NAVSHIPS 94309

HEWLETT-PACKARD COMPANY

166D

DELAY GENERATOR

AND

MX-2962/USM-105A TIME DELAY GENERATOR

NAVSHIPS 94309

OPERATING AND SERVICE MANUAL

MODEL 166D
DELAY GENERATOR

AND

MX-2962/USM-105A
TIME DELAY GENERATOR

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INTRODUCTION

NAVSHIPS 94309 contains operating and servicing instructions for the MX-2962/USM-105A Time Delay Generator manufactured by the Hewlett-Packard Company in Palo Alto, California on Contract NObsr 85537, dated 23 June 1961. The MX-2962/USM-105A is an auxiliary unit for plug-in installation in the front-panel receptacle of the oscilloscopes listed below. The purpose of the MX-2962/USM-105A is to delay the start of the oscilloscope sweep a selected time interval after application of a triggering signal. No circuit adjustments are required and no loss in specified calibration accuracy occurs to the MX-2962/USM-105A when it is used interchangeably in any of these oscilloscopes:

AN/USM-105A	supplied on Contracts NObsr 75278 and NObsr 81535; see NAVSHIPS 93658.
AN/USM-139	
AN/USM-140	
AN/USM-141	

NAVSHIPS 94309 consists of the commercial instruction manual for the Hewlett-Packard Model 166D Delay Generator with a new cover, title page and parts list which apply to the MX-2962/USM-105A (which is the military version of the Model 166D). The MX-2962/USM-105A and 166D are alike in performance specifications and electrical circuits, but are different in that additional Military approved parts are used in the MX-2962/USM-105A.

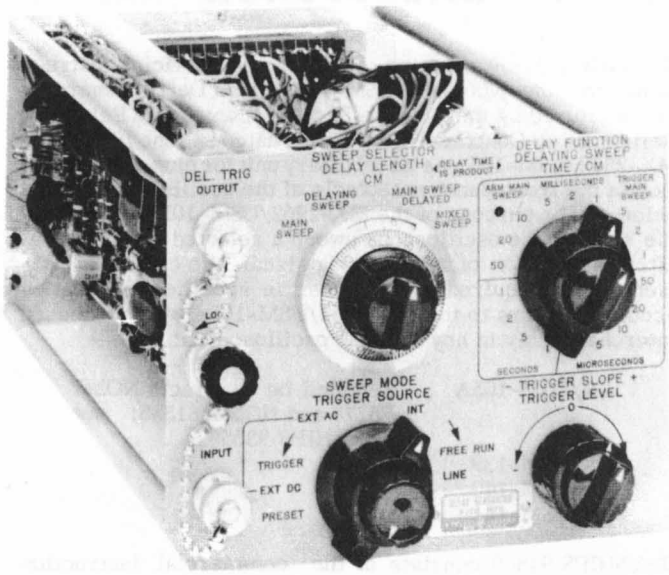


Figure 1-1. Model 166D Delay Generator

SECTION I
GENERAL INFORMATION

1-1. FUNCTIONAL DESCRIPTION.

The Model 166D Delay Generator is a plug-in unit which provides the Ⓗ Models 160B and 170A Oscilloscopes with delayed sweep capability. Two modes of delay are provided, one in which the oscilloscope sweep starts at the end of the delay period, and one in which the oscilloscope sweep is armed at the end of the delay period but does not start until triggered independently.

The Model 166D itself generates a linear sweep (the delaying sweep). The delaying sweep can be used to measure delay, indicate the starting point of the delayed sweep of the oscilloscope, and provide mixed sweeps in which the delaying sweep drives the trace for approximately the delay period and the oscilloscope sweep drives the trace for the duration of the display.

The Model 166D is designed with specification MIL-E-16400C as a guide. The instrument meets the environmental specifications of oscilloscope models 160B and 170A when installed in an oscilloscope.

Model H02 166D Delay Generator is identical to Model 166D in specifications, operation, and application. However, the Model H02 166D uses electron tube and semiconductor types which are MIL approved. Where these types differ from the commercial types used in the Model 166D, both types are listed and identified with the correct model in the table of replaceable parts. All other references to the Model 166D apply equally well to the Model H02 166D. Tables 1-1 through 1-4 list reference data for the Model 166D.

1-2. ELECTRON TUBE TYPES 6922/6DJ8.

Electron tube types 6922 and 6DJ8 are equivalent, and either type can be used where called for in the instrument. However, the two types draw different heater current. Since the heater circuit is balanced to ground, use only one type or the other.

1-3. CHANGES.

The Model 166D carries a five-digit serial number with a three-digit prefix: 000-00000. The three digit prefix appears on the title page of this manual to indicate to which instruments this manual applies directly. A supplement or change sheet may be included with this manual to indicate the manual changes required to make the manual apply directly to instruments which carry a different serial prefix.

Table 1-1. Specifications *

Delay Time:
1 μsec to 10 seconds

Delaying Sweep:
18 calibrated ranges from 2 μsec/cm to 1 second/cm in 1, 2, 5, and 10 sequence.

Delayed Length:
0 to 10 cm

When delaying sweep functions in place of main sweep, setting in cm controls occurrence of main sweep. When delayed main sweep is used, setting acts as multiplier on Delaying Sweep setting to determine total delay time.

Accuracy:
±1% 2 μsec to 0.1 second ranges; ±3% 0.2, 0.5, 1 second ranges

±0.2% linearity, all but 2, 5, and 10 μsec ranges; ±0.5% linearity, 2, 5, 10 μsec ranges.

Jitter: Less than 0.01 μsec or ±0.005% of total delay.

Delay Functions:
(a) Trigger main sweep. (b) Arm main sweep.

Triggering:
Internal, power line or vertical input signal. (2 mm or more vertical deflection. External, 1/2 volt peak-to-peak or more.)

Triggering Point:
Positive or negative going voltage. Trigger level of external sync signal adjustable -30 to +30 volts.

Sweep Selector:
(a) Main Sweep

(b) Delaying Sweep. Brightened segment of trace indicates time relationship between delaying sweep display and main sweep display.

(c) Main Sweep Delayed

(d) Mixed Sweep

Delayed Trigger Output:
Approximately 20 volts positive

Power:
Supplied by 160B or 170A

Weight:
Net 4-1/2 lbs, shipping 7 lbs

* with Ⓗ Models 160B or 170A Oscilloscopes

Table 1-2. Equipment Supplied

Quantity per Equipment	Nomenclature		Overall Dimensions				
	Name	Designation	Height (in.)	Width (in.)	Depth (in.)	Volume (cu. in.)	Weight (lbs)
1	Delay Generator	166D or H02 166D	4-5/8	6	12-5/8	350	4-1/2
1	Operating and Servicing Manual						

Table 1-3. Shipping Data

Box Number	Nomenclature		Overall Dimensions				
	Name	Designation	Height (in.)	Width (in.)	Depth (in.)	Volume (cu. in.)	Weight (lbs)
1	Delay Generator	166D or H02 166D	10-5/8	9	18-1/4	1.0	7

Table 1-4. Electron Tube, Transistor and Diode Complement

	Model H02 166D											Model 166D											
	Electron Tubes					Transistor		Diodes				Electron Tubes					Transistor		Diodes				
	6922	6AU6	NE2E1	G-84E	Total	2N384	Total	1N754A	1N277	G-29E-2	Total	6DJ8	6AU6	NE2E1	G-84E	Total	OC170	Total	1N55	G-29A-74	G-29E-2	1N90	Total
Sweep Generator	7	1	3	3	14			1	2	2	5	7	1	3	3	14			1	1	2	1	5
Delayed Trigger Generator	2				2	1	1		2		2	2				2	1	1				2	2
Total	9	1	3	3	16	1	1	1	4	2	7	9	1	3	3	16	1	1	1	1	2	3	7

SECTION II
INSTALLATION

2-1. UNPACKING AND INSPECTION.

Unpack and inspect the Model 166D as soon as possible after receipt. Save the packing materials until the inspection is complete, for these materials may be needed for reshipment in the event of shipping damage.

Inspect the Model 166D for signs of physical damage such as an abraded panel, broken knobs, etc. If possible, install the Model 166D in either an hp Model 160B or 170A Oscilloscope and check the unit electrically. Refer to paragraph 6-3. If there is any damage, file a claim with the carrier. Refer to the warranty page at the rear of this manual.

2-2. INSTALLATION.

The Model 166D is a plug-in unit for hp Models 160B and 170A Oscilloscopes. To install the Model 166D, slide it into the front-panel opening of the oscilloscope directly below the crt. Lock the unit in place to insure good electrical and mechanical connection. All necessary operating power for the Model 166D is supplied by the oscilloscope. To check the Model 166D performance, refer to paragraph 6-3.

Note

To realize the specified accuracy of the Model 166D, operate it in an oscilloscope in which the +110 volt and -100 volt power supply voltages are within 0.4% of their nominal values.

2-3. REPACKAGING FOR SHIPMENT.

The following is a general guide for repackaging an instrument for shipment. If you have any questions, contact your authorized Hewlett-Packard sales office.

(1) If possible, use the original container designed for the instrument.

(2) Wrap the instrument in heavy paper or plastic before placing it in the shipping container.

(3) Use plenty of packing material around all sides of the instrument and protect panel faces with cardboard strips.

(4) Use a heavy cardboard carton or wooden box to house the instrument and use heavy tape or metal bands to seal the container.

(5) Mark the packing box with "Fragile", "Delicate Instrument", etc. as appropriate.

Note

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach to the instrument a tag identifying the owner and indicating the service or repair to be accomplished. In any correspondence, identify the instrument by model number, serial number, and serial number prefix.

SECTION III
OPERATOR'S SECTION

3-1. FUNCTIONAL OPERATION.

The Model 166D is a plug-in unit for use with hp 160B and 170A Oscilloscopes. The unit generates a linear delaying sweep which permits delay of the main sweep of the oscilloscope for a selected time interval after an input trigger. At the end of the delay period, the Model 166D produces a trigger pulse which either triggers or arms the main sweep, depending upon the delay function selected. The trigger is also available at the front panel for external use. The sweep or combination of sweeps to appear on the crt is determined by one of four sweep selections: 1) MAIN SWEEP, in which the main sweep operates normally and drives the trace across the crt with no delay; 2) DELAYING SWEEP, in which the delaying sweep drives the trace across the crt and the delayed main sweep appears as an intensified segment of the delaying sweep; 3) MAIN SWEEP DELAYED, in which the delayed main sweep drives the trace across the crt; and 4) MIXED SWEEP, in which the delaying sweep drives the trace across the crt for approximately the delay period, and the main sweep completes the trace.

3-2. PREPARATION FOR USE.

The Model 166D can be operated in any Model 160B or 170A Oscilloscope. However, for rated accuracy, the +110 volt and -100 volt power supply voltages in the oscilloscope must be within 0.4% of their nominal values. Check and if necessary adjust these voltages.

To permit best use of mixed-sweep operation, the trace produced by the main sweep must be a given amount longer than the trace produced by the delaying sweep. Check the relative sweep lengths as follows:

(1) On Model 166D, set SWEEP SELECTOR to MIXED SWEEP, DELAY LENGTH to about 5 CM, DELAY FUNCTION to TRIGGER MAIN SWEEP, and SWEEP MODE to FREE RUN.

(2) On oscilloscope, set SWEEP MODE to PRESET.

(3) Set DELAYING SWEEP on Model 166D to 20, 10, 5, 2, and 1 MILLISECOND and set SWEEP TIME on oscilloscope so main sweep is in each case 100 times faster than delaying sweep.

(4) Observe trace on crt for each combination of sweeps. Left half of trace should be brighter than right half. An increase of trace intensity at right end of the trace indicates incorrect relative sweep lengths. Refer to section IV of this manual and to oscilloscope manual for sweep length adjustments.

3-3. OPERATING PROCEDURES.

a. FRONT-PANEL CONTROLS. - Front-panel controls and their functions are shown in figure 3-1. The paragraphs below expand upon the control and connector functions indicated in the figure.

b. SWEEP START CONTROL. - Four front-panel controls affect the start of the delaying sweep. They include the TRIGGER SOURCE switch, TRIGGER LEVEL control, TRIGGER SLOPE switch, and SWEEP MODE control.

The TRIGGER SOURCE switch selects the source of the sweep trigger: the power line (LINE), the signal applied to the vertical amplifier of the oscilloscope (INT), or an external signal applied to the TRIGGER SOURCE INPUT connector (EXT AC or EXT DC).

The TRIGGER LEVEL control selects the voltage level on the trigger signal at which the sweep starts. The control provides continuous adjustment of the trigger level from about -30 volts to about +30 volts on external signals and over a range equivalent to about six centimeters of vertical deflection on internal trigger signals.

The TRIGGER SLOPE switch determines whether the delaying sweep starts on the positive-slope or negative-slope portion of the trigger signal.

The SWEEP MODE control determines whether the delaying sweep requires a trigger or free runs. The control is continuously adjustable with a switched position at its counterclockwise extreme. The switched position, PRESET, is the best overall setting for the control when the trigger signal is below about 10 mc. This position is internally set for optimum trigger operation. For trigger signals above about 10 mc, free-running operation may be better. In this case the trigger signal synchronizes the delaying sweep with the signal being viewed. For very high frequency trigger signals, a fine adjustment of the SWEEP MODE and/or TRIGGER LEVEL controls may be necessary to stabilize the presentation on the crt.

c. DELAY CONTROL. - The DELAY FUNCTION, DELAYING SWEEP, DELAY LENGTH, and SWEEP SELECTOR controls all affect the delay or the way the delay appears on the crt.

The DELAY FUNCTION switch determines whether the Model 166D triggers or arms the main sweep at the end of the delay period. With the DELAY FUNCTION set to TRIGGER MAIN SWEEP, the Model 166D starts the main sweep immediately after the delay period. After completing its cycle, the main sweep is ready for another starting trigger from the Model 166D.

With the DELAY FUNCTION set to ARM MAIN SWEEP, the Model 166D arms but does not start the main sweep at the end of the delay period. The main sweep then requires a trigger as selected by the TRIGGER SOURCE switch of the oscilloscope. After one cycle, the main sweep remains disabled until rearmed by the Model 166D.

The DELAYING SWEEP switch determines the sweep time of the delaying sweep whether or not the delaying sweep appears on the crt. This sweep is the reference for delay measurements.

The DELAY LENGTH control determines delay length measured in centimeters along the delaying sweep. Thus the delay period is the product of DELAY LENGTH and DELAYING SWEEP settings.

The SWEEP SELECTOR determines the horizontal presentation on the crt. There are four options:

(1) MAIN SWEEP. - The oscilloscope operates normally; the main sweep drives the trace across the crt; and there is no delay.

(2) DELAYING SWEEP. - The delaying sweep drives the trace across the crt. The main sweep is triggered (or armed) at the end of the delay period, and the time interval of the main sweep is indicated by a brightened segment on the crt display.

(3) MAIN SWEEP DELAYED. - The main sweep drives the trace across the crt after the delay period. The display on the crt is the expansion of the brightened part of the delaying sweep display.

(4) MIXED SWEEP. - The delaying sweep drives the trace for the delay period, after which the main sweep starts. The trace is then driven by the sweep which is farther along in its cycle. To drive the trace during any part of the display, then, the main sweep must be fast enough to pass the delaying sweep before the delaying sweep drives the trace off the right-hand side of the crt screen. (There is a display on the crt even though the main sweep is slower than the delaying sweep, but it is not usable.) Since there is some delay beyond that indicated by the DELAY LENGTH control, total delay should be read from the crt.

3-4. GENERAL OPERATING NOTES.

a. DELAYED TRIGGER OUTPUT. - The delayed trigger available at the front-panel DEL. TRIG. OUTPUT connector coincides with the trigger signal

applied internally to the main sweep generator of the oscilloscope. The delay indicated by the DELAY LENGTH control and DELAYING SWEEP switch is the time interval between the start of the delaying sweep and the delayed trigger regardless of whether the main sweep is triggered or armed. Thus the delayed trigger can be used as an accurately delayed trigger for external circuits, as a timing pulse, etc. regardless of the delay function selected.

b. DELAY FUNCTION. - The DELAY FUNCTION determines whether the main sweep is triggered or armed at the end of the delay period. The TRIGGER MAIN SWEEP function is intended for actual delay measurements. Since the main sweep starts at the end of the delay period, the DELAY LENGTH dial indicates the delay between the start of the delaying sweep and main sweep. Additional delay can be measured along the delayed main sweep, and high resolution is possible when main-sweep speed is high compared to delaying-sweep speed. However, the oscilloscope delays the vertical signal before applying it to the crt (refer to the oscilloscope manual); this delay should be accounted for when using the fastest delaying and main sweeps.

The ARM MAIN SWEEP function effectively eliminates jitter between the trigger for the delaying sweep and the trigger for the main sweep because the main sweep is armed only, not started, at the end of the delay period. An additional trigger starts the main sweep, and this trigger need not be synchronized with the delaying sweep. For example, if there is pulse-to-pulse jitter in a train of pulses, it is possible to trigger the delaying sweep with one pulse and trigger the main sweep with the first pulse to occur after the delay period. The signal immediately following the main-sweep trigger pulse can then be observed jitter-free even though it is not synchronized with the delaying-sweep trigger. In the ARM MAIN SWEEP function, the DELAY LENGTH dial indicates minimum possible delay. Actual delay must be read from the crt.

c. SWEEP SELECTION. - There are three combinations of delaying and delayed main sweeps. DELAYING SWEEP permits selection of delay and main sweep time prior to selection of the delayed presentation, for the time relationship of the delayed main sweep to the delaying sweep is indicated by a brightened segment on the crt display. The brightened segment then can be positioned with the DELAY control and lengthened or shortened with the oscilloscope SWEEP TIME switch to cover just that part of the display to be examined in detail.

MAIN SWEEP DELAYED provides the delayed presentation. The display is the brightened segment of the delaying sweep expanded to the full ten centimeters of the crt horizontal axis.

MIXED SWEEP permits both slow and fast sweeps to appear along the same trace. The delaying sweep is the slow sweep and starts at the left side of the crt. The main sweep is the fast sweep and takes over from the delaying sweep at a point determined by the DELAY LENGTH setting and difference in sweep speeds. Thus, for example, a train of pulses can be observed on the left side of the crt on the slow part of the trace while a single pulse can be examined in detail on the right side of the crt on the fast part of the trace.

3-5. SUMMARY OF OPERATING PROCEDURE.

Figures 3-2 through 3-5 give operating instructions for the Model 166D. These instructions supplement the operating instructions given in the oscilloscope manuals. Instructions are given step by step, and each step is numbered. Controls to which a step refers are keyed by the same number as the step.

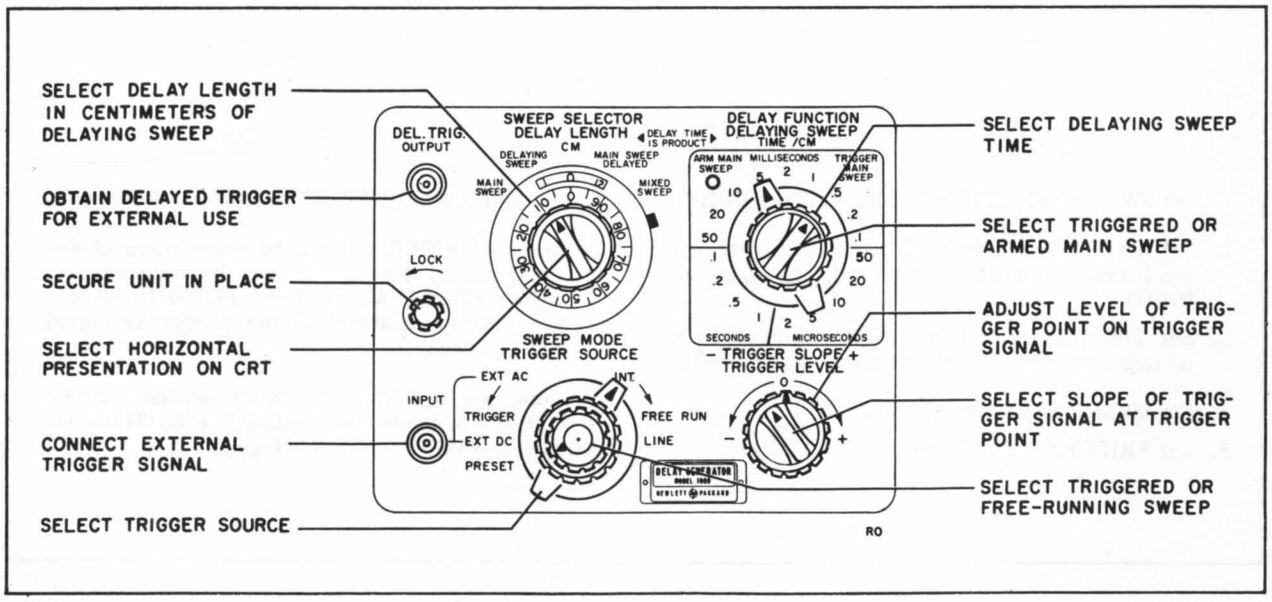
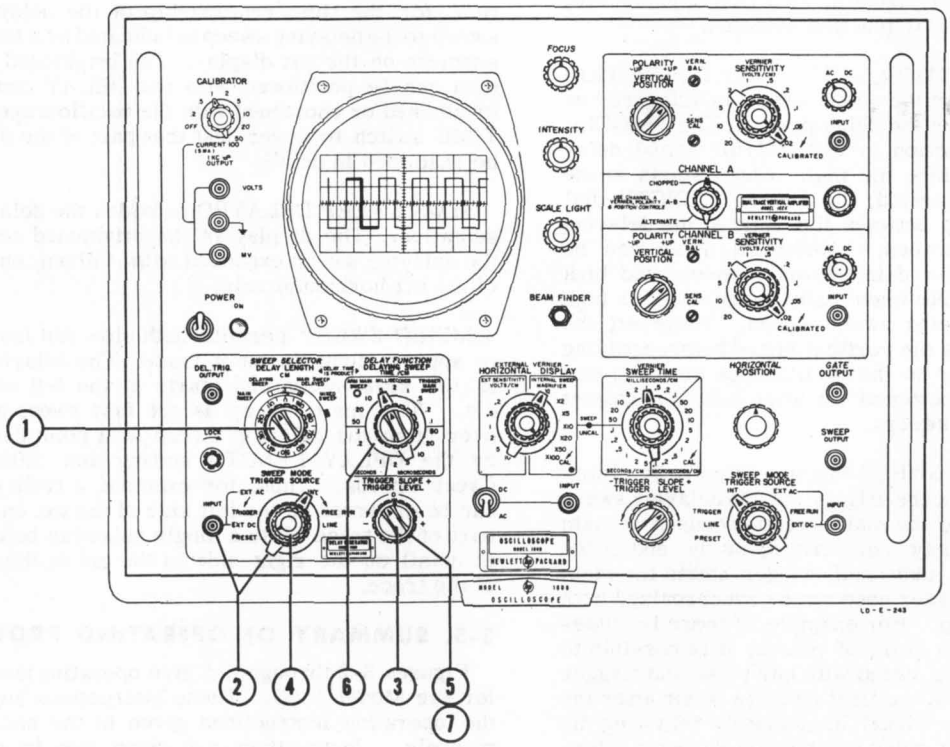


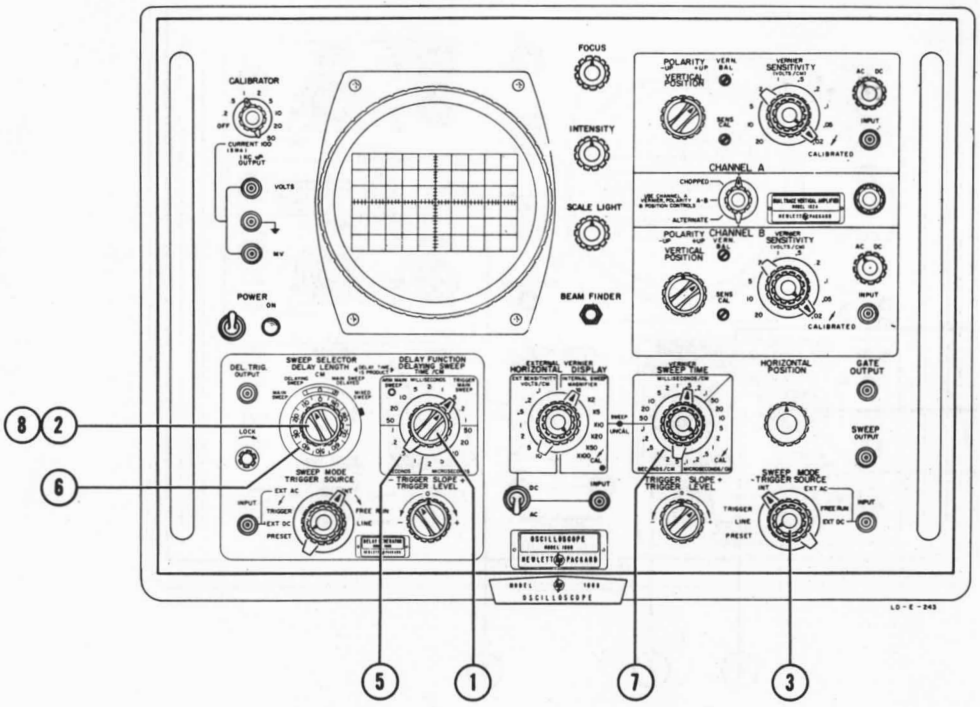
Figure 3-1. Front Panel Controls and Connectors



1. Set SWEEP SELECTOR to DELAYING SWEEP.
2. Set TRIGGER SOURCE as desired. If external triggering is used, connect trigger signal to INPUT.
3. Set TRIGGER SLOPE for triggering on positive or negative slope of trigger signal as desired.
4. Set SWEEP MODE to PRESET.
5. Set TRIGGER LEVEL to 0.
6. Set DELAYING SWEEP to desired sweep time.
7. Reset TRIGGER LEVEL to start trace at desired signal level. It may be necessary to switch SWEEP MODE from PRESET and select a better setting for the particular signal being viewed.

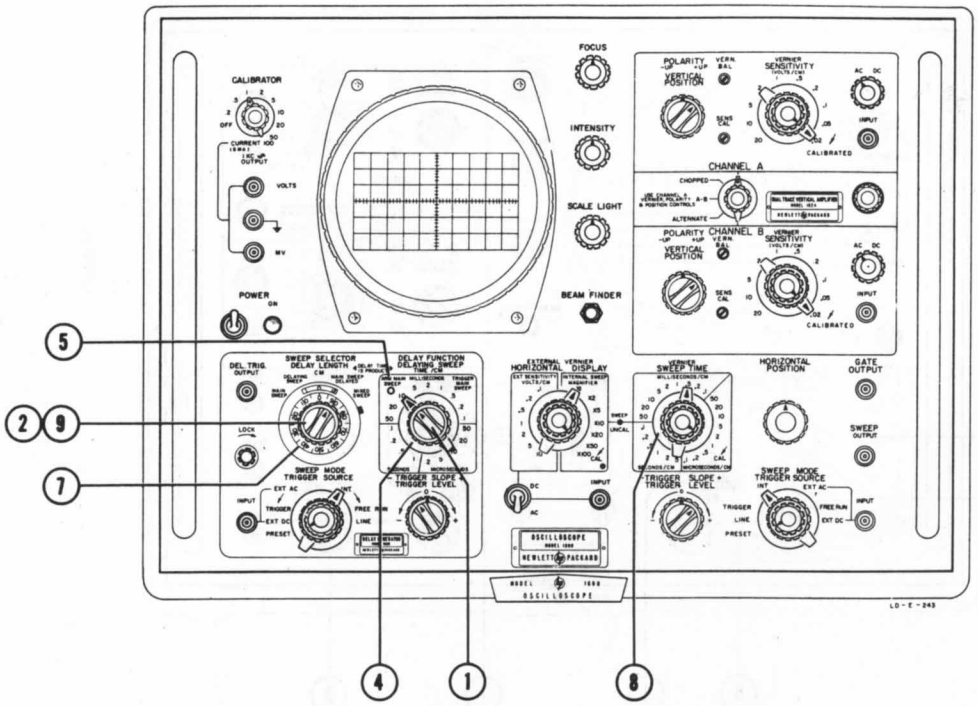
The position and length of the intensified segment of the trace depends upon DELAY LENGTH and oscilloscope SWEEP TIME settings.

Figure 3-2. Delaying Sweep



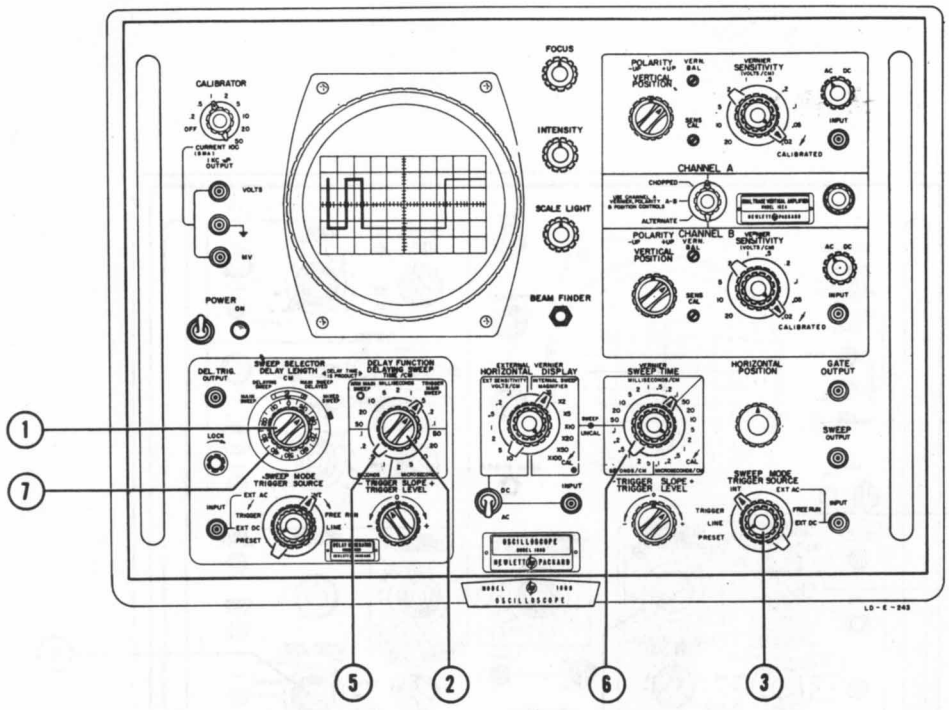
1. Set DELAY FUNCTION to TRIGGER MAIN SWEEP.
2. Set SWEEP SELECTOR to DELAYING SWEEP.
3. Set SWEEP MODE on oscilloscope to PRESET.
4. Trigger delaying sweep as desired. See Delaying Sweep.
5. Set DELAYING SWEEP to desired sweep time. Delayed main sweep appears as intensified segment on delaying sweep.
6. Set DELAY LENGTH for desired delay.
7. Set SWEEP TIME so intensified segment includes that part of signal you want to see on delayed main sweep.
8. Set SWEEP SELECTOR to MAIN SWEEP DELAYED.

Figure 3-3. Main Sweep - Delayed and Triggered



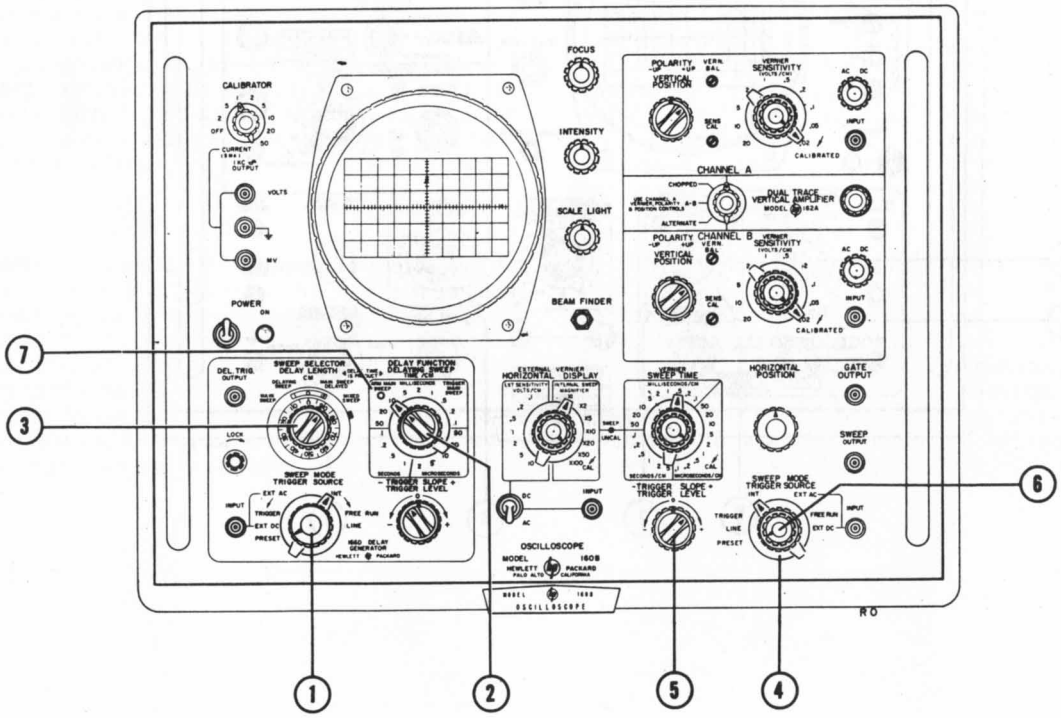
1. Set DELAY FUNCTION to ARM MAIN SWEEP.
2. Set SWEEP SELECTOR to DELAYING SWEEP.
3. Trigger delaying sweep as desired. See Delaying Sweep.
4. Set DELAYING SWEEP to desired sweep time.
5. Main-sweep-armed indicator lights at end of delay period indicating main sweep can sweep. After sweep, indicator goes out, and main sweep is disabled until rearmed by delaying sweep.
6. Trigger main sweep as desired. Delayed main sweep appears as intensified segment on delaying sweep.
7. Set DELAY LENGTH for desired delay.
8. Set SWEEP TIME so intensified segment includes that part of signal you want to see on delayed main sweep.
9. Set SWEEP SELECTOR to MAIN SWEEP DELAYED.

Figure 3-4. Main Sweep - Delayed and Armed



1. Set SWEEP SELECTOR to MIXED SWEEP.
2. Set DELAY FUNCTION to TRIGGER MAIN SWEEP.
3. Set SWEEP MODE on oscilloscope to PRESET.
4. Trigger delaying sweep as desired. See Delaying Sweep.
5. Set DELAYING SWEEP to desired sweep time.
6. Set SWEEP TIME to desired sweep time (faster than delaying sweep).
7. Set DELAY LENGTH to desired delay. (Delay is not calibrated.)

Figure 3-5. Mixed Sweep



1. Set 166D SWEEP MODE to TRIGGER (just out of preset).
2. Set 166D DELAY FUNCTION to ARM MAIN SWEEP.
3. Set 166D SWEEP SELECTOR to MAIN SWEEP DELAYED.
4. Set 160B/170A TRIGGER SOURCE according to trigger signal used.
5. Set 160B/170A TRIGGER SLOPE and TRIGGER LEVEL as desired.
6. To arm sweep, switch 160B/170A SWEEP MODE to TRIGGER and back to PRESET.
7. ARM MAIN SWEEP indicator on 166D should light.
8. Repeat step 6 to re-arm sweep after each trigger.

Figure 3-6. Single Sweep

SECTION IV
PRINCIPLES OF OPERATION

4-1. OVERALL FUNCTIONAL DESCRIPTION.

The Model 166D provides the hp Model 160B and 170A Oscilloscopes with delayed sweep operation. The unit inserts a known amount of delay, which can be selected at the front panel, between a reference trigger and the start of the main sweep generated by the oscilloscope. The Model 166D itself consists of a sweep generator and a delayed-trigger generator as shown in figure 4-1. The sweep generator generates a linear voltage ramp, the delaying sweep, which is applied to the delayed-trigger generator. The delayed-trigger generator generates a trigger at the end of the delay period selected at the front panel and delivers the trigger to the main sweep generator of the oscilloscope, which then provides the delayed sweep.

4-2. SWEEP GENERATOR.

A block diagram of the delaying sweep generator is shown in figure 4-2. In addition to the actual sweep generating circuits (V5, 7, 9, 10, and 13) the sweep generator contains amplifying and shaping circuits (V1 and 4) and gating circuits(V8). The amplifying and shaping circuits provide adequate triggering of the sweep circuits, and the gating circuits provide unblanking to the crt.

a. AMPLIFIER AND TRIGGER GENERATOR. - The input or reference trigger is applied to one grid of amplifier V1, a differential amplifier, and a dc signal from the TRIGGER LEVEL control is applied to the other grid. The output of the amplifier is a single-ended signal which is proportional to the instantaneous difference between the trigger and dc signals. As shown in the figure, the TRIGGER SLOPE switch reverses the trigger and dc signals when switched from one polarity position to the other. The switch thereby determines the phase between the trigger signal and the output of the amplifier. With the switch set to +, the output of amplifier V1 is 180° out of phase with the trigger signal; with the switch set to -, the output of the amplifier is in phase with the trigger signal.

The output of amplifier V1 must be negative-going and must cross the +110-volt level to start a sweep. Since the output of the amplifier is proportional to the difference between the trigger signal and the dc value selected by the TRIGGER LEVEL control, the point on the trigger signal at which the amplifier output is +110 volts depends upon the setting of the control. Thus the TRIGGER LEVEL control permits selection of the voltage level which the trigger signal must cross to start a sweep.

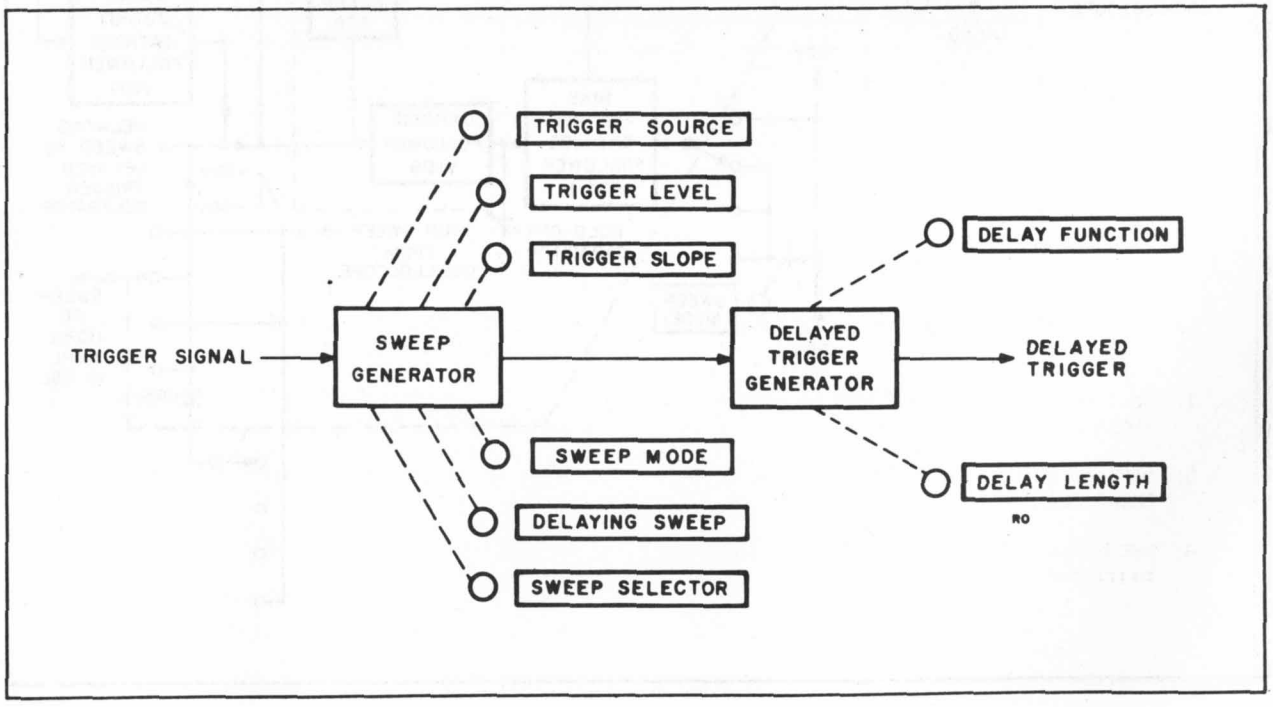


Figure 4-1. Overall Block Diagram

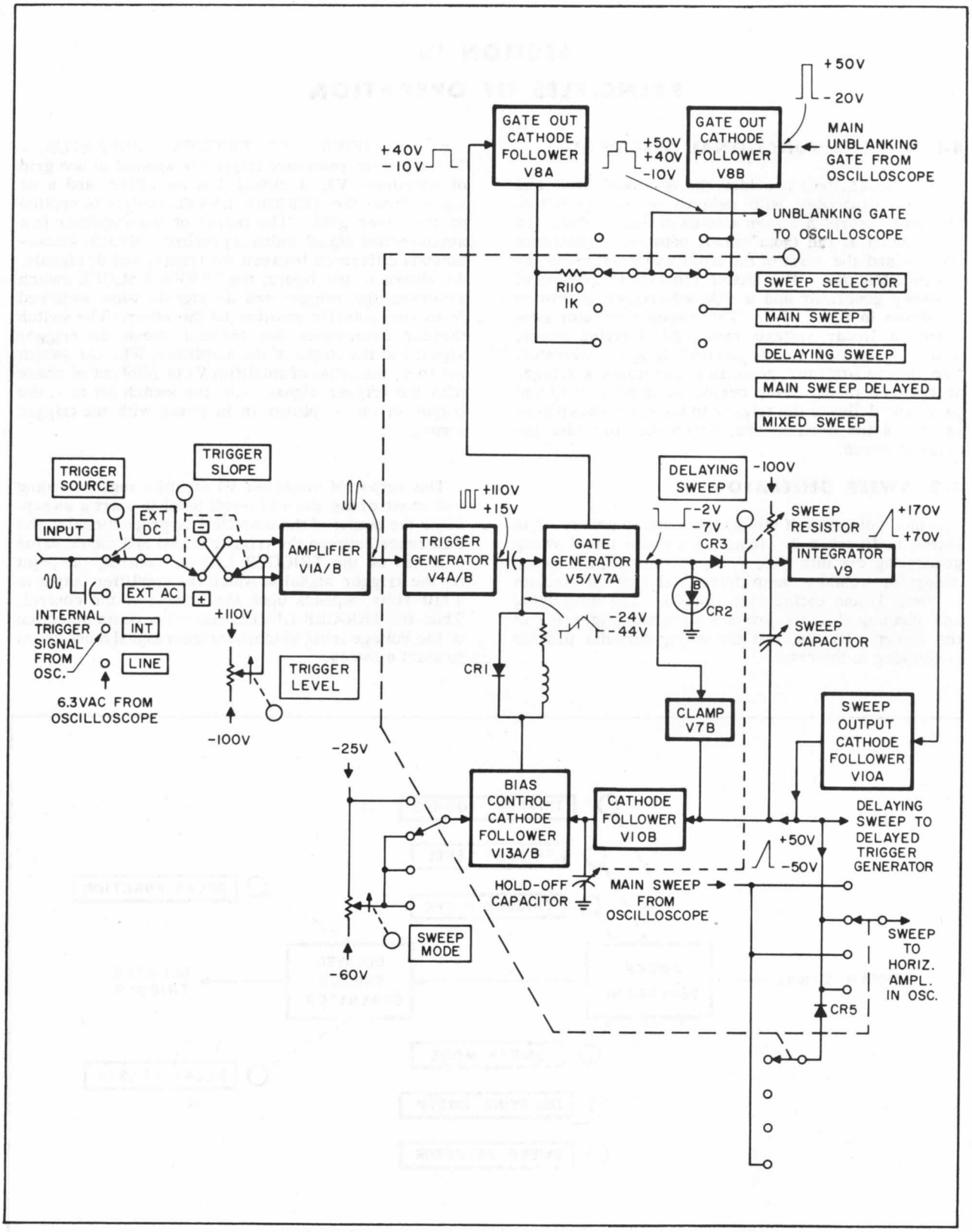


Figure 4-2. Delaying Sweep Generator

The signal from amplifier V1 is applied to trigger generator V4, a schmitt trigger with narrow hysteresis limits. (See paragraph 4-4 for a discussion of schmitt triggers.) Provided the signal crosses both hysteresis limits, the trigger generator switches back and forth between its two stable states, generating positive-going and negative-going voltage steps at its output. These steps are differentiated to form short pulses and applied as triggers to gate generator V5/V7A. Only the negative triggers are used, and CR1 reduces the amplitude of the positive triggers.

b. SWEEP GENERATOR. - Gate generator V5/V7A is a schmitt trigger with wide hysteresis limits. Between sweeps, the A section of bias control cathode follower V13 holds the bias at the input of the gate generator close to the lower hysteresis limit. A positive trigger from trigger generator V4 has no effect, but a negative trigger drives the input to the gate generator below the lower hysteresis limit and causes the gate generator to switch.

When it switches, gate generator V5/V7A provides a positive and negative gate. The positive gate is applied to the high voltage power supply in the oscilloscope to unblank the crt beam. The negative gate is applied to diode CR3 to start the sweep. Prior to the gate, CR3 had been forward biased and had been holding the input to integrator V9 at about -2 volts. The negative gate reverse biases the diode and frees the integrator input.

Once freed, the input to the integrator starts going more negative, for it is connected to -100 volts through the sweep resistor. Integrator V9 amplifies and inverts its input and produces a large, positive-going output which is applied back to the input through sweep output cathode follower V10A and the sweep capacitor. As a result, the input to the integrator changes by about 0.5 volt during sweep time. The voltage across the sweep resistor therefore changes about 0.5% during sweep time, and the current through the resistor changes by the same percent. Since the current through the sweep resistor is the charging current for the sweep capacitor, the voltage across the sweep capacitor changes quite linearly with time, and the sweep signal is a nearly linear voltage ramp. The DELAYING SWEEP switch changes the value of the sweep resistor or capacitor to change sweep time. The sweep output is applied to the delayed-trigger generator and to the SWEEP SELECTOR switch.

An attenuated sweep signal is applied to the input of gate generator V5/V7A through cathode follower V10B and the B section of bias control cathode follower V13. This signal drives the input of the gate generator to the upper hysteresis limit and causes the gate generator to switch back to its pre-sweep state. The gate generator then ends the gates, removing its unblanking signal from the crt and forward biasing CR3. The diode then returns the input to integrator V9 to its pre-sweep level, resetting the sweep.

During sweep time, cathode follower V10B charges a hold-off capacitor. After the sweep ends, this capacitor lets the input to gate generator V5/V7A down slowly enough to prevent that circuit from being triggered again until the remaining sweep circuits have recovered. The DELAYING SWEEP TIME switch changes the size of the hold-off capacitor with sweep time.

Clamp V7B insures that each sweep starts from the same voltage level, about -50 volts.

The SWEEP MODE control determines the pre-sweep bias at the input to gate generator V5/V7A by setting the bias on the A section of bias control cathode follower V13. With the control set to PRESET or in the TRIGGER portion of its adjustable range, the gate generator bias cannot drop below its lower hysteresis limit unless trigger generator V4 provides a trigger. However, with the SWEEP MODE control set in the FREE RUN part of its range, the gate generator bias can drop below its lower hysteresis limit. Thus as the hold-off capacitor discharges, it lets the gate generator bias fall to the lower hysteresis limit, and another sweep starts automatically.

c. SWEEP SELECTION. - The SWEEP SELECTOR switch determines the way the delaying and main sweeps appear on the crt. With the switch set to MAIN SWEEP, the delaying sweep generator is disabled by the fixed bias applied to gate generator V5/V7A, the main sweep from the oscilloscope is routed back to the horizontal amplifier of the oscilloscope, and the main unblanking gate from the oscilloscope is applied back to the oscilloscope through gate out cathode follower V8B.

With the SWEEP SELECTOR set to DELAYING SWEEP, the delaying sweep generator operates normally, the delaying sweep is applied to the horizontal amplifier in the oscilloscope, and the main sweep is disconnected. The unblanking gates from the delaying sweep generator and the main sweep generator in the oscilloscope are mixed in the common cathode circuits of V8. The delaying sweep unblanking gate is reduced in amplitude by R110, and as a result, the main unblanking gate appears as a pedestal on top of the delaying sweep unblanking gate. The pedestal brightens the trace on the crt during the time of the delayed main sweep.

With the SWEEP SELECTOR set to MAIN SWEEP DELAYED, the delaying sweep generator operates normally, but the delayed main sweep is applied to the horizontal amplifier in the oscilloscope. The main unblanking gate is applied to the oscilloscope, and the delaying sweep unblanking gate is disconnected.

With the SWEEP SELECTOR set to MIXED SWEEP, the delaying sweep is applied to the horizontal amplifier in the oscilloscope, and the delayed main sweep is applied to the anode of diode CR5. The cathode of CR5 is connected to the delaying sweep output. Therefore the delaying sweep signal is applied to the oscilloscope as long as the delaying sweep is more positive than the delayed main sweep. When the main sweep becomes the more positive signal, CR5 becomes forward biased, and the main sweep is applied both to the oscilloscope and to gate generator V5/V7A. Thus the main sweep completes the trace on the crt and terminates the delaying sweep as well.

4-3. DELAYED TRIGGER GENERATOR.

a. DELAYED TRIGGER. - The delayed-trigger generator is shown in figure 4-3. The signal applied to cathode follower V14A is the algebraic sum of the delaying sweep signal and a dc voltage selected by the DELAY LENGTH control. The delay period is the time required for the delaying sweep to make the sum equal to about zero volts. As long as the sum is negative, the cathode of V14A is negative. Diode CR6 is therefore forward biased and holds the junction of CR6 and CR7 negative. Diode CR7 and transistor Q1 are then cut off. As the sweep progresses, the algebraic sum of the sweep and delay voltage approaches zero volts, the cathode of V14A goes positive, and the junction of CR6 and CR7 also goes positive. Diode CR7 then becomes forward biased, and current flows into the emitter of Q1. As the delaying sweep continues, CR6 becomes reverse biased and disconnects CR7 from the output of cathode follower V14A.

As Q1 starts to conduct, it produces a positive-going signal at its collector. The positive-going signal is applied to delayed trigger generator V15, a schmitt trigger, which then switches states and produces a positive voltage step at its output. The step is differentiated into a short pulse and applied to phase inverter V14B. The phase inverter provides both positive and negative pulses. The positive pulse is applied to the DELAY FUNCTION switch and to the front-panel DEL. TRIG. OUTPUT connector. The negative pulse is applied only to the DELAY FUNCTION switch.

b. DELAY FUNCTION. - The DELAY FUNCTION switch selects either the positive or negative pulse from phase inverter V14B and applies the pulse to bias control cathode follower V113A in the sweep generator of the oscilloscope. In addition, the DELAY FUNCTION determines the type of operation of the main sweep generator. With the DELAY FUNCTION set to TRIGGER MAIN SWEEP, the main sweep generator operates normally, and the negative pulse from phase inverter V14B starts the main sweep.

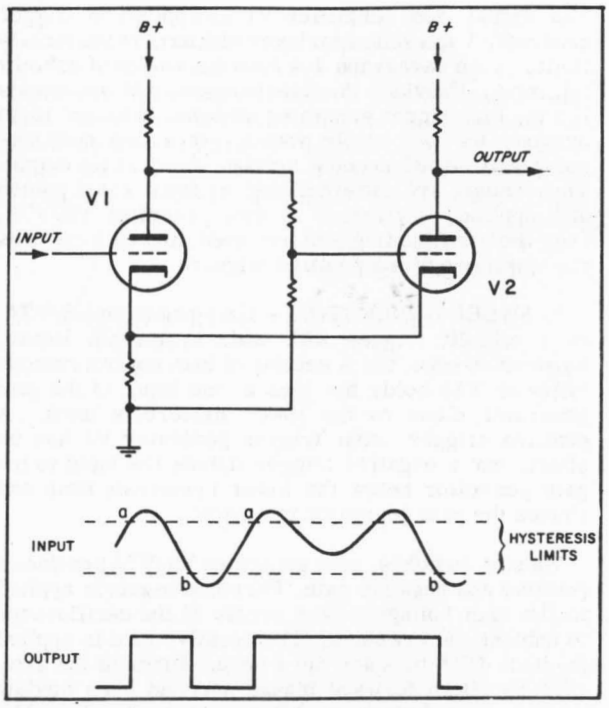


Figure 4-4. Simplified Schmitt Trigger and Waveform

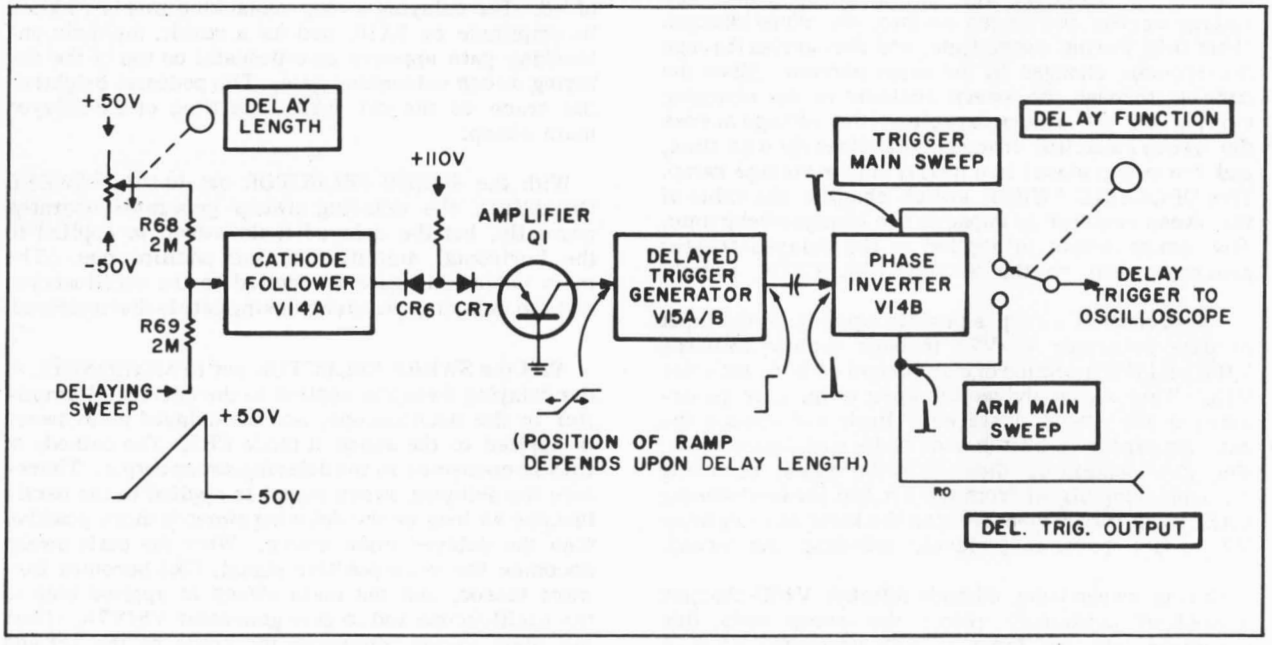


Figure 4-3. Delay Trigger Generator

When set to ARM MAIN SWEEP, the DELAY FUNCTION switch converts V113 in the oscilloscope sweep generator to a schmitt trigger, thereby setting the main sweep generator for single-sweep operation. The positive pulse from phase inverter V14B sets the schmitt trigger circuit of V113 to arm the main sweep generator, which then produces a sweep when triggered through the triggering circuits of the oscilloscope itself.

4-4. SCHMITT TRIGGER.

The schmitt trigger circuit is a form of bi-stable multivibrator used where fast-rising signals are required. Figure 4-4 shows a simplified schmitt circuit and input and output waveforms. If initially the input voltage is such that V1 is cut off, V2 conducts. As the input voltage becomes more positive, it will eventually reach a predetermined level (a) at which the circuit changes state; V1 conducts and V2 is cut off. If the input voltage then goes negative, the common cathode potential decreases and V2 grid goes positive. When the input reaches a second predetermined level (b), V2 conducts and the circuit switches back to its initial state. The output of the circuit is a voltage step, either positive or negative depending upon the slope of the input. In the case of trigger generator V4, a differentiating network differentiates the voltage steps into short pulses.

The input voltage levels at which a schmitt trigger switches are the hysteresis limits. Note that the circuit does not switch unless the input crosses both limits.

SECTION V
TROUBLESHOOTING

5-1. INTRODUCTION.

The procedure for troubleshooting the Model 166D is divided into two categories: (1) overall or system troubleshooting and (2) sectional troubleshooting. For the purpose of system troubleshooting, the Model 166D is considered to be a system; the oscilloscope is not included. The Model 166D is divided into the three sections shown in figure 5-1. System troubleshooting procedures isolate troubles to one of the sections, and sectional troubleshooting procedures isolate troubles within the sections.

5-2. TEST EQUIPMENT.

The voltmeter-ohmmeter indicated in table 5-1 is the only external test equipment required for troubleshooting the Model 166D. The oscilloscope in which the Model 166D is installed can be used to obtain waveforms where called for.

5-3. SYSTEM TROUBLESHOOTING.

Before starting the system troubleshooting, visually check the Model 166D for such items as loose or broken parts, cold solder joints, etc. Following the visual inspection, proceed to the system troubleshooting procedure given in table 5-2. When a faulty section is located, check the section for obvious troubles. In many cases instrument failure is due to a defective electron tube. The instrument can then be returned to service by replacing the tube and checking the calibration of the particular circuit repaired. Table 6-6 lists the adjustment required following replacement of tubes, transistors, and diodes. If the trouble in the faulty section is not obvious, proceed to the appropriate sectional troubleshooting table.

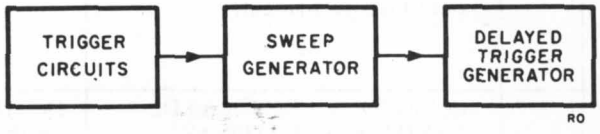


Figure 5-1. Functional Block Diagram

5-4. SECTIONAL TROUBLESHOOTING.

Tables 5-3, 5-4, and 5-5 provide procedures for sectional troubleshooting. The test points called out in the tables are located in figure 5-2 and are shown on the schematic diagrams, figures 6-2 and 6-3. Voltage and resistance diagrams are given in figures 5-6 and 5-7.

5-5. LOCATION OF PARTS.

Figures 5-3, 5-4, and 5-5 show locations of assemblies and components not called out in the instrument itself. These assemblies and components are called out by reference designation and cross-referenced in table 7-1.

Table 5-1. Test Equipment for Troubleshooting

Instrument Type	Required Characteristics	Use	Recommended Instrument
DC Voltmeter/ Ohmmeter	Voltage Range: 1 volt to 400 volts Accuracy: 3% Input Resistance: 100 megohms Resistance Range: 10 ohms to 10 megohms	Voltage and resistance measurements	ME-25A/U or hp 410B or hp 412A

Table 5-2. System Troubleshooting

Step	Preliminary Action	Normal Indication	Next Step
1	Set SWEEP SELECTOR to MAIN SWEEP and check oscilloscope for proper operation. Refer to oscilloscope manual.	Oscilloscope operates normally	If necessary, troubleshoot oscilloscope. Refer to oscilloscope manual. If oscilloscope operates normally, proceed to step 2.
2	Set SWEEP SELECTOR to DELAYING SWEEP, DELAY LENGTH to about 4 CM, DELAY FUNCTION to TRIGGER MAIN SWEEP, DELAYING SWEEP to .5 MILLISECONDS/CM, and SWEEP MODE to FREE RUN. On oscilloscope set SWEEP MODE to PRESET and SWEEP TIME to .1 MILLISECONDS/CM.	Delaying sweep appears on crt with 2-cm brightened segment approximately centered on trace.	If indication is normal, proceed to step 3. If neither delaying sweep nor brightened segment appears, check delaying sweep generator. Refer to table 5-4. If brightened segment does not appear, check delay trigger generator. Refer to table 5-5.
3	Set SWEEP MODE to PRESET. On oscilloscope set CALIBRATOR to .5, and connect VOLTS terminal of calibrator to trigger INPUT of Model 166D.	Delaying sweep appears on crt with 2-cm brightened segment approximately centered on trace.	If indication is normal, all circuits are functioning. Check instrument performance as instructed in section VI. If no sweep appears, refer to table 5-3.

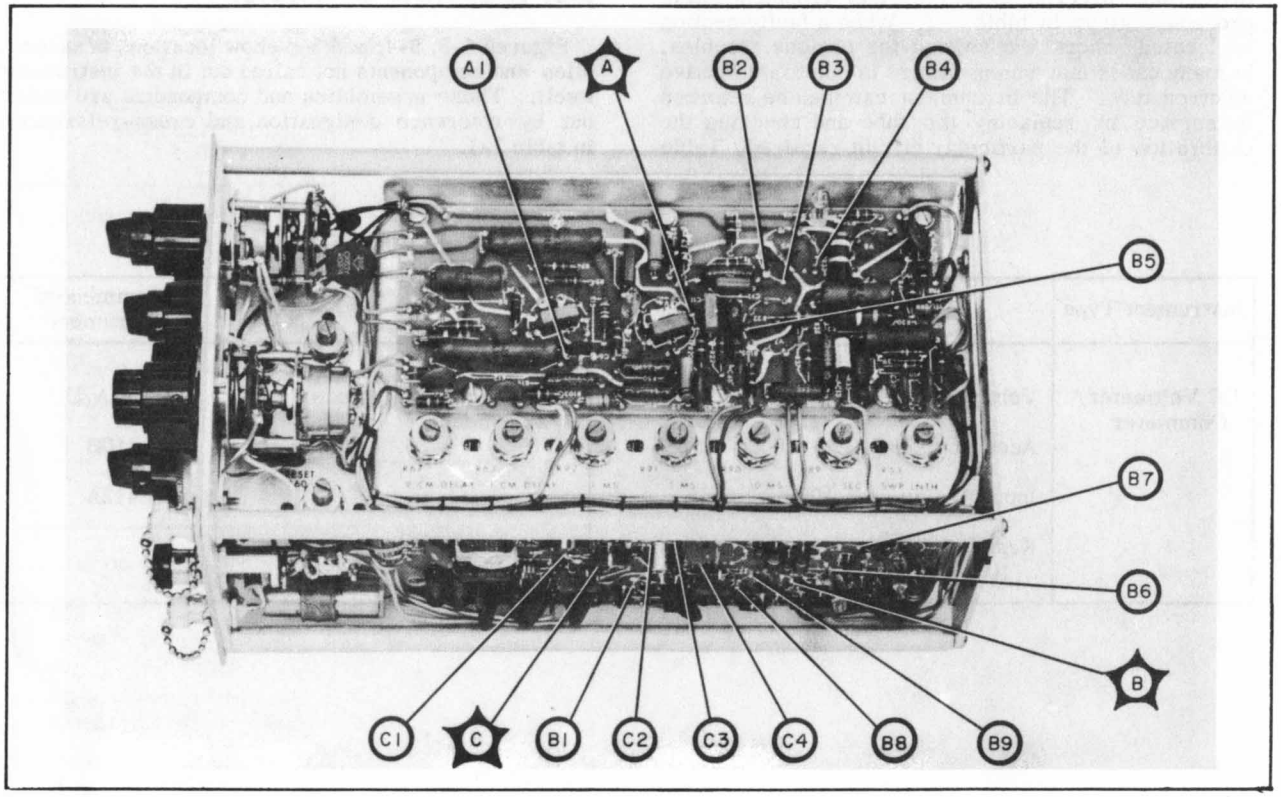


Figure 5-2. Location of Test Points

Table 5-3. Delaying Sweep Trigger Circuits Troubleshooting

Step	Test Point	Preliminary Action	Normal Indication	Next Step
1	A	Set TRIGGER SOURCE to EXT AC, TRIGGER LEVEL to 0, and SWEEP SELECTOR to MAIN SWEEP. On oscilloscope, set CALIBRATOR to .5, SWEEP TIME to .5 MILLISECONDS/CM, TRIGGER SOURCE to INT, SWEEP MODE to PRESET. Connect VOLTS terminal of CALIBRATOR to INPUT of Model 166D. Observe waveform at test point A on oscilloscope. Use probe and set vertical sensitivity for adequate deflection on crt. Some adjustment of TRIGGER LEVEL controls may be necessary.	As indicated on schematic diagram, figure 6-2	If indication is normal, proceed to step 2. If no signal is present, proceed to step 3.
2	B_2	Observe waveform at test point B_2	Positive and negative pulses about 2 volts and 5 volts peak respectively.	If indication is normal, delaying sweep trigger circuits are operating properly. If pulses are low in amplitude, check C11, CR1, R25, L3. If pulses have nearly equal amplitude, check CR1.
3	A_1	Observe waveform at test point A_1	Square wave about 2.5 volts peak-to-peak.	If indication is normal, check V4 circuit. If signal is low in amplitude, check V1 circuit.

Table 5-4. Delaying Sweep Generator Troubleshooting

Step	Test Point	Preliminary Action	Normal Indication	Next Step
1	B	Set DELAYING SWEEP to 1 SECOND/CM and SWEEP MODE to FREE RUN. Measure voltage at test point B	Voltage should cycle as shown on schematic diagram, figure 6-2, every 10 seconds	If indication is normal, sweep generator is operating. Check V8 if delaying sweep still does not appear on crt. If voltage remains negative, proceed to step 2. If voltage remains positive, proceed to step 3.

Table 5-4. Delaying Sweep Generator Troubleshooting (Cont'd)

Step	Test Point	Preliminary Action	Normal Indication	Next Step
2	(B1) thru (B9)	Measure voltages at test points B_1 through B_9.	Voltages at B_3 and B_4 should be at more positive value shown on schematic diagram. Voltage at B_5 should be at more negative value. Other voltages should be progressing toward end-of-sweep value. Since sweep is inoperative, these voltages may have progressed beyond end-of-sweep values.	Check first circuit giving incorrect indication.
3	(B1) thru (B9)	Set SWEEP MODE to 12 o'clock. Measure voltage at test points B_8 and B_9, then B_1 through B_7.	Voltages at B_3 and B_4 should be at more negative value shown on schematic diagram. Voltage at B_5 should be at more positive value. Voltages at B_6 and B_7 should be at presweep levels. Since voltage at B is at most positive extreme, voltages at B_8 and B_9 should also be at positive extreme.	Check circuit giving incorrect indication.

Table 5-5. Delay Trigger Generator Troubleshooting

Step	Test Point	Preliminary Action	Normal Indication	Next Step
1	(C)	Set SWEEP SELECTOR to DELAYING SWEEP, DELAY LENGTH to about 4 CM, DELAYING SWEEP to 50 MICROSECONDS/CM, and SWEEP MODE to FREE RUN. Observe waveform at test point C. Use probe and set vertical sensitivity for adequate deflection on crt.	Positive pulse about 15 volts peak as shown on schematic diagram. Pulse position shifts with DELAY LENGTH setting.	If indication is normal, delay trigger generator is operating properly. If pulse does not appear, proceed to step 2.
2	(C1) thru (C4)	Observe waveforms at test points C_1 through C_4.	As indicated on schematic diagram.	Check first circuit giving incorrect waveform.

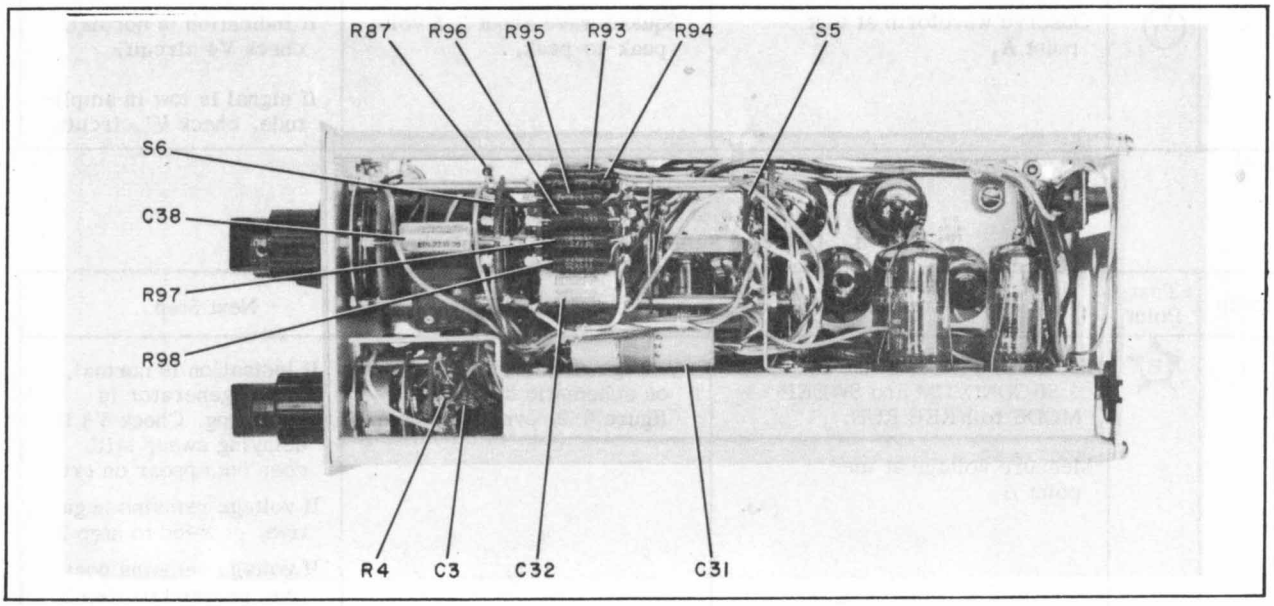


Figure 5-3. Location of Parts, Right Side View

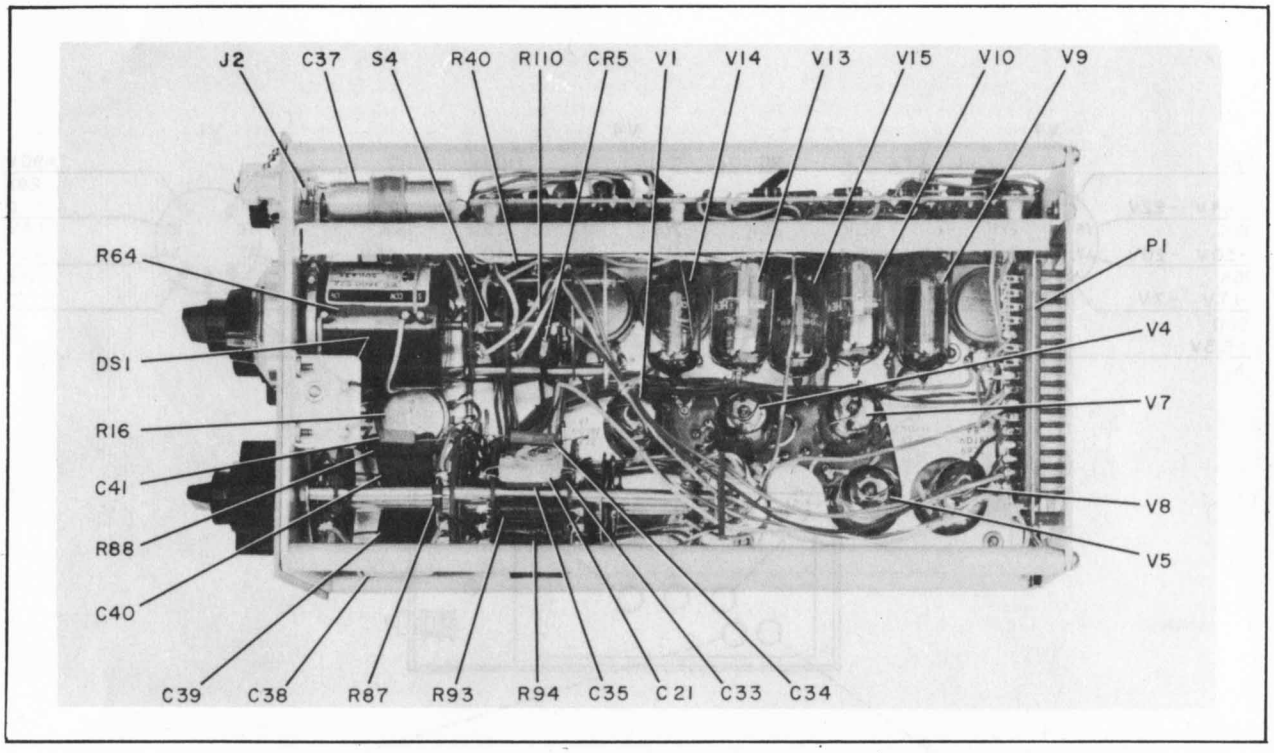


Figure 5-4. Location of Parts, Top View

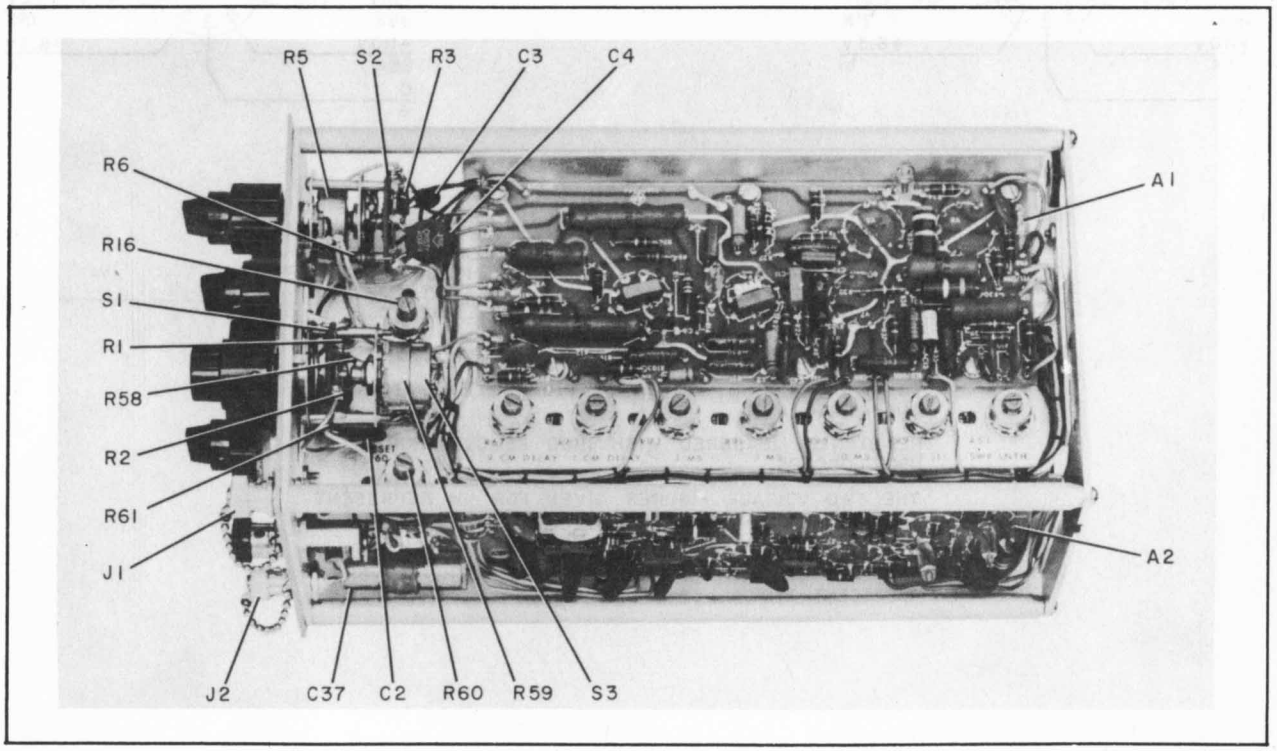
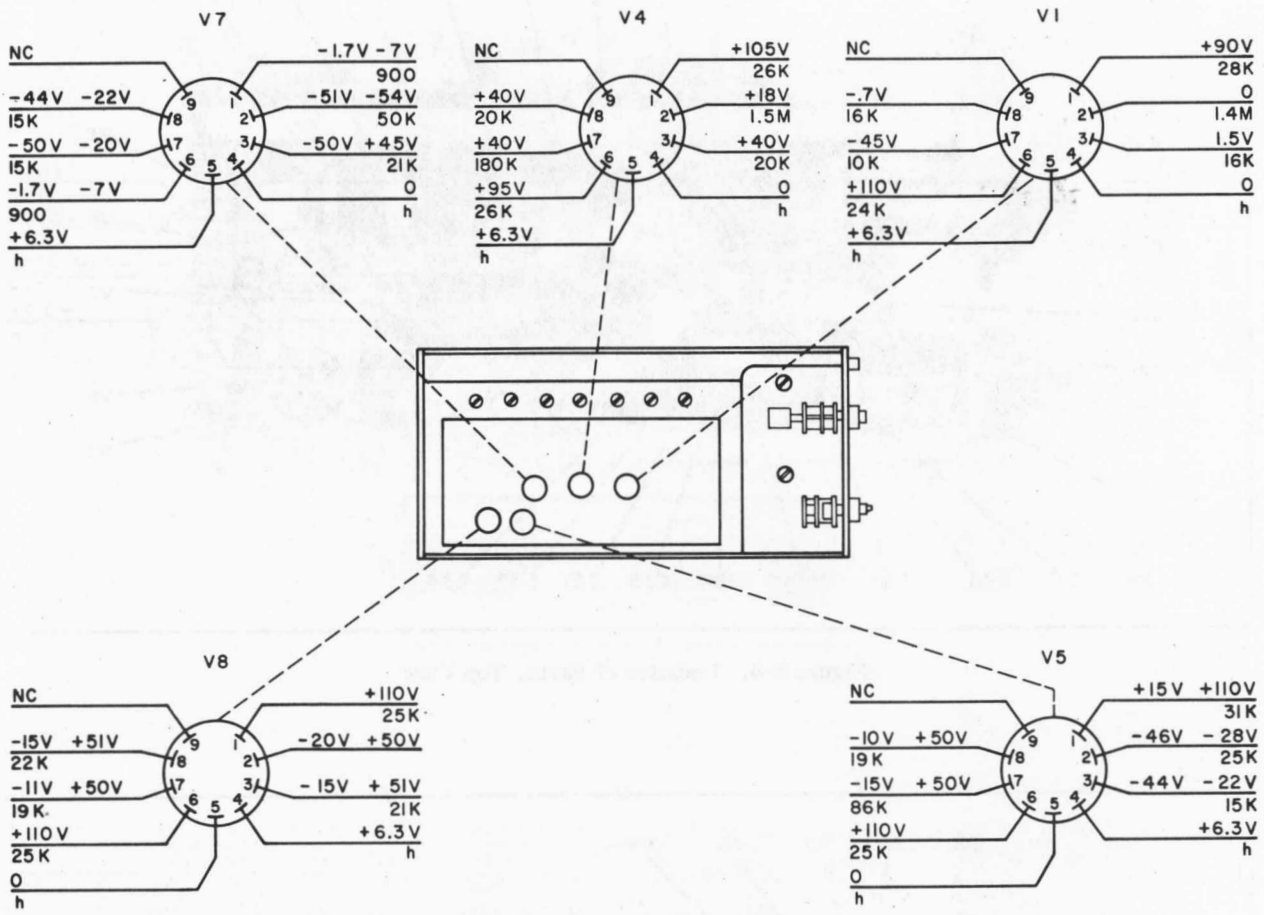


Figure 5-5. Location of Parts, Bottom View



NOTES

VOLTAGES MEASURED WITH CONTROLS SET AS FOLLOWS:

SWEEP SELECTOR	DELAYING SWEEP
DELAY LENGTH	1 SEC/CM
MAIN SWEEP (160B OR 170A)	.5 SEC/CM
SWEEP MODE	PRESET
TRIGGER SLOPE	−
TRIGGER LEVEL	CCW

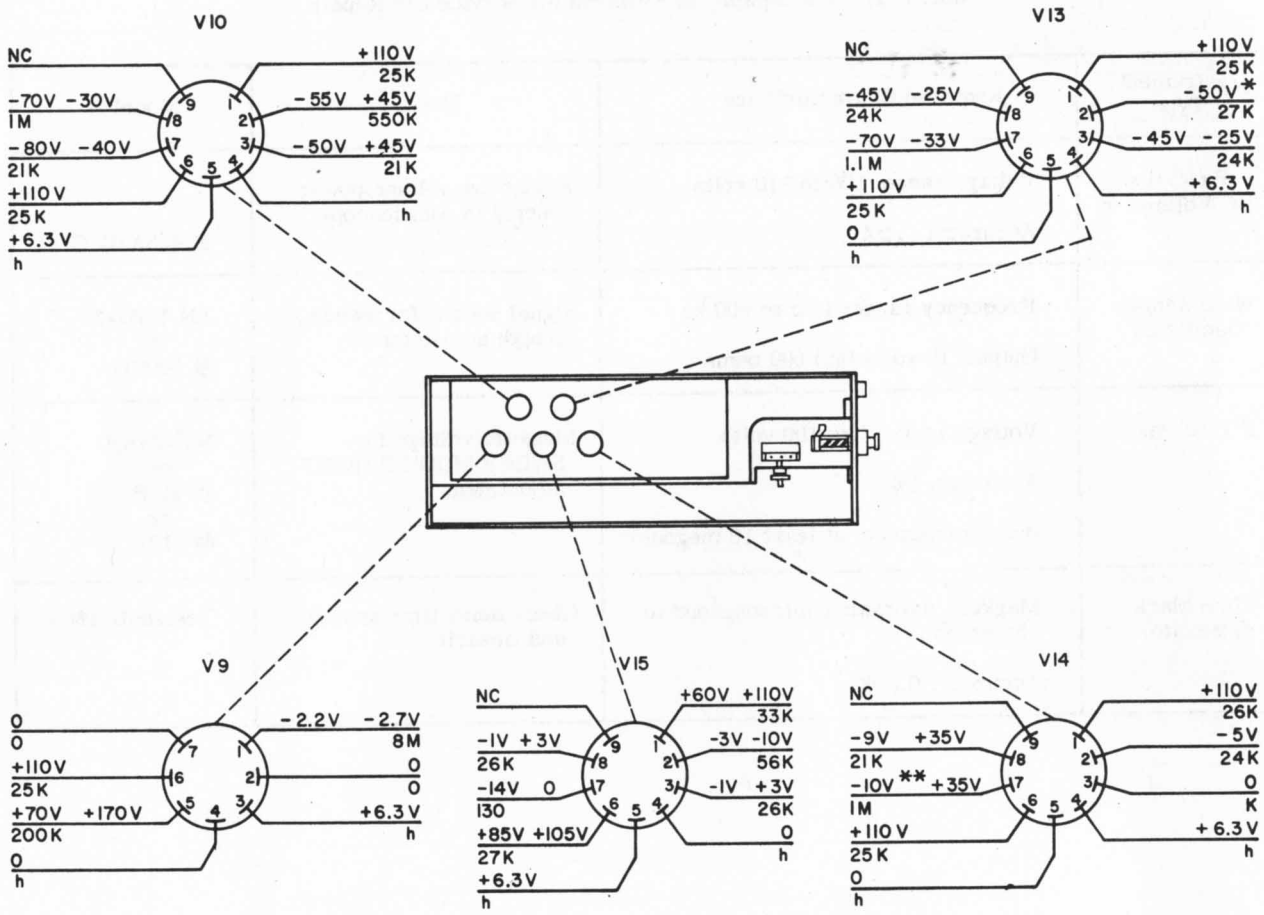
TRIGGER SWEEP BY ROTATING TRIGGER LEVEL TO +, THEN FULL CCW.

RESISTANCE MEASURED WITH 166D REMOVED FROM OSCILLOSCOPE.

THE TWO VOLTAGE FIGURES GIVEN FOR V4 REPRESENT TYPICAL VOLTAGE LEVELS IN EITHER STATE OF THE SCHMITT TRIGGER CIRCUIT.

THE TWO VOLTAGE FIGURES GIVEN FOR OTHER TUBES REPRESENT TYPICAL SWEEP LIMITS.

Figure 5-6. Sweep Generator, Voltage and Resistance Measurements



NOTES

* -25V TO -60V DEPENDENT ON POSITION OF SWEEP MODE

** -3V TO -50V DEPENDENT ON DELAY LENGTH

Figure 5-7. Delayed Trigger Generator, Voltage and Resistance Measurements

Table 6-1. Test Equipment Required for Service and Repair

Instrument Type	Required Characteristics	Use	Model
Precision DC Voltmeter	Voltage range: 100 to 110 volts Accuracy: .2%	Adjust low voltage power supply in oscilloscope	℗ 405A/B/C
Wide Range Oscillator	Frequency range: 1 kc to 600 kc Output: 10 volts into 600 ohms	Signal source for sweep length adjustments	AN/USM-30 or ℗ 200CD
DC Voltmeter	Voltage range: 1 to 100 volts Accuracy: 3% Input impedance: at least 10 megohms	Measure voltage for SWEEP MODE PRESET adjustment	ME-25A/U or ℗ 410B or ℗ 412A
Time Mark Generator	Markers interval: 1 microsecond to 5 seconds Accuracy: 0.05%	Check delay time accuracy and linearity	Tektronix 180A

SECTION VI
SERVICE AND REPAIR

6A PREVENTIVE MAINTENANCE

6-1. INTRODUCTION.

No preventive maintenance is required for the Model 166D Delay Generator except an occasional visual inspection. However, to preserve the interchangeability of the Model 166D without loss of accuracy, periodically check the +110 volt and -100 volt power supply voltages in the 160B and 170A Oscilloscopes in which the Model 166D is to be used, and maintain the output of these supplies within 0.4% of their nominal values.

6B PERFORMANCE STANDARDS

6-2. TEST EQUIPMENT.

Test equipment required for the performance check and adjustment of the Model 166D is listed in table 6-1. Equipment of equivalent characteristics may be substituted for those listed.

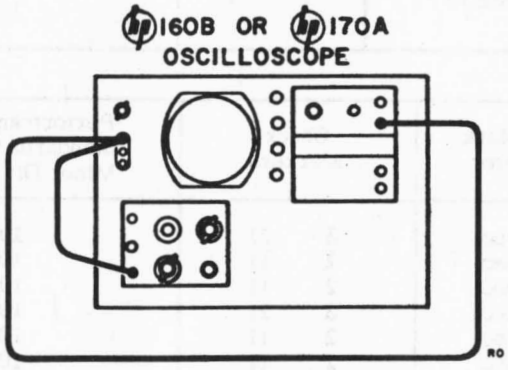
6-3. PERFORMANCE CHECKS.

Performance checks for the Model 166D, plugged into an hp Model 160B or Model 170A Oscilloscope, are given in tables 6-2, 6-3, and 6-4.

Note

The delay time accuracy of the Model 166D depends on the +110 and -100 voltages supplied by the oscilloscope. These voltages should be adjusted to within 0.4% of their normal values before performance checks or adjustments are made. Refer to the oscilloscope Operating and Servicing Manual for adjustment procedure.

Table 6-2. Trigger Sensitivity

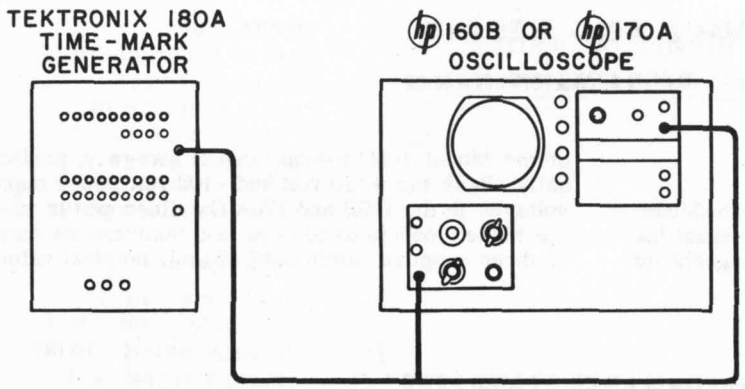


OSCILLOSCOPE:
VERTICAL SENSITIVITY TO 1 VOLT/CM
VERNIER TO CALIBRATED
SWEEP TIME TO 1 MILLISECOND/CM
CALIBRATOR TO .2

MODEL 166D:
TRIGGER LEVEL TO 0
TRIGGER SLOPE TO +
SWEEP MODE TO PRESET
TRIGGER SOURCE TO INT

Step	Preliminary Action	Read Indication On	Performance Standard
1	Connect VOLTS terminal of calibrator to vertical INPUT and to Model 166D trigger INPUT.	Oscilloscope	Sweep triggered without jitter.
2	Switch TRIGGER SOURCE to EXT and CALIBRATOR to .5.	Oscilloscope	Sweep triggered without jitter.

Table 6-3. Delaying Sweep Accuracy



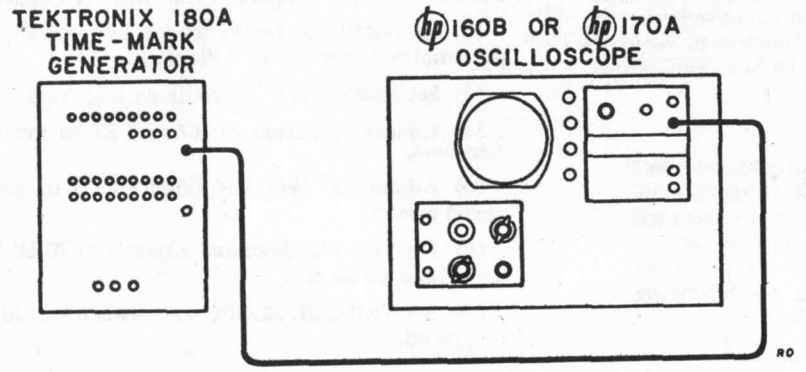
MODEL 166D:
SWEEP SELECTOR TO DELAYING SWEEP
SWEEP MODE TO PRESET
TRIGGER SLOPE TO +
TRIGGER SOURCE TO EXT AC
DELAY FUNCTION TO TRIGGER MAIN SWEEP
DELAY LENGTH TO 10

OSCILLOSCOPE:
SWEEP MODE TO PRESET
TRIGGER SLOPE TO +
TRIGGER SOURCE TO INT
SWEEP TIME TO .1 MICROSECONDS/CM

Step	Preliminary Action	Read Indication On	Performance Standard
1	Connect Time Mark Generator (1 microsecond markers) to Oscilloscope vert INPUT. Set Model 166D DELAYING SWEEP TIME to 2 microseconds and adjust trigger level controls for stable sweep. Adjust DELAY LENGTH to put brightened part of trace under third marker (approximately 1 cm). Set Sweep selector to MAIN SWEEP DELAYED and adjust DELAY LENGTH to put leading edge of marker at start of trace. Record DELAY LENGTH.	DELAY LENGTH DIAL	Difference between DELAY LENGTH readings must be 9 cm +10 minor divisions
2	Adjust DELAY LENGTH to put leading edge of 21st marker at start of trace (approximately 10 cm). Record DELAY LENGTH.		
3	Repeat for all ranges of DELAYING SWEEP TIME as listed in the following table.		

Delaying Sweep Time/CM	160B/170A Sweep Time	Time Mark Generator	Check Markers		Performance Standards 9 CM + Minor Divisions
2 usec	.2 usec	1 usec	3	21	10
5 usec	.5 usec	5 usec	2	11	10
10 usec	1 usec	10 usec	2	11	10
20 usec	2 usec	10 usec	3	21	10
50 usec	5 usec	50 usec	2	11	10
.1 msec	10 usec	100 usec	2	11	10
.2 msec	20 usec	100 usec	3	21	10
.5 msec	50 usec	500 usec	2	11	10
1 msec	.1 msec	1 msec	2	11	10
2 msec	.2 msec	1 msec	3	21	10
5 msec	.5 msec	5 msec	2	11	10
10 msec	1 msec	10 msec	2	11	10
20 msec	2 msec	10 msec	3	21	10
50 msec	5 msec	50 msec	2	11	10
.1 sec	10 msec	100 msec	2	11	10
.2 sec	20 msec	100 msec	3	21	30
.5 sec	50 msec	500 msec	2	11	30
1 sec	.1 sec	1 sec	2	11	30

Table 6-4. Delaying Sweep Linearity



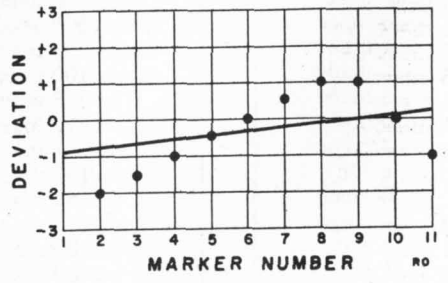
MODEL 166D:
SWEEP SELECTOR TO DELAYING SWEEP
DELAY FUNCTION TO TRIGGER MAIN SWEEP
DELAYING SWEEP TIME 1 MILLISECOND
TRIGGER SOURCE TO INT.

OSCILLOSCOPE:
SWEEP TIME TO 10 MICROSECONDS/CM
TRIGGER SOURCE TO INT
TRIGGER SLOPE TO +
SWEEP MODE TO PRESET

Step	Preliminary Action	Read Indication On	Performance Standard
1	Connect Time Mark Generator (1 millisecond markers) to Oscilloscope vert INPUT. Adjust TRIGGER LEVEL controls for stable sweep. Align markers with graticule. Adjust DELAY LENGTH to put brightened part of trace under second marker. Set SWEEP SELECTOR to MAIN SWEEP DELAYED and adjust DELAY LENGTH to put leading edge of marker at start of trace. Record DELAY LENGTH.	DELAY LENGTH dial	
2	Repeat for remaining markers (third through eleventh)	DELAY LENGTH dial	
3	Plot deviation from integral number on DELAY LENGTH dial versus marker as shown below. Draw a straight line through the points with minimum deviation of points from the line.	DELAY LENGTH dial	No point may deviate vertically from the line by more than two minor dial divisions.
4	Repeat steps 1, 2, and 3 with DELAYING SWEEP TIME at 5 microseconds, Oscilloscope SWEEP TIME at .1 microsecond/cm, and 5 microsecond markers.	DELAY LENGTH dial	No point may deviate from the line by more than five divisions.

Example:

Marker Number	DELAY LENGTH	Deviation Minor Divisions
2	0.98	-2
3	1.985	-1.5
4	2.99	-1
5	3.995	-.5
6	5.00	0
7	6.005	+.5
8	7.01	+1
9	8.01	+1
10	9.00	0
11	9.99	-1



6C REPAIR

6-4. ADJUSTMENT PROCEDURES.

a. INTRODUCTION. - The procedures below give instructions for the complete calibration of the Model 166D. Table 6-1 lists the test equipment required for calibration. Table 6-6 lists the adjustments required following replacement of individual tubes, transistors, and diodes.

Note

The delay time accuracy of the Model 166D depends on the +110 and -100 voltages supplied by the oscilloscope. These voltages should be adjusted to their nominal values ±0.4% before adjustments are made. Refer to the oscilloscope Operating and Servicing Manual for adjustment procedure.

b. PRESET.

(1) Connect DC Voltmeter between pin 3 and V13A and ground.

(2) Set Model 166D controls as follows:

TRIGGER SLOPE . . . . . +
TRIGGER SOURCE . . . . . INT
SWEEP MODE . . . . . PRESET
DELAYING SWEEP TIME . . .5 MILLISECONDS
SWEEP SELECTOR . . . . . DELAYING SWEEP

(3) Rotate SWEEP MODE to FREE RUN, then back toward PRESET until sweep just stops. Observe reading on voltmeter for reference.

(4) Set SWEEP MODE to PRESET and adjust Preset R60 (figure 6-1) to give reading 1.5 volts more positive than reference.

c. TRIGGER SYMMETRY

(1) Connect oscillator output to oscilloscope vertical INPUT and set vertical SENSITIVITY to 10 v/cm.

(2) Set oscillator frequency for 1 kc and adjust output amplitude for 2 mm deflection.

(3) Set Model 166D controls as in paragraph b (2).

(4) Connect junction of R7 and S2 to ground with clip lead.

(5) Adjust TR Sym R16 (figure 6-1) to give triggered sweep.

(6) Remove clip lead and adjust TRIGGER LEVEL for triggered sweep.

(7) Set TRIGGER SLOPE to -; sweep should remain triggered.

d. SWEEP LENGTH.

(1) Connect oscillator output to oscilloscope vertical INPUT; adjust frequency to 600 kc and amplitude for 5 cm deflection.

(2) Set Model 166D controls as in paragraph b (2).

(4) Adjust TRIGGER LEVEL to give shortest sweep possible.

(5) Adjust Swp Lnth (figure 6-1) for sweep length of 10.2 cm.

e. DELAYING SWEEP CALIBRATION.

(1) Connect Time Mark Generator to oscilloscope and set controls as shown in table 6-3.

(2) Table 6-5 lists adjustments and tolerances for each range of DELAYING SWEEP TIME. Align 1st marker with left side of graticule using HORIZONTAL POSITION control. Align 11th/21st marker with right side of graticule with adjustment listed in table 6-5.

Table 6-5. Sweep Calibration

Delaying Sweep Time/CM	Time Mark Generator	Action	* Tolerance ±
5 usec	5 usec	adjust C36	1 marker/cm
10 usec	10 usec	check	1 mm
2 usec	1 usec	check	1 mm
50 usec	50 usec	adjust R92	1 marker/cm
.1 msec	.100 usec	check	1 mm
20 usec	10 usec	check	1 mm
.5 msec	.500 usec	adjust R91	1 marker/cm
1 msec	1 msec	check	1 mm
.2 msec	.100 usec	check	1 mm
5 msec	5 msec	adjust R90	1 marker/cm
10 msec	10 msec	check	1 mm
2 msec	1 msec	check	1 mm
.1 sec	.100 msec	adjust R89	1 marker/cm
50 msec	50 msec	check	1 mm
20 msec	10 msec	check	1 mm
.2 sec	.100 msec	check	3 mm
.5 sec	.500 msec	check	3 mm
.1 sec	1 sec	check	3 mm

*These tolerances do not apply after setting DELAYING SWEEP TIME accuracy (step 4 in paragraph 6-4h).

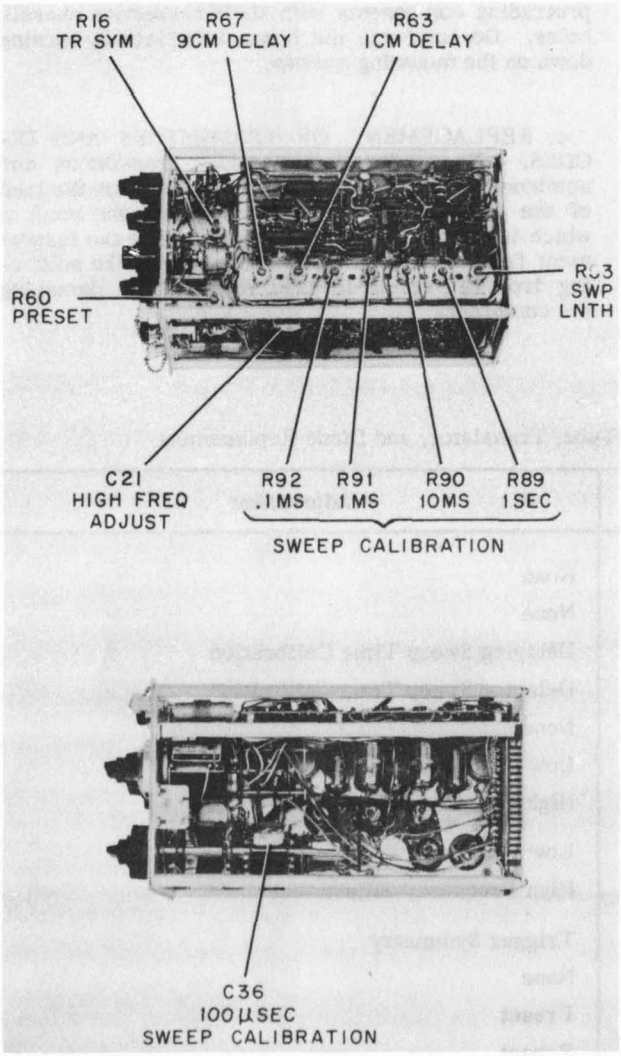


Figure 6-1. Location of Adjustments

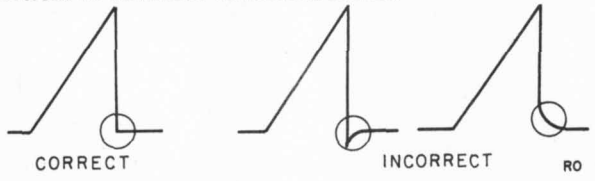
f. FREQUENCY COMPENSATION.

(1) Set oscilloscope SWEEP TIME to 1 millisecond/cm and SWEEP MODE to PRESET.

(2) Set Model 166D controls as follows:

DELAYING SWEEP TIME . . . 0.2 milliseconds/cm
SWEEP MODE . . . . . .FREE RUN
TRIGGER SOURCE . . . . . EXT
SWEEP SELECTOR . . . . . .MAIN SWEEP DELAY
DELAY FUNCTION . . . . . .TRIGGER MAIN SWEEP
DELAY LENGTH. . . . . .Greater than 1 cm.

(3) Observe sawtooth at cathode (pin 8) of V14A using a compensated hp AC-21A probe and the oscilloscope in which the Model 166D is installed. Adjust C1 until bottom of sawtooth waveform is flat.



g. LOW FREQUENCY ADJUSTMENT.

Complete step f before performing low frequency adjustment.

(1) Set oscilloscope SWEEP TIME to 10 microseconds/cm and SWEEP MODE to PRESET. Set Model 166D controls as follows:

SWEEP TIME. . . . . 1 millisecond/cm
SWEEP MODE . . . . . PRESET
TRIGGER LEVEL. . . . . +
TRIGGER SOURCE. . . . . INT
SWEEP SELECTOR . .MAIN SWEEP DELAYED
DELAY FUNCTION . .TRIGGER MAIN SWEEP

(2) Set Time Mark Generator for 1 ms markers and connect to oscilloscope vertical INPUT. Set DELAY LENGTH to 1 cm. Adjust 1 cm Delay R63 (figure 6-1) to set second marker at beginning of sweep. Switching to DELAYING SWEEP will show which marker is being displayed.

(3) Set DELAY LENGTH to 10.00 cm. Adjust 9 cm Delay R67 (figure 6-1) to set 11th marker at beginning of sweep. Adjustment of R63 and R67 interact. Repeat as necessary.

h. HIGH FREQUENCY ADJUSTMENT.

Complete steps f and g before performing high frequency adjustment.

(1) Reset controls on the Model 166D as follows:

SWEEP TIME . . . . . 50 microseconds/cm
SWEEP MODE . . . . . PRESET
TRIGGER SOURCE . . . . . INT
SWEEP SELECTOR. . MAIN SWEEP DELAYED

(2) Connect Time Mark Generator (50 μsec markers) to oscilloscope Vert INPUT. Adjust DELAY LENGTH to set leading edge of second marker at beginning of trace (approx. 1 cm). Increase DELAY LENGTH reading by 9 cm. Adjust R92 to set leading edge of 11th marker at beginning of trace.

(3) Repeat (2) with DELAYING SWEEP TIME at 5 μsec using 5 μsec markers. Adjust C36 (see figure 6-1).

(4) Check DELAYING SWEEP TIME accuracy (see table 6-3). Delaying sweep time calibration may have to be changed slightly to meet specifications.

6-5. REMOVAL OF COMPONENTS AND SUBASSEMBLIES.

a. INTRODUCTION. The following paragraphs describe the procedures for removal and replacement of those subassemblies and components which may require replacement or repair within the lifetime of the instrument and whose replacement is sufficiently complicated to require instructions. Table 6-6 lists adjustments required following tube, transistor and diode replacement. These adjustments may also be required following component replacement in associated circuits.

b. COMPONENT REPLACEMENT ON ETCHED CIRCUIT BOARDS. The etched circuit boards used in the instrument are constructed with eyelets for

component mounting; nevertheless, remove and replace components carefully. Use a small soldering iron, one with a maximum rating of 50 watts. Following removal of a component, clean circuit boards and eyelets of old solder. Tin the leads of new components before inserting them into a board, and cut the leads short enough that they do not project below the circuit board and contact the chassis or other leads. Use a minimum of solder for the bond.

If a circuit board must be removed, first remove all electron tubes and tube clamps. When reinstalling the board, carefully align tube sockets and other protruding components with their respective chassis holes. Do not force the board into place by turning down on the mounting screws.

c. REPLACEMENT OF TRANSISTORS AND DIODES. - To solder and unsolder transistors and semiconductor diodes, place a heat sink on the lead of the component between its body and the point to which heat is applied. In addition, isolate the instrument from ground or ground the body of the soldering iron to prevent leakage voltage from damaging the component.

Table 6-6. Required Adjustments Following Tube, Transistor, and Diode Replacement

Tube or Transistor	Function	Adjustment
CR1	Limiter	None
CR2	Limiter	None
CR3	Switch Diode	Delaying Sweep Time Calibration
CR4	Turn on Protection	Delaying Sweep Time Calibration
CR5	Sweep Mixing Diode	None
CR6	Coupling Diode	Low Frequency Adjustment
		High Frequency Adjustment
CR7	Coupling Diode	Low Frequency Adjustment
		High Frequency Adjustment
V1	Trigger Amplifier	Trigger Symmetry
V4	Trigger Generator	None
V5	Gate Generator	Preset
V7	Gate Generator/Clamp	Preset
V8	Cathode Follower	None
V9	Integrator	Delaying Sweep Time Calibration
V10	Cathode Follower	None
V13	Bias Control Cathode Follower	None
V14	Cathode Follower/Phase Inverter	Low Frequency Adjustment
V15	Delay Trigger Generator	Delaying Sweep Time Calibration
Q1	Amplifier	Low Frequency Adjustment
		High Frequency Adjustment

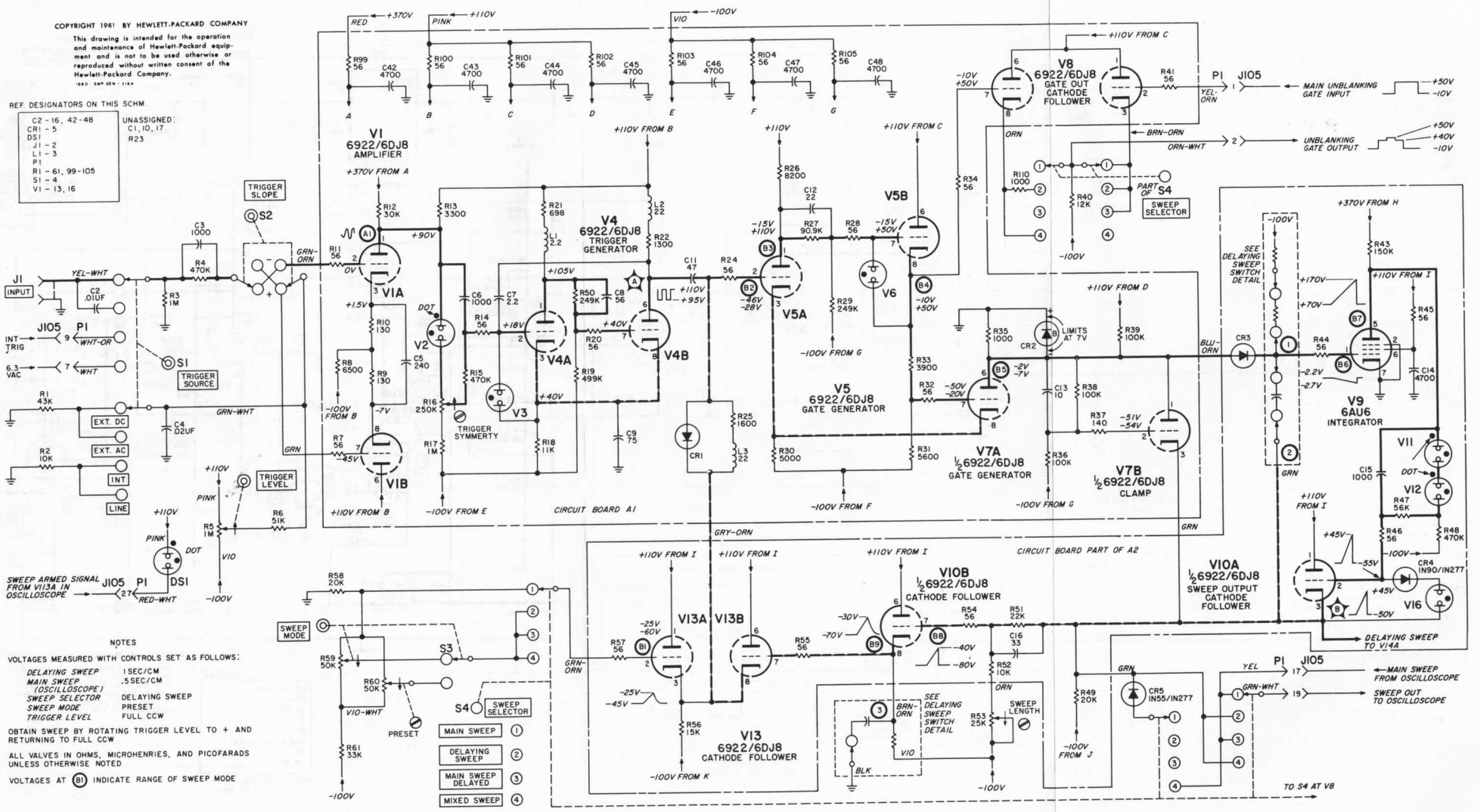
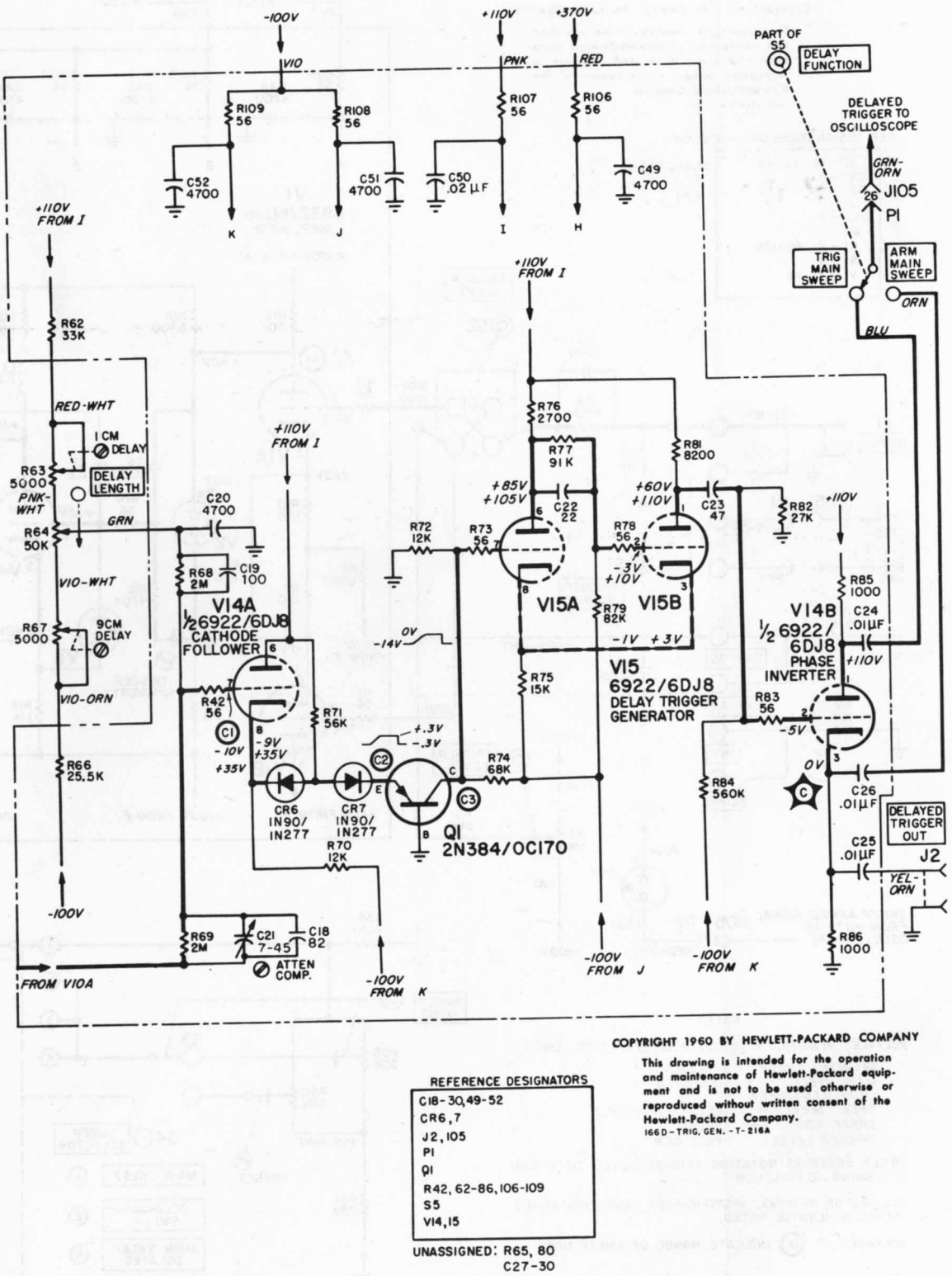


Figure 6-2. Sweep Generator



REFERENCE DESIGNATORS

C18-30, 49-52
CR6, 7
J2, 105
P1
Q1
R42, 62-86, 106-109
S5
V14, 15

UNASSIGNED: R65, 80
C27-30

Figure 6-3. Delayed Trigger Generator

01227-1

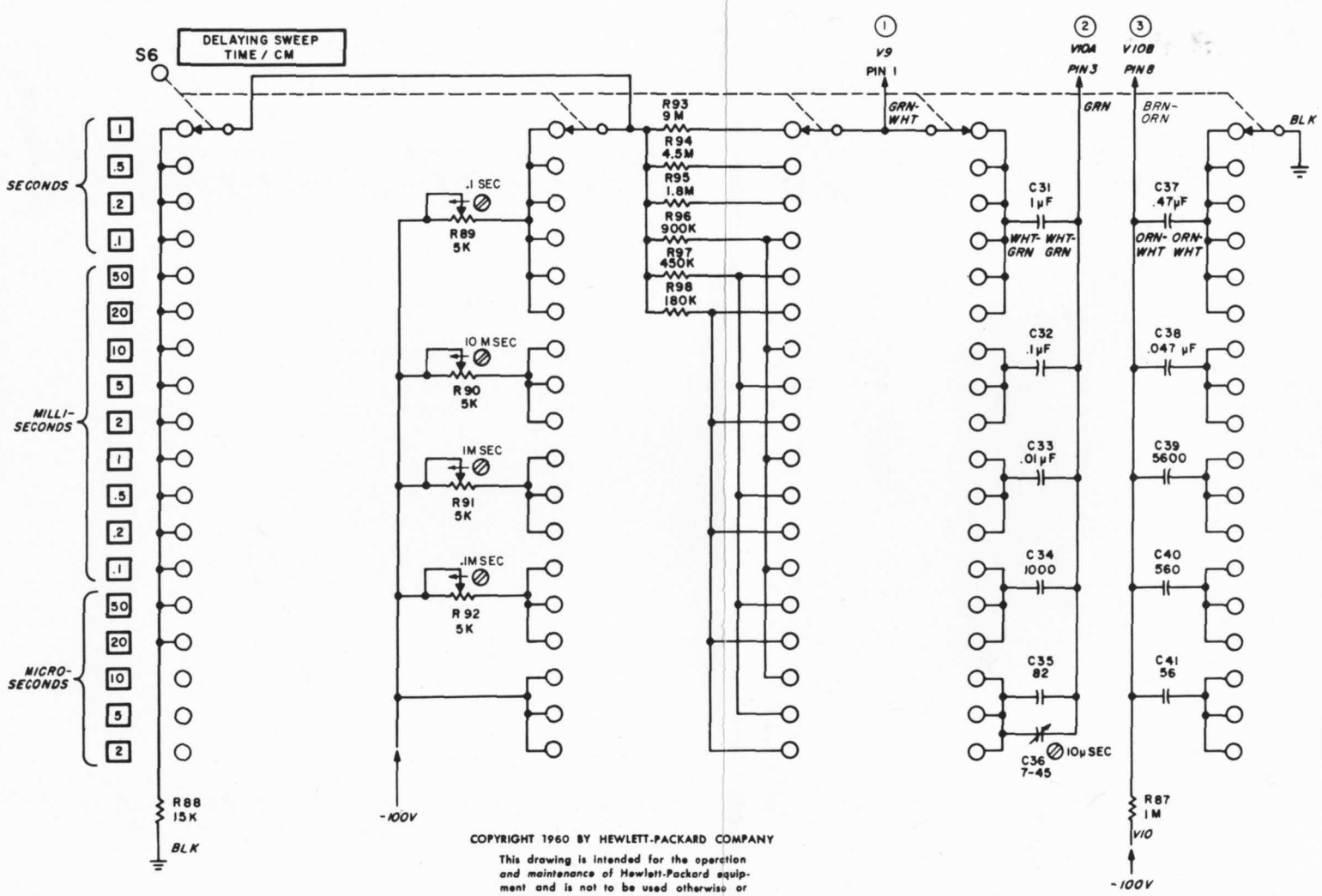


Figure 6-4. Delaying Sweep Time Switch

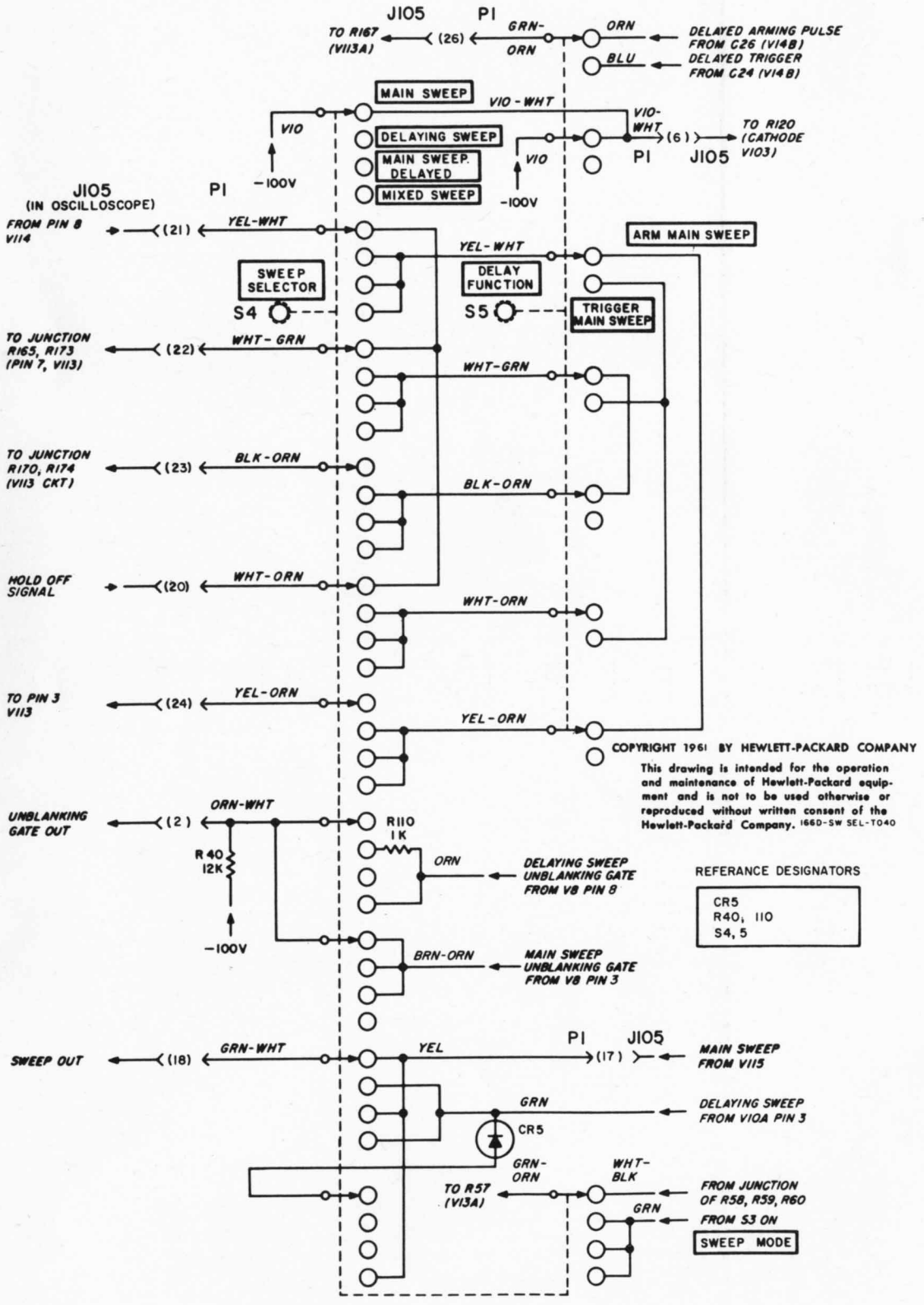
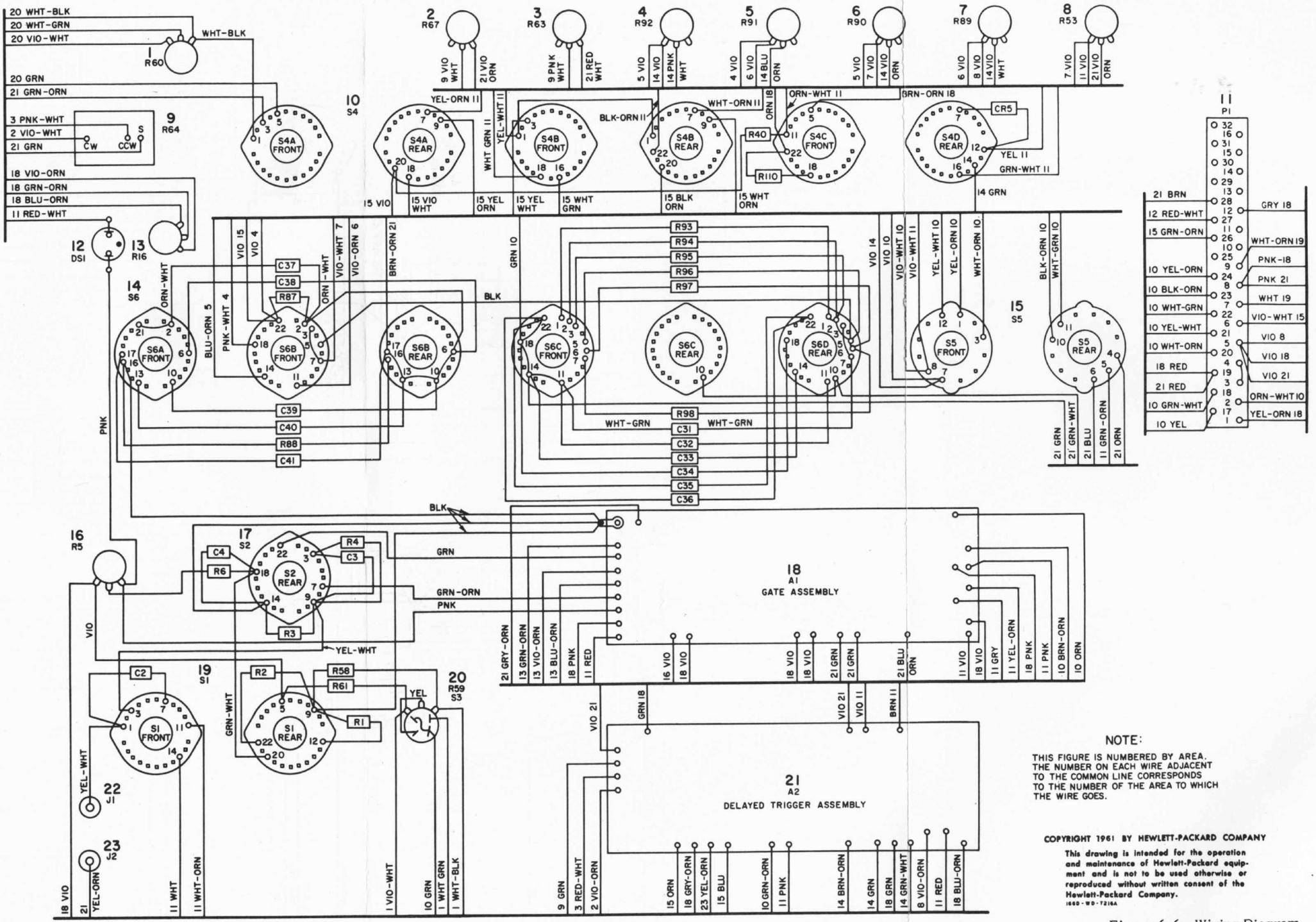


Figure 6-5. Sweep Selector and Delay Function Switches



NOTE:

THIS FIGURE IS NUMBERED BY AREA. THE NUMBER ON EACH WIRE ADJACENT TO THE COMMON LINE CORRESPONDS TO THE NUMBER OF THE AREA TO WHICH THE WIRE GOES.

Figure 6-6. Wiring Diagram

SECTION VII
PARTS LIST

7-1. INTRODUCTION.

Reference designations are assigned to identify all maintenance parts of the Model 166D. They are used for marking the instrument (adjacent to the part they identify) and are included on the schematics, wiring diagrams, and the parts list, table 7-1. The letter prefix of a reference designation indicates the kind of part-resistor, capacitor, electron tube, etc. The number differentiates between parts in the same group. Sockets associated with electron tubes, fuses, and like items include the reference designation of the associated part and a prefix X.

7-2. MAINTENANCE PARTS LIST.

Table 7-1 lists maintenance parts in alpha-numerical order of their reference designators. Detailed information on a part used more than once in the instrument is listed opposite the first reference designator applying to the part. Other reference designators applying to the same part refer to the initial designator. Miscellaneous parts are included at the end of the list. Detailed information includes the following:

a. Reference designator.

b. Full description of the part.

c. Locating function.

d. Manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

e. Hewlett-Packard stock number.

f. Total quantity used in the instrument (TQ col).

g. Recommended spare quantity for complete maintenance during one year of isolated service (RS col).

7-3. ORDERING INFORMATION.

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

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.

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

TABLE 7-1. MAINTENANCE PARTS LIST

CKT REF.	DESCRIPTION	FUNCTION	MFR.	STOCK NO.	TQ	RS	NOTE
A1	Assembly, Sweep Generator: includes CR5 thru C9, C11 thru C13, C42 thru C48, CR1, CR2, L1 thru L3, R7 thru R15, R17 thru R22, R24 thru R39, R41, R50, R99 thru R105, V1 thru V8, XV1, XV4, XV5, XV7, XV8	Delaying Sweep Generator Circuit Board Figure 5-5	28480	166D-65A(N)	1	0	
A2	Assembly, Delayed Trigger: includes C14 thru C16, C18 thru C26, C50 thru C52 CR3, CR4, CR6, CR7, Q1, R42 thru R49, R51, R52, R54 thru R57, R62, R67 thru R79, R81 thru R86, R106 thru R109	Delayed Trigger Generator Circuit Board. Figure 5-5	28480	166D-65B(N)	1	0	
A3	Assembly, Trigger Level Switch: includes C3, C4, R3 thru R6, S2	Trigger Slope, Figure 5-5	28480	166D-19A(N)	1	1	
A4	Assembly, Trigger Source Switch: includes C2, R1, R2, R58, R59, R61, S1, S3	Trigger Source. Figure 5-5	28480	166D-19B(N)	1	1	
A5	Assembly, Sweep Selector Switch: includes CR5, R40, R110, S4	Sweep Selector. Figure 5-4	28480	166D-19C(N)	1	1	
A6	Assembly, Sweep Time Switch: includes C32 thru C36, C38 thru C41, R87, R88, R93 thru R98, S5, S6	Delay Function Selector. Figure 5-3	28480	166D-19D(N)	1	1	
C1	Not assigned						
C2	Capacitor: fixed, ceramic, 0.01 μf + 80% -20%, 500 vdcw (CK63AW103M per MIL-C-11015B)	Coupling Capacitor for Trigger Input Figure 5-5	72982	0150-0081-9	4	1	
C3	Capacitor: fixed, ceramic, 1000 pf + 100% -20%, 500 vdcw (CK61Y102Z per MIL-C-11015A)	Coupling Capacitor for V1. Figure 5-5 and Figure 5-3	72982	0150-0069-9	3	1	
C4	Capacitor: fixed, ceramic, 0.02 μf ±20%, 500 vdcw	Decoupling Capacitor for Trigger Reference Level. Figure 5-5	72982	0150-0070-9	2	1	1

TABLE 7-1. MAINTENANCE PARTS LIST (Cont'd)

CKT REF.	DESCRIPTION	FUNCTION	MFR.	(hp) STOCK NO.	TQ	RS	NOTE
C5	Capacitor: fixed, mica, 240 pf ±5%, 300 vdcw (CM15C241JN3 per MIL-C-5B)	Cathode Bypass Capacitor for V1	76433	0140-0051-9	1	1	
C6	Same as C3	Coupling Capacitor for V4					
C7	Capacitor: fixed, ceramic, 2.2 pf ±0.25 pf, 500 vdcw (CC22CK2RC per MIL-C-20/3A)	Feedback Capacitor for V4	71590	0160-0130-9	1	1	
C8	Capacitor: fixed, mica, 56 pf ±10%, 500 vdcw (CM20B560K per JAN-C-5)	Coupling Capacitor for V4	76433	0140-0014-9	2	1	
C9	Capacitor: fixed, mica, 75 pf ±5%, 500 vdcw (CM15C750JN3 per MIL-C-5B)	Cathode Bypass Capacitor for V4	00853	0140-0040-9	1	1	
C10	Not assigned						
C11	Capacitor: fixed, mica, 47 pf ±5%, 500 vdcw (CM15C470JN3 per MIL-C-5B)	Coupling Capacitor for V5	76433	0140-0039-9	2	1	
C12	Capacitor: fixed, mica, 22 pf ±5%, 500 vdcw (CM15C220JN3 per MIL-C-5B)	Coupling Capacitor for V5	00853	0140-0034-9	2	1	
C13	Capacitor: fixed, ceramic, 10 pf ±0.5 pf, 500 vdcw (CC50CH100D per MIL-C-21/16A)	Coupling Capacitor for V7	71590	0160-0129-9	1	1	
C14	Capacitor: fixed, ceramic, 4700 pf ±20%, 500 vdcw (CK62AW472M per MIL-C-11015B)	Screen Bypass Capacitor for V9	56289	0150-0086-9	12	3	

TABLE 7-1. MAINTENANCE PARTS LIST (Cont'd)

CKT REF.	DESCRIPTION	FUNCTION	MFR.	℗ STOCK NO.	TQ	RS	NOTE
C15	Same as C3	Coupling Capacitor for V10					
C16	Capacitor: fixed, mica, 33 pf ±5%, 500 vdcw (CM75C330JN3 per MIL-C-5/1D)	Coupling Capacitor for V10	00853	0160-0131-9	1	1	
C17	Not assigned						
C18	Capacitor: fixed, mica, 82 pf ±5%, 300 vdcw (CM15C820JN3)	Frequency compensating capacitor for signal attenuator for V14	76433	0140-0048-9	1	1	
C19	Capacitor: fixed, mica, 100 pf ±5%, 300 vdcw (CM15C101JN3 per MIL-C-5B)	Frequency compensating capacitor for signal attenuator for V14	76433	0140-0041-9	1	1	
C20	Same as C14	Decoupling capacitor for Grid bias for V14					
C21	Capacitor: variable, ceramic, 7-45 pf, 500 vdcw (CV11C450 per MIL-C-81)	Attenuator compensating adjustment for V14. Figure 6-1	72982	0130-0001-9	2	1	
C22	Same as C12	Coupling capacitor for V15					
C23	Same as C11	Coupling capacitor for V14					
C24	Same as C2	Plate output coupling capacitor for V14					
C25	Same as C2	Coupling capacitor for J2					
C26	Same as C2	Cathode output coupling capacitor for V14					
C27 thru C30	Not assigned						
C31	Capacitor: fixed, mylar, 1.0 μf ±5%, 200 vdcw (CQ05B1VC105J per MIL-C-19978)	Sweep timing capacitor on S6. Figure 5-3	72928	0170-0046-9	1	1	

TABLE 7-1. MAINTENANCE PARTS LIST (Cont'd)

CKT REF.	DESCRIPTION	FUNCTION	MFR.	ⓗ STOCK NO.	TQ	RS	NOTE
C32	Capacitor: fixed, mylar, 0.1 μf ±5%, 200 vdcw (CQ05A1VC104J per MIL-C-19978)	Sweep timing capacitor on S6. Figure 5-3	72928	0170-0045-9	1	1	
C33	Capacitor: fixed, mylar, 0.01 μf ±5%, 200 vdcw (CQ05A1VC103J per MIL-C-19978)	Sweep timing capacitor on S6. Figure 5-4	72928	0170-0047-9	1	1	
C34	Capacitor: fixed, mica, 1000 pf ±5%, 500 vdcw (CM30D102J per MIL-C-5A)	Sweep timing capacitor on S6. Figure 5-4	76433	0140-0018-9	1	1	
C35	Capacitor: fixed, mica, 82 pf ±10%, 500 vdcw (CM20B820K per MIL-C-5A)	Sweep timing capacitor on S6. Figure 5-4	00853	0140-0006-9	1	1	
C36	Same as C21	10 microsecond adjust on S6. Figures 5-4 and 6-2					
C37	Capacitor: fixed, paper, 0.47 μf ±20%, 200 vdcw (CPO9A1EC474M per MIL-C-25A)	Sweep timing capacitor on S6. Figures 5-4 and 5-5	72928	0160-0068-9	1	1	
C38	Capacitor: fixed, paper, 0.047 μf ±20%, 200 vdcw (CPO9A1EC473M per MIL-C-25A)	Sweep timing capacitor on S6. Figures 5-4 and 5-3	72928	0160-0067-9	1	1	
C39	Capacitor: fixed, mica, 5600 pf ±1%, 500 vdcw (CM35E562G per MIL-C-5A)	Sweep timing capacitor on S6. Figure 5-4	00656	0140-0071-9	1	1	
C40	Capacitor: fixed, mica, 560 pf ±10%, 500 vdcw (CM30B561KN3 per MIL-C-5B)	Sweep timing capacitor on S6. Figure 5-4	76433	0140-0028-9	1	1	
C41	Same as C8	Sweep timing capacitor on S6. Figure 5-4					
C42 thru C49	Same as C14	Bypass capacitors for supply voltages					

TABLE 7-1. MAINTENANCE PARTS LIST (Cont'd)

CKT REF.	DESCRIPTION	FUNCTION	MFR.	STOCK NO.	TQ	RS	NOTE
C50	Same as C4	Bypass capacitors for supply voltages					
C51,52	Same as C14	Bypass capacitors for supply voltages					
CR1	Diode, silicon: 1N3064 (MIL-S-19500/144)	Grid bypass diode for V5	07263	1901-0038-9	2	2	
CR2	Diode, silicon: 1N754A (per MIL-E-1/1258)	Plate reference diode for V7	01295	1902-0003-9	1	1	
CR3	Same as CR1	Switch diode for grid of V9					
CR4	Diode, germanium: 1N277 (EIA Type 1N277 per MIL-E-1/993A)	Blocking diode for grid of V10	03877	1910-0014-9	4	4	
CR5	Same as CR4	Sweep mixing diode. Figure 5-4					
CR6	Same as CR4	Coupling diode to emitter of Q1					
CR7	Same as CR4	Coupling diode to emitter of Q1					
DS1	Lamp, neon: NE-2E1	ARM MAIN SWEEP indicator. Figure 5-4	24455	2140-0018-9	1	1	1
J1	Connector, female: BNC, type UG-1094A/U (MS35179-1094A per MS35179, Revised 22 July 1960)	INPUT connector. Figure 5-5	91737	1250-0118-9	2	1	
J2	Same as J1	DEL. TRIG OUTPUT connector. Figures 5-4 and 5-5					
L1	Inductor, fixed: 2.2 μh $\pm$10% (LT7K132 per MIL-C-15305B)	Peaking coil for V4	99800	9140-0133-9	1	1	1
L2	Inductor, fixed: 22 μh $\pm$10% (LT7K143 per MIL-C-1530B5)	Peaking coil for V4	99800	9140-0132-9	2	1	1
L3	Same as L2	Peaking coil for V5					
P1	Connector, male: 32 pin	Connector plug for connections to Oscilloscope. Figure 5-4	02660	1251-0136-9	1	1	1

TABLE 7-1. MAINTENANCE PARTS LIST (Cont'd)

CKT REF.	DESCRIPTION	FUNCTION	MFR.	STOCK NO.	TQ	RS	NOTE
Q1	Transistor: 2N2084 (USN2N2084 per MIL-S-19500/213	Transistor amplifier	73445	1850-0097-9	1	1	
R1	Resistor: fixed, composition, 47,000 ohms ±10%, 1/2 W (RC20GF473K per MIL-R-11D)	Grid bias resistor for V1. Figure 5-5	01121	0687-4731-9	4	1	
R2	Resistor: fixed, composition, 10,000 ohms ±10%, 1/2 W (RC20GF103K per MIL-R-11D)	Grid bias resistor for V1. Figure 5-5	01121	0687-1031-9	2	1	
R3	Resistor: fixed, composition, 1 megohm ±10%, 1/2 W (RC20GF105K per MIL-R-11D)	Grid bias resistor for V1. Figures 5-5 and 5-3	01121	0687-1051-9	3	1	
R4	Resistor: fixed, composition, 470,000 ohms ±10%, 1/2 W (RC20GF474K per MIL-R-11D)	Coupling resistor for V1. Figures 5-5 and 5-3	01121	0687-4741-9	4	1	
R5	Part of A3; component not separately replaceable	TRIGGER LEVEL control. Figure 5-5					
R6	Same as R1	Grid bias resistor for V1. Figure 5-5					
R7	Resistor: fixed, composition, 47 ohms ±10%, 1/2 W (RC20GF470K per MIL-R-11D)	Parasitic suppressor for V1	01121	0687-4701-9	31	6	
R8	Resistor: metal film, 6-49K ohms ±2%, 2 W (RD65 per MIL-R-11804/2)	Cathode bias resistor for V1	07115	0763-0008-9	1	1	
R9, 10	Resistor: fixed, composition, 150 ohms ±10%, 1/2 W (RC20GF151K per MIL-R-11D)	Cathode resistor for V1	01121	0687-1511-9	2	1	
R11	Same as R7	Parasitic suppressor for V1					

TABLE 7-1. MAINTENANCE PARTS LIST (Cont'd)

CKT REF.	DESCRIPTION	FUNCTION	MFR.	STOCK NO.	TQ	RS	NOTE
R12	Resistor: fixed, metal film, 30.1K ohms ±2%, 4 W (RD70 per MIL-R-11804/2)	Plate load resistor for V1	07115	0769-0002-9	1	1	
R13	Resistor: fixed, composition, 3300 ohms ±10%, 1 W (RC32GF332K per MIL-R-11D)	Plate load resistor for V1	01121	0690-3321-9	1	1	
R14	Same as R7	Parasitic suppressor for V4					
R15	Same as R4	Coupling resistor for V4					
R16	Resistor: variable, composition, 250,000 ohms ±10% (RV4LXXSA254A per MIL-R-94B)	Trigger symmetry adjust for V4. Figures 5-4, 5-5 and 6-1	01121	2100-0029-9	1	1	
R17	Same as R3	Grid bias resistor for V4					
R18	Resistor: fixed, metal film, 11,000 ohms ±5%, 2 W (RD65 per MIL-R-11804/2)	Cathode resistor for V4	07115	0764-0010-9	1	1	
R19	Resistor: fixed, deposited carbon, 487K ohms ±1%, 1/2 W (RN70B4873F per MIL-R-10509C)	Grid bias resistor for V4	19701	0727-0383-9	1	1	
R20	Same as R7	Parasitic suppressor for V4					
R21	Resistor: fixed, deposited carbon, 681 ohms ±1%, 1/2 W (RN70B6810F per MIL-R-10509D)	Plate load resistor for V4	19701	0727-0384-9	1	1	
R22	Resistor: fixed, composition, 1500 ohms ±10%, 1/2 W (RC20GF152K per MIL-R-11D)	Plate load resistor for V4	01121	0687-1521-9	2	1	
R23	Not assigned						
R24	Same as R7	Parasitic suppressor for V5					
R25	Same as R22	Grid return for V5					

TABLE 7-1. MAINTENANCE PARTS LIST (Cont'd)

CKT REF.	DESCRIPTION	FUNCTION	MFR.	℗ STOCK NO.	TQ	RS	NOTE
R26	Resistor: fixed, metal film, 8.25K ohms ±5%, 2 W (RD65 per MIL-R-11804/2)	Plate load resistor for V5	07115	0764-0009-9	1	1	
R27	Resistor: fixed, deposited carbon, 90,900 ohms ±1%, 1/2 W (RN70B9092F per MIL-R-10509C)	Coupling resistor for V5	19701	0727-0314-9	1	1	
R28	Same as R7	Parasitic suppressor for V5					
R29	Resistor: fixed, deposited carbon, 249,000 ohms ±1%, 1/2 W (RN70B2493F per MIL-R-10509C)	Grid bias resistor for V5	19701	0727-0224-9	2	1	
R30	Resistor: fixed, metal film, 5.11K ohms ±5%, 2 W (RD65 per MIL-R-11804/2)	Cathode resistor for V5	07115	0764-0008-9	1	1	
R31	Resistor: fixed, composition, 6800 ohms ±10%, 2 W (RC42GF682 per MIL-R-11B)	Cathode resistor for V5	01121	0693-6821-9	1	1	
R32	Same as R7	Parasitic suppressor for V7					
R33	Resistor: fixed, composition, 4700 ohms ±10%, 2 W (RC42GF472K per MIL-R-11D)	Cathode resistor for V5	01121	0693-4721-9	1	1	
R34	Same as R7	Parasitic suppressor for V8					
R35	Resistor: fixed, deposited carbon, 1000 ohms ±1%, 1/2 W (RN70B6043F per MIL-R-10509C)	Plate load resistor for V7	19701	0727-0315-9	1	1	
R36	Resistor: fixed, deposited carbon, 100,000 ohms ±1%, 1/2 W (RN70B1003F per MIL-R-10509C)	Grid bias resistor for V7	19701	0727-0304-9	2	1	
R37	Same as R7	Parasitic suppressor for V7					
R38	Same as R36	Coupling resistor for V7					

TABLE 7-1. MAINTENANCE PARTS LIST (Cont'd)

CKT REF.	DESCRIPTION	FUNCTION	MFR.	℗ STOCK NO.	TQ	RS	NOTE
R39	Resistor: fixed, composition, 100,000 ohms ±10%, 1/2 W (RC20GF104J per MIL-R-11D)	Plate load resistor for V7	01121	0687-1041-9	1	1	
R40	Resistor: fixed, composition, 15,000 ohms ±10%, 2 W (RC42GF153K per MIL-R-11D)	Cathode resistor for V8. Figure 5-4	01121	0693-1531-9	3	1	
R41	Same as R7	Parasitic suppressor for V8					
R42	Same as R7	Parasitic suppressor for V14					
R43	Resistor: fixed, composition, 150,000 ohms ±10%, 2 W (RC20GF154K per MIL-R-11D)	Plate load resistor for V9	01121	0693-1541-9	1	1	
R44	Same as R7	Parasitic suppressor for V9					
R45	Same as R7	Screen grid resistor for V9					
R46	Same as R7	Parasitic suppressor for V10					
R47	Same as R1	Coupling resistor for V10					
R48	Same as R4	Grid bias resistor for V10					
R49	Resistor: fixed, composition, 22,000 ohms ±10%, 1 W (RC32GF223K per MIL-R-11D)	Cathode resistor for V10	01121	0690-2231-9	1	1	
R50	Same as R29	Coupling resistor for V4					
R51	Resistor: fixed, composition, 22,000 ohms ±10%, 1/2 W (RC20GF223K per MIL-R-11D)	Coupling resistor for V10	01121	0687-2231-9	3	1	
R52	Same as R2	Grid bias resistor V10					

TABLE 7-1. MAINTENANCE PARTS LIST (Cont'd)

CKT REF.	DESCRIPTION	FUNCTION	MFR.	℗ STOCK NO.	TQ	RS	NOTE
R53	Resistor: variable, composition linear taper, 25,000 ohms ±10%, 2 W (RV4LAYSA253A per MIL-R-94B)	Sweep length adjust for V10. Figure 6-1	01121	2100-0256-9	1	1	
R54	Same as R7	Parasitic suppressor for V10					
R55	Same as R7	Parasitic suppressor for V13					
R56	Same as R40	Cathode resistor for V13					
R57	Same as R7	Parasitic suppressor for V13					
R58	Same as R51	Grid bias resistor for V13. Figure 5-5					
R59	Part of A4; component not separately replaceable	SWEEP MODE control. Figure 5-5					
R60	Resistor: variable, composition, 50,000 ohms ±10% (RV4LAXSA503A per MIL-R-94B)	Present adjust for V13. Figures 5-5 and 6-1	01121	2100-0028-9	1	1	
R61	Resistor: fixed, composition, 33,000 ohms ±10%, 1/2 W (RC20GF333K per MIL-R-11D)	Grid bias resistor for V13. Figure 5-5	01121	0687-3331-9	1	1	
R62	Resistor: fixed, deposited carbon, 33.2K ohms ±1%, 1/2 W (RN 70B3322F per MIL-F-10509D)	Grid bias resistor for V14	19701	0727-0381-9	1	1	
R63	Resistor: variable, composition, linear taper, 5000 ohms ±10% (RV4LAXSA502A per MIL-R-94B)	1 cm Delay adjust for V14. Figure 6-1	01121	2100-0026-9	5	2	
R64	Resistor: variable, wirewound, linear taper, 50,000 ohms ±3%, 5 W	DELAY LENGTH control. Figure 5-5	73138	2100-0255-9	1	1	1

TABLE 7-1. MAINTENANCE PARTS LIST (Cont'd)

CKT REF.	DESCRIPTION	FUNCTION	MFR.	℗ STOCK NO.	TQ	RS	NOTE
R65	Not assigned						
R66	Resistor: fixed, deposited carbon, 26.1K ohms ±1%, 1/2 W (RN170B2612F per MIL-R-10509D)	Grid bias resistor for V14	19701	0727-0385-9	1	1	
R67	Same as R63	9 cm Delay adjust for V14. Figure 6-1					
R68	Resistor: fixed, deposited carbon, 2.05 megohms ±1%, 1/2 W (RN70B2054F per MIL-R-10509D)	Grid return resistor for V14	19701	0727-0382-9	2	1	
R69	Same as R68	Coupling resistor for V14					
R70	Same as R40	Cathode resistor for V14					
R71	Same as R1	Emitter bias resistor for Q1					
R72	Resistor: fixed, composition, 15K ohms ±10%, 1/2 W (RC20GF153K per MIL-R-11D)	Grid bias resistor for V15	01121	0687-1531-9	1	1	
R73	Same as R7	Parasitic suppressor for V15					
R74	Resistor: fixed, composition, 68,000 ohms ±10%, 1/2 W (RC20GF683K per MIL-R-11D)	Collector load resistor for Q1	01121	0687-6831-9	1	1	
R75	Resistor: fixed, composition, 15,000 ohms ±10%, 1 W (RC32GF153K per MIL-R-11D)	Cathode resistor for V15	01121	0690-1531-9	1	1	
R76	Resistor: fixed, composition, 2700 ohms ±10%, 1/2 W (RC20GF272K per MIL-R-11D)	Plate load resistor for V15	01121	0687-2721-9	1	1	
R77	Resistor: fixed, composition, 91,000 ohms ±5%, 1/2 W (RC20GF913J per MIL-R-11D)	Coupling resistor for V15	01121	0686-9135-9	1	1	
R78	Same as R7	Parasitic suppressor for V15					

TABLE 7-1. MAINTENANCE PARTS LIST (Cont'd)

CKT REF.	DESCRIPTION	FUNCTION	MFR.	ℌ STOCK NO.	TQ	RS	NOTE
R79	Resistor: fixed, composition, 82,000 ohms ±5%, 1/2 W (RC20GF823J per MIL-R-11D)	Grid bias resistor for V15	01121	0686-8235-9	1	1	
R80	Not assigned						
R81	Resistor: fixed, composition, 8200 ohms ±10%, 1/2 W (RC20GF822K per MIL-R-11D)	Plate load resistor for V15	01121	0687-8221-9	1	1	
R82	Same as R51	Grid bias resistor for V14					
R83	Same as R7	Parasitic suppressor for V14					
R84	Same as R4	Grid bias resistor for V14					
R85	Resistor: fixed, composition, 1000 ohms ±10%, 1 W (RC32GF102K per MIL-R-11D)	Plate load resistor for V14	01121	0690-1021-9	2	1	
R86	Same as R85	Cathode resistor for V14					
R87	Same as R3	Cathode resistor for V10 on S6. Figures 5-4 and 5-3					
R88	Resistor: fixed, metal film, 14.7K ohms ±5%, 2 W (RD65 per MIL-R-11804/2	Sweep timing resistor on S6. Figure 5-4	07115	0764-0011-9	1	1	
R89	Same as R63	.1 second adjust. Figure 6-1					
R90	Same as R63	10 millisecond adjust. Figure 6-1					
R91	Same as R63	1 millisecond adjust. Figure 6-1					
R92	Resistor: fixed, deposited carbon, 4-47 megohms ±1%, 1 W (RN75B4474F per MIL-R-10509D)	.1 millisecond adjust. Figure 6-1	19701	0730-0160-9	1	1	
R93	Resistor: fixed, deposited carbon, 4-53 megohms ±1%, 1 W (RN75B4534F per MIL-R-10509D)	Sweep timing resistor on S6. Figures 5-4 and 5-3	19701	0730-0159-9	1	1	

TABLE 7-1. MAINTENANCE PARTS LIST (Cont'd)

CKT REF.	DESCRIPTION	FUNCTION	MFR.	(hp) STOCK NO.	TQ	RS	NOTE
R94	Resistor: fixed, deposited carbon, 4.5 megohms ±1%, 1 W (RN75B4504F per MIL-R-10509D)	Sweep timing resistor on S6. Figures 5-4 and 5-3	19701	0730-0158-9	1	1	
R95	Resistor: fixed, deposited carbon, 1.8 megohms ±1%, 1/2 W (RN70B6043F per MIL-R-10509C)	Sweep timing resistor on S6. Figure 5-3	19701	0727-0311-9	1	1	
R96	Resistor: fixed, metal film, 900,000 ohms ±1/4%, 1/2 W (RN70C9003C per MIL-R-10509D)	Sweep timing resistor on S6. Figure 5-3	19701	0757-0018-9	1	1	
R97	Resistor: fixed, metal film, 450,000 ohms ±1/4%, 1/2 W (RN70D4503C per MIL-R-10509D)	Sweep timing resistor on S6. Figure 5-3	19701	0757-0020-9	1	1	
R98	Resistor: fixed, metal film, 180,000 ohms ±1/4%, 1/2 W (RN70C1803C per MIL-R-10509D)	Sweep timing resistor on S6. Figure 5-3	19701	0757-0019-9	1	1	
R99	Same as R7	Decoupling resistor for +370 volt supply					
R100	Same as R7	Decoupling resistor for +110 volt supply					
R101	Same as R7	Decoupling resistor for +110 volt supply					
R102	Same as R7	Decoupling resistor for +110 volt supply					
R103	Same as R7	Decoupling resistor for -100 volt supply					
R104	Same as R7	Decoupling resistor for -100 volt supply					
R105	Same as R7	Decoupling resistor for -100 volt supply					
R106	Same as R7	Decoupling resistor for +370 volt supply					
R107	Same as R7	Decoupling resistor for +110 volt supply					
R108	Same as R7	Decoupling resistor for -100 volt supply					
R109	Same as R7	Decoupling resistor for -100 volt supply					

TABLE 7-1. MAINTENANCE PARTS LIST (Cont'd)

CKT REF.	DESCRIPTION	FUNCTION	MFR.	℗ STOCK NO.	TQ	RS	NOTE
R110	Resistor: fixed, composition, 1000 ohms ±10%, 1/2 W (RC20GF102K per MIL-R-11C)	Cathode resistor for V8. Figure 5-4	01121	0687-1021-9	1	1	
S1	Part of A4; component not separately replaceable	Trigger Source. Figure 5-5					
S2	Part of A3; component not separately replaceable	Trigger Slope. Figure 5-5					
S3	Part of R59; component not separately replaceable	Part of Sweep Mode control. Figure 5-5					
S4	Part of A5; component not separately replaceable	Sweep Selector. Figure 5-4					
S5	Part of A6; component not separately replaceable	Delay Function selector. Figure 5-3					
S6	Same as S5	Sweep Time selector. Figures 5-4 and 5-3					
V1	Tube, electron: 6922 (USN6922 per MIL-E-1/1168	Trigger Amplifier. Figure 5-4	80131	1932-0015-9	9	9	1
V2	Lamp, neon: NE76	Voltage dropping element for V1	24455	2140-0019-9	7	7	1
V3	Same as V2	Protecting device for V4					
V4	Same as V1	Trigger Generator. Figure 5-4					
V5	Same as V1	Gate Generator. Figure 5-4					
V6	Same as V2	Protecting device for V5					
V7	Same as V1	Gate Generator/clamp. Figure 5-4					
V8	Same as V1	Gate out Cathode Follower. Figure 5-4					
V9	Tube, electron: 6AU6 (JAN-6AU6 per MIL-E-1B)	Integrator. Figure 5-4	80131	1923-0021-9	1	1	

TABLE 7-1. MAINTENANCE PARTS LIST (Cont'd)

CKT REF.	DESCRIPTION	FUNCTION	MFR.	hp STOCK NO.	TQ	RS	NOTE
V10	Same as V1	Cathode follower. Figure 5-4					
V11	Same as V2	Voltage dropping element for V9					
V12	Same as V2	Voltage dropping element for V9					
V13	Same as V1	Bias Control Cathode Follower. Figure 5-4					
V14	Same as V1	Cathode Follower/Phase Inverter. Figure 5-4					
V15	Same as V1	Delay Trigger Generator. Figure 5-4					
V16	Same as V2	Protecting device for V10					
V17 thru V113	Not assigned						
V114	Same as V2						
XV1	Socket, tube: 9 pin		91662	1200-0048	9	1	1
XV2, 3	Not assigned						
XV4, 5	Same as XV1						
XV6	Not assigned						
XV7, 8	Same as XV1						
XV9	Socket, tube: 7 pin		91662	1200-0047	1	1	1
XV10	Same as XV1						
XV11, 12	Not assigned						
XV13, 14, 15	Same as XV1						
XV16	Not assigned						

TABLE 7-1. MAINTENANCE PARTS LIST (Cont'd)

CKT REF.	DESCRIPTION	FUNCTION	MFR.	STOCK NO.	TQ	RS	NOTE
	MISCELLANEOUS						
	Assembly, dial		28480	166D-40A	1	0	
	Cap, BNC: with chain		91737	1250-0053	2	0	
	Knob, red: 3/4 in. bar w/arrow	SWEEP SELECTOR DELAY FUNCTION	28480	G-74E	2	0	
	Knob, black: 1 in. bar w/arrow	TRIGGER SOURCE DELAYING SWEEP TIME/CM	28480	G-74Q	2	0	
	Knob, red: 3/4 in. bar w/arrow	TRIGGER SLOPE	28480	G-74AT	1	0	
	Knob, red: w/arrow	SWEEP MODE	28480	G-74AU	1	0	
	Knob, black: concentric shaft w/arrow	TRIGGER LEVEL	28480	G-74BE	1	0	
	Knob, black: 5/8 in.	Latch	28480	G-74CE	1	0	

Note 1: No assigned military designation.

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
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04870	P M Motor Co.	Chicago, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05624	Barber Colman Co.	Rockford, Ill.
05729	Metropolitan Telecommunications Corp., Metro Cap. Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls; N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronics, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71528	Standard-Thomson Corp., Clifford Mfg. Co. Div.	Waltham, Mass.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Products Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.

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APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91921	Minneapolis-Honeywell Regulator Co., Micro-Switch Division	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

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

0000F	Malco Tool and Die	Los Angeles, Calif.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000W	Webster Electronics Co. Inc.	New York, N.Y.
0000X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000Y	Midland Mfg. Co. Inc.	Kansas City, Kans.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CC	Computer Diode Corp.	Lodi, N.J.
000EE	A. Williams Manufacturing Co.	San Jose, Calif.
000FF	Carmichael Corrugated Specialties	Richmond, Calif.
000GG	Goshen Die Cutting Service	Goshen, Ind.
000HH	Rubbercraft Corp.	Torrance, Calif.
00011	Birtcher Corporation, Industrial Division	Monterey Park, Calif.

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