, Calif.
76493	J. W. Miller Co.	Los Angeles, Calif.	84396	A. J. Glesener Co., Inc.	San Francisco, Calif.	98291	Sealcraft Corp.	Mamaroneck, N.Y.
76530	Monadnock Mills	San Leandro, Calif.			Ogallala, Neb.	98405	Carad Corp.	Redwood City, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio	84411	Good All Electric Mfg. Co.	Bloomington, Ind.	98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
76584	Oak Manufacturing Co.	Chicago, Ill.	84970	Sarkes Tarran, Inc.	Boonton, N.J.	98821	North Hills Electric Co.	Minneapolis, N.Y.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.	85454	Bontoon Molding Company	San Francisco, Calif.	98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
77221	Phaoltron Instrument and Electronic Co.	South Pasadena, Calif.	85474	R. M. Bracamonte & Co.	New Haven, Conn.	98978	International Electronic Research Corp.	Burbank, Calif.
77232	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.	85660	Koiled Kords, Inc.	Chicago, Ill.	99109	Columbia Technical Corp.	New York, N.Y.
77630	Radio Condenser Co.	Camden, N.J.	85911	Seamless Rubber Co.	Harrison, N.J.	99313	Varian Associates	Palo Alto, Calif.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.	86684	Radio Corp. of America, RCA Electron Tube Div.	Lansdale, Pa.	99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
77764	Resistance Products Co.	Harrisburg, Pa.	87216	Philco Corp. (Lansdale Division)	San Francisco, Calif.	99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
78283	Signal Indicator Corp.	New York, N.Y.	87473	Western Fibrous Glass Products Co.	Lincoln, Ill.	99800	Delevan Electronics Corp.	East Aurora, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.	88140	Cutler-Hammer, Inc.	Schenectady, N.Y.	99848	Wilco Corporation	Indianapolis, Ind.
78488	Stackpole Carbon Co.	St. Marys, Pa.	89473	General Electric Distributing Corp.	Baler Co.	99934	Renbrandt, Inc.	Boston, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio	90436	Carler Parts Div. of Economy	Chicago, Ill.	99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
78790	Transformer Engineers	Pasadena, Calif.	90665	United Transformer Co.	Chicago, Ill.	99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.
78947	Ucinite Co.	Newtonville, Mass.	91079	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.			
79142	Veeder Root, Inc.	Hartford, Conn.	90970	Bearing Engineering Co.	San Francisco, Calif.			
79251	Wenco Mfg. Co.	Chicago, Ill.	91260	Connor Spring Mfg. Co.	San Francisco, Calif.			
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.	91418	Radio Materials Co.	Chicago, Ill.			
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.	91506	August Brothers, Inc.	Attleboro, Mass.			
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.	91637	Dale Electronics, Inc.	Columbus, Nebr.			
80130	Times Facsimile Corp.	New York, N.Y.	91662	Elco Corp.	Philadelphia, Pa.			
80131	Electronic Industries Association	Any brand tube meeting EIA standards	91737	Greiner Mfg. Co., Inc.	Wakefield, Mass.			
		Washington, D.C.	91827	K F Development Co.	Redwood City, Calif.			
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.	91921	Minneapolis-Honeywell Regulator Co., Micro-Switch Division	Freepport, Ill.			
80248	Oxford Electric Corp.	Chicago, Ill.	92196	Universal Metal Products, Inc.	Bassett Puente, Calif.			
80294	Bourns Laboratories, Inc.	Riverside, Calif.	93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.			
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio	93369	Robbins and Myers, Inc.	New York, N.Y.			
80486	All Star Products Inc.	Defiance, Ohio	93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio			
80583	Hammerlund Co., Inc.	New York, N.Y.	93983	Insuline-Van Norman Ind., Inc.	Manchester, N.H.			
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.	94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.			
81030	International Instruments, Inc.	New Haven, Conn.	94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newtown, Mass.			
81415	Wilkor Products, Inc.	Cleveland, Ohio	94148	Scientific Radio Products, Inc.	Loveland, Colo.			
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.	94154	Tung-Sol Electric, Inc.	Newark, N.J.			
81483	International Rectifier Corp.	El Segundo, Calif.	94197	Curtis-Wright Corp., Electronics Div.	East Paterson, N.J.			
81860	Barry Controls, Inc.	Watertown, Mass.	94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.			
82042	Carler Parts Co.	Skokie, Ill.	94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.			
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.	95236	Allies Products Corp.	Miami, Fla.			
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.	95238	Continental Connector Corp.	Woodside, N.Y.			
82209	Maguire Industries, Inc.	Greenwich, Conn.	95263	Leecraft Mfg. Co., Inc.	New York, N.Y.			
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.						
82376	Astron Co.	East Newark, N.J.						
82389	Switchcraft, Inc.	Chicago, Ill.						

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000 F	Malco Tool and Die	Los Angeles, Calif.
0000 I	Telefunken (c/o American Elite)	New York, N.Y.
0000 L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000 M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000 N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000 P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000 T	Texas Instruments, Inc.	Versailles, Ky.
0000 U	Tower Mfg. Corp.	Providence, R.I.
0000 W	Webster Electronics Co., Inc.	New York, N.Y.
0000 X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000 Y	Midland Mfg. Co., Inc.	Kansas City, Kans.
0000 Z	Willow Leather Products Corp.	Newark, N.J.
0000 A	British Radio Electronics Ltd.	Washington, D.C.
0000 B	Precision Instrument Components Co.	Van Nuys, Calif.
0000 C	Computer Diode Corp.	Lodi, N.J.
0000 E	A. Williams Manufacturing Co.	San Jose, Calif.
0000 F	Carmichael Corrugated Specialties	Richmond, Calif.
0000 G	Goshen Die Cutting Service	Goshen, Ind.
0000 H	Hubbercraft Corp.	Torrance, Calif.

From: F.S.C. Handbook Supplements
H4-1 Dated November 1961
H4-2 Dated November 1961

00015-20
Revised: 23 January 1962



WARRANTY

All our products are warranted against defects in materials and workmanship for one year from the date of shipment. Our obligation is limited to repairing or replacing products (except tubes) which prove to be defective during the warranty period. We are not liable for consequential damages.

For assistance of any kind, including help with instruments under warranty, contact your authorized  Sales Representative for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of instruments under warranty, *except transportation charges*. Estimates of charges for non-warranty or other service work will always be supplied, if requested, before work begins.

CLAIM FOR DAMAGE IN SHIPMENT

Your instrument should be inspected and tested as soon as it is received. The instrument is insured for safe delivery. If the instrument is damaged in any way or fails to operate properly, file a claim with the carrier or, if insured separately, with the insurance company.

SHIPPING

On receipt of shipping instructions, forward the instrument prepaid to the destination indicated. You may use the original shipping carton or any strong container. Wrap the instrument in heavy paper or a plastic bag and surround it with three or four inches of shock-absorbing material to cushion it firmly and prevent movement inside the container.

GENERAL

Your authorized  Sales Representative is ready to assist you in any situation, and you are always welcome to get directly in touch with Hewlett-Packard service departments:

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Cable: "HEWPACKSA"





PRINTED IN U.S.A.



MANUAL CHANGES

MODEL 114BR

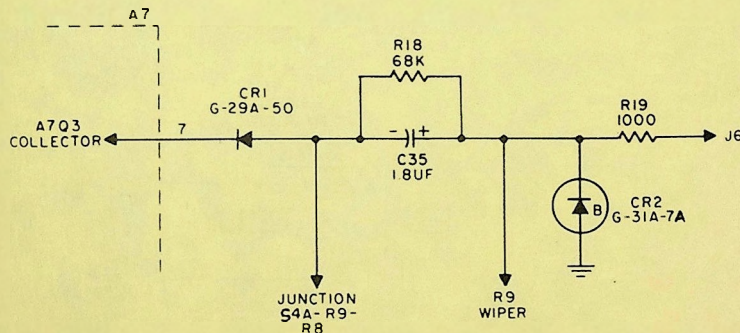
TIME COMPARATOR

Serials Prefixed: 112-
Manual Printed: 7/61

STANLEY ASSOCIATES, INC.
FEB 12 1962
DAYTON OFFICE

The following changes adapt this manual to instruments having the serial prefixes listed below:
(Ch. # = Change Number; Ser.Pre. = Serial Prefix)

Ch. #	Ser. Pre.	New Data
1	112-	For instruments with Serials Prefixed <u>112-</u>, except serial no. <u>112-00051</u>, include the following manual changes: In Table 6-2: Change stock number of diodes A3CR5, A4CR5, and A5CR5 to <u>1901-0022</u>. In figure 5-12: Delete R6 In figure 5-12: Add parallel network of R20 (1 megohm $\pm 10\%$, 1/2 W, Stock No. <u>0687-1051</u>) and C36 (820 pf $\pm 10\%$, mica, Stock No. <u>0140-0091</u>) between pin 11 of A5 and chassis. Add parallel network of R21 (1 megohm $\pm 10\%$, 1/2 W, Stock No. <u>0687-1051</u>) and C37 (820 pf $\pm 10\%$, mica, Stock No. <u>0140-0091</u>) between pin 11 of A4 and chassis. Add parallel network of R22 (1 megohm $\pm 10\%$, 1/2 W, Stock No. <u>0687-1051</u>) and C38 (820 pf $\pm 10\%$, mica, Stock No. <u>0140-0091</u>) between pin 11 of A3 and chassis. In figure 5-17: Delete A7CR1, A7R10, A7C2, A7CR2, A7R11. Change sweep circuitry associated with A7 as shown in the following schematic:



Note: description for new parts shown above in schematic corresponds to description for old parts deleted above as follows:

Ch. # Ser. Pre.

New Data

1 112-

Designation	
New	Old
C35	A7C2
CR1	A7CR1
CR2	A7CR2
R18	A7R10
R19	A7R11

2 136- For instruments with Serials Prefixed: 136-, this manual, including all above changes, applies directly.

3 150- Include Change #1 and the following:

Table 6-2,

Delete: Stock No. 3101-0012. Switch, toggle: DPDT, Mfr. 04009, TQ 1, RS 1.

Add: Stock No. 3100-0147. Switch, lever: 3 positions, Mfr. 71590.

Table 6-1,

Delete: W5: Stock No. 114B-65G.

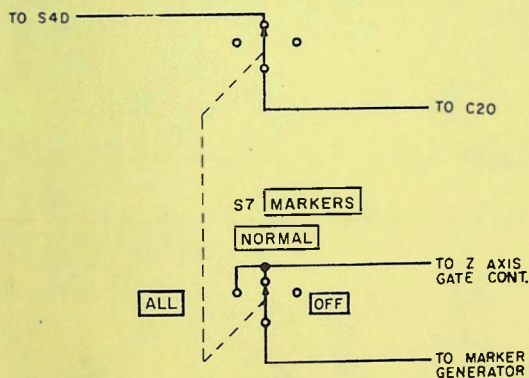
S7: Change to Stock No. 3100-0147.

Figure 3-1 and Table 3-1,

Note that location of switch S7 MARKERS (ALL, NORMAL and OFF positions) is changed to front panel.

Figure 5-12,

Change schematic as shown below:



4 112- Table 6-1,
136- A7R4 should be 0684-2211.
150- A7R7 should be 0684-4721.

Figure 5-17,

R7: Change to 4700 ohms.

Ch. #	Ser. Pre.	New Data
-------	-----------	----------

4	(cont. from) Table 6-1, (page 2)	Add R18, Ⓢ Stock No. 0684-6831 Add R19, Ⓢ Stock No. 0687-1021
---	-------------------------------------	--

MANUAL CHANGES

MODEL 114BR

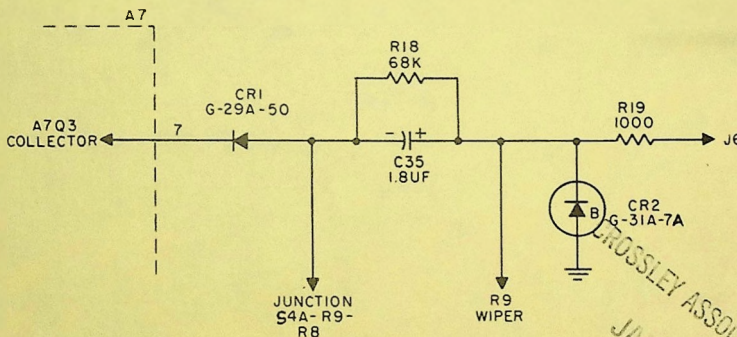
TIME COMPARATOR

Serials Prefixed: 112-

Manual Printed: 7/61

The following changes adapt this manual to instruments having the serial prefixes listed below:
(Ch. # = Change Number; Ser. Pre. = Serial Prefix)

Ch. #	Ser. Pre.	New Data
1	112-	For instruments with <u>Serials Prefixed 112-</u>, except serial no. <u>112-00051</u>, include the following manual changes: In Table 6-2: Change stock number of diodes A3CR5, A4CR5, and A5CR5 to <u>1901-0022</u>. In figure 5-12: Delete R6 In figure 5-13: Add parallel network of R20 (1 megohm $\pm 10\%$, 1/2 W, Stock No. 0687-1051) and C36 (820 pf $\pm 10\%$, mica, Stock No. 0140-0091) between pin 11 of A5 and chassis. Add parallel network of R21 (1 megohm $\pm 10\%$, 1/2 W, Stock No. 0687-1051) and C37 (820 pf $\pm 10\%$, mica, Stock No. 0140-0091) between pin 11 of A4 and chassis. Add parallel network of R22 (1 megohm $\pm 10\%$, 1/2 W, Stock No. 0687-1051) and C38 (820 pf $\pm 10\%$, mica, Stock No. 0140-0091) between pin 11 of A3 and chassis. In figure 5-17: Delete A7CR1, A7R10, A7C2, A7CR2, A7R11. Change sweep circuitry associated with A7 as shown in the following schematic:



Note: description for new parts shown above in schematic correspond to descriptions for old parts deleted above as follows:

Ch. # Ser. Pre.

New Data

1 112-

Designation	
New	Old
C35	A7C2
CR1	A7CR1
CR2	A7CR2
R18	A7R10
R19	A7R11

2 136-

For instruments with Serials Prefixed: 136-, this manual, including all above changes, applies directly.

3 150-

Include Change #1 and the following:

Table 6-2,

Delete: Stock No. 3101-0012. Switch, toggle: DPDT, Mfr. 04009, TQ 1, RS 1.

Add: Stock No. 3100-0147. Switch, lever: 3 positions, Mfr. 71590.

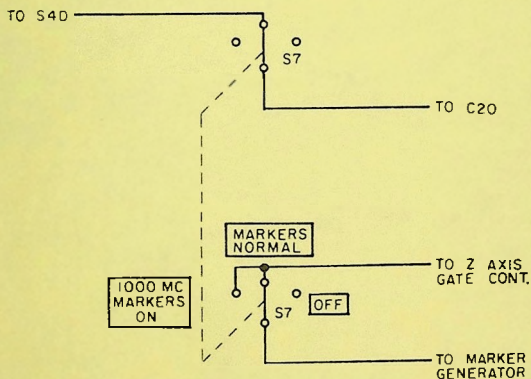
Table 6-1,

Delete: W5: Stock No. 114B-65G.

S7: Change to Stock No. 3100-0147.

Figure 5-12,

Change schematic as shown below:



CROSSLEY ASSOCIATES, INC.
MAY 19 1965
DAYTON OFFICE

MANUAL CHANGES

MODEL 114BR

TIME COMPARATOR

Manual Serial Prefixed: 150-
Manual Printed: Feb 1962

MAKE ALL CORRECTIONS IN THIS MANUAL ACCORDING TO ERRATA BELOW, THEN CHECK THE FOLLOWING TABLE FOR YOUR INSTRUMENT SERIAL PREFIX (3 DIGITS) OR SERIAL NUMBER (8 DIGITS) AND MAKE ANY LISTED CHANGE(S) IN THE MANUAL.

► NEW ITEM.

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES	SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES
416-	1		

ERRATA

Table 1-1, Specifications,
Under Accessories Furnished,

Change: 114BR-16A to 114B-16A
114BR-16B to 114B-16B
114BR-16C to 114B-16C
114BR-16D to 114B-16D

Figure 5-12,

Change: CR1 to 1901-0033.
Change: CR2 to 1902-0121.

Figure 5-13, Table 6-1:

Change: A1CR1, A1CR2, to 1902-0074.

Figure 5-14, Table 6-1:

Change: A2CR1 to 1902-0172.
Change: A2CR2 to 1902-0074
R19: Change to 1/2W.

Figure 5-16, Table 6-1:

Change: A6CR3, A6CR4, A6CR5, A6CR6, and A6CR7 to 1902-0074.

Figure 5-18, Table 6-1:

Change A8CR2 to 1902-0228.
Change A8CR3 to 1902-0074.

Table 6-2, Replaceable Parts,

G-29A-50: Change Ⓢ Part No. to 1901-0033.
G-31A-7A: Change Ⓢ Part No. to 1902-0074.
G-31A-15H: Change Ⓢ Part No. to 1902-0172.
G-31G-27L: Change Ⓢ Part No. to 1902-0228.

► Table 6-1, 6-2,

Change C20 Part No. to 0150-0093, 100V.

CHANGE 1

Figure 5-17, Table 6-1, Table 6-2,

Delete A7R4, 220 ohms 10%; Ⓢ Stock No. 0684-2211.
Add A7R4, 270 ohms 5%; Ⓢ Stock No. 0683-2715.

May 5, 65

Supplement A for
114B-900



MANUAL CHANGES

MODEL 114BR

TIME COMPARATOR

Manual Serial Prefixed: 150-

Manual Printed: FEB 1962

CROSSLEY ASSOCIATES, INC.

APR 20 1965

DAYTON OFFICE

MAKE ALL CORRECTIONS IN THIS MANUAL ACCORDING TO ERRATA BELOW, THEN CHECK THE FOLLOWING TABLE FOR YOUR INSTRUMENT SERIAL PREFIX (3 DIGITS) OR SERIAL NUMBER (8 DIGITS) AND MAKE ANY LISTED CHANGE(S) IN THE MANUAL.

► NEW ITEM.

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES	SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES
136-, 112-	1		

ERRATA

Table 1-1, Specifications,
Under Accessories Furnished,

Change: 114BR-16A to 114B-16A
114BR-16B to 114B-16B
114BR-16C to 114B-16C
114BR-16D to 114B-16D

- Figure 5-12,
Change: CR1 to 1901-0033.
Change: CR2 to 1902-0121.
- Figure 5-13, Table 6-1:
Change: A1CR1, A1CR2, to 1902-0074.
- Figure 5-14, Table 6-1:
Change: A2CR1 to 1902-0172.
Change: A2CR2 to 1902-0074.
R19: Change to 1/2W.
- Figure 5-16, Table 6-1:
Change: A6CR3, A6CR4, A6CR5, A6CR6, and A6CR7 to 1902-0074.
- Figure 5-18, Table 6-1:
Change A8CR2 to 1902-0228.
Change A8CR3 to 1902-0074.
- Table 6-2, Replaceable Parts,
G-29A-50: Change  Part No. to 1901-0033.
G-31A-7A: Change  Part No. to 1902-0074.
G-31A-15H: Change  Part No. to 1902-0172.
G-31G-27L: Change  Part No. to 1902-0228.

CHANGE 1

Figure 3-1, Page 3-2,
Item 8, MARKERS Switch, should appear as a toggle switch on the
REAR panel with the following positions:
MARKERS
NORMAL
OFF
1000 MS
MARKERS ON

3/29/65

Supplement B for
114B-900

CHANGE 1
(Cont'd)

Table 3-1, Page 3-3,
Item 8 "control" column
Change to read MARKERS NORMAL
OFF
1000 MS MARKERS ON

Item 8 "function" column
Change NORMAL to MARKER NORMAL,
Change ALL to 1000 MS MARKERS ON.

Figure 5-12, Page 5-17/5-18,
Change schematic as shown below:

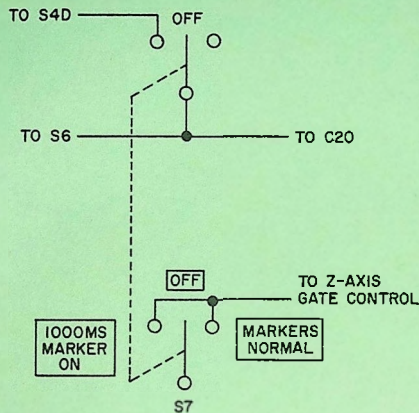


Table 6-1, Page 6-19,
Change S7 to 3101-0012; switch, tog: DPDT center off.

Table 6-2, Page 6-25,
Delete: 3100-0147 Switch, lever: 3 pos. mfr. 71590.
Add: 3101-0012 Switch, tog: DPDT mfr. 04009, TQ 1, RS 1.