USAF LA-265-A

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OSCILLOSCOPE LA-265-A

INSTRUCTIONS AND PARTS BREAKDOWN

Lavoie Laboratories, Inc.
MORGANVILLE, NEW JERSEY

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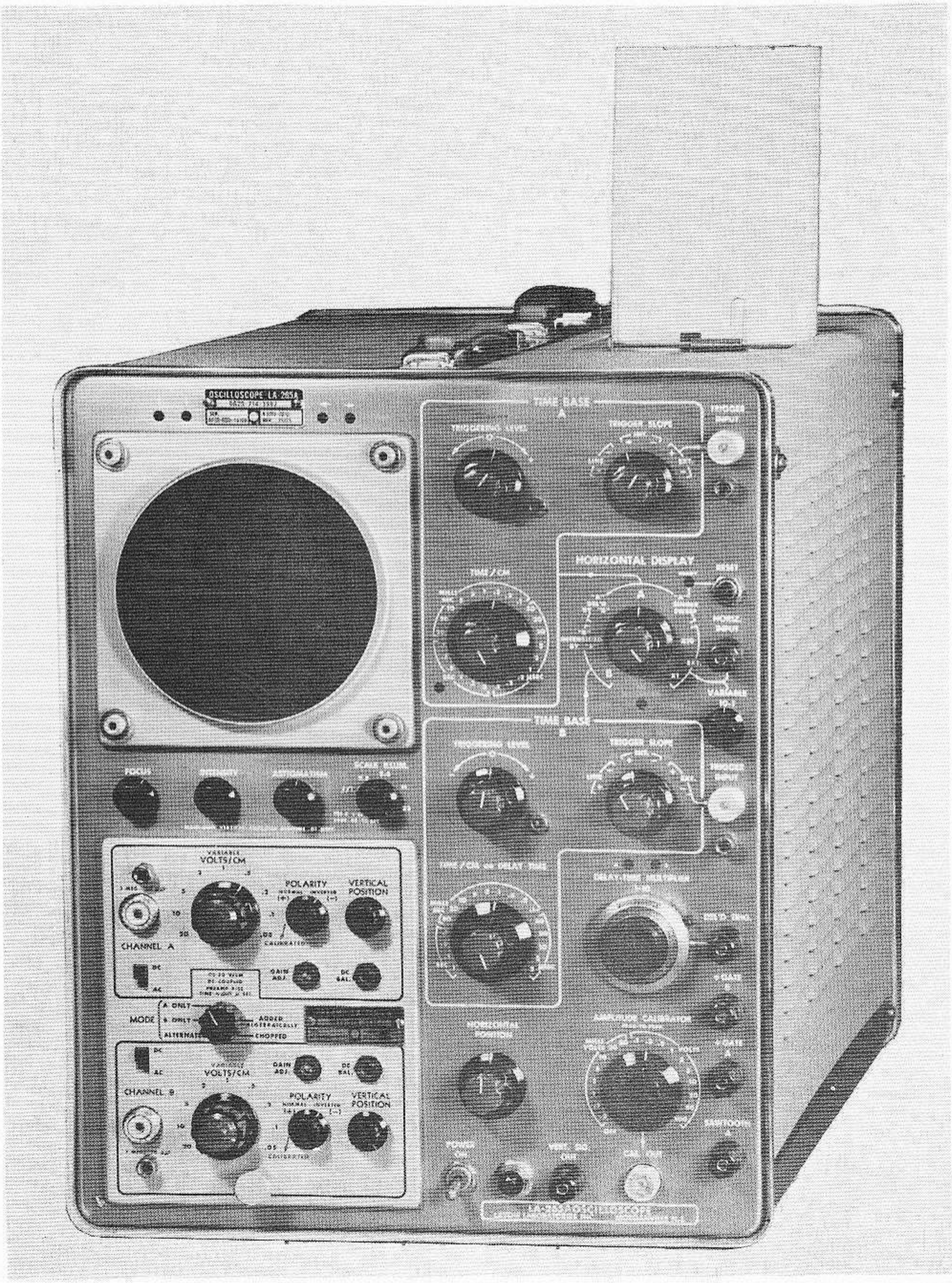


Figure 1-1. Oscilloscope LA-265A

SECTION I

INTRODUCTION AND DESCRIPTION

1-1. INTRODUCTION.

1-2. This technical manual presents operation and service instructions for the Oscilloscope, LA-265A. The oscilloscope is manufactured by Lavoie Laboratories, Inc., Morganville, New Jersey. (See figure 1-1.)

1-3. PURPOSE.

1-4. The oscilloscope is a wide-range general purpose shop and laboratory test instrument, which provides accurate amplitude and/or time duration measurement of electrical impulses within the frequency range of dc to 30 megacycles.

1-5. LEADING PARTICULARS.

1-6. Figure 1-2 lists the physical and electrical characteristics of the oscilloscope.

1-7. PHYSICAL DESCRIPTION.

1-8. The oscilloscope is a portable test instrument, measuring 13 inches wide, 16-3/4 inches high, and 24 inches in depth. Power connection to operate the oscilloscope is made through a connector at the rear. The signal under test is displayed on a five-inch cathode ray tube (crt) located in the upper left corner. All controls for operation of the oscilloscope are mounted on the front panel. An opening in the front panel lower left corner permits the oscilloscope operator to plug in any one of the different preamplifiers, each of which provides specific input preamplifier characteristics depending upon application.

1-9. OTHER EQUIPMENT USED IN CONJUNCTION WITH OSCILLOSCOPE.

1-10. PLUG-IN PREAMPLIFIERS. Several plug-in preamplifiers with the characteristics listed in figure 1-3 are available for use with the oscilloscope, to extend the range of the vertical amplifier, and to provide specific application characteristics.

1-11. ACCESSORIES. (See figure 1-4.) The accessories supplied with each oscilloscope are described herein, and are illustrated in figure 1-4.

a. Two 10X attenuator probes are supplied. The probes must be used to display complex waveforms to prevent circuit loading and waveform distortion.

b. Two binding post adapters are supplied. The binding posts are designed to connect to the front panel UHF connectors, and permit cables not terminated in UHF connectors to be attached to the oscilloscope.

c. One test lead is supplied. The test lead fits into the various front panel connectors and binding posts, and is utilized for testing the oscilloscope.

d. One light filter is supplied. The light filter contains the engraved graticule, thus permitting amplitude and time duration measurements to be made directly on the crt.

1-12. PRINCIPLES OF OPERATION.

1-13. GENERAL. To provide the maintenance personnel with a working knowledge of the oscilloscope, simplified principles of operation for the various chassis and circuits are presented. Block diagrams of the major circuits are provided in this section. Description of the circuits is referenced to the schematic diagrams located within Section VI. Because sweep generator A and B are almost identical, only sweep generator A is described.

1-14. VERTICAL AMPLIFIER CIRCUIT DESCRIPTION. (See figures 1-5 and 6-2.)

1-15. INPUT AMPLIFIERS. The push-pull signal inputs from the plug-in preamplifier are applied to pins 1 and 3 of the interconnecting socket, and are then fed to the grids of the two input amplifiers, tubes V1014 and V1024. The Gain Adj potentiometer R1027, common to the cathodes of tubes V1014 and V1024, sets the gain of the input amplifiers. Thus, when the preamplifier VARIABLE control is set to the CALIBRATED position, the gain of the input amplifiers agrees with the fixed position of the control. Peaking coils L1014 and L1024 function as high-frequency compensators for the input amplifiers.

1-16. CATHODE FOLLOWERS. The push-pull signals from tubes V1014 and V1024 are coupled to the first half of a dual cathode follower stage consisting of tubes V1033A and V1043A. Chokes L1036 and L1046 provide peaking at very high frequencies. The second stage of cathode followers, tubes V1033B and V1043B, are direct coupled. The cathode followers provide the necessary low impedance output required to drive the distributed amplifiers, and to isolate the input amplifiers from the distributed amplifiers.

1-17. DISTRIBUTED AMPLIFIERS. The deflection plates of the crt are driven by a six stage distributed amplifier consisting of tubes V1104, V1114, V1124, etc., through V1214. Tapped inductors L1104, L1103, L1113 and L1114 serve to isolate each tube from the capacitance of its adjacent stage. The amplified signal at the plate is fed to the plate line, and thus becomes an integral part of the wave travelling along the line to the deflection plates. The tapped inductors between each stage of the distributed amplifier provide approximately 0.003 microseconds delay. A total

Vertical Deflection (with type L preamplifier)	
Bandpass	dc to 30 megacycles.
Rise time	0. 012 microseconds.
Triggering Modes	
Time base A	Automatic, AC, DC, AC low frequency reject, and high frequency synchronization.
Time base B	Automatic, AC, and DC.
Triggering Level Requirements	
Internal	Minimum signal of two millimeters vertical deflection.
External	Signal between 0. 2 and 10 volts amplitude.
High frequency sync	An internal trigger of two centimeters vertical deflection, external signal greater than two volts.
Sweep Times	
Time base A	0. 1 microseconds to five seconds per centimeter in 24 fixed cabibrated steps. A continuously variable control permits selection of sweep times between 0. 1 microsecond and 12 seconds per centimeter.
Time base B	Two microseconds to one second per centimeter in 18 fixed calibrated steps.
Accuracy	Typically one percent. Maximum error three percent in fixed calibrated positions.
Horizontal Input (External)	
Deflection factor	0. 2 to 15 volts per centimeter, continuously variable.
Frequency response	DC to 240 kc, down 3 db at 240 kc.
Input impedance	One megohm, shunted by approx. 55 micro-microfarads.
Sweep Delay	Continuously variable from one to ten microseconds.
Calibrator Voltage	
Waveform	1000 cycle square wave, 0. 2 millivolts (P-P) to 100 volts (P-P) in 18 fixed steps.
Accuracy	Three percent of control setting.
Input Power Requirements	
Line voltage	105 to 125 volts or 210 to 250 volts AC
Line frequency	50 to 60 cycles
Power	Approx. 600VA with Preamplifier LA-265-CA installed.
Unit Weight	65 pounds
Unit Size	13 x 16-3/4 x 24 inches

Figure 1-2. Table of Leading Particulars

Preamplifier Nomenclature	Part No.	Bandpass	Risetime	Calibrated Deflection Factor	Input Capacitance
High-Gain Differential	LA-265-D	dc to 2 mc	0.18 usec	1 MV - 50 volts/cm	47 uuf
Dual-Trace	LA-265-CA	dc to 24 mc	0.015 usec	0.05v - 20 volts/cm	20 uuf
Wide-Band High Gain	LA-265-B	3 cps to 12 mc dc to 20 mc	0.03 usec 0.018 usec	5 mv - 0.05 volts/cm 0.05 v - 20 volts/cm	47 uuf
Fast-Rise High Gain	LA-265-L	3 cps to 24 mc dc to 30 mc	0.015 usec 0.012 usec	5 mv - 2 volts/cm 0.05v - 20 volts/cm	20 uuf

Figure 1-3. Electrical Characteristics of Plug-in Preamplifiers for Use in Oscilloscope LA-265A

delay of approximately 0.015 microseconds is attributed to the distributed amplifier, an additional 0.185 microseconds delay is caused by the delay line (see figure 6-3), thus providing a total vertical signal delay of 0.2 microseconds between the distributed amplifier input and the deflection plates. This fixed delay of 0.2 microsecond permits the leading edge of fast rise signals to be displayed on the crt. The termination resistance of plate lines L1104 and L1114 are increased during dc and low frequency operation by the addition of R1090 and C1093B, and R1095 and C1093D, respectively. A small amount of regeneration feedback from the distributed amplifier plate line is accomplished by R1092, R1094, and C1093A, and R1097, R1099, and C1093C to compensate for extremely low-frequency signals, thus ensuring no dc drift within the amplifiers. The dc Shift Adjust potentiometer R1091 is connected between the two plate lines to permit balancing the circuit drift due to circuit aging.

1-18. BEAM POSITION NEONS. If the beam on the crt is positioned or driven vertically, neon tubes B1083 and B1087 indicate the direction of movement, should the trace be driven off the face of the crt. As the vertical position control is rotated in either direction, the current flow through one half of indicator amplifier tube V1084 is changed. The section of the tube which conducts causes its associated neon to glow, due to the drop in plate voltage, which causes a large enough potential to be placed across the neon. When the sweep trace is centered, both neons will be extinguished.

1-19. INTERNAL TRIGGER AMPLIFIERS. When internal triggering is selected (black TRIGGER SLOPE knob in either the + or - INT position), a portion of the vertical signal is applied to the grids of the internal trigger amplifiers, tubes V1054 and V1064. The output signal is developed across the inductive

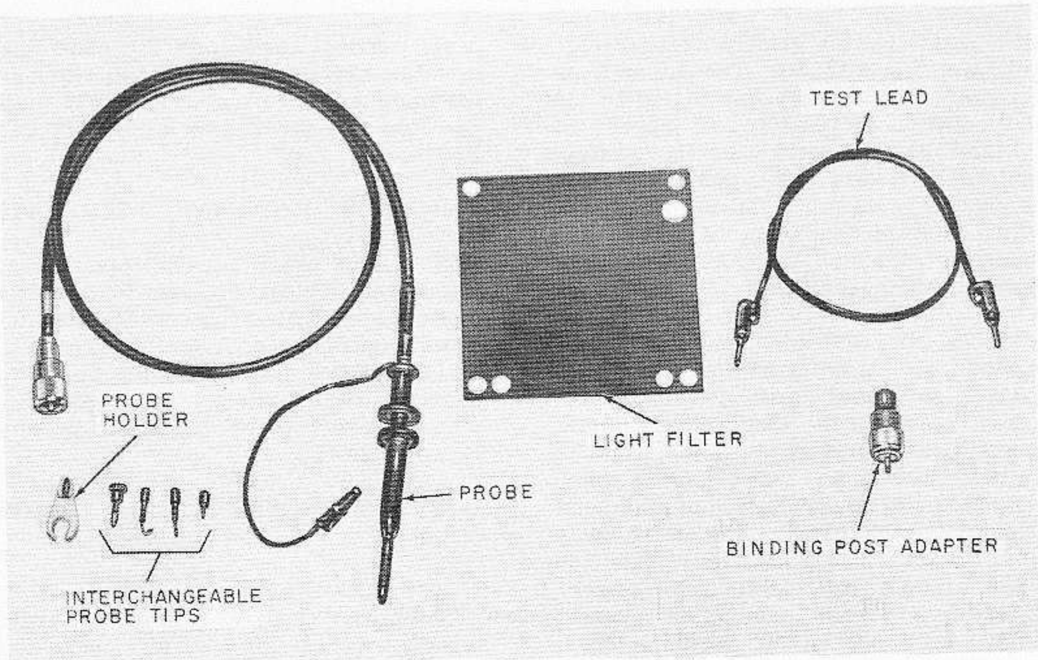


Figure 1-4. Accessories Supplied with Oscilloscope LA-265A

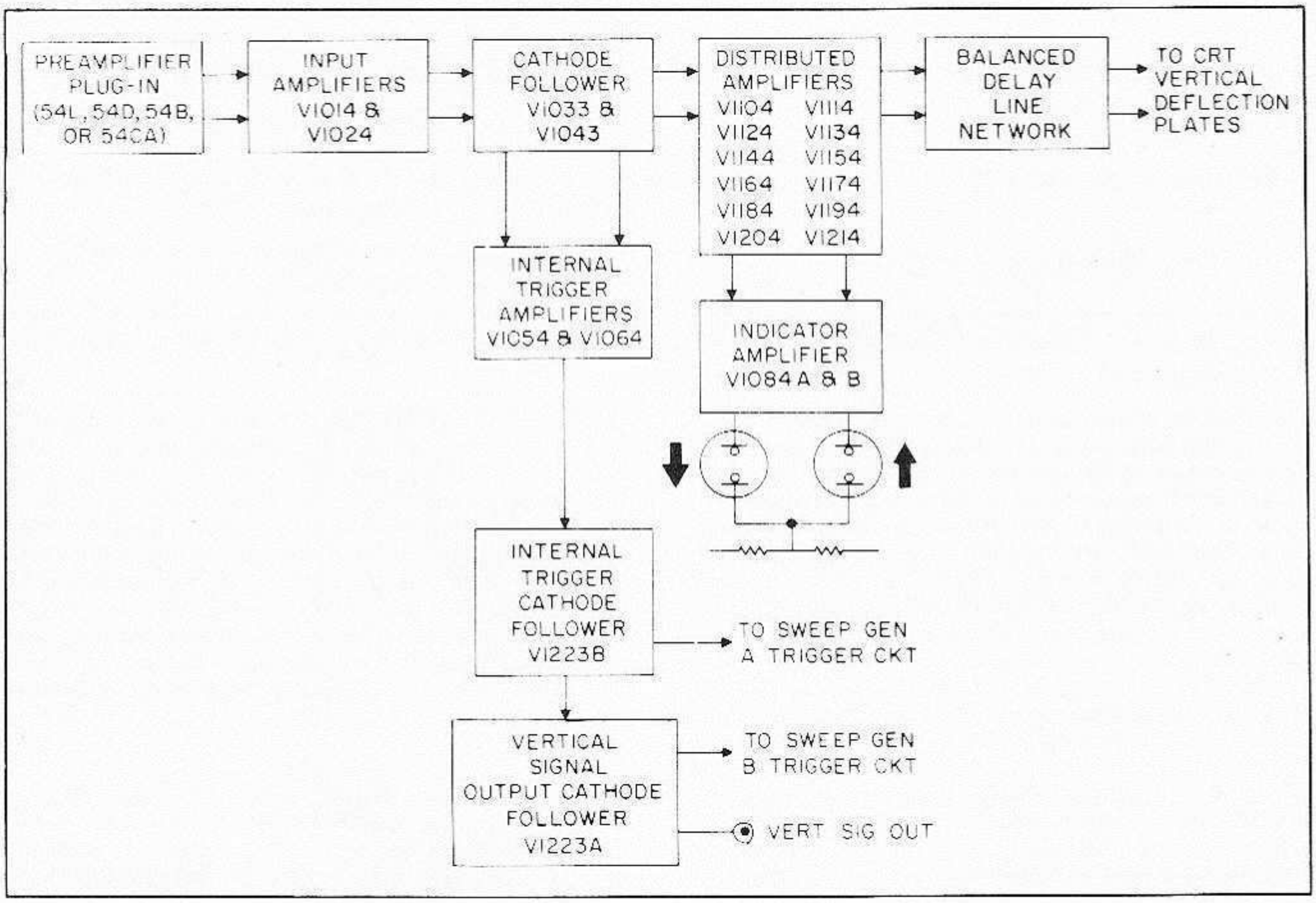


Figure 1-5. Vertical Amplifier, Block Diagram

plate load L1064, and fed to the grid of internal trigger cathode follower, tube V1223B. The output from the internal trigger cathode follower is fed to the TRIGGER SLOPE switch SW10A, and to the second half of tube V1123A which functions as the vertical signal output cathode follower. The output signal from tube V1223A is coupled by capacitor C1228 to the front panel VERT. SIG. OUT binding post. A second use for the output signal from tube V1223A is to trigger the sweep generator B trigger circuit.

1-20. DELAY LINE NETWORK. (See figure 6-3.) The output push-pull signals from the distributed amplifiers are passed through the balanced delay line network, which ensures that the leading edge of fast rise time signals will be delayed sufficient time to allow the crt to be unblanked, and the horizontal sweep trace to be triggered prior to application of the signal to the crt vertical deflection plates. The entire delay line consisting of the distributed amplifier plate line L1104 and L1114 (see figure 6-3), is reverse-terminated. The plate line reverse termination network, consisting of fixed resistors R1030, R1032, R1034, R1035, R1040, R1042, R1044, and R1045, dissipate both the dc and ac energy in the plate line by presenting a constant resistance over the frequency range of the vertical amplifier. The plate line reverse termination network provides 640 ohms in each side of the line, tapered or distributed in steps. The plate line load is optimized by adjustment of potentiometer R1043.

1-21. HORIZONTAL SWEEP GENERATOR CIRCUITS.

1-22. GENERAL. The horizontal sweep circuits are illustrated in block diagram form in figure 1-6. The block diagram illustrates sweep circuit A, (there are two sweep circuits, A and B). The detailed description that follows is concerned with sweep circuit A, however, the circuitry for sweep circuit B is almost identical except that the choice of sweep speeds differs between the two.

1-23. SWEEP GENERATOR A TRIGGER. (See figure 6-4.)

1-24. TRIGGER INPUT AMPLIFIER. The trigger input amplifier, tube V24, may be triggered by an internal, external, or line frequency signal depending upon the setting of the TRIGGER SLOPE switch, SW10A. The + and - LINE positions of switch SW10A-1R connect 6.3 volts ac to tube V24 as a source of triggering. In the external mode of triggering, a signal from the front panel TRIGGER INPUT connector is utilized. In the internal mode of triggering (most common) a trigger from the internal trigger cathode follower tube V1223B (vertical amplifier), is utilized.

1-25. The trigger input amplifier, tube V24, functions as a polarity inverting cathode-coupled amplifier, and performs two basic functions. First, it provides a negative going signal to drive the following stage (the trigger multivibrator, tube V45). Secondly, by means of TRIGGERING LEVEL control R17 it enables the operator to select the signal level at which triggered operation of the sweep generator will occur. To trigger from a negative going signal, the grid of tube V24A is connected to the input signal source. The grid of V24B is connected to a dc bias source which is adjustable with the TRIGGERING LEVEL control. The bias voltage from potentiometer R17 determines the voltage present at the plate of tube V24B during no-signal conditions. The voltages at the grid of V24A and the plate of V24B are in phase with each other; thus, section V24A acts as a cathode follower, and the signal developed across the cathode resistor is applied to the grid of V24B. When triggering with a positive going signal, the grid of tube V24A is connected to TRIGGERING LEVEL control R17 and the grid of V24B is connected to the input signal; thus, the plate voltage at tube V24B is 180 degrees out of phase with the input signal.

1-26. For each mode of triggering, except HF SYNC, a negative going signal is produced at the plate of tube V24B regardless of the polarity of the input signal; and the amplitude of the triggering signal necessary to operate the following stage is determined by the setting of the TRIGGERING LEVEL control. With the TRIGGERING MODE switch placed on HF SYNC the signal present at the input of the trigger input amplifier is coupled directly into the Sweep Generator A and the A Trigger circuitry is not used.

1-27. TRIGGER MULTIVIBRATOR. Trigger multivibrator V45 is a cathode-coupled Schmitt Trigger. In its stable-state, V45A is conducting heavily from the positive voltage connection to pin 1 of V24B and V45B is cut-off by the negative bias applied to its grid. Therefore, the plate voltage on V45A is at minimum and on V45B, maximum. When a negative-going signal from V24B is applied to pin 2 of V45A, it ceases conduction and the rise in plate voltage develops a positive pulse. Applying this pulse to the grid of V45B, brings it out of cut-off and into conduction. As V45B starts conduction, its plate voltage drops and a negative-going output pulse is developed. Cathode-coupling between the two sections of V45, causes the cathode of V45B to swing negative and V45A, to swing positive. As a result, V45A is rapidly switched back to its stable-state and remains in that state until triggered again. During the above action, the plate voltage of V45A drops, the plate of V45B rises and a positive-going output pulse is produced. The result of this switching, develops a square-wave output which is used to trigger the Sweep Gating Multivibrator in the Sweep Generator A circuit.

1-28. SWEEP GENERATOR A. (See figure 6-5.)

1-29. SWEEP GATING MULTIVIBRATOR. The sweep gating multivibrator using cathode-coupled pair V135

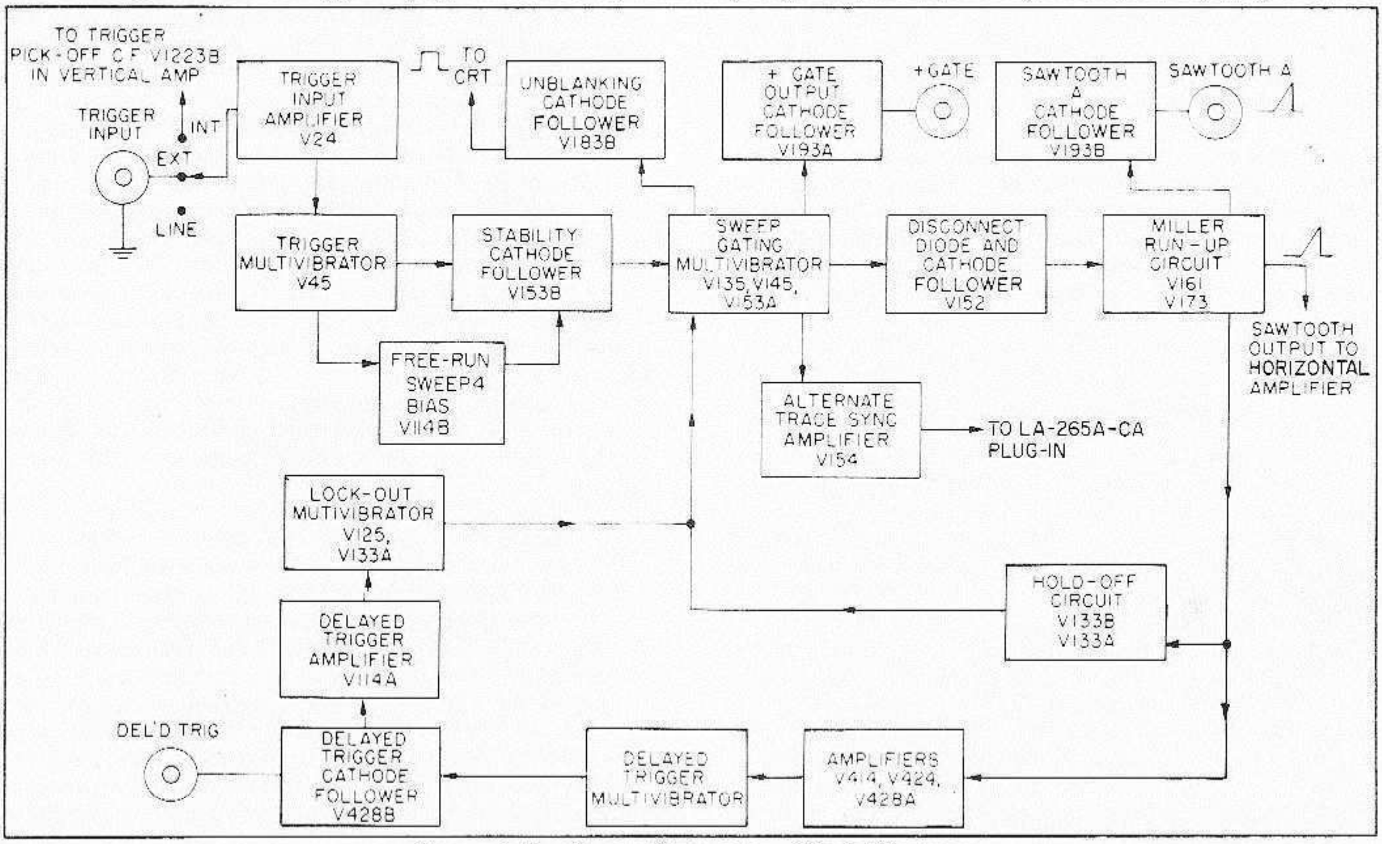


Figure 1-6. Sweep Generator, Block Diagram

and V145, is a Schmitt trigger circuit. In the absence of a negative-going trigger pulse from C131, V135A is conducting from the positive voltage received through the d-c path completed from pin 8 of V135B to pin 2 of V135A. The plate of V135A is coupled to V145 through cathode-follower V135B which isolates the positive-going plate signal of V135A from other circuits requiring a positive pulse. Tube V145 is cut-off from the large negative bias applied to its grid and produces no output signal. Tube half V153A provides isolation for HF SYNC triggering and operation of the hold-off circuit.

1-30. When a negative trigger pulse appears at C131, V135A is driven to cut-off and the rise in plate voltage develops a positive pulse. This positive pulse appearing on the cathode of V135B, drives V145 into conduction. When V145 conducts, its plate voltage drops and a negative pulse is produced. Any spiking that may occur in the grid circuit of V145 is removed by C141 and R141. Upon the arrival of a positive-going trigger pulse on C131 (or the absence of a trigger), the sweep gating multivibrator reverts back to its initial stable-state condition. When the multivibrator begins to revert back to a stable state, the conduction of V135A produces a negative-going output pulse which drives V145 to cut-off. As the plate voltage of V145 rises, a positive pulse is developed. Switching the sweep gating multivibrator, from one state to the other, initiates the Miller Run-up circuit. The initial triggering conditions of the sweep gating multivibrator depends upon the setting of the STABILITY control (R110). If this control is advanced (toward minus 150 volts), the voltage transferred through cathode follower V153B, will make the grid of V135A more negative (or less positive). As the grid becomes more negative, a lesser value of triggering signal is required. The STABILITY control is effective in any triggering mode except AUTO. In AUTO, R111 is pre-set for best overall results.

1-31. Since the sweep gating multivibrator does not free-run during the absence of a trigger pulse unless the STABILITY control is advanced, provisions have been made to obtain a free-running sweep and CRT base line without requiring an input signal. This function is made available when the TRIGGERING MODE switch is in AUTO position which is the most useful mode of operation. When switch SW10B is set to AUTO, the circuit of V114B applies a control bias to V153B which causes the sweep gating multivibrator to free-run without a triggering signal. During the absence of a sync pulse from V45B, V114B is conducting heavily and applies a negative bias to the grid of V153B. This bias voltage is equivalent to the value that could be obtained by advancing the front panel STABILITY control (toward minus 150 volts) to the point where the amount of negative voltage transferred to pin 2 of V135A is sufficient to cause the sweep gating multivibrator to free-run. In the AUTO triggering mode, the STABILITY control R110 is simply replaced by the bias control function of V114B. When a negative-going sync pulse arrives from V45B, the d-c voltage rectified by V25 biases V114B to cut-off and its plate swings in a positive direction. The bias developed on V153B is then exactly equal to that obtained from the normal setting of STABILITY control and the circuit operates as though V114B was not in the circuit. The main feature of the above circuit is that with no input signal, there will be no change in CRT base line brilliance since the time base generator will free-run at the rate set by the front panel sweep controls.

1-32. MILLER RUN-UP CIRCUIT. The miller run-up circuit is essentially a class A amplifier employing negative feedback to achieve a linear rate of charge on the timing capacitor switched in by the TIME/CM switch.

1-33. In the quiescent state, tube V152A is above cut-off, consequently diode V152B is conducting and the grid of miller tube V161 is held slightly negative. Tube V173A is also conducting, preventing the sweep sawtooth pedestal from dropping. As the sawtooth pedestal is prevented from rising by clamping the grid of miller run-up tube V161 through diode V152B, the sawtooth pedestal voltage is maintained constant, insuring the start of the sweep from precisely the same point each time. When the sweep-gating multivibrator tube V135A is triggered to change state and initiate a sweep, V145 starts to conduct, the plate falls, and the negative signal applied to the grid of cathode follower V152A causes the plate of diode V152B to drop and the diode ceases to conduct. The grid of the miller tube V161 is now released and starts to go more negative, causing the plate to rise. The positive-going plate carries the grid of the run-up cathode follower, tube V183B, with it. When the cathode of tube V173A starts to rise with the sawtooth, tube V173A is cut off. A constant difference is maintained between the grid voltage of tube V173B and the plate voltage of miller tube V161 by the neon lamp, B169. Capacitor C167 and resistor R168 improve the rise time of the circuit. Capacitor C165 reduces the charging time of the stray capacitances and further improves rise time.

1-34. The cathode voltage of tube V173B rises as the grid goes positive resulting in a linear rise in voltage at the top side of capacitor C160. Since the capacitor cannot charge instantaneously, this rise in voltage at the top of capacitor C160 is coupled to the grid of miller tube V161 and corrects for the attempt of the grid to go negative. Timing resistor R160 (or any other switched in by the TIME/CM switch) completes the current charging path for timing capacitor C160. Since the miller tube grid voltage is almost constant, the voltage across timing resistor R160 is almost constant, resulting in a constant current source for capacitor C160. This is what provides the linear charge resulting in an accurate sweep sawtooth waveform.

1-35. The sweep generator sawtooth is taken from the cathode of tube V173B and fed to the HORIZONTAL DISPLAY switch SW347A-2F in the horizontal amplifier and the delayed pickoff circuits. This sawtooth voltage rises until a positive step from the sweep gating multivibrator causes the run-up circuitry to revert to its quiescent state. A second output from tube V173B is fed via the hold-off circuit consisting of tubes V183A and V133B to the sweep-gating multivibrator, causing that circuit to switch back to its quiescent state and await the next triggering pulse. A third output from tube V173B is fed to the sawtooth output cathode follower V193B and then to the SAW-TOOTH A binding post on the front panel.

1-36. DELAYED PICK-OFF CIRCUIT. The delayed pick-off circuit receives its input from the output of tube V173B (sweep generator A), or from tube V283B (sweep generator B). The output of the delayed pick-off circuit, consisting of tubes V414, V424, V445, and V428, is applied as delayed trigger pulses to the sweep gating multivibrator in either the A or B channel.

1-37. DIFFERENCE AMPLIFIER. Tubes V414 and B424 functioning as difference amplifiers receive a portion of the sweep generator A or B output sawtooth, and convert it into a pulse of step form. Before pick-off time, tube V414 is cut-off and tube V424 is conducting. The cathodes of the two tubes are connected to constant current tube, V428A, which supplies cathode current from the minus 150 volt supply. Tube V424 determines the common cathode voltage by virtue of the front panel, 10 turn, helical resistor, DELAY-TIME MULTIPLIER, R433. Tube V424 is so connected that the cathode current is large, with a small variation of cathode voltage. Since the cathode current variation is small, so is the plate current variation through resistor R424 and coil L424, thus the plate voltage of tube V424 can be maintained very close to the triggering point of the following stage, tube V445A.

1-38. When the positive going sawtooth applied to the grid of tube V414 rises above the cathode voltage, as determined by the DELAY-TIME MULTIPLIER setting, tube V414 starts conducting, and tube V424 is cut-off. Delay Stop Adj potentiometer R432, and Delay Start Adj potentiometer R436, adjust the upper and lower limits of tube V424 grid voltage so that the delay can be read directly from the micrometer dial on the DELAY-TIME MULTIPLIER.

1-39. DELAYED TRIGGER MULTIVIBRATOR. Tube V445, functioning as a trigger multivibrator, is triggered into conduction when tube V424 is cut-off. The falling plate voltage in V445A cuts V445B off, causing its plate voltage to rise rapidly. The output square signal from V445B is differentiated by capacitor C454 and resistor R454. The resultant spiked pulses are fed via delayed trigger cathode follower V428B to sweep generator A or B, and to the front panel DEL'D TRIG binding post.

1-40. HOLD-OFF CIRCUIT. The hold-off circuit prevents the sweep gating multivibrator from returning to its quiescent state until the miller sweep circuit has had time to run down. The hold-off time is determined by the switched value of capacitor C180. The sawtooth at the cathode of tube V173B is coupled through Sweep Length potentiometer R176 to the grid of tube V183A. Potentiometer R176 is adjusted to terminate the sawtooth after the trace has passed the right hand limit of the graticule. Potentiometer R176 adjusts the voltage on capacitor C180, through cathode follower V183A. The positive sawtooth applied to the grid of V183A charges capacitor C180. This positive voltage is also applied through cathode follower V133B, to the grid of tube V153A in the sweep gating multivibrator causing it to revert. Tube V398A, the grid of which is coupled to the common cathodes of V135A and V145, acts to prevent tube V153A from starting to conduct on its grid rise before the reverting point on the rise of the sawtooth is reached. When V145 conducts, its cathode rise, coupled through tube V398 to the cathode of V153A, prevents tube V153A from conducting until the full reverting voltage is reached. After revertion, V145 is cut off and V153A remains conducting for the duration of the hold-off period. The multivibrator is prevented from returning to its quiescent state until capacitor, C180 has discharged, as the plate of tube V135A cannot rise until tube V153A ceases to conduct due to common plate load resistor, R134.

1-41. SINGLE SWEEP. When the HORIZONTAL DISPLAY switch SW301-3F, located in the plate circuit of tube V133A, is set to the A SINGLE SWEEP position, plus 100 volts is applied to tube V133A, through resistor R128 causing it to function in conjunction with tube V125 as a bistable lockout multivibrator.

1-42. The first stable state exists upon the completion of a sweep. In this state tube V125 is cut-off and tube V133A is conducting. The cathode voltage for these tubes and the grid voltage on tube V153A is set by Lockout Level Adj potentiometer R125. This voltage is set to cause tube V153A to conduct.

1-43. As stated previously, the plates of tubes V153A and V135A are connected to a common load resistor. The plate of tube V135A, therefore, cannot rise while tube V153A is conducting, and negative trigger pulses arriving at the grid of tube V135A during this interval are prevented from triggering the sweep gating multivibrator, effectively "locking out" the sweep.

1-44. Depressing RESET switch SW103 grounds capacitor C102 and resistor R102 causing a positive impulse to be applied to the grid of tube V114, at which time the plates of tubes V114 and V125 fall. This negative-going signal is coupled to the grid of tube V133A causing the lockout multivibrator to revert to its other stable state with tube V125A conducting and tube V133 cutoff. The plate rise of tube V133 then lights the READY lamp. With the change in stable state, tube V153A no longer conducts, and the grid level of tube V135A again controls the sweep gating multivibrator.

1-45. A sweep can now be generated in one of two ways. If the STABILITY control is turned full clockwise, the grid of tube V135A will be lowered, causing the sweep gating multivibrator to switch to its other stable state and initiate a sweep. If the STABILITY control is rotated for triggered operation, the sweep is triggered by the first negative trigger pulse to arrive at the grid of tube V135A. As the sweep begins, the rising sawtooth voltage raises the cathode of tube V133B by the hold-off action described in paragraph 1-40. As the cathodes of the lockout multivibrator rise to follow the cathode of tube V133B, tube V125 cuts off, and tube V133A is driven into conduction. As the cathodes continue to rise, due to the sawtooth sweep voltage, tube V133A is once again cut off. Both tubes, V125 and V133A are held cut-off for the remainder of the sweep, and the READY lamp stays on. When the grid of tube V153A rises to the point at which the sweep gating multivibrator is switched, the sweep is terminated.

1-46. As the hold-off capacitor, C180, discharges, the cathodes of the lockout multivibrator start to fall. The grid voltage of tube V133A is so biased that it starts conducting first. As tube V133A conducts, its plate voltage drops, extinguishing the READY lamp. A new sweep cannot be started unless the RESET switch is depressed once again.

1-47. UNBLANKING CATHODE FOLLOWER. Tube V183B functions to feed a portion of the positive-going square wave from the cathode of tube V135B, to unblank the crt. The square wave signal fed to the crt is of the same time duration as the sweep sawtooth, therefore unblanking the crt during sweep time, and blanking it during fly back time.

1-48. + GATE A OUTPUT CATHODE FOLLOWER. The same square wave fed to the unblanking cathode follower, is also fed to the + Gate output cathode follower, tube V193A. Tube V193A in turn feeds the front panel binding post marked + GATE A, with a positive going square wave, 30 volts in amplitude.

1-49. SAWTOOTH A CATHODE FOLLOWER. The sweep sawtooth voltage from the cathode of tube V173, is fed via the sawtooth cathode follower, tube V193B to the front panel binding post labeled SAWTOOTH A. The waveform available at this post starts at ground potential and rises linearly to a 145 volt level.

1-50. DUAL TRACE SYNC AND BLANKING. When Plug-in Preamplifier LA-265-CA is utilized, synchronizing pulses are supplied to the preamplifier by tube V154A. When the sweep gating multivibrator, tube V145, is cut-off, a sharply differentiated positive pulse is developed across coil LR149 in the screen grid circuit. This pulse is coupled through capacitor C151 to the grid of tube V154A causing it to go into conduction. As tube V154A goes into conduction, a negative pulse is picked off the plate, and fed through pin 16 of the preamplifier interconnecting plug, to switch the multivibrator in the LA-265-CA preamplifier employed for alternate sweeps. (Refer to LA-265-CA Manual for additional details.

1-51. CHOPPED BLANKING. When the LA-265-CA Plug-in Preamplifier is utilized in the chopped mode, tube V154B blanks any transients from appearing on the crt. When the chopped mode is selected, the multivibrator in the LA-265-CA Preamplifier is free running to produce chopped sweeps. A negative pulse is applied to the grid of tube V154B, from the plate of tube V154A. The resultant positive pulse at the plate of tube V154B is coupled to the cathode of the crt to blank out the sweep trace during the chopped switching.

1-52. HORIZONTAL AMPLIFIER CIRCUITS. (See figures 1-7 and 6-6.)

1-53. GENERAL. The horizontal amplifier block diagram is illustrated in figure 1-7. The horizontal amplifier functions to convert the single-ended sawtooth output from the sweep generator into a double-ended push-pull sawtooth signal which is utilized to drive the horizontal deflection plates in the crt.

1-54. INPUT CATHODE FOLLOWER. (See figure 6-6.) The single-ended sawtooth output from either sweep generator A or B is applied to the grid of input cathode follower, tube V343A, through an attenuating network consisting of variable capacitor C330, and fixed resistor R330. The attenuating network attenuates the input sawtooth signal, and variable capacitor C330 permits the input circuitry to be adjusted for optimum frequency response. The front panel HORIZONTAL POSITION and VERNIER controls vary the dc level on the grid of tube V343A. The dc level established in the input cathode follower stage determines the dc level for the entire amplifier, thus controlling the horizontal positioning on the crt.

1-55. 5X MAGNIFIER. The output signal taken from the cathode of tube V343A is fed to the driver cathode follower, tube V343B, by means of the 5X MAGNIFIER switch. When the switch is in the OFF position, an attenuating network consisting of variable capacitor C348, and resistors R348 and R349, is placed in the signal path. This network attenuates the signal by a factor of five. When the 5X MAGNIFIER switch is set

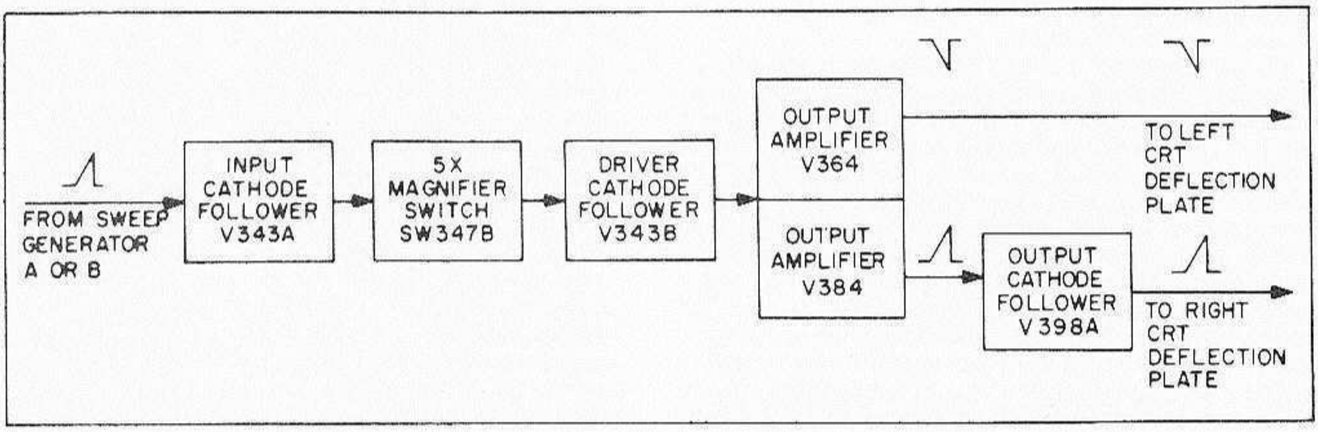


Figure 1-7. Horizontal Amplifier, Block Diagram

to the ON position, the network is shorted out, and the full signal strength is passed. The Swp. Cal. potentiometer R348 adjusts the sweep lwngth by changing the attenuation of the network. Variable capacitor C348 provides optimum linearity on the fastest sweep speeds. Potentiometer R358 adjusts the position of the unmagnified sweep so that it corresponds with the position of the magnified sweep. The output from tube V343B is direct coupled to the grid of the output amplifier, tube V364A.

1-56. OUTPUT AMPLIFIER. The single ended sawtooth is applied to the grid of paralleled dual triode output amplifier V364 which is cathode coupled to a similar paralleled dual triode V384, the operation of these two tubes providing a double ended push-pull signal. The cathodes of these tubes are connected to a common network consisting of the Mag. Gain potentiometer R375 and capacitors C375 and C390. Potentiometer R375 permits adjusting the gain of the horizontal amplifier so the ratio of magnified to unmagnified sweeps is correct. Capacitor C375 effects the linearity of the beginning of fast sweep speeds.

1-57. The negative going signal from the output of tube V364 is connected directly to the left hand deflection plate of the crt. A cathode follower is employed for optimum drive and matching of the positive going output of tube V384. This output is coupled through cathode follower tube V398A to the right-hand horizontal deflection plate.

1-58. CALIBRATOR. (See figure 6-10.)

1-59. GENERAL. The calibrator is a square-wave generator whose output is fed to a front panel connector labeled CAL. OUT. The square-wave is adjustable in amplitude from 0.002 volts to 100 volts in 18 steps, and is utilized for testing and calibrating the oscilloscope.

1-60. The calibrator circuit (see figure 6-10) consists of two tubes, V885 and V875. The calibrator multivibrator is comprised of tubes V885A and V875 which free run at approximately 1 KC. Either tube V885A or V875 will conduct first due to the dissimilarity in the tubes. As the plate voltage of tube V875 is high or low depending upon the multivibrator switching action, the calibrator output cathode follower, tube V885B follows. When tube V875 is cut-off, its plate voltage is high, approximately plus 100 volts, thus causing tube V885B to conduct heavily and its cathode voltage rises to a 100 volt level. When tube V875 is conducting, its plate voltage drops to a value low enough to cause tube V885B to be cut-off, thus allowing the cathode to effectively be at ground potential. The resultant waveform available at the CAL. OUT connector is a symmetrical square-wave whose amplitude is determined by the setting of the AMPLITUDE CALIBRATOR control, a 19-position switch with range from 0.002 volts to 100 volts.

1-61. The Cal. Adj. potentiometer R879 is adjusted so the CAL. Test Point (cathode of tube V885B) is exactly plus 100 volts when tube V875 is cut-off. Capacitor C885 compensates for any overshoot.

1-62. LOW VOLTAGE POWER SUPPLY. (See figures 6-11 and 1-8.)

1-63. GENERAL. The low voltage power supply consists of five regulated power supplies providing minus 150, plus 100, plus 225, plus 350, and plus 500 volts dc. A single power transformer supplies all the power supplies, and in addition, various taps supply filament voltages throughout the oscilloscope. The regulators maintain their constant output over an input range from 105 to 125 volts ac. (The power transformer connections may be changed for 210 to 250 volts operation.)

1-64. MINUS 150 VDC SUPPLY. The minus 150 volt dc supply is the reference voltage for the other four supplies. This supply is comprised of tubes V609, V624, V634, V627, V637, and V647. Voltage regulator tube V609 maintains a fixed voltage on the grid of difference amplifier tube V624A. The grid voltage for tube V624B is obtained from a divider network consisting of resistor R615, -150 Volt Adj. potentiometer R616, and R617. Because the divider network is connected between ground and the minus 150 volt output, any change in the output is felt on the grid of tube V624B and applied to the grid of dc amplifier tube V634. The error signal amplified by tube V634 is applied to the series regulator tubes V627, V637, and V647 causing them to either increase or decrease conduction, thus causing the attempted change in the minus 150 volt output to be regulated back to the minus 150 volt value. Capacitor C640 acts as a filter for the minus 150 volt supply. Additional ripple is removed by the application of ripple voltage through resistor R637 to the screen grid of tube V634 which, when amplified, cancels most of the ripple. Diodes V642A, B, C and D form a bridge network providing full wave rectification.

1-65. PLUS 100 VDC SUPPLY. The plus 100 volt dc regulated supply consists of tubes V664 and V677A. The rectified output from bridge rectifier V672A, B, C and D is filtered by capacitor C670 and C671 and fed throughout the oscilloscope. The grid of DC amplifier tube V664 is connected between the plus 100 volt line and the minus 150 volt output. Thus any change in the plus 100 volt output is sensed by tube V664, amplifier, and applied to the grid of series regulator V677A. The increase or decrease in conduction of tube V677A regulates the output voltage back to the plus 100 volt value.

1-66. PLUS 225 VDC SUPPLY. The plus 225 volt supply is stacked on the plus 100 volt supply to furnish plus 335 volts to the series regulator tube, V667B. Rectified voltage is supplied from terminals 7 and 10 of transformer T601. The plus 225 volt supply is regulated by comparing the grid voltage of tube V684A to the voltage tapped off between resistors R680 and R681, which are connected between the plus 225 output line, and the minus 150 volt dc reference. Any error signals existing between the grids of difference amplifier tube V684 is amplified and fed to dc amplifier tube V694. Tube V694 in turn controls series regulator tube V677B, thus the plus 225 volt dc output. The plus 225 volt supply also furnishes plus 325 volts dc unregulated to the high voltage oscillator for use within the crt circuits.

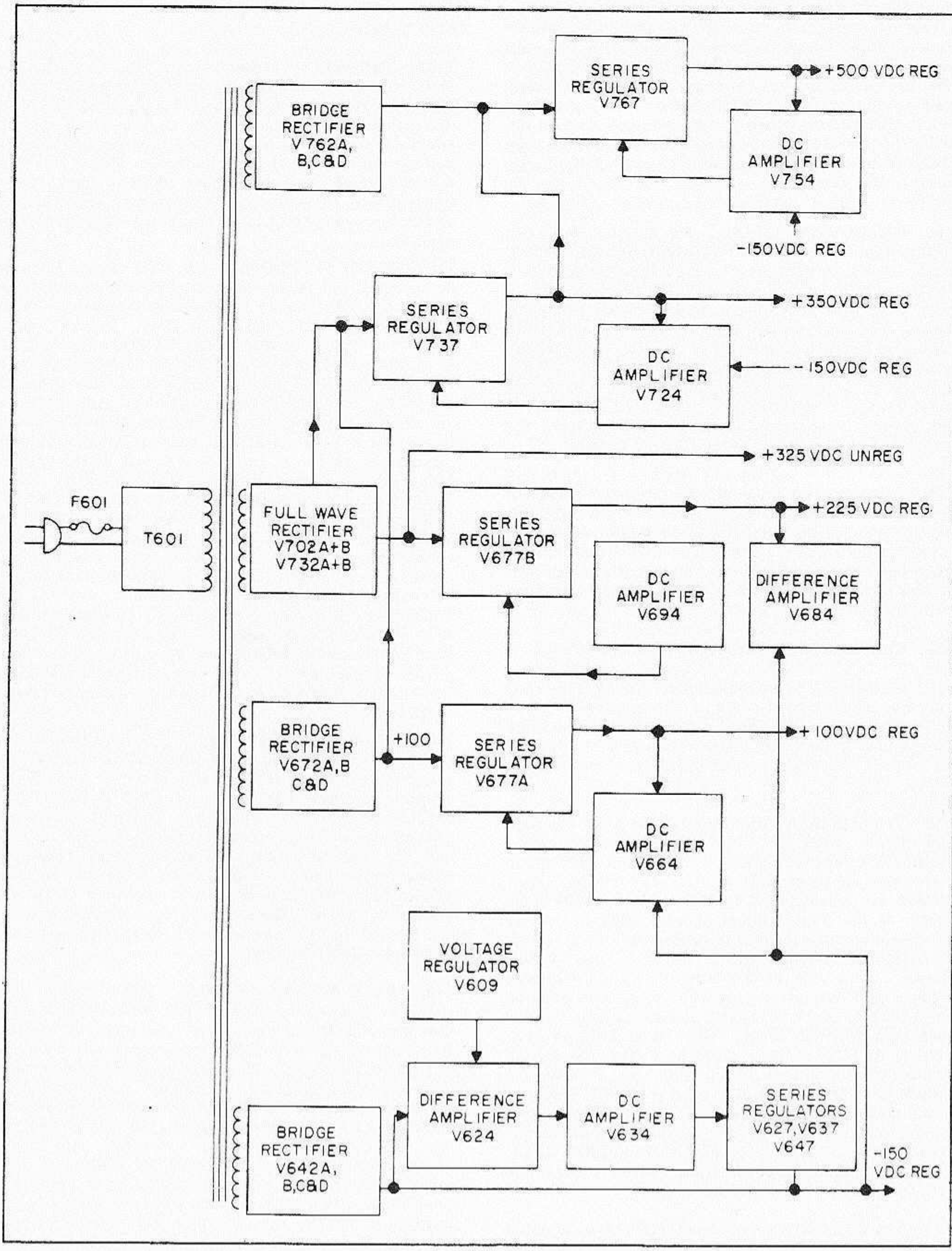


Figure 1-8. Low Voltage Power Supply, Block Diagram

1-67. PLUS 350 VDC SUPPLY. The rectified output from terminals 5 and 14 of transformer T601 are stacked with the plus 100 volt supply across capacitor C730 to furnish voltage for the plus 350 volt supply. The dc amplifier tube V724 receives its reference from the tap between resistor R710 and R711. The action of the plus 350 volt supply is the same as previously described for the plus 100 volt supply.

1-68. PLUS 500 VDC SUPPLY. The rectified voltage from diodes V672A, B, C and D is stacked with the plus 350 volt supply output, to furnish voltage to the plus 500 volt supply. The dc amplifier tube V754 receives its reference from the tap between resistors R740 and R741. The plus 500 volt supply also functions as described for the plus 100 volt supply.

1-69. TIME DELAY RELAY K600. Time delay relay K600 receives 6.3 volts ac from transformer T601 when the power switch is set to ON. Twenty-five seconds later relay K600 closes, applying B+ voltages to the tubes throughout the oscilloscope.

1-70. FILAMENTS. The tube filaments are supplied directly from transformer T601. Several of the filament terminals are elevated in voltage (plus 100, plus 225, plus 350, and minus 1350) to prevent damage to the tubes due to excessive difference in potential between filament and cathode.

1-71. CATHODE RAY TUBE (CRT) CIRCUITS.

1-72. GENERAL. The cathode ray tube is a five-inch display tube; which may be fed either by the vertical amplifier circuits, or by direct connection to the crt deflection plates. The crt circuits are illustrated in block diagram form in figure 1-9.

1-73. CRT CONTROL CIRCUITS. (See figure 6-12.) Intensity of the crt beam is controlled by the INTENSITY control, potentiometer R826, which varies the bias voltage at the control grid of the crt. The FOCUS control, potentiometer R856, which is connected into a divider network between minus 1350 volts dc and ground, varies the voltage at the focusing ring. The ASTIGMATISM control, potentiometer R864, is connected between a plus 500 and plus 225 volt dc source. Rotation of the control varies the voltage on the astigmatism anode to focus to beam in both dimensions simultaneously. Geom. Adj. potentiometer R861, controls the linearity at the extreme ends of the sweep trace, by controlling the magnetic field the beam encounters as it leaves the deflection plates.

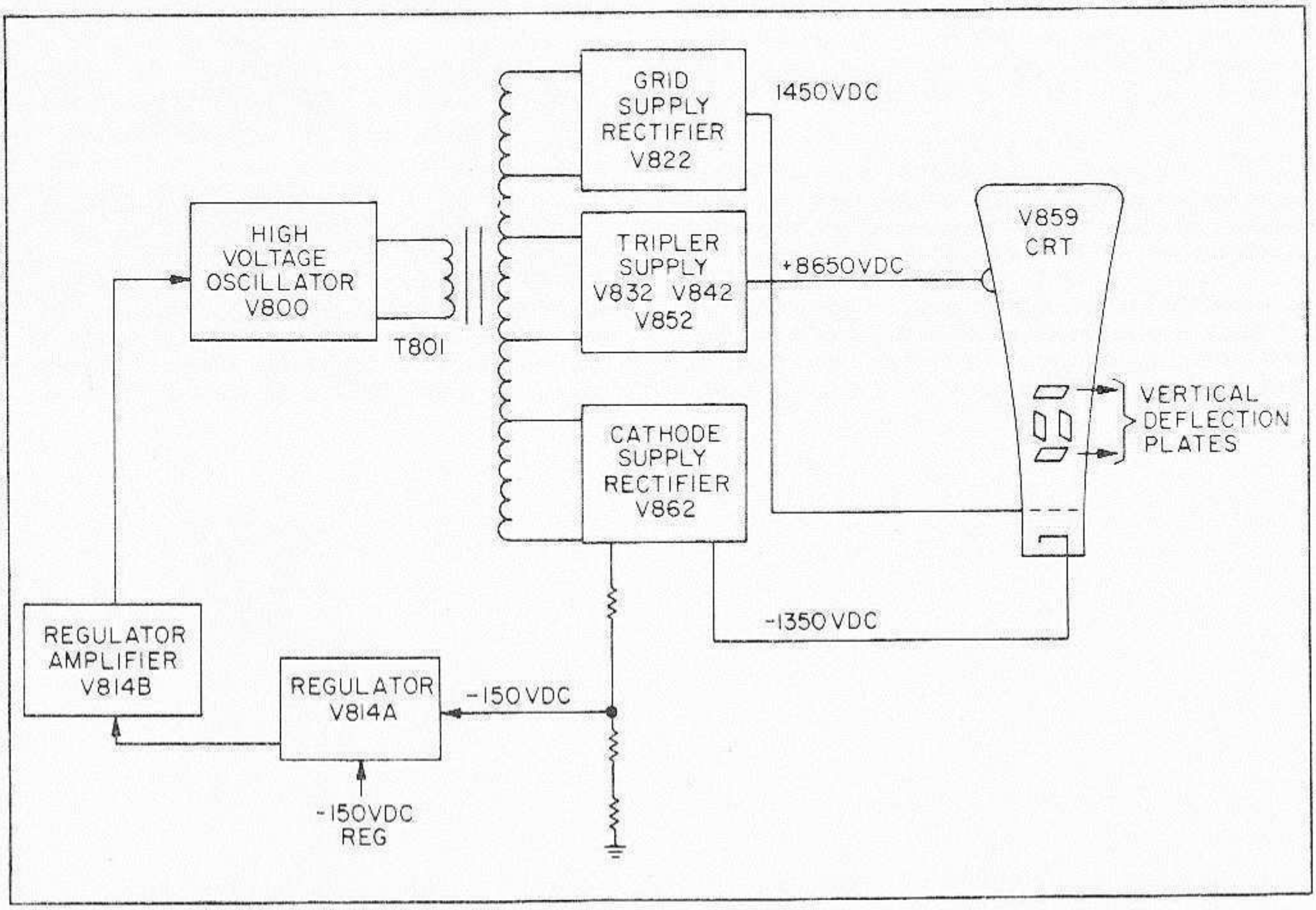


Figure 1-9. Crt and High Voltage, Block Diagram

1-74. CRT CATHODE CIRCUIT. The crt cathode, by means of a selector switch and binding post, may be connected for normal operation, dual trace chopped blanking, or intensity modulation. When CRT CATHODE SELECTOR switch SW848, located on the rear of the oscilloscope, is set to the DUAL-TRACE CHOPPED BLANKING position, the cathode receives positive square waveforms from tube V154B in the sweep generator to blank the crt during switching while operating an LA-265-CA preamplifier in the chopped mode.

1-75. When the CRT CATHODE SELECTOR switch is set to the EXTERNAL CRT CATHODE position, the crt cathode is connected to a pair of binding posts located on the rear of the oscilloscope. If the bar is in place between the two posts, the cathode is connected to ground through capacitor C848. When the bar is removed, an external intensity modulating signal can be fed to the crt cathode via capacitor C848.

1-76. HIGH VOLTAGE POWER SUPPLY. A free running Hartley oscillator, operating at approximately 60 KC, feeds three power supplies which furnish the high voltage for the crt. The inductance of the primary winding of transformer T801 and the capacitance of capacitor C808 control the frequency of the oscillator.

1-77. Tube V862, functioning as a half-wave rectifier, provides minus 1350 volts dc to the crt cathode. Tubes V832, V842 and V852 functioning as a voltage-tripler stage, provide plus 8650 volts dc to the crt post-anode accelerator. Capacitor C836 filters the tripler stage. Resistor R801 and capacitor C801 function as a decoupling network, to isolate the plus 100 volt dc regulated supply.

1-78. Another half wave rectifier, tube V822, connected to utilize half the high voltage secondary winding of transformer T801, supplies a negative voltage of about minus 1450 volts dc to the grid of crt.

1-79. The three power supplies are regulated by controlling the conduction of the Hartley oscillator, tube V800. When the minus 1350 volt supply is normal, the grid voltage of tube V814A is close to minus 150 volts dc. This voltage is obtained from the tap between resistor R841 and R842. The cathode of tube V814A is connected to the minus 150 volt dc regulated power supply, therefore, should a change in the minus 1350 volt dc supply take place, an error signal is developed at the grid of tube V814A. This error signal is amplified by tube V814B and in turn controls the screen grid voltage of the Hartley oscillator. When the conduction of Hartley oscillator tube V800 changes, the three supplies change proportionately.

1-80. UNBLANKING. Dc-coupled unblanking is accomplished by employing a separate rectifier, tube V822, for the crt grid voltage as previously mentioned. The negative voltage from the plate of tube V822 is applied through resistors, R824 and R825, to a series connected group of approximately 31 NE-2 neon lamps. The other end of the series connects to the dc-coupled unblanking signal. This "block of constant voltage" represented by the neon lamps, has a flexible reference with respect to the cathode supply because of series resistors, R824 and R825. It is maintained at a pedestal supplied by the unblanking line and follows the rise and fall of each unblanking pulse. This bias voltage, riding on the unblanking pedestal, is connected to the grid of the crt through the INTENSITY control potentiometer R826, which is connected across a portion of the neon regulators.

1-81. At the faster sweep speeds, the stray capacitance in the circuit makes it difficult to pull up the grid supply fast enough to unblank the crt in the required time. To overcome this, an isolation network comprised of capacitors C827 and C828, and resistor R827, is employed. The network permits the fast rise leading edge of the unblanking pulse to be coupled to the crt grid.

1-82. EXTERNAL HORIZONTAL AMPLIFIER. With the HORIZONTAL DISPLAY switch in the EXT. position, tube V314A receives its signal from the HORIZ. INPUT connector. Tube V314B balances the horizontal amplifier for dc potentials. Potentiometer R314, in the cathode circuit of V314A and V314B is used to control the conduction of V314A, thereby controlling the amplitude of the signal at the plate of V314A.

SECTION II

SPECIAL SERVICE TOOLS

2-1. INTRODUCTION

2-2. Special tools or fixtures are not required for the operation or maintenance of the oscilloscope. A listing of standard test equipment utilized during calibration of the oscilloscope will be found in figure 7-1.

SECTION III

PREPARATION FOR USE, STORAGE, OR SHIPMENT

3-1. PREPARATION FOR USE.

3-2. INSPECTION. Remove the oscilloscope from its shipping container using care to avoid denting, scratching, or marring any surface of the equipment. Visually inspect the oscilloscope as follows:

a. Inspect the case for dents, distortion or moisture damage.

b. Check the front panel controls for ease of operation and security.

c. Remove the oscilloscope covers and visually check for security of tubes, and parts.

3-3. SELECTION OF PLUG-IN PREAMPLIFIER. Prior to operating the oscilloscope, the proper plug-in preamplifier supplying the electrical characteristics desired must be selected. Figure 1-3 describes the electrical characteristics of the various plug-in preamplifiers available. Upon selecting the preamplifier required, slide it into the front panel opening in the lower left hand corner, and press firmly into its mating socket, secure in place with the thumb screw at the bottom of the preamplifier.

3-4. FACILITIES REQUIRED. Since the oscilloscope is portable, measuring 13 x 16-3/4 x 24 inches, space requirements are not critical. The oscilloscope may be set on a work bench, or placed on a moveable stand which would make it more convenient if more than one person were to use it during a work period. The only external connection required to prepare the oscilloscope for use is connection to 115 volts ac, single phase, 60 cycles. (The power transformer may be required for 210 to 250 volt operation as described in Section V.)

3-5. STORAGE.

3-6. For short term storage intervals, the oscilloscope may be placed on a shelf in a weather protected area where it will not be subjected to damage or rough handling. Storage for longer intervals requires that bagged dessicant, Specification MIL-D-3464, be placed inside the shipping container. Fungus treatment shall be performed according to Specification MIL-T-152, to the extent required by local climate conditions.

SECTION IV

OPERATING INSTRUCTIONS

4-1. INTRODUCTION.

4-2. This section describes operation of the oscilloscope. To realize the full capabilities of the oscilloscope, operating personnel must thoroughly understand the function of each front panel control. In addition to describing the function of each control, this section provides information required for the operator to perform various testing functions. Since the oscilloscope may be utilized for numerous applications, this section will provide general testing methods, from which, based upon experience, will allow the operator to perform specific tests.

4-3. USE OF PLUG-IN PREAMPLIFIERS. Prior to operating the oscilloscope, the operator must determine which plug-in preamplifier satisfies the requirements of the intended application. For general troubleshooting and maintenance, the LA-265-L Fast-Rise Plug-in Preamplifier is suitable. For specific applications, refer to figure 1-3 for the preamplifier with the electrical characteristics most suitable.

4-4. When a plug-in preamplifier has been selected, insert it into the recessed opening in the oscilloscope front panel, pressing firmly back in place until the connectors mate. Then secure into place with the thumbscrew at the bottom of preamplifier.

4-5. PRELIMINARY CONTROL SETTINGS. Prior to applying power to the oscilloscope, set the following controls as indicated:

a. INTENSITY	Fully counterclockwise
b. TIME/CM	1 MILLISEC
c. 5X MAGNIFIER	OFF
d. HORIZONTAL DISPLAY	A
e. HORIZONTAL POSITION	Mid-Position
f. VERTICAL POSITION (Preamplifier)	Mid-Position
g. FOCUS	Full clockwise

4-6. APPLICATION OF POWER. Connect the power cable to the rear of the oscilloscope, and to a source of 115 volts ac, single phase, 60 cycles. Set the POWER switch to the ON position; the adjacent indicator lamp shall light.

Note

A 25 second time delay period is provided for tube warm-up, before a trace will appear on the crt.

4-7. SETTING THE INTENSITY, FOCUS AND ASTIGMATISM CONTROLS. Rotate the INTENSITY control until a spot appears on the crt. Center the spot with the HORIZONTAL and VERTICAL POSITION controls. Rotate the ASTIGMATISM control for the most circular spot. Rotate the FOCUS control to reduce the spot to minimum size.

Note

The FOCUS and ASTIGMATISM controls must be adjusted with no input signals connected to the oscilloscope.

4-8. METHOD OF CONNECTING OSCILLOSCOPE TO EQUIPMENT UNDER TEST. The waveform to be displayed on the crt must be connected to the INPUT connector located on the preamplifier. The best results are obtained by utilizing one of the probes supplied with the oscilloscope as they provide a minimum of loading to the waveform, therefore providing a more accurate display. In event the probe is not used, a shielded piece of cable is the second best method of coupling the waveform to the INPUT connector. The shielded cable must be grounded to both the oscilloscope and equipment under test. In all cases, keep the cable as short as possible to minimize pick-up of stray signals.

4-9. PURPOSE AND USE OF OPERATING CONTROLS.

4-10. The operating controls are listed and described in figure 4-1, and are illustrated in figure 4-2.

4-11. OPERATING PROCEDURES.

4-12. GENERAL. Since operation of the oscilloscope cannot be described in a step-by-step procedure because of its many applications, paragraphs 4-13 through 4-48 describe in detail the technique for the use of various controls. The instructions that follow will only pertain to the less commonly known controls, and will not describe operation of the INTENSITY, FOCUS, etc.; these controls are adequately described in figure 4-1.

4-13. Basically, the main operations to be considered are selection of sweep speed, method of triggering, sweep delay, and sweep magnification. The controls effecting the operation of these functions of the oscilloscope will be described in detail.

4-14. SELECTION OF SWEEP SPEED.

4-15. GENERAL. The oscilloscope contains circuitry which enables the operator to select either the A or B sweep generator to display the input signal. Both sweep generators are used simultaneously to obtain a calibrated, delayed sweep, with sweep generator B furnishing the delay.

Control, Connector or Indicator	Purpose or Use
INTENSITY control	Adjusts intensity of beam and displayed waveform.
FOCUS control	Utilized in conjunction with ASTIGMATISM control to obtain sharp focused display.
ASTIGMATISM control	Utilized in conjunction with FOCUS control to obtain sharp focused display.
SCALE ILLUM	Varies brightness of graticule markings. Control is marked in f: stops for convenience of photographic work.
Graticule markings	Marked with 10 horizontal and four vertical 1 centimeter divisions, with 2 millimeter intermediate divisions. Markings match factor of VOLTS/CM control thereby allowing direct amplitude and time duration readings to be made from crt.
TRIGGERING LEVEL control	Determines the point on the triggering waveform where triggering of the sweep occurs. Utilized in conjunction with the STABILITY control to obtain a stable display.
STABILITY control	Utilized in conjunction with TRIGGERING LEVEL control to obtain a stable display in all triggering modes except AUTO.
TRIGGER SLOPE control	Six-position selector which triggers sweep on either the rising (+) or falling (-) portion of the triggering waveform. Most important application is when a fast sweep is selected.
TRIGGERING MODE control	Selects the mode of triggered operation. Time Base A has five modes, Time Base B has three.
TRIGGER INPUT connector	External trigger is applied.
HORIZONTAL DISPLAY control	Selects the type of display to be presented.
TIME/CM control	Selects the sweep speed in fixed steps.
VARIABLE control	When in CALIBRATED position, sweep speed is read on TIME/CM control. When uncalibrated, sweep speed is continuously variable.
5X MAGNIFIER control	When ON, the center, two centimeter, portion of unmagnified trace is expanded to cover 10 centimeters.
VARIABLE 10-1 control	Controls the gain of the horizontal amplifier for external horizontal input signals.
	Note TIME BASE B controls function same as TIME BASE A.
DELAY-TIME MULTIPLIER control	Sets the delay time duration.
DEL'D TRIG binding post	Delay trigger output available for external use.
+ GATE A and B binding posts	Positive going square wave available for triggering external equipment.
AMPLITUDE CALIBRATOR control	Controls the amplitude of the calibrator square wave in 18 fixed steps.
CAL. OUT connector	Provides connection to calibrator output.
HORIZONTAL POSITION and VERNIER control	Moves sweep trace horizontally.
POWER ON switch	Applies power to oscilloscope.

Figure 4-1. Operating Controls

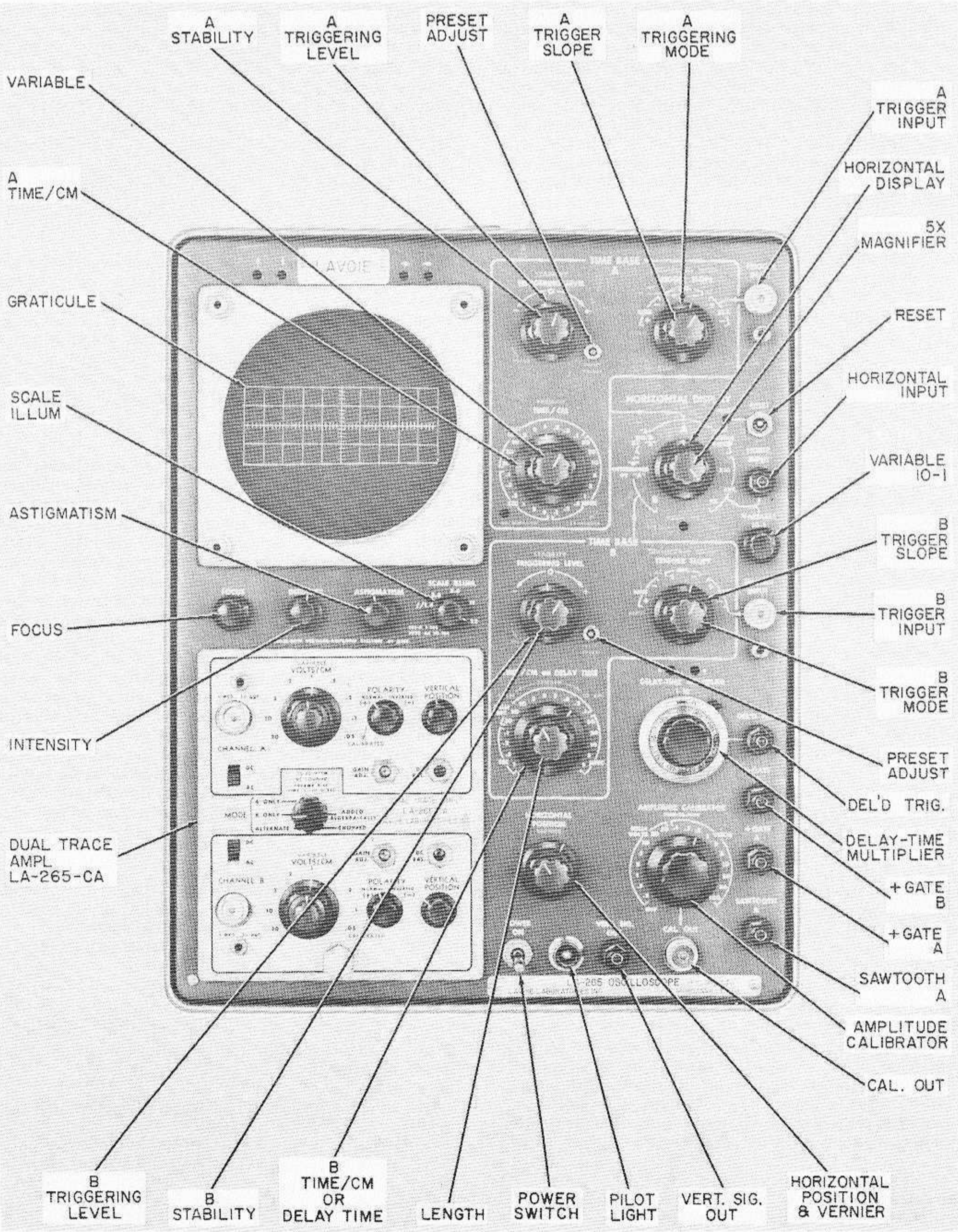


Figure 4-2. Front Panel Operating Controls (LA-265A)

4-16. When the HORIZONTAL DISPLAY control is set to one of the A positions, the front panel controls within the boxed area labeled TIME BASE A, control sweep speed, and sweep triggering selection. When the B positions are selected, the controls within the TIME BASE B area do likewise. When the EXT. position of the HORIZONTAL DISPLAY control is selected, an externally derived waveform deflects the trace horizontally. When the A or B positions are selected, the speed at which the beam sweeps across the crt is determined by the setting of the respective TIME/CM control. The proper position of either TIME/CM control is determined by rotating the control until a display suitable for analysis is obtained. Selecting too fast a speed will cause the waveform to spread across the entire crt, too slow a sweep speed will cause too many cycles to be displayed, thus making it difficult to observe the waveform.

4-17. Time Base A has 24 accurately calibrated sweep speeds when the VARIABLE (red) control is rotated to the CALIBRATED position. In the CALIBRATED position, each centimeter engraving on the graticule is equivalent to the time duration at which the TIME/CM (black) control is set. When the VARIABLE control is rotated from the calibrated position, the UNCALIBRATED lamp is illuminated, and each setting of the TIME/CM control is then continuously variable. In the CALIBRATED position, the TIME BASE A sweep speeds range from .1 microseconds to 5 seconds per centimeter in 24 steps. When uncalibrated operation is selected, the sweep speed range varies from .1 microseconds to 12 seconds per centimeter.

4-18. The TIME BASE B sweep speeds range from 2 microseconds to 1 second per centimeter, in 18 fixed steps. A variable sweep speed is not provided, however, the LENGTH control (red), changes the length of the sweep and is adjustable from four to ten centimeters.

4-19. DELAYED SWEEP OPERATION. Delayed sweep operation affords the operator additional features which increase the versatility of the oscilloscope. Delayed operation provides a means whereby very accurate time duration measurements may be made, accurate analysis of waveform instability can be performed, and many other operations are readily adaptable.

4-20. One mode of delayed sweep operation is selected when the HORIZONTAL DISPLAY control is set to the 'A' DEL'D BY 'B' position. This mode permits continuously variable delay times ranging from one microsecond to 10 seconds after the application of a trigger, before the A sweep generator will produce a trace. When accurate time duration and waveform instability analysis are to be performed, the 'A' DEL'D BY 'B' mode should be utilized.

Note

The TIME BASE A STABILITY control shall be set to the full clockwise position for this mode of delayed sweep operation.

4-21. The amount of delay occurring after the application of the triggering signal, until a trace is presented on the crt, is indicated directly by the setting of the TIME/CM or DELAY TIME and DELAY TIME MULTIPLIER controls. The setting of the two controls are multiplied to obtain the desired time delay. For example, if the TIME/CM or DELAY TIME control is set at the 1 SEC position, and the DELAY TIME MULTIPLIER is set at 5.00, the start of a horizontal sweep trace would not be displayed until five seconds after the application of a triggering signal; provided the TIME BASE A STABILITY control is set full clockwise.

4-22. The second mode of delayed sweep operation differs from that just described in that the start of the delay time is initiated by a trigger applied to Time Base B, but the sweep does not start until Time Base A receives a trigger pulse. The TIME BASE A STABILITY control is not positioned fully clockwise, but for normal triggering. The primary purpose of this mode is to eliminate instability from the displayed waveform.

4-23. The 'B' INTENSIFIED BY 'A' position of the HORIZONTAL DISPLAY presents a display whereby the portion of the sweep trace which is brighter than the rest is the delayed sweep. This mode of delayed sweep operation will only function when the TIME BASE A TIME/CM control is set to a faster sweep speed than the TIME BASE B control. The start of the brightened portion is moved right or left by the DELAY TIME MULTIPLIER, and the length of the brightened portion is adjusted by the TIME BASE A TIME/CM control. To expand a portion of the displayed waveform, the brightened portion of the sweep is positioned to include the portion to be expanded. Then, by rotating the HORIZONTAL DISPLAY control to the 'A' DEL'D BY 'B' position, the brightened portion will expand the full width of the crt (see figure 4-3). The amount of magnification obtainable in this mode is the ratio of the TIME/CM or DELAY TIME control setting to the TIME/CM control setting. An example of this follows:

$$\text{MAGNIFICATION} = \frac{\text{TIME/CM OR DELAY TIME}}{\text{TIME/CM}} = \frac{\text{1MILLISEC}}{\text{1MICROSEC}} = \frac{.001\ \text{SEC}}{.000001\ \text{SEC}} = 1000$$

Thus, in the example, the brightened portion of the sweep is magnified 1000 times.

4-24. In some applications when high magnification is desired, the display intensity is low and difficult to see; and cannot be improved with the INTENSITY control. To remedy this, rotate the HORIZONTAL DISPLAY control back to the 'B' INTENSIFIED BY 'A' position and adjust the SWEEP LENGTH control (red) until the sweep extends only slightly past the brightened portion. Then return the HORIZONTAL DISPLAY control to the 'A' DEL'D BY 'B' position.

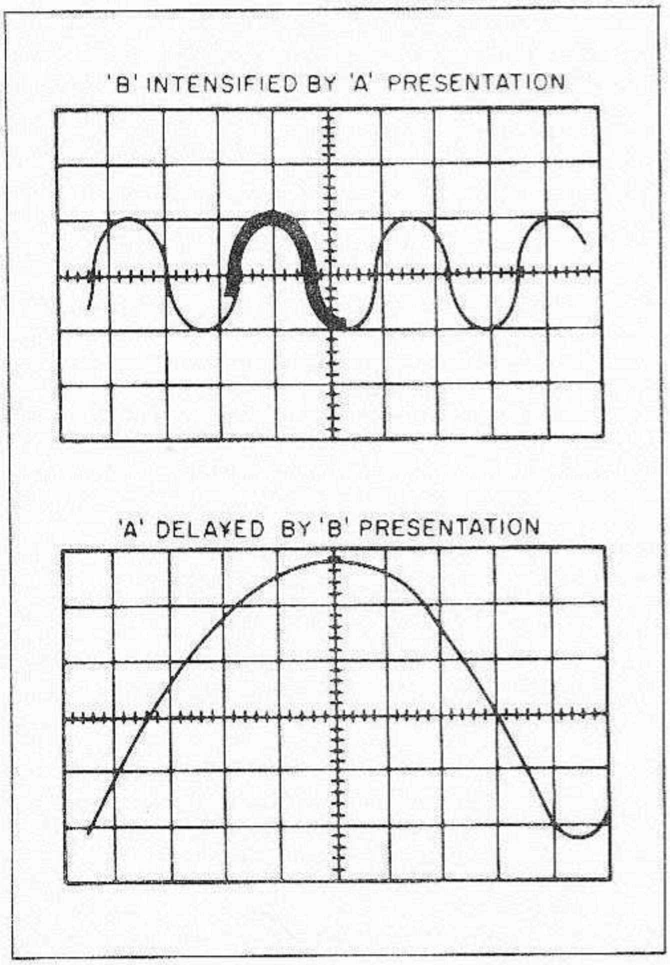


Figure 4-3. Delayed Sweep Magnification Presentation

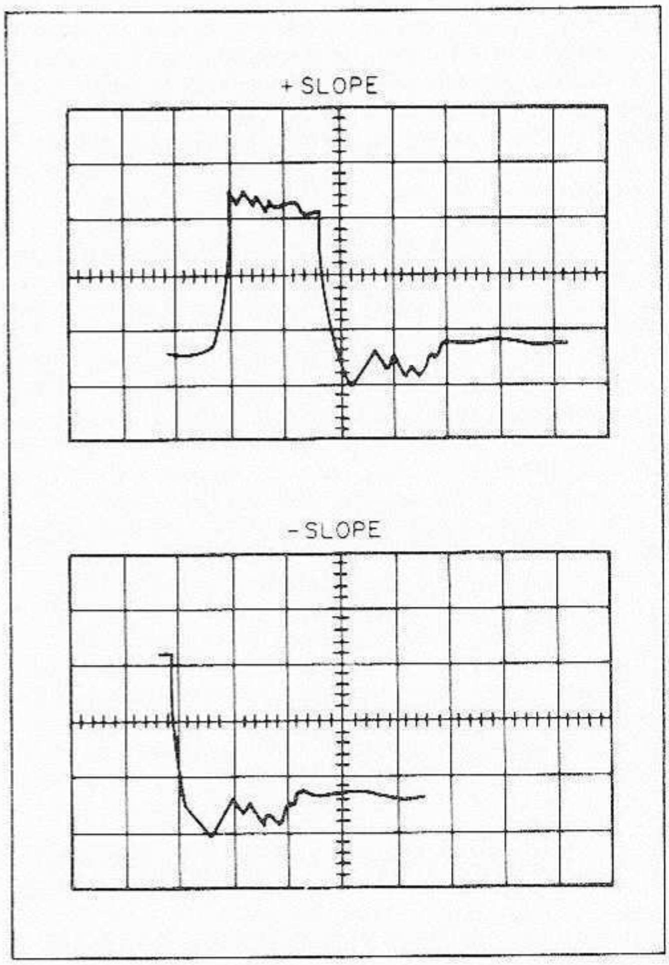


Figure 4-4. Portion of Waveform on Fast Sweep Time When + and - Slope are Selected

4-25. SELECTION OF SWEEP TRIGGER SOURCE, SLOPE AND LEVEL. The ability of the oscilloscope to display the waveform in the same position each time even though it may be reoccurring at a rate of several thousand times per second, is a function of starting the sweep and displaying the waveform with a fixed time relationship. This is accomplished by triggering the sweep start with either the waveform to be displayed or by some external waveform bearing a fixed time relationship. The instructions that follow describe the utilization of the TRIGGER SLOPE, TRIGGERING MODE, TRIGGERING LEVEL, and STABILITY controls. Usage of these controls is similar for both TIME BASE A and B operation.

4-26. Triggering from the displayed waveform is most commonly used (internal triggering). This source of triggering is selected by setting the TRIGGER SLOPE control to either the +INT or -INT position. This source is convenient and no external cable connections must be made, and in most cases satisfactory results are obtained.

4-27. Extremely stable triggering is obtained when it is desired to observe a waveform which has some relationship to the line frequency, by setting the TRIGGER SLOPE control to the +LINE or -LINE position.

4-28. External triggering is accomplished by connecting the external trigger source to the TRIGGER INPUT connector, and setting the TRIGGER SLOPE control to either the +EXT. or -EXT. position. Because an external trigger source always remains constant in amplitude and frequency, it is possible to observe shaping and amplification of a signal in the external equipment without resetting the oscilloscope controls for each observation. An additional advantage of external triggering is that time and phase relationships can be observed. If, for example, the external trigger source is obtained from the input to a stage or circuit, the waveforms displayed on the crt from other points within the same stage or circuit contain a definite time and phase relationship to the input signal, and will be presented on the crt accordingly. The external mode of triggering is the only one of the three which provides the operator with a means of observing and measuring waveform jitter, but to do this, the external trigger must be known to be a stable triggering source.

4-29. SELECTION OF + OR - TRIGGER SLOPE. (See figure 4-4.) When the TRIGGER SLOPE control is set to the + position, the sweep is triggered on the rising portion of the triggering waveform. If the - position is selected, triggering occurs on the falling portion. In many applications the triggering slope is not important. In some applications, such as observation of a pulse on a fast sweep speed, to observe the leading edge of the pulse it would be necessary to trigger with the + slope. If it were desired to observe the trailing edge of the pulse, the - slope position must be utilized.

4-30. SELECTION OF TRIGGER MODE. After the triggering source and triggering slope have been selected, the next step is to select the most useful mode. Sweep generator A has five triggering modes DC, AC, AC LF REJECT, AUTO, and HF SYNC. Sweep generator B has only three modes; DC, AC, and AUTO. The primary consideration in selecting the above triggering modes is whether or not it permits you to obtain the desired display with or without a CRT base line reference. In all positions of the TRIGGERING MODE switch except AUTO, no base line will appear on the CRT until either the time base generator is triggered with an input signal or forced to free-run by advancing the STABILITY control. In the AUTO triggering mode, the time base generator will free-run in the absence of an input signal and provide a convenient base line reference. The brilliance of the base line will remain constant regardless of whether an input signal is present or not because the sweep will continue to run at the rate set by the sweep controls.

4-31. AUTO TRIGGERING MODE. The AUTO mode should be selected first, since it usually provides the desired triggering in most cases, without the necessity of adjusting the STABILITY or TRIGGERING LEVEL controls. If satisfactory triggering cannot be obtained in the AUTO mode, then it will be necessary to try one of the other modes. In the AUTO mode it is only necessary to select the triggering source (INT., LINE, or EXT), and the triggering slope (+ or -).

4-32. DC TRIGGERING MODE. When triggering in the frequency range of dc to five megacycles, excellent triggering is obtained by setting the TRIGGERING MODE control to the DC position. In this mode, the TRIGGERING LEVEL control is operative, and permits the operator to select the point on the triggering waveform at which the sweep generator will be triggered.

4-33. When operating in the DC mode, the operator must adjust the STABILITY and TRIGGERING LEVEL controls after the triggering source and slope have been selected. It is further necessary to adjust the STABILITY control before setting the TRIGGERING LEVEL control. Adjustment of these two controls is identical for the AC, DC and AC LF REJECT modes.

4-34. To properly set the STABILITY and TRIGGERING LEVEL controls proceed as follows:

a. Rotate the STABILITY control fully counterclockwise to the PRESET position.

b. Rotate the TRIGGERING LEVEL control toward either the +, -, or 0 position to obtain the desired display (see figure 4-5).

4-35. If it is difficult or impossible to obtain triggering with the STABILITY control set at the PRESET position, proceed as follows:

a. Rotate the TRIGGERING LEVEL control fully counterclockwise.

b. Rotate the STABILITY control slowly from the PRESET position until the sweep trace just appears (free running), then just back off until the sweep trace just disappears.

c. Rotate the TRIGGERING LEVEL control clockwise until the sweep trace and desired display is obtained.

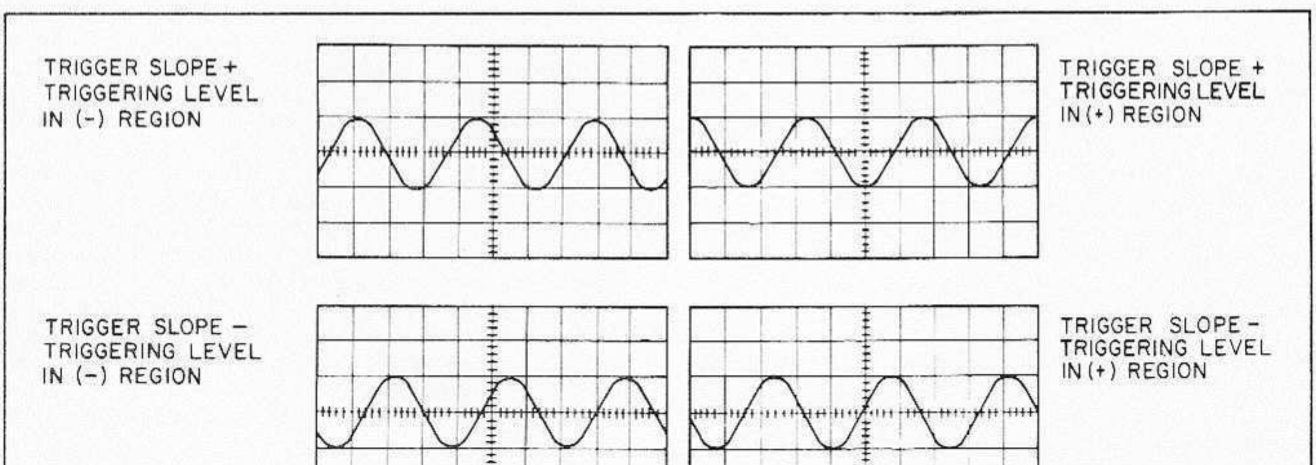


Figure 4-5. Displays as Effected by Trigger Level Control

4-36. The TRIGGERING LEVEL control determines the point on the triggering waveform at which the sweep generator will be triggered. If the display is vertically centered under the graticule, setting the TRIGGERING LEVEL control to the 0 position will cause the sweep generator to be triggered at approximately the mid-voltage point of the display. The + region causes sweep triggering to occur on more positive portion of the waveform. Likewise, the - region causes triggering on the more negative portion of the waveform.

Note

When operating in the DC mode, rotation of the preamplifier VERTICAL POSITION control will change the point on the triggering waveform where the sweep is started.

4-37. AC TRIGGER MODE. The AC mode of triggering has one advantage over the DC, in that it is not effected by the VERTICAL POSITION control, or by the dc component of the triggering signal. Generally, good triggering is provided in the frequency range of 15 cycles to five megacycles. Setting of the STABILITY and TRIGGERING LEVEL controls is the same as described for the DC mode of operation.

4-38. AC LF REJECT TRIGGERING MODE. The AC LF REJECT mode is similar to the AC mode, except that it rejects low frequency noise and pickup. Thus, it is ideally suited for triggering purposes when it is necessary to use a high frequency that also has some line frequency or low frequency noise components. Obtaining stable triggering with frequencies below 1000 cycles cannot be expected in this mode. Setting of the STABILITY and TRIGGERING LEVEL controls is the same as described for the DC mode of operation.

4-39. HF SYNC TRIGGERING MODE. When it is desired to display a waveform with frequencies higher than five megacycles, the HF SYNC mode must be used. In this mode, the TRIGGERING LEVEL control is non-operative. The sweep trace and display is obtained by starting from the counterclockwise position of the STABILITY control and rotating clockwise until a trace and stable display appear.

Note

The PRESET position of the STABILITY control is non-operative in the HF SYNC MODE of operation.

4-40. FREE-RUNNING SWEEP OPERATION. In unusual cases, it may be desired to trigger the equipment under test with a waveform obtained from either the + GATE, or SAWTOOTH A posts located on the front panel, which then synchronizes the equipment with the sweep. (See figure 4-6.) In this method of synchronization, the sweep free-runs. The sweep can be made to free-run with any setting of the TRIGGERING MODE switch, by rotating the STABILITY control fully clockwise. The number of sweeps per second is determined by the setting of the TIME/CM controls.

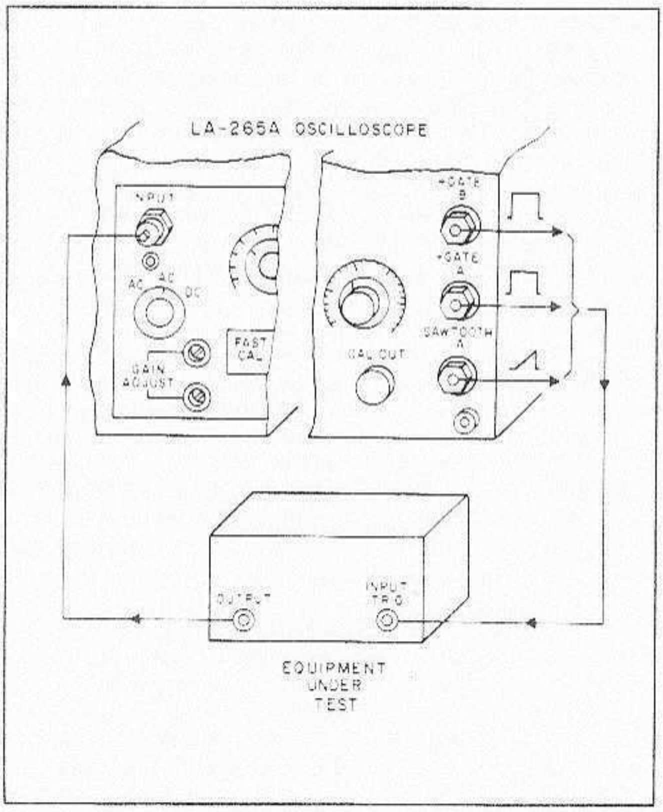


Figure 4-6. Synchronizing External Equipment With + Gate or Sawtooth Output

4-41. SINGLE SWEEP OPERATION. Single sweep operation is advantageous when the displayed waveform is not repetitive, or varies in amplitude, shape, or time duration. Single sweep operation affords a means of observing such a waveform, which otherwise might be displayed as a jumbled presentation. By rotating the HORIZONTAL DISPLAY control to the 'A' SINGLE SWEEP position, a single sweep, initiated by depressing the RESET button, eliminates repetitive sweeps and a clear display is presented. When the STABILITY control is set fully clockwise, unless the TRIGGERING MODE switch is in the AUTO position, a single sweep runs immediately each time the reset button is depressed. However, if the TIME BASE A controls are set for triggered operation with the TRIGGERING MODE control in other than the HF SYNC position, the single sweep does not occur when the RESET button is depressed, unless a triggering signal is applied to sweep generator A. Instead, the READY lamp illuminates to indicate the sweep is ready to be triggered. When a triggering signal is applied, the single sweep runs and the READY lamp goes out. This process is repeated each time the RESET button is depressed.

4-42. DELAYED TRIGGER OPERATION. The DEL'D TRIG binding post furnishes a delayed trigger pulse which can be utilized to initiate some action after a desired delay period. The delay period is determined by the setting of the TIME BASE A or TIME BASE B, TIME/CM controls multiplied by the DELAY TIME MULTIPLIER setting. This provides an adjustable delay from 0.1 microsecond to 50 seconds. With the

HORIZONTAL DISPLAY switch on "A" or "A" SINGLE SWEEP the trigger delay is determined by the TIME BASE A controls and the delay period occurs after the start of the sweep. In all other positions of the HORIZONTAL DISPLAY switch the trigger delay is set by the TIME BASE B controls and the delay period also occurs after the start of the sweep except when using delayed sweep ("A" DEL'D BY "B"). With the HORIZONTAL DISPLAY switch set at "A" DEL'D BY "B" the delayed trigger occurs at the start of the delayed sweep.

4-43. To obtain a delayed trigger you must first adjust the appropriate time-base unit for triggered operation or for free-running operation, depending upon the application. The delay is then set with the appropriate TIME/CM control and the DELAY-TIME MULTIPLIER. The lights above the DELAY-TIME MULTIPLIER control indicate which time-base unit is used to produce the delayed trigger with each setting of the HORIZONTAL DISPLAY control.

4-44. HORIZONTAL EXTERNAL INPUT. When it is desired to plot one function against another, the sweep trace can be deflected horizontally by applying an external waveform to the HORIZ. INPUT binding post. The HORIZONTAL DISPLAY control must be set to either EXT. X1 or EXT. X10. The horizontal deflection factor is continuously variable from approximately 0.2 volts to approximately 15 volts per centimeter with the VARIABLE 10-1 control and the setting of the HORIZONTAL DISPLAY control (X1 or X10).

4-45. SWEEP MAGNIFICATION. The sweep magnification circuitry allows any two-centimeter portion of the sweep to be expanded to the full ten centimeter width of the graticule for a closer observation of a waveform. First, center the portion of the display, using the HORIZONTAL POSITION control, then set the 5X MAGNIFIER control to the ON position. The 5X MAGNIFIER lamp shall illuminate, and the display will expand across the entire graticule. Rotation of the HORIZONTAL POSITION control will allow any portion of the original unmagnified display to be moved into the magnified viewing area.

4-46. AMPLITUDE CALIBRATOR. The 1 KC (approximate) squarewave output from the CAL. OUT connector is used primarily to adjust probes, and check calibration of the vertical deflection circuits. The AMPLITUDE CALIBRATOR control provides 18 fixed peak-to-peak amplitudes, ranging from 0.2 millivolts to 100 volts, and is ±3 percent accurate when a high impedance output load is connected.

4-47. INTENSITY MODULATION. Intensity modulation of the crt can be applied when additional information such as time markers are desired. A positive external modulation signal of approximately 25 volts is required. The intensity modulation signal is connected to the EXTERNAL CRT CATHODE binding post (located on the rear of the oscilloscope), and the grounding bar must be removed. In addition, the CRT CATHODE SELECTOR switch, also located on the rear of the oscilloscope, must be in the EXTERNAL CRT CATHODE position.

4-48. DUAL TRACE OPERATION. When Plug-in Preamplifier LA-265-CA is being used in the chopped mode to provide dual trace operation, the CRT CATHODE SELECTOR switch (located on the rear of the oscilloscope) should be set to the DUAL TRACE CHOPPED BLANKING position to eliminate switching transients from being displayed on the crt.

4-49. PROBE ADJUSTMENT. Before using a probe, it must be checked to ensure its input capacitance has been standardized to the preamplifier being used. Proceed as follows to check and adjust the probe prior to use:

a. Set controls as indicated:

1.	HORIZONTAL DISPLAY	A
2.	A TRIGGERING MODE	AUTO
3.	A TRIGGER SLOPE	+INT
4.	AMPLITUDE CALIBRATOR	2 centimeters vertical deflection
5.	TIME/CM	3 to 4 cycles

b. Connect probe to preamplifier INPUT connector.

c. Connect probe tip to CAL. OUT connector.

d. Adjust variable probe capacitor for a flat top display.

SECTION V

PERIODIC INSPECTION, MAINTENANCE, AND LUBRICATION

5-1. INTRODUCTION.

5-2. This section contains instructions pertaining to periodic inspections, general maintenance procedures, and lubrication of the oscilloscope.

5-3. PERIODIC INSPECTION.

5-4. Figure 5-1 outlines an inspection procedure for the oscilloscope.

5-5. MAINTENANCE.

5-6. Maintenance of the oscilloscope is limited to correcting defects or failures discovered during normal operation, or during periodic inspection. If any defective parts must be replaced, be sure to accomplish the calibration procedures described in Section VII.

5-7. MAINTENANCE OF AIR FILTER. The air filter at the rear of the oscilloscope must be cleaned at least once every month under normal operating schedules. More frequent or less frequent operation of the oscilloscope, and local conditions will dictate the individual cleaning times. Normally, the filter is a shiny metal color when clean; visual inspection will quickly determine when cleaning is necessary. The filter is removed by unscrewing two screws and may then be rinsed with running tap water if not excessively dirty, or, if necessary a mild detergent may be used for heavier dirt deposits. After washing, let dry and coat by spraying or dipping the filter as directed in the instructions on the filter.

CAUTION

The filter must be cleaned regularly to prevent overheating of the oscilloscope. In addition, do not operate the oscilloscope (except for maintenance) without the side covers, as they are necessary for proper ventilation.

5-8. SOLDERING CONSIDERATIONS. Good soldering practices such as secure mechanical connections, minimum amount of solder, and joints which are not "cold" shall be observed.

CAUTION

To avoid excessive heat from being applied to the ceramic slots, do not use a soldering iron exceeding 75 watts rating.

Component	Time Period	Inspection
Front panel controls, switches, connectors, lamps, and markings	3 months	Check for security, damage, ease of operation, and cleanliness as applicable.
Fuse holders	3 months	Check for availability and proper value fuse (6ASB) in both the active and spare fuseholders.
Chassis parts, wires, terminal strips and tubes	3 months	Check for mounting, security, signs of discoloration, abraded wires, and cleanliness as applicable.
Probes	3 months	Check for general condition.
Filter	Every month	Check for cleanliness.

Figure 5-1. Periodic Inspection Schedule

5-9. OPERATION ON 210-250 VOLTS LINE INPUT. When shipped by the manufacturer, the oscilloscope is wired for 105 to 125 volts ac operation. The power transformer and fan motor can be connected for 210 to 250 volts ac operation, if desired. Paragraphs 5-10 and 5-11 describe the modification to convert from 105-115 volts to 210-250 volts operation.

5-10. POWER TRANSFORMER CONNECTIONS. When shipped by the manufacturer, power transformer T601 is wired with two bus wires connecting terminals 1 and 2, and 3 and 4. To convert to 210-250 volts ac line input, remove the two bus wires, and connect one bus wire between terminals 2 and 3.

5-11. FAN MOTOR CONNECTIONS. When shipped by the manufacturer, the fan motor is wired for 105-125 volt operation. If the power transformer is rewired for 210-250 volt operation as described in paragraph 5-10, the fan motor shall be rewired as follows. Trace the fan power leads back to the ceramic strip located next to the power transformer. Unsolder the fan lead connected to the fifth slot, and resolder it into the third slot.

5-12. TUBE REPLACEMENT. Standard stock tubes may be used to replace all tubes in the power supply circuitry, however tubes employed in the sweep circuitry are of selected quality and proper performance of the balanced vertical amplifier may require the use of matched pairs. When it is necessary to replace a tube, try several in the circuit, selecting the tube providing the best performance.

WARNING

Personnel must observe extreme caution at all times while performing the following adjustment. A shock condition exists when power is applied.

5-13. CRT RANGE TAP ADJUSTMENT (see figure 5-2). This adjustment shall be performed only when the crt intensity becomes too bright, or too dim and cannot be corrected with the INTENSITY control on the scope front panel. The reason for this condition is due to aging or burning out of the neon tubes in the CRT circuit. The procedure for adjusting the CRT Range tap is as follows:

a. Remove power cord.
b. Remove both side covers.
c. Unsolder bare jumper from tap presently in use.
d. Replace power cord and turn oscilloscope ON.
e. Set controls as follows:

HORIZONTAL DISPLAY	A
A TIME/CM	1 MILLISEC
A TRIGGER MODE	AUTO
MAGNIFIER	OFF
INTENSITY	mid-point

f. Using an insulated tool, move bare jumper (see figure 5-2) from tap to tap until the CRT trace is just visible. (No. 1 tap will cause brightest trace.)
g. When correct tap is found, form jumper wire so no danger of shorting exists, and solder.
h. Replace handle assembly.
i. Replace H.V. assembly cover.
j. Replace side covers.

5-14. LUBRICATION.

5-15. The only points requiring lubrication are the fan motor bearings. (See figure 5-3.) One or two drops of machinery oil conforming to MIL-L-7870 shall be applied every four months to the two points illustrated in figure 5-3.

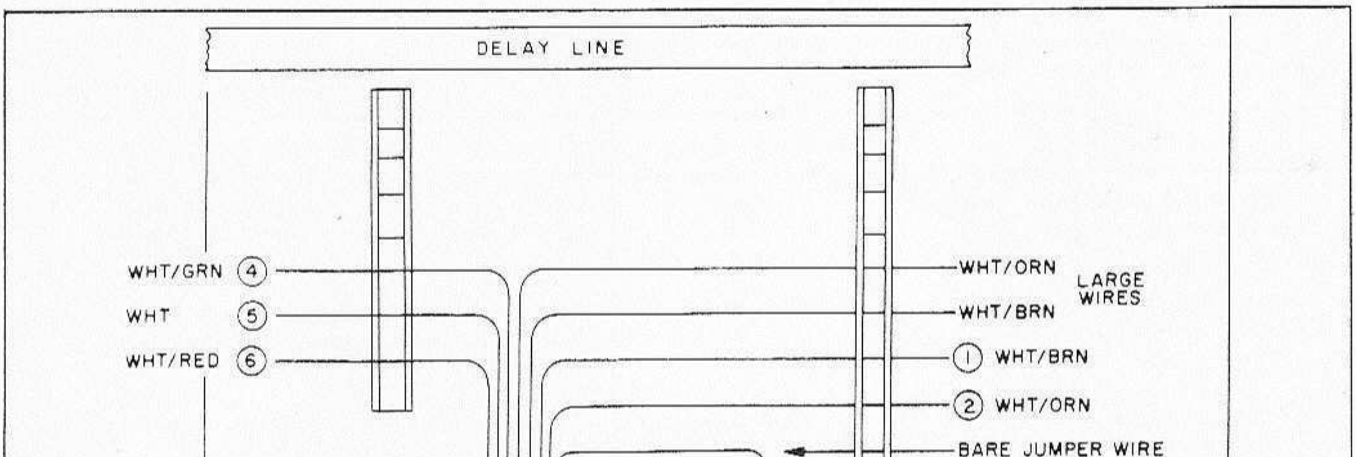


Figure 5-2. CRT Bias Range Tap Adjustment

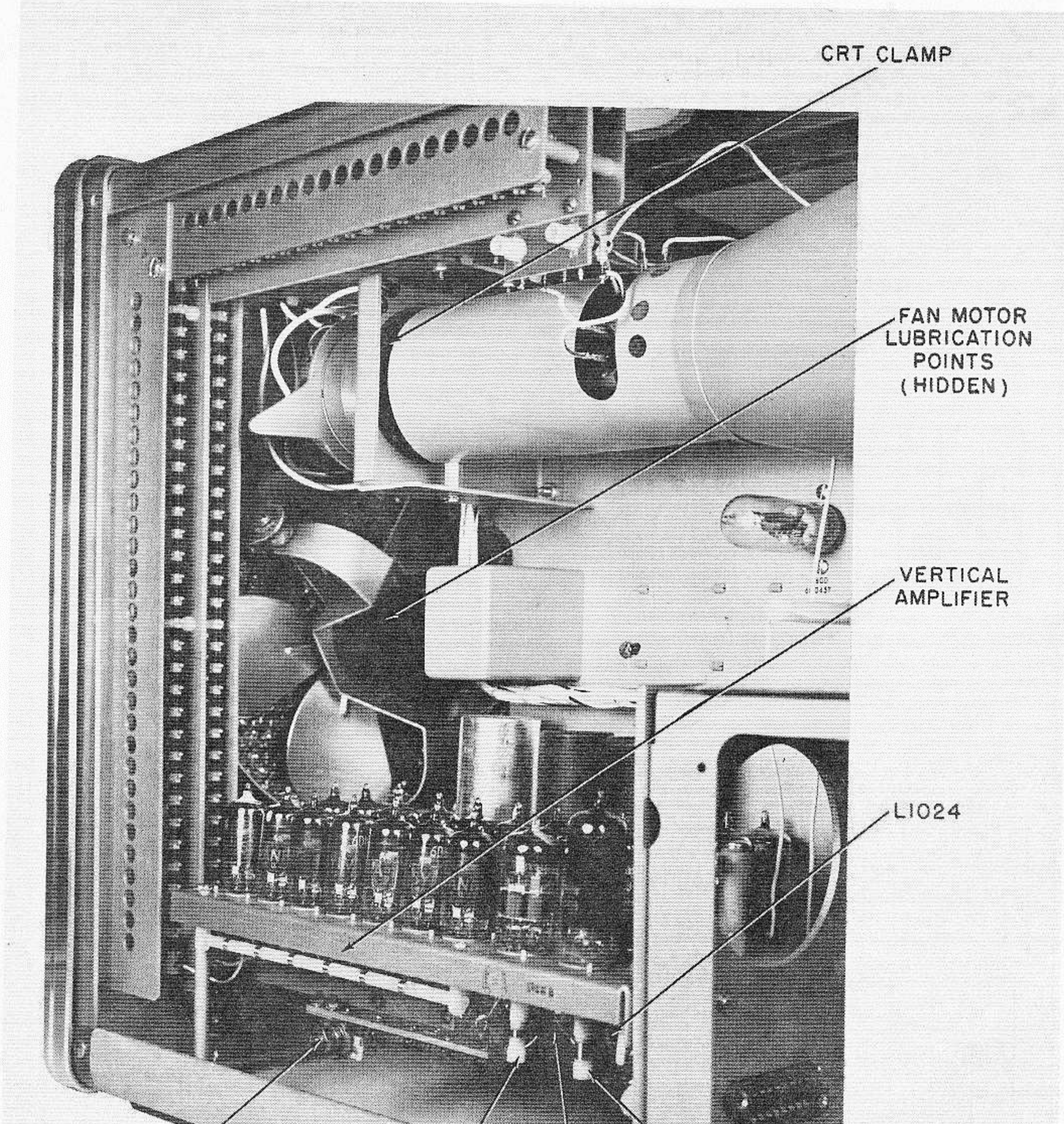


Figure 5-3. Fan Motor Lubrication Points

5-16. WAVEFORM DISPLAYS. (See figure 5-4.)

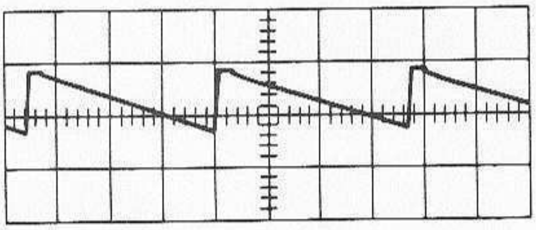
5-17. All waveform and voltage readings were taken under the following conditions and those specified under "conditions" for the individual voltage chart or waveform:

a. All readings taken with respect to ground.
b. All voltage readings taken with VTVM.
c. All waveforms taken with LA-265A oscilloscope.
d. Oscilloscope controls set as follows:

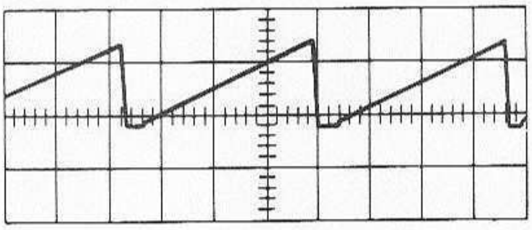
1. POWER ON	ON
2. HORIZONTAL DISPLAY	'A'
3. TIME/C	.5 MILLISEC
4. TRIGGERING MODE	CW
5. TRIGGERING MODE	DC
6. STABILITY	PRESET
7. TRIGGER SLOPE	+EXT
8. LENGTH	CW
9. MAGNIFIER	ON

SWEEP GENERATOR A WAVEFORMS

Note: Conditions as described in paragraph 5-17 and the following:
STABILITY Preset



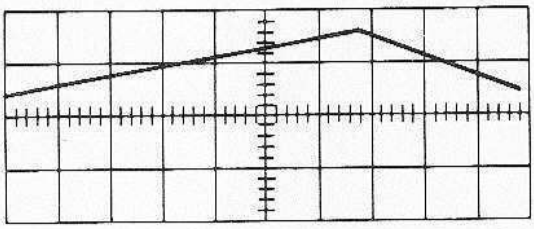
V161, Pin 1 -3.6V



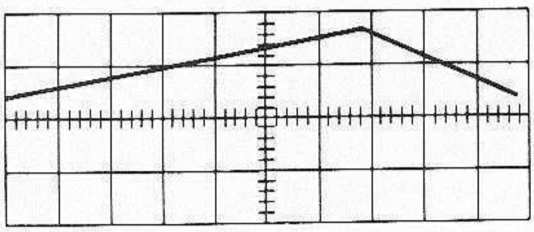
V173, Pin 7, Levels +153 V
-7 V

SWEEP GENERATOR B WAVEFORMS

Note: Conditions as described in paragraph 5-17 and the following:
LENGTH control CW
STABILITY control Preset



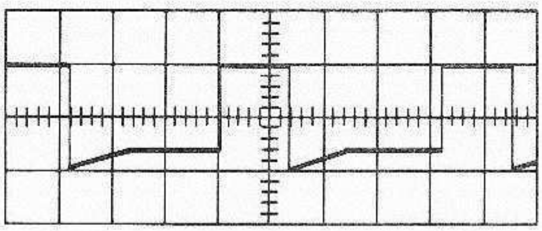
JUNCTION, R281 (4.7 megohm) and R283 (1K ohm)
from Pin 7 V233, Levels -37V
-83V



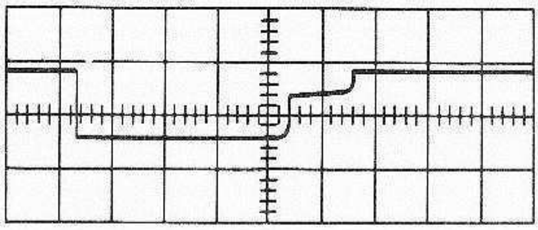
V233, Pin 8, Levels -47V
-65V

Figure 5-4. Significant Waveform Points (Sheet 1 of 4)

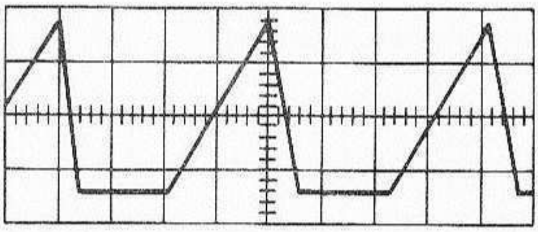
SWEEP GENERATOR B WAVEFORMS (cont)



V235, Pin 8, Levels +86V
+40V



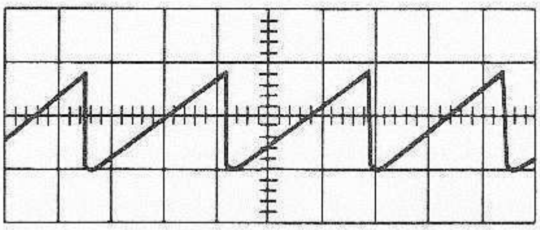
V252, Pin 6, Levels -4V
-7.3V



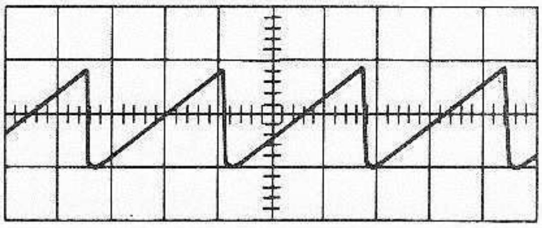
V283, Pin 8, Levels +153V
-7V

HORIZONTAL AMPLIFIER WAVEFORMS

Note: Conditions as described in paragraph 5-17 and the following:
HORIZONTAL DISPLAY "A"



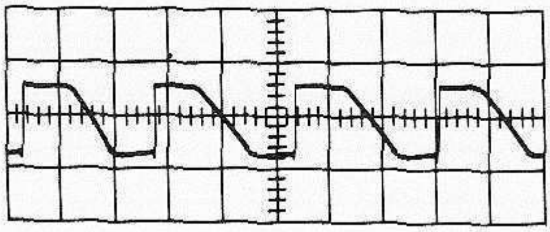
V343, Pin 3, Levels +107 V
+83 V



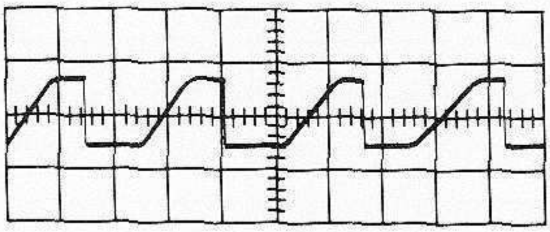
JUNCTION C340 (4.7 uuf) and R341 (100 ohm) from Pin 7, V343

Figure 5-4. Significant Waveform Points (Sheet 2 of 4)

HORIZONTAL AMPLIFIER WAVEFORMS (cont)



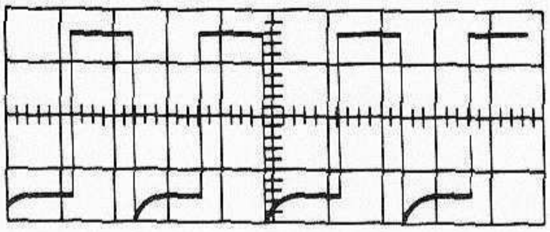
V364, Pin 6, Levels +370 V
+215 V



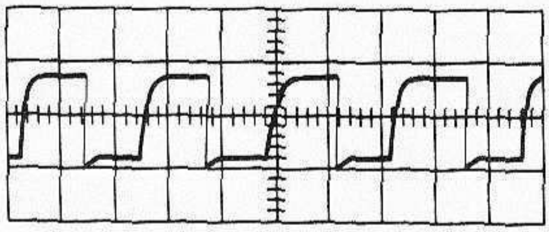
V398, Pin 3, Levels +370 V
+266 V

AMPLITUDE CALIBRATOR WAVEFORMS

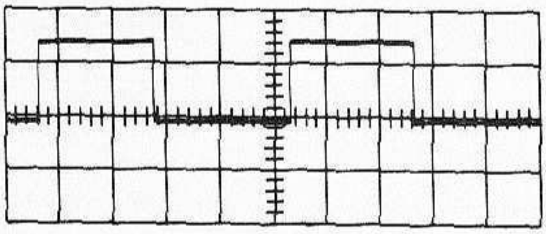
Note: Conditions as described in paragraph 5-17 and the following:
AMPLITUDE CALIBRATOR ON



V875, Pin 5, Levels +100 V
-45 V



V885, Pin 6, Levels 0 V
-140 V

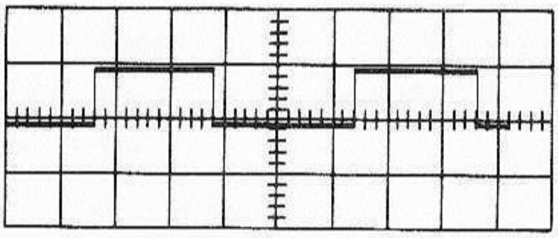


CAL TEST POINT, Levels +100 V
0 V

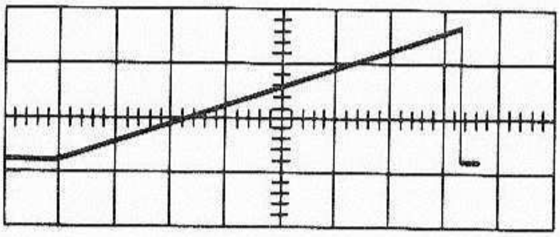
Figure 5-4. Significant Waveform Points (Sheet 3 of 4)

DELAY PICKOFF WAVEFORMS

Note: Conditions as described in paragraph 5-17.



V424, Pin 5, Levels +225 V
+180 V

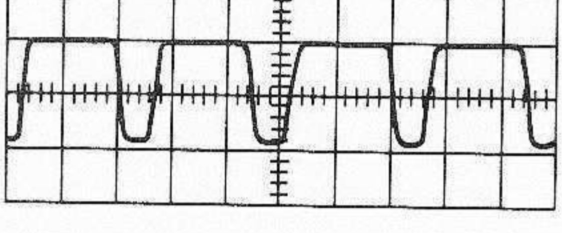


V428, Pin 6, Levels +150 V
+30 V

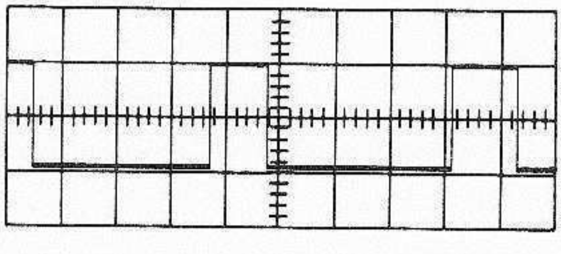
SWEEP GENERATOR A TRIGGER WAVEFORMS

Note: Conditions as described in paragraph 5-17 and the following:

Ext. Trigger Signal	2 Kc
TRIGGERING LEVEL Control	CW



V24, Pin 1, Levels +100 V
+56 V



V45, Pin 6, Levels +228V
+211 V

Figure 5-4. Significant Waveform Points (Sheet 4 of 4)

SECTION VI

TROUBLESHOOTING

6-1. INTRODUCTION.

6-2. GENERAL. Troubleshooting the oscilloscope is not difficult if approached properly. Personnel responsible for servicing the oscilloscope must be thoroughly familiar with the principles of operation as described in Section I, and operating procedures as described in Section IV. Prior to any extensive troubleshooting, determine that the malfunction is not the result of a defective plug-in preamplifier by substituting a known good one. Secondly, determine that the apparent malfunction is not due to improper settings of the operating controls.

6-3. Once it is determined the oscilloscope circuits are the actual cause of malfunction, try to determine from the indications or lack of indications, such as no trace from sweep generator B only, or no vertical deflection, etc., the general area of malfunction. Figures 7-2, 7-3 and 7-8 illustrate the location of the major circuits within the oscilloscope. The next step is to visually inspect the circuit thought to be defective for any signs of overheating, broken parts or solder connections, security of tubes in sockets, and indication of filament operation. If these items appear to be normal, substitute a tube of the same type which is known to be good; do not depend upon tube tester results if substitute tubes are available. If tube substitution does not locate or correct the malfunction, replace all tubes in their original sockets and proceed with detailed troubleshooting procedures as described in figure 6-1, also see the schematic diagram of the affected circuit, located within this section.

CAUTION

Refer to paragraph 5-12 for tubes which are selected, and must be replaced only by selected types.

6-4. To aid the maintenance personnel during troubleshooting, an explanation of the reference symbols found on the schematic diagrams follows. The rotary wafer switches are coded to locate the wafers more readily. For example wafer 3F indicates that this is the front contacts on the third wafer from the front. 2R indicates the rear of the second wafer, etc. In addition, the reference symbols assigned to each circuit are as follows:

a. Sweep Generator A and B Trigger	All symbols less than 100
b. Sweep Generator A	100 series
c. Sweep Generator B	200 series
d. Horizontal Amplifier	300 series
e. Delay Pickoff	400 series
f. Low Voltage Power Supply	600 and 700 series
g. Crt, High Voltage, and calibrator	800 series
h. Vertical Amplifier	1000, 1100 and 1200 series
i. Delay Line	1300 series

6-5. LOCALIZING MALFUNCTION. As previously stated, the indication or lack of indication on the crt is a great help in isolating the trouble to a particular circuit. A procedure using front panel controls is presented whereby the maintenance man should be able to first isolate the malfunction to one of the following nine chassis, and then to proceed to the detailed procedures described in figure 6-1:

a. Low Voltage Power Supply
b. Vertical Amplifier and Delay Line
c. Sweep Generator A Trigger
d. Sweep Generator B Trigger
e. Sweep Generator A
f. Sweep Generator B
g. Crt and High Voltage Power Supply
h. Horizontal Amplifier
i. Calibrator

Note

The LA-265-L Plug-in Preamplifier is recommended for troubleshooting procedures, although any other preamplifier may be utilized.

6-6. CONTROL SETTINGS FOR TROUBLESHOOTING. Set the following controls to the positions indicated unless otherwise specified.

Oscilloscope

a. STABILITY	full clockwise
b. TRIGGERING LEVEL	0
c. TRIGGERING MODE	AC
d. TRIGGER SLOPE	+INT.
e. VARIABLE (TIME/CM)	full clockwise
f. TIME/CM	5 MILLISEC
g. HORIZONTAL DISPLAY	A
h. FOCUS	mid-position
i. INTENSITY	full counterclockwise
j. ASTIGMATISM	mid-position
k. SCALE ILLUM	mid-position
l. HORIZONTAL POSITION	mid-position
m. VERNIER	mid-position

Plug-in Preamplifier

n. VOLTS/CM	1 VOLT
o. VERTICAL POSITION	mid-position
p. AC-DC-ACX10	AC

6-7. The first check to be made is to turn the POWER switch to the ON position. The fan shall start to run immediately. Twenty five seconds later, time delay relay K600 shall close, as indicated by an audible click. If this does not happen, refer to the low voltage power supply section. Adjust the INTENSITY, FOCUS and ASTIGMATISM controls for a normal display. If no display is present, note the Beam Position Indicator neons. If they are illuminated, indicating the sweep trace is driven off the crt, try and position it back with the VERTICAL or HORIZONTAL POSITION controls. If unsuccessful, refer to the vertical amplifier troubleshooting procedures. Trouble within either the sweep generator A trigger, or sweep generator itself, is evident by unstable triggering, no horizontal sweep, non-linear sweep, or insufficient horizontal deflection. A quick check of the B channel will determine if a malfunction in the power supply or horizontal amplifier might be the cause, or if the fault lies within the A channel. A malfunction within the calibrator circuit is evidenced by the lack of, or distorted, square waves.

Trouble	Probable Cause	Remedy
	VERTICAL AMPLIFIER	
No trace or beam on crt	a. Defective low voltage power supply.	1. Calibrate as described in paragraph 7-7. 2. Refer to power supply section of chart.
	b. Crt circuit or high voltage supply defective.	1. Refer to crt and high voltage section of chart.
	c. Dc unbalance in vertical amplifier.	1. Set INTENSITY control to mid-position, STABILITY control full clockwise, and TIME/CM control to 1 MILLISEC. Using insulated screw-driver, short deflection plates on crt marked BLUE (UPPER) and BROWN (LOWER). If trace appears, fault lies in vertical amplifier.
	CAUTION Do not short either pin to pin marked ORANGE, (GEOM), or to crt shield.	
		If trace does not appear, fault may lie in horizontal amplifier which can be checked in the same manner using associated pins.
	d. Delay line defective.	1. Using shorting strap (see figure 6-13), short input of delay line. If trace appears, delay line is not at fault. If trace does not appear, remove power and check for delay line continuity.
	e. Distributed amplifier defective.	1. Connect shorting strap across input to distributed amplifier (control grids of tubes V1104 and V1114). Trace should appear if fault is in distributed amplifier. If trace does not appear, fault lies in input stage. 2. Check for open grid or plate line. 3. Check R1206 and R1216 at grid line termination. 4. Check plate line reverse termination network resistors.
	f. Input stage defective.	1. Check voltages associated with tubes V1014, V1024, V1033, V1043, V1054, V1064. Comparing the results between the two channels, replace parts as necessary.

Figure 6-1. Troubleshooting Chart (Sheet 1 of 7)

Trouble	Probable Cause	Remedy
	VERTICAL AMPLIFIER (cont)	
Insufficient or no vertical deflection	a. Parts affecting gain defective.	1. If slight loss of gain is noticed, recalibrate as described in paragraph 7-31. 2. Check common cathode, grid and plate resistors.
Beam Position Indicator neons not functioning	a. Defective tube.	1. Check tube V1084. 2. Check and replace as necessary associated tube parts.
Waveform Distortion		1. To locate source of distortion apply a 400 Kc square wave from the Model 107 Square Wave Generator using a type L (or K) preamplifier. Set vertical amplitude at 3 cm. and TIME/CM to .2 usec. for initial viewing (other ranges may be used to obtain a better view of the distortion being observed). Adjust for stable display, observe waveform and use data following to assist in locating trouble. Also refer to paragraphs 7-33 through 7-37.

CAUTION

Paragraphs 7-33 through 7-37 shall be read before attempting any of the following adjustments.

Trouble	Probable Cause	Remedy
Overshoot of leading edge	a. Defective preamplifier. b. Cathode interface in vertical amplifier tube. c. Over compensation in Vertical Amplifier. d. Inductors at end of delay line maladjusted. e. Capacitors at crt end of delay line maladjusted.	Check by substitution. If defective see appropriate preamplifier Operation and Service Manual. Check by substitution and replace. Adjust as described in paragraph 7-37c. Adjust as described in paragraph 7-37c. Adjust as described in paragraph 7-37c.
Overshoot plus bumps and wrinkles	a. General maladjustment of delay line. b. Defective distributed amplifier tube.	Adjust as described in paragraph 7-37a, b and c. Check by substitution and replace.
Ringing of leading edge	a. Defective preamplifier. b. Over compensation in Vertical Amplifier.	Check by substitution. If defective, see appropriate preamplifier Operation and Service Manual. Adjust as described in paragraph 7-37c.
Undershoot (roll-off) of leading edge	a. Defective preamplifier. b. Low GM tube in Vertical Amplifier. c. Insufficient high frequency compensation. d. Shorted Turns on peaking coils. e. Inductors at end of delay line maladjusted. f. Capacitors at crt end of delay line maladjusted.	Check by substitution. If defective, see appropriate preamplifier Operation and Service Manual. Check by substitution and replace. Adjust as described in paragraph 7-37c. Check and replace. Adjust as described in paragraph 7-37c. Adjust as described in paragraph 7-37c.

Figure 6-1. Troubleshooting Chart (Sheet 2 of 7)

Trouble	Probable Cause	Remedy
VERTICAL AMPLIFIER (cont)		
Long duration bumps on top portion.	a. Group of delay line capacitors maladjusted.	Adjust as described in paragraph 7-37b.
Short duration bumps at random intervals on top portion.	a. General maladjustment of delay line.	Adjust as described in paragraph 7-37a, b, and c.
Single short duration bump on top portion.	a. Single maladjusted delay line capacitor. b. Snapped lead from L1104 or L1114 to plate of distributed amplifier tube.	Adjust as described in paragraph 7-37a, b, and c. Visually check and repair.
Upward or downward step from leading edge to termination bump.	a. Plate line reverse termination maladjusted.	Adjust as described in paragraph 7-37a. If proper adjustment cannot be be obtained, see Plate Line Termination troubleshooting chart.
PLATE LINE REVERSE TERMINATION		
Upward or downward step from leading edge to termination bump.	a. Plate line reverse termination maladjusted.	1. Adjust as described in paragraph 7-37a. If waveform still indicates maladjustment proceed as follows: a. Shut off oscilloscope, set potentiometer R1043 for maximum resistance and connect one terminal of Wheatstone Bridge to junction of resistors R1030 and R1040. b. Connect other terminal of bridge to junction of resistors R1035 and R1085 and measure resistance. Resistance must be between 625 and 650 ohms. c. If less than 625 ohms, substitute 180 ohm, 1 watt 5% resistors for resistors R1033, R1034, and R1035 as required to obtain a resistance within the range mentioned in step b. Note precise value of resistance measured. d. Move Wheatstone Bridge from junction of R1035 and R1085 to junction of resistors R1045 and R1089. Measure resistance. Resistance shall be the same as the final value in step c within ±1%. If not replace resistors R1042, R1044 and R1045 as required to obtain 1% match. e. Leaving bridge connected as in step d, adjust potentiometer R1043 to obtain a resistance reading of 620 ohms.
SWEEP GENERATOR TRIGGER CIRCUIT		
NOTE The troubleshooting procedures that follow are for sweep generator trigger A, but the procedure for B is identical.		
Unstable triggering	a. Defective pickoff tube.	1. Check for trigger at VERT. SIG. OUT binding post.

Figure 6-1. Troubleshooting Chart (Sheet 3 of 7)

Trouble	Probable Cause	Remedy
SWEEP GENERATOR TRIGGER CIRCUIT (cont)		
Unstable triggering (cont)		2. Replace tube V1223 in vertical amplifier if no trigger in step 1.
	b. Defective input amplifier tube.	1. Substitute new tube for V24. 2. Check associated circuit parts.
	c. Defective trigger multivibrator stage.	1. Substitute tube for V45. 2. Recalibrate stage as described in paragraph 7-13.
SWEEP GENERATOR		
No sweep trace	a. Miller run-up circuit defective.	1. Measure voltage at grid of tube V161 with VTVM or 20,000 ohm per volt meter. If reading is -15 volts or more, check tubes V152, V173, and resistors R147 and R148. 2. If indication in step 1 is close to zero volts, measure plate voltage on tube V161. If approximately +350 volts is indicated, check tube V173 and neon tube B167. If plate voltage is zero or slightly negative check resistors R164, R165 and R166. 3. If plate voltage of tube V161 is approximately +45 volts, check all other tubes in sweep generator circuit. 4. If all tubes have been checked, check for open plate or cathode resistors, in the sweep gating multivibrator, hold-off and run-up cathode follower circuits. 5. Determine that the STABILITY control varies the voltage at grid of tube V153B.
Improper triggering, free running	a. Sweep gating multivibrator defective.	1. Check to see if free running operation can be obtained in AUTO or with STABILITY control. If normal, check tubes V153 and V135, V114. 2. Check capacitor C131.
Non-linear sweep	a. Defective timing capacitor or miller run-up tube.	1. Check tube V161 if non-linearity occurs on all sweep speeds. 2. Defective timing capacitor, check and replace. 3. If non-linearity occurs on fast sweep speeds only, check capacitor C165.
Insufficient horizontal deflection, sweep timing normal	a. Defective Hold-off circuit.	1. Check tubes V133 and V183, replace as necessary. 2. Check associated circuit parts. 3. Check cathode resistance for tube V173. 4. Recalibrate Swp Length R176 as described in paragraph 7-26.
Erratic sweep start	a. Defective tubes.	1. Check tube V152A. 2. Check tube V173A.
	b. Defective resistors.	1. Check resistor R117. Resistance must be 22K ±5%. 2. Check resistor R172. Resistance must be 8.2K ±5%.
"B" sweep time error	a. Misadjustment of capacitor C260	1. Adjust as described in paragraph 7-29. Check as described in paragraph 7-62.
	b. Series padding resistors.	1. Select new padding resistors as described in paragraph 6-8.

Figure 6-1. Troubleshooting Chart (Sheet 4 of 7)

Trouble	Probable Cause	Remedy
	HORIZONTAL AMPLIFIER	
No beam or trace on crt	DC unbalance in horizontal amplifier.	1. Perform check as described for vertical amplifier using RED (LEFT) and GREEN (RIGHT) deflection plates. 2. Using shorting strap, short like elements of tubes in push-pull circuits, starting at deflection plate end and move back. Example, short the grid of tube V364A to grid of V384A. When a state is reached where the trace does not appear, check for defective parts.
Insufficient or no horizontal deflection	a. Out of calibration. b. Parts affecting gain defective.	1. Recalibrated as described in paragraph 7-26. 1. Check tubes, and common cathode resistors.
	CRT AND HIGH VOLTAGE	
No beam or trace on crt	a. Defect in horizontal or vertical amplifiers.	Refer to applicable portion of this chart.

NOTE

If the no beam or trace trouble is due to a malfunction in either horizontal or vertical amplifier, it can be distinguished from the crt and high voltage malfunction. With ambient light at a low level, turning the INTENSITY control full clockwise will cause a glow to appear on the crt when the horizontal or vertical amplifier is defective.

Trouble	Probable Cause	Remedy
	b. High voltage supply defective.	1. Voltage at H. V. Adj. test point should indicate approximately -1350 volts, if not, check and replace tubes V800, V814 and V822 as necessary. 2. Check tubes V832, V842 and V852. They should be glowing if operating properly; if all are not glowing, tube V800 or circuit is defective. 3. Since V800 oscillates at approximately 60 KC, its operation can be checked by measuring for approximately -6.5 volts at the control grid.
	c. Crt defective.	1. Replace as necessary.
Intensity of trace very bright, cannot be decreased, or intensity very dim, cannot be increased with INTENSITY control.	a. Bias supply defective	1. Check tube V822, replace as necessary. 2. Check for open between crt grid (pin 3) and INTENSITY control R826. 3. Check and replace crt as necessary. 4. Select different tap on CRT neon coupling assy (see figure 6-12 and paragraph 5-13) as follows: a. Remove power cord. b. Remove both side covers. c. Unsolder bare jumper from tap presently in use. d. Replace power cord and turn oscilloscope ON.

Figure 6-1. Troubleshooting Chart (Sheet 5 of 7)

Trouble	Probable Cause	Remedy
CRT AND HIGH VOLTAGE (cont)		
Intensity of trace very bright, cannot be decreased, or intensity very dim, cannot be increased with INTENSITY control. (cont)		e. Set controls as follows: HORIZONTAL DISPLAY — A A TIME/CM — 1 MILLISEC A TRIGGER MODE — AC A STABILITY — fully clockwise MAGNIFIER — OFF INTENSITY — mid-point f. Using an insulated tool, move bare jumper (see figure 5-2) from tap to tap until the CRT trace is just visible. (No. 1 tap will cause the brightest trace.) g. When correct tap is found, form jumper wire so no danger of shorting exists, and solder. h. Replace handle assembly. i. Replace H. V. assembly cover. j. Replace side covers.

CAUTION

If any parts in the crt or high voltage supplies are changed, including tubes, a complete recalibration of the oscilloscope shall be performed.

Trouble	Probable Cause	Remedy
LOW VOLTAGE POWER SUPPLY		

WARNING

Personnel must at all times observe extreme caution when working on the power supplies as voltages dangerous to life exist.

Trouble	Probable Cause	Remedy
Power ON lamp and fan non-operative when POWER ON switch is ON.	a. Power cord.	1. Check that power cord is fastened securely at both ends.
	b. Fuse F601 defective.	1. Check for blown fuse, replace as necessary.
	c. Heat interlock open.	1. Check terminal cut-out TK601 for operation (fan will operate even though TK601 is open).
All regulated supplies too high or too low.	-150 volt supply defective.	Adjust -150 volt adj. as described in paragraph 7-7.

Note

Figure 7-2 illustrates the points at which each power supply may be measured. The following troubleshooting procedures apply to all five regulated supplies, -150, +100, +225, +350, and +500 VDC.

Figure 6-1. Troubleshooting Chart (Sheet 6 of 7)

Trouble	Probable Cause	Remedy
LOW VOLTAGE POWER SUPPLY (cont)		
Output voltage too high with excessive ripple.	a. Line voltage too high. b. DC amplifier, difference amplifier or series regulator defective. c. Insufficient load.	1. Check line voltage. 1. Check and replace tube as necessary. 1. Check for voltage throughout oscilloscope.
Output voltage high, but ripple is normal	Dividers defective.	Check value of dividers using accurate test equipment (dividers use 1% resistors).
Output voltage low with excessive ripple.	a. Low line voltage. b. Shorted voltage regulator tube. c. Series regulators defective d. Excessive loading. e. Open or leaky filter capacitor. f. Defective rectifiers.	1. Check and adjust. 1. Check and replace as necessary. 1. Check and replace as necessary. 1. Check for circuit which might be drawing excessive current, such as a tube plate glowing red. 1. Substitute for suspected capacitor. 1. With power off, measure front to back resistance of diodes; must indicate at least a 1-10 ratio.
Output voltage low, ripple is normal.	Defective divider resistor or capacitor.	Check and replace as necessary.
CALIBRATOR		
Calibrator square-wave non-symmetrical.	a. Calibrator multivibrator tube defective. b. Defective capacitor or resistor in multivibrator circuit.	1. Check and replace tubes V885 and V875 as necessary. 1. Check capacitor C871 and C874, and associated discharge resistors. 2. Check value of resistors R870 and R875. 3. Check value of plate load resistor for tube V875.
Calibrator voltage incorrect	a. Requires calibration. b. Precision divider network defective.	1. Recalibrate as described in paragraph 7-8. 2. Check tubes, replace as necessary. 1. Check value of resistors in cathode of tube V875.

Figure 6-1. Troubleshooting Chart (Sheet 7 of 7)

6-8. "B" SWEEP PADDING RESISTOR SELECTION. Proceed as follows:

a. Set the following controls on the oscilloscope as indicated.

HORIZONTAL DISPLAY	A
TRIGGERING MODE (A)	AC
TRIGGER SCOPE (A)	+INT.
TIME/CM (A)	1 MILLISEC
5X MAGNIFIER	ON
VOLTS/CM (L plug-in)	2

b. Set power input using VARIAC and AC voltmeter to exactly 117 volts. Maintain this voltage for all adjustments. Connect 180A time mark generator to vertical INPUT.

c. Adjust R1602 (see figure 7-6) to midrange. Obtain 1 millisecond and 100 microsecond markers from Time Mark Generator and adjust "A" TRIGGER for a stable display.

d. Adjust MAG. GAIN potentiometer (see figure 7-4) to obtain a 1 millisec marker every 5 centimeters and two 100 usec markers every centimeter.

e. Set sweep magnifier registration by leaving MAGNIFIER ON, and adjusting HORIZONTAL POSITION until the first marker falls on the center graticule line. Turn MAGNIFIER OFF and adjust NORM/MAG REGIS potentiometer (see figure 7-4) to restore the marker to this position if required.

f. Adjust sweep by setting oscilloscope controls as indicated.

HORIZONTAL DISPLAY	A
TIME/CM (A)	1 MILLISEC
TRIGGERING MODE	AC
TRIGGER SCOPE	+INT.
5 X MAGNIFIER	OFF
VOLTS/CM (L Plug-in)	2

g. Using 1 millisec markers from the Time Mark Generator, adjust "A" sweep controls for a stable display. Adjust SWP CAL potentiometer R348 (see figure 7-2) for 1 time mark per centimeter.

h. Set oscilloscope controls as indicated.

HORIZONTAL DISPLAY	B
TIME/CM (B)	2 MILLISEC
TRIGGERING MODE	AC
TRIGGER SCOPE	+INT.
5X MAGNIFIER	OFF
VOLTS/CM (L Plug-in)	2

i. With the Time Mark Generator connected to the vertical INPUT, use 1 millisec markers and adjust "B" sweep controls for a stable display. Line up leading edge of first time mark with first horizontal centimeter division. The display shall be 2 time marks per centimeter. The leading edge of the last time mark shall line up with the ninth horizontal centimeter division ±3%.

j. If display is in error, turn off scope and disconnect one end of the carbon padding resistor portion of R260A mounted on the sweep time switch.

k. Obtain a potentiometer about 25% higher in value than the color coded resistor, and using short clip leads, connect the center tap and one end across the resistor tie points.

l. Turn scope ON, and after stabilization, adjust the potentiometer to obtain the correct timing as indicated by the display. Without disturbing shaft position remove potentiometer and measure adjusted value with resistance bridge.

m. Select a carbon resistor within 5% of this value and connect it in place of the original padding resistor.

n. Repeat steps j through m, to check, and replace if necessary the padding resistors used in conjunction with timing resistors R260 B, C, D, E, and F, as shown below. Adjust padding resistors in the same order shown in the table, as the final values are interactive, R260 A, B and C, and also R260 D, E, F being series connected.

Time Base B TIME/CM	Time Mark Generator	Marker Displayed	Timing Resistor
2 millisec	1 millisec	2/CM	R260A
5 millisec	5 millisec	1/CM	R260B
10 millisec	10 millisec	1/CM	R260C
.2 second	100 millisec	2/CM	R260D
.5 second	500 millisec	1/CM	R260E
1 second	1 second	1/CM	R260F

o. Steps j through n correct all "B" sweep rates except .1 MILLISEC and faster. While these rates are also timed by resistors R260 A, B, and C (see figure 6-9) they are also provided with capacitive trimmers. Capacitor C260 A adjusts the 2.5 and 10 usec rates and C260 B adjusts the 20 and 50 usec and 1. millisec rates. After correcting the timing resistors as described in steps j through n, these capacitors should be adjusted as described in paragraph 7-29.

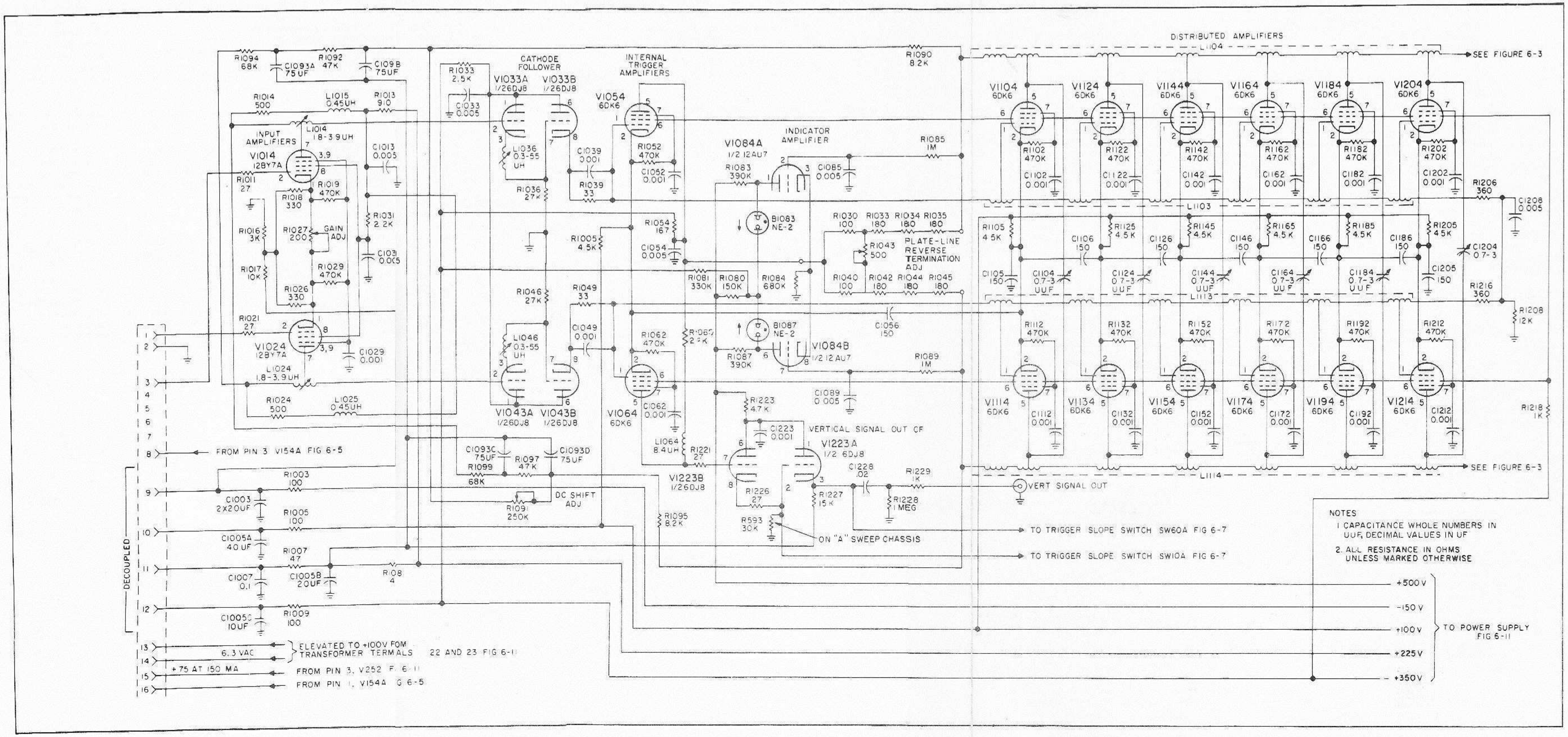


Figure 6-2. Vertical Amplifier, Schematic Diagram

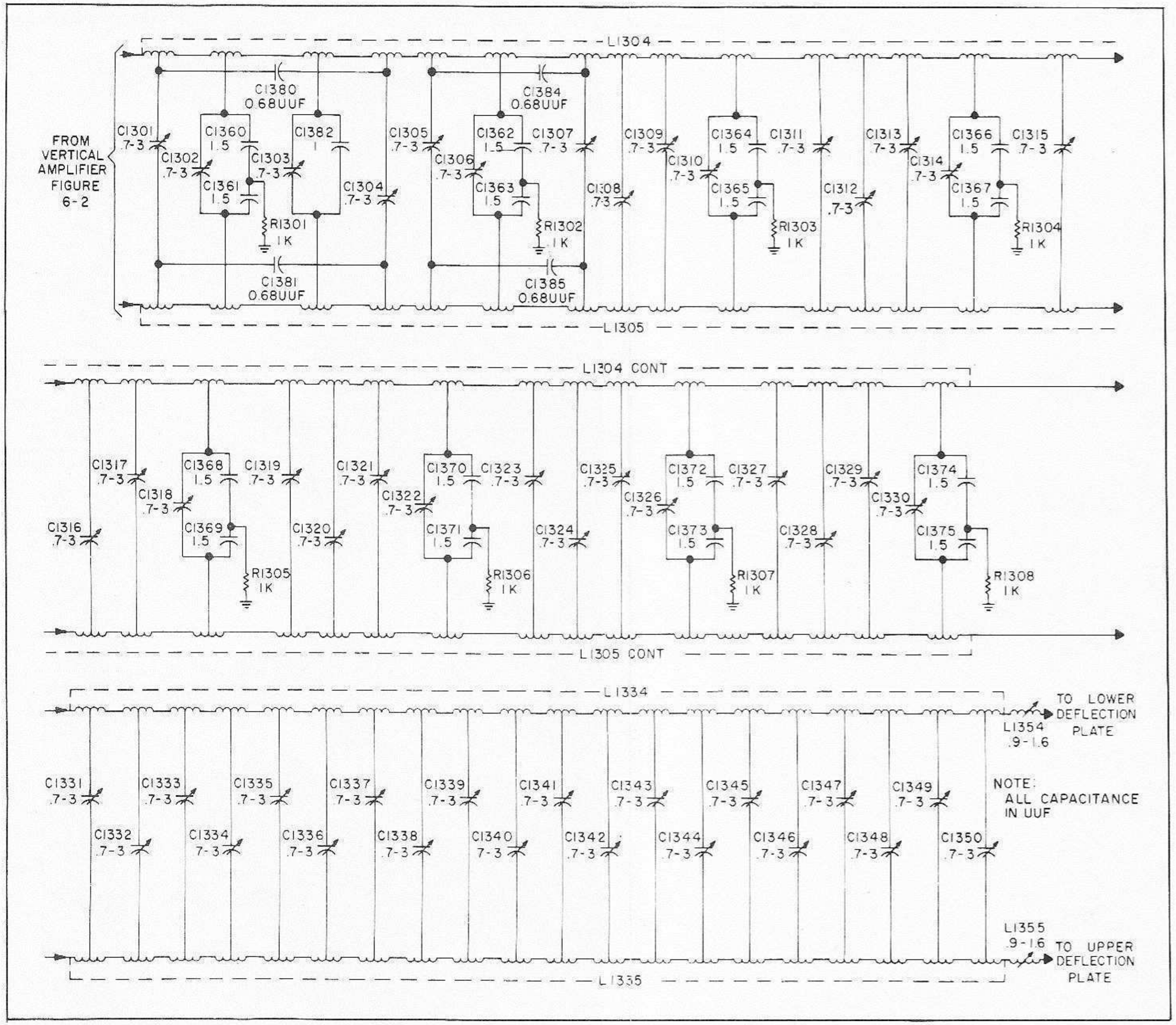


Figure 6-3. Balanced Delay Line Network, Schematic Diagram

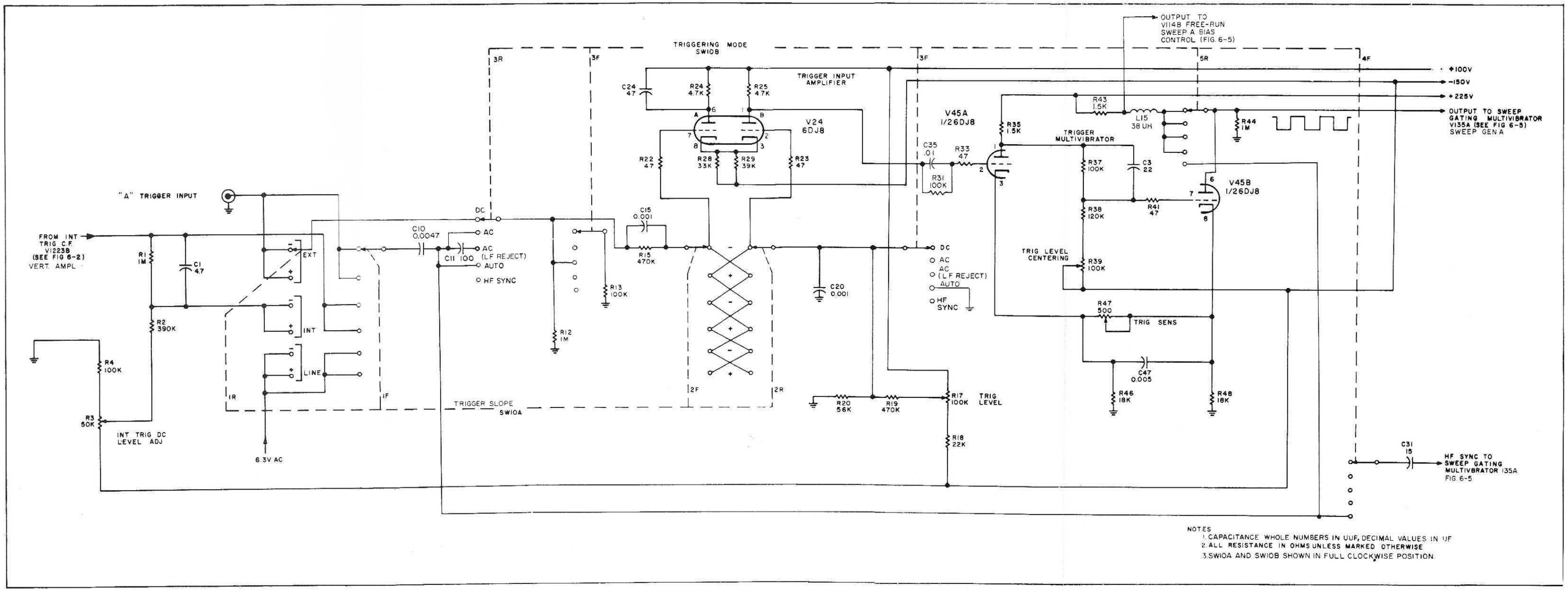


Figure 6-4. Sweep Generator A Trigger, Schematic Diagram

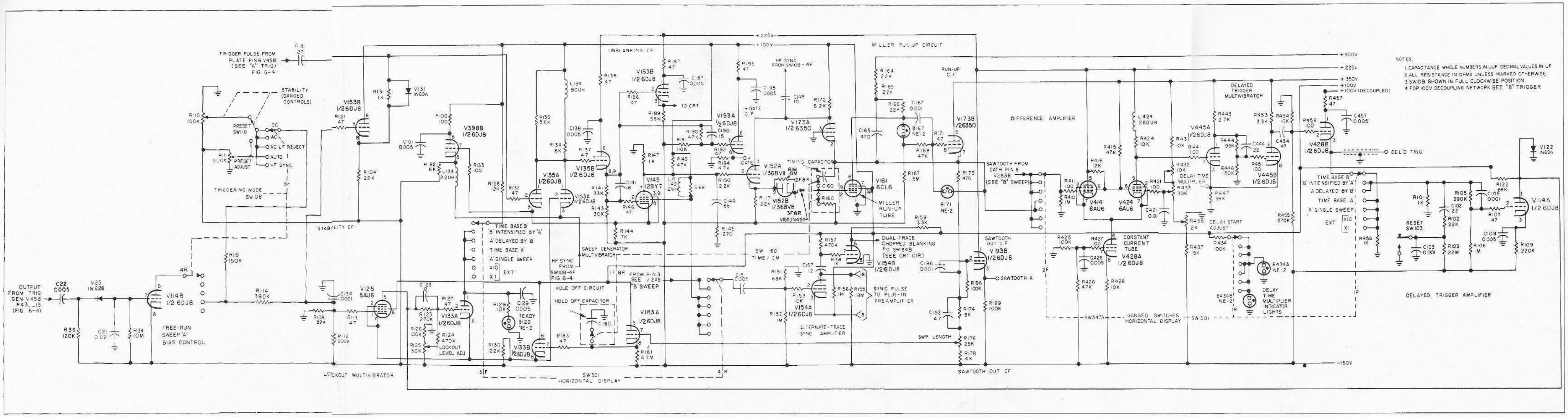


Figure 6-5. Sweep Generator A, Schematic Diagram

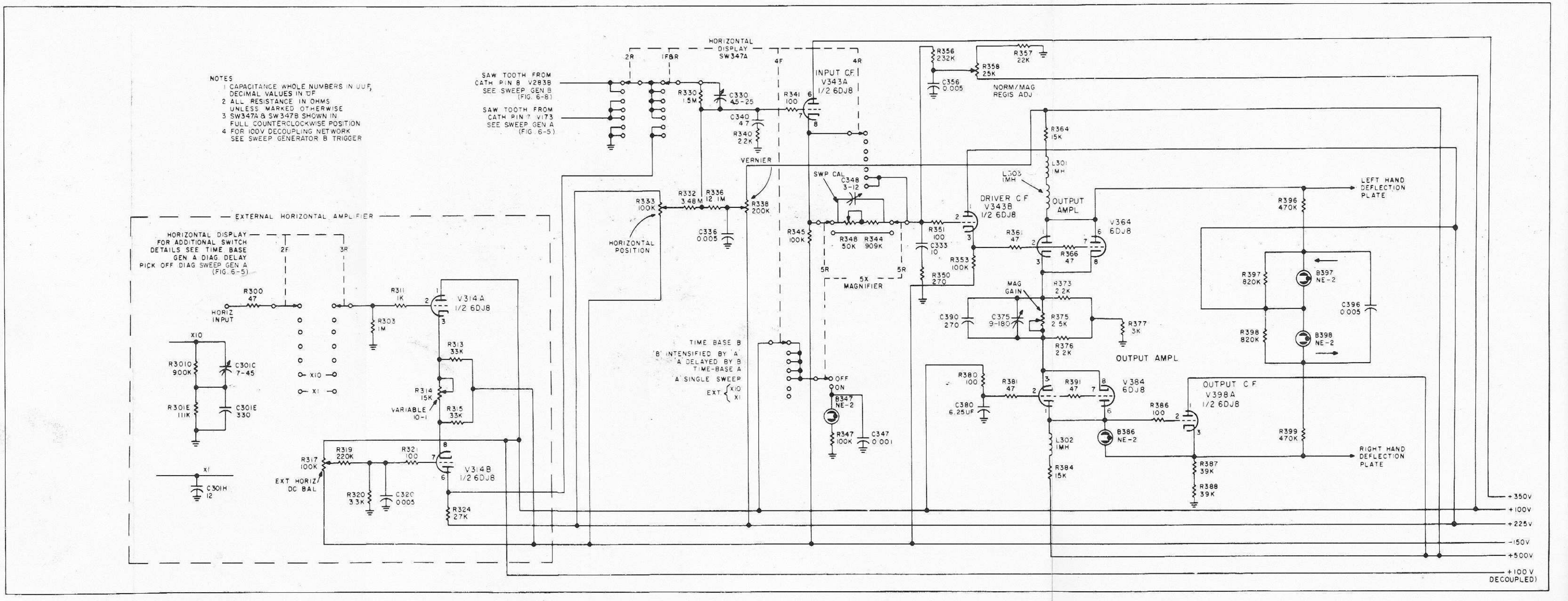
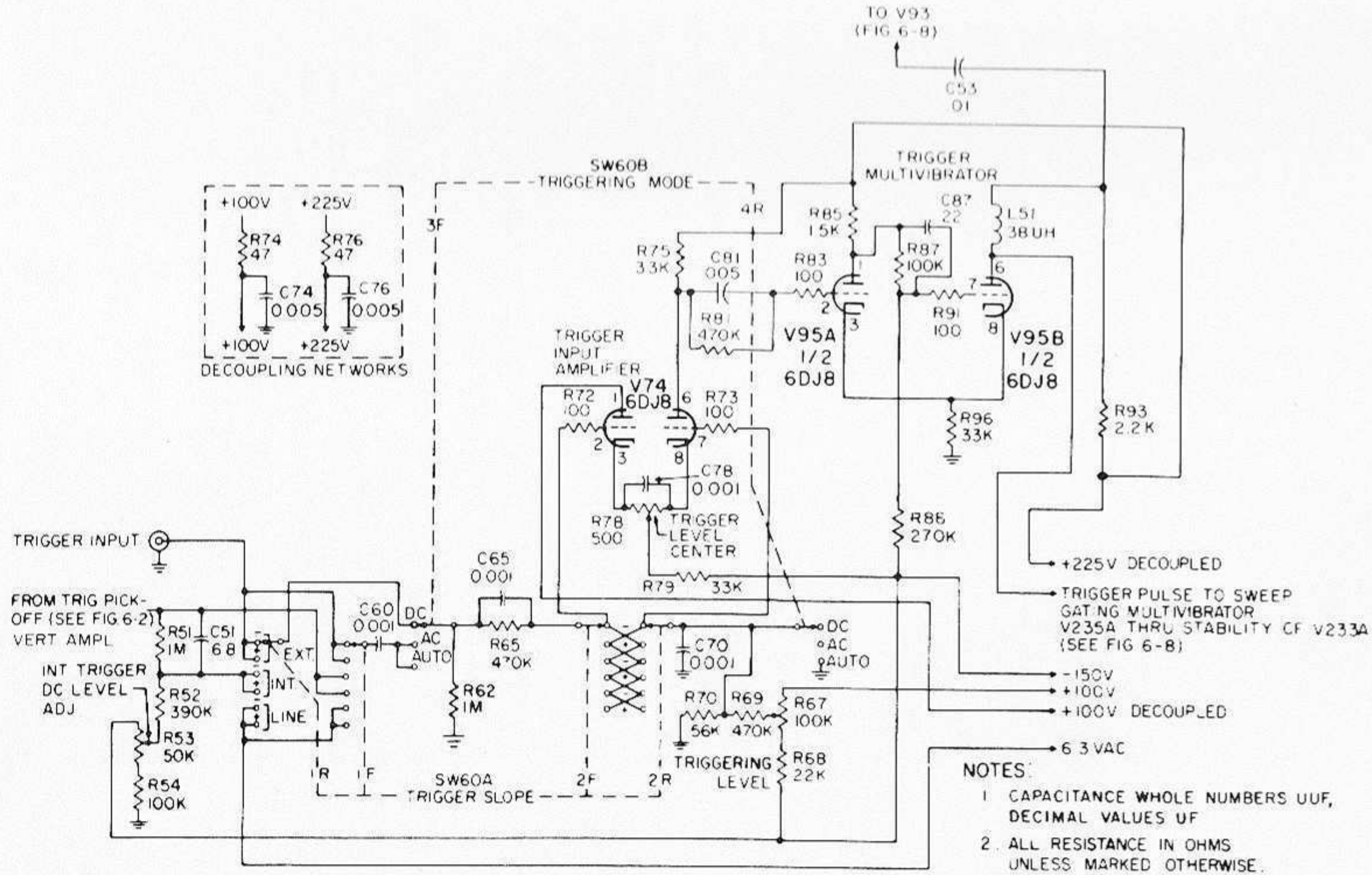


Figure 6-6. Horizontal Amplifier, Schematic Diagram



NOTES:

1. CAPACITANCE WHOLE NUMBERS UUF, DECIMAL VALUES UF
2. ALL RESISTANCE IN OHMS UNLESS MARKED OTHERWISE.
3. SW60A AND SW60B SHOWN IN FULL CLOCKWISE POSITION.

Figure 6-7. Sweep Generator B Trigger, Schematic Diagram

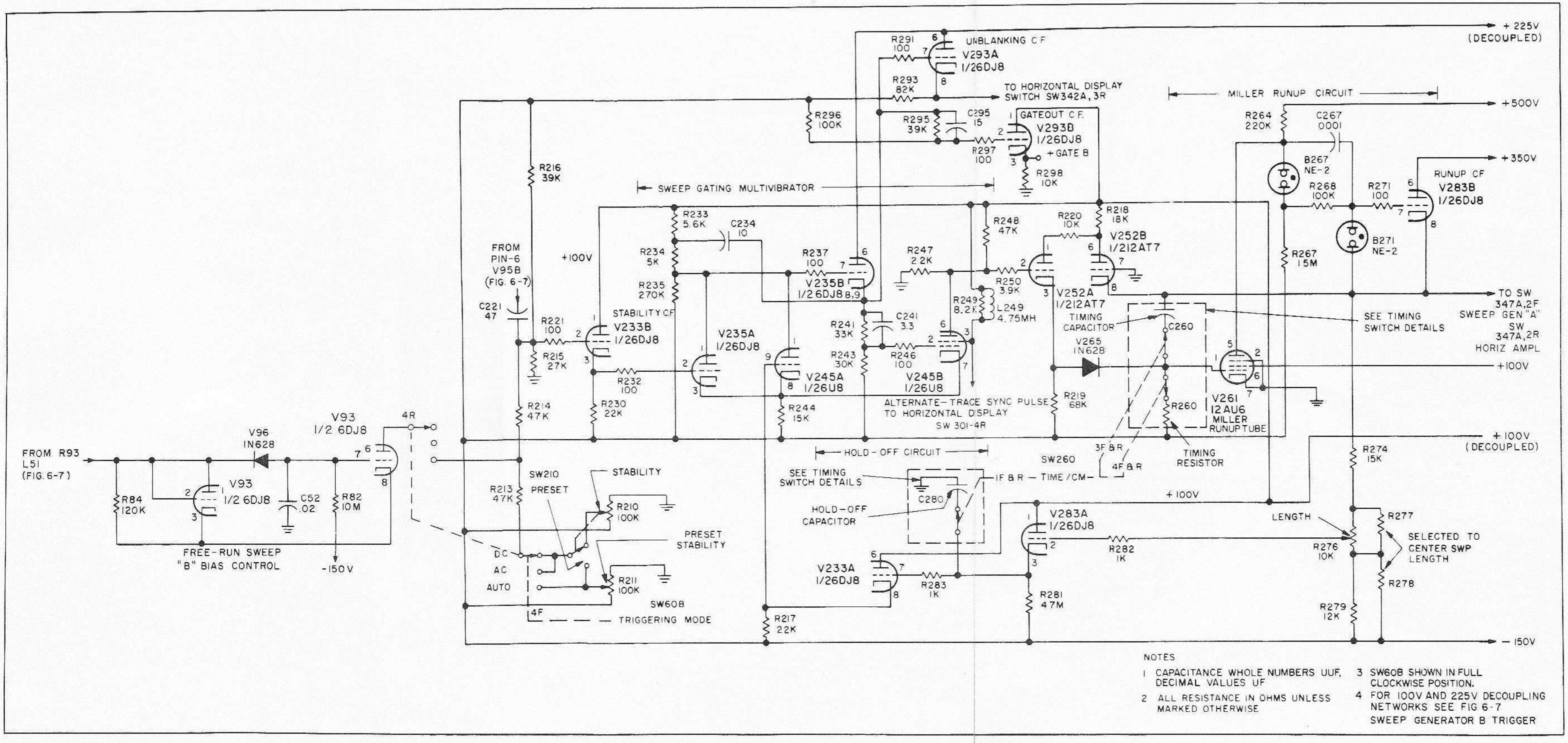


Figure 6-8. Sweep Generator B, Schematic Diagram

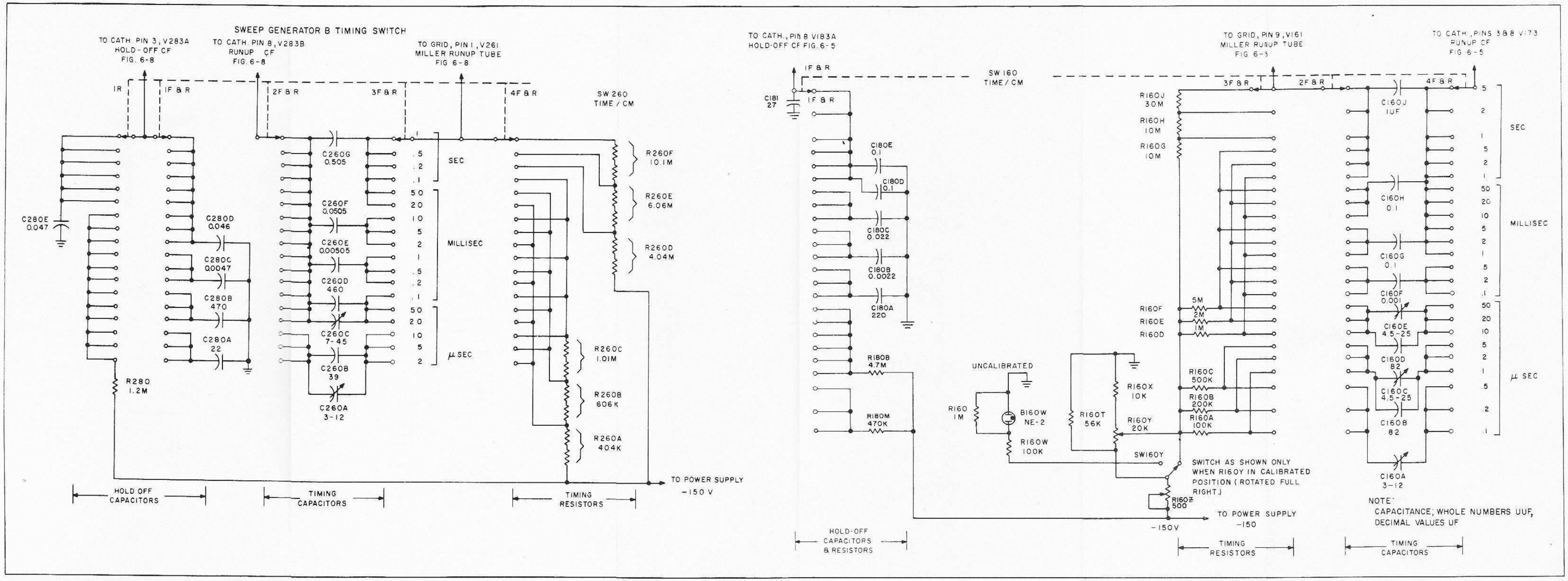
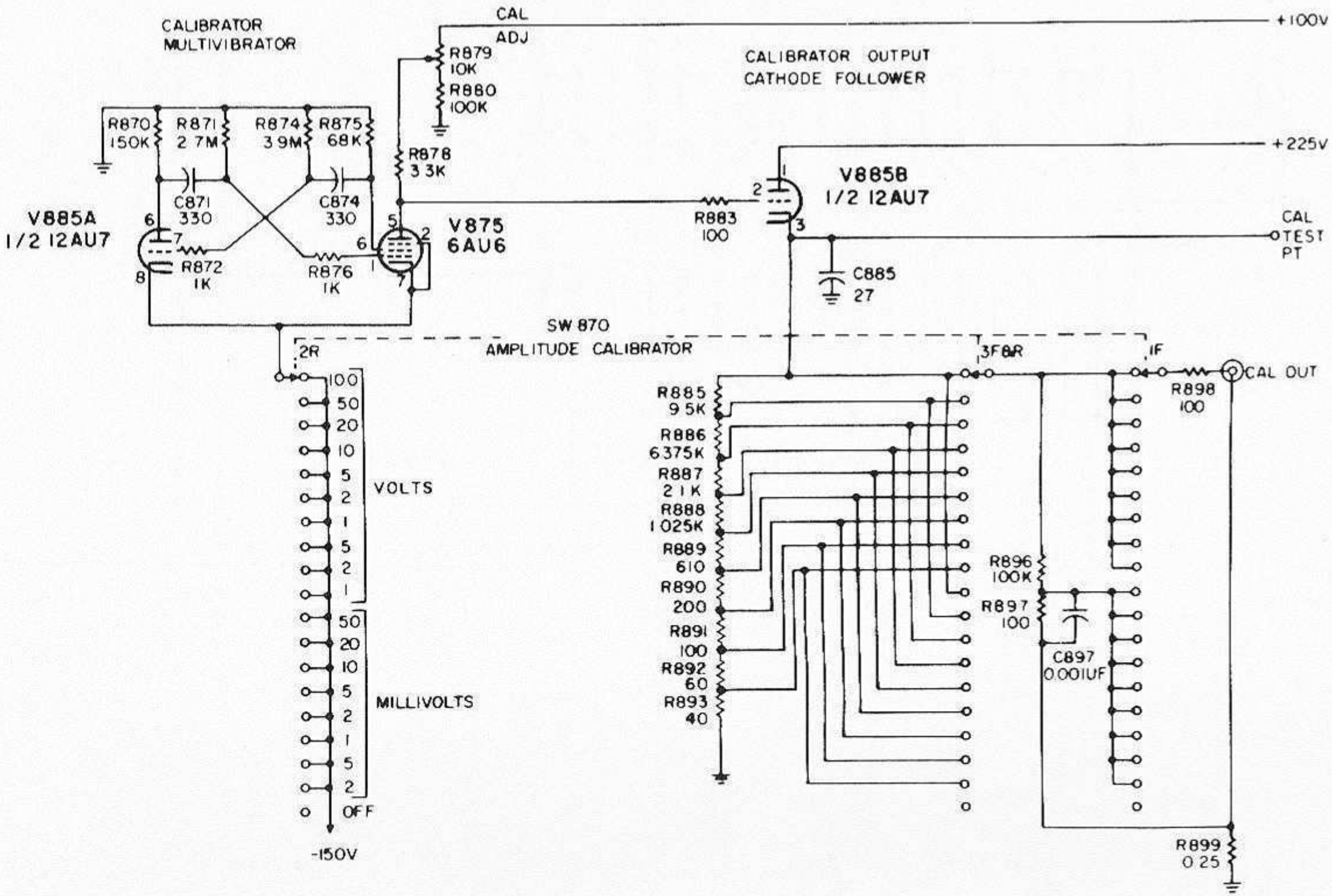


Figure 6-9. Sweep Generator A and B Time/CM Switch, Schematic Diagram



NOTE:
1. ALL RESISTANCE IN OHMS UNLESS MARKED OTHERWISE.
2. ALL CAPACITANCE IN UUF UNLESS MARKED OTHERWISE.

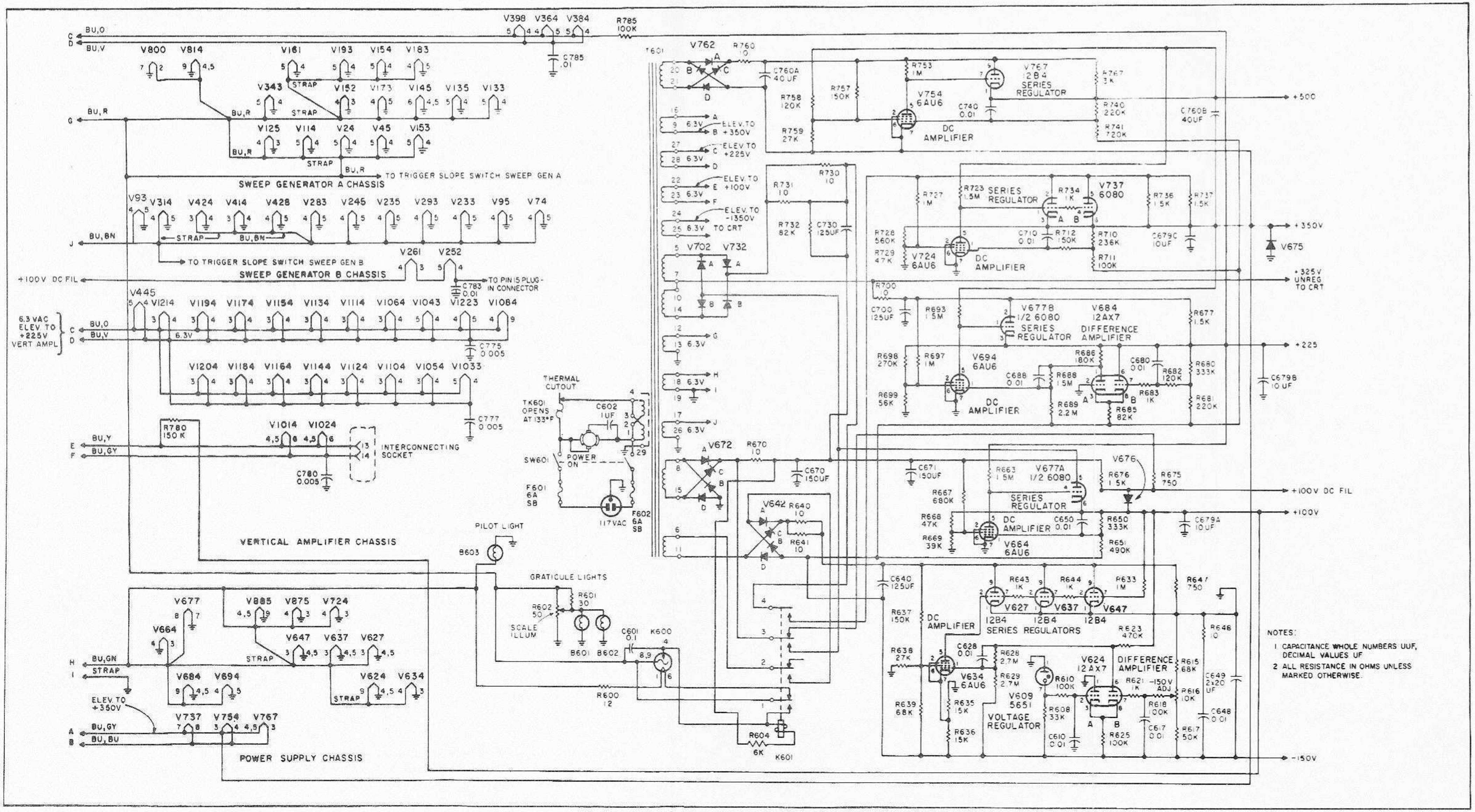


Figure 6-11. Low Voltage Power Supply, Schematic Diagram

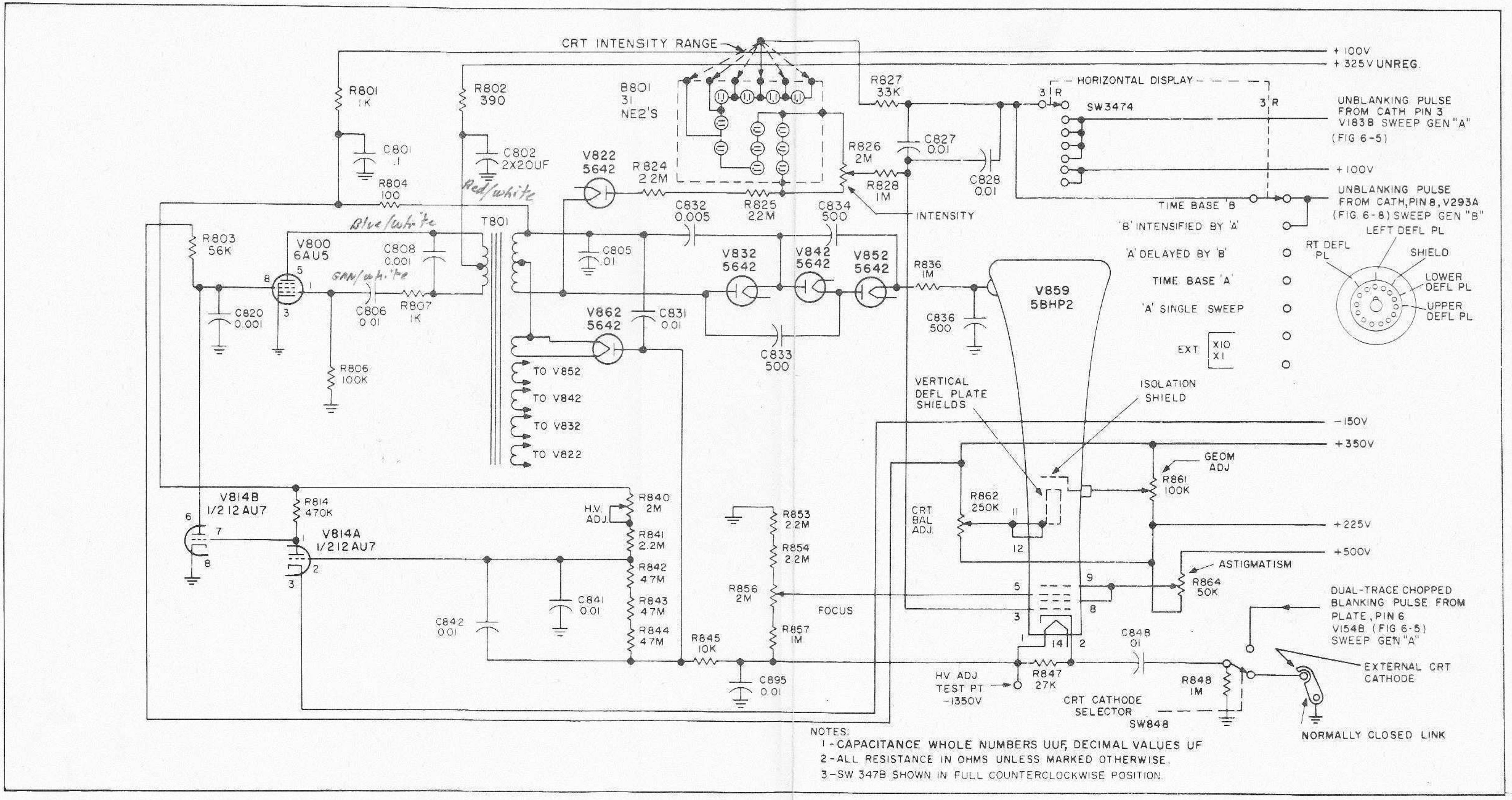


Figure 6-12. Cathode Ray Tube Circuits, Schematic Diagram

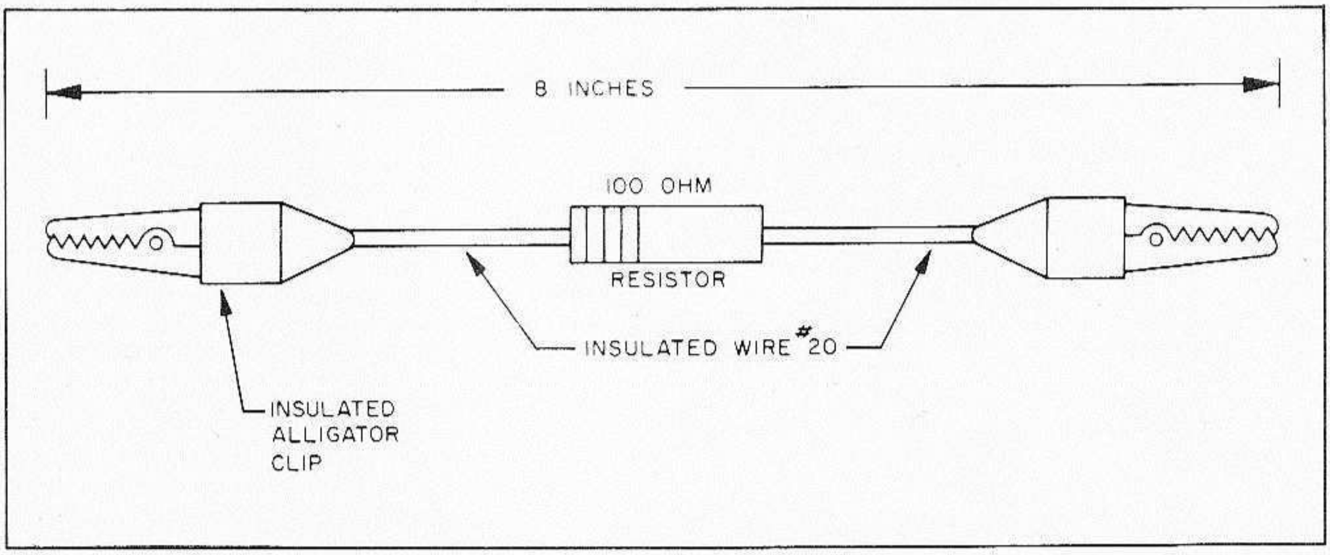


Figure 6-13. Preparation of Shorting Strap

SECTION VII

CALIBRATION

7-1. INTRODUCTION.

7-2. This section contains calibration procedures for the oscilloscope. The oscilloscope shall be calibrated following parts replacement, prolonged storage, shipment, after 400 hours of use or every six months, whichever occurs first. For parts replacement, it is not necessary to calibrate the complete oscilloscope, unless the parts were changed in the low voltage power supply, or the crt and high voltage power supply. Upon completion of calibration, perform final testing as described in paragraph 7-38 to ensure that the oscilloscope is serviceable.

7-3. TEST EQUIPMENT REQUIRED FOR CALIBRATION. The test equipment required to calibrate the oscilloscope is listed in figure 7-1. The test equipment may be replaced or supplemented by equipment of equivalent capabilities.

7-4. PRELIMINARY PROCEDURES. Calibration procedures are performed on the oscilloscope using either the type TU-2 test load or a plug-in preamplifier, whichever is specified for the particular procedure. Because the LA-265-L preamplifier is a general purpose plug-in preamplifier, covering a frequency range of dc to 30 megacycles, its use is suggested if available. Initially, connect the oscilloscope, with the test load TU-2 inserted, to the power line through the Variac. Adjust the Variac to 117 VAC as indicated on the AC voltmeter. Set the INTENSITY control on the scope fully counterclockwise; and place the TEST LOAD switch to LO LOAD. Set the front panel controls of the oscilloscope and preamplifier as follows and allow a ten minute warmup period prior to performing the calibration procedures. The side and bottom covers should be removed prior to applying power.

Oscilloscope Controls

INTENSITY	Full counterclockwise
HORIZONTAL DISPLAY	A
TRIGGERING MODE (A and B)	AC
TRIGGER SLOPE (A and B)	+INT

Oscilloscope Controls (cont)

STABILITY (A and B)	Counterclockwise (not PRESET)
TIME/CM	.5 MILLISEC
VARIABLE	Full clockwise
AMPLITUDE CALIBRATOR	OFF

Preamplifier Controls (When used)

AC-DC-ACX10GAIN	DC
VOLTS/CM	.05
VARIABLE	CALIBRATED (full clockwise)

7-5. At the rear of the oscilloscope, check that the shorting bar is in place between the EXTERNAL CRT CATHODE and GROUND binding posts, and that the CRT CATHODE SELECTOR switch is set at the EXTERNAL CRT CATHODE position.

7-6. CALIBRATION PROCEDURE.

7-7. LOW VOLTAGE POWER SUPPLIES ADJUSTMENT. Proceed as follows:

a. Connect Model 801 differential voltmeter to the -150 volts dc test point (see figure 7-2).

b. Adjust the -150 Adj. (see figure 7-2) for exactly -150 volts dc.

c. Check the +100, +225, +350 and 500 volt dc supplies, readjust -150 adj slightly to bring within ±2% tolerance (see figure 7-9).

d. With both sweeps non-operating, using the shop standard oscilloscope and preamplifier check the ripple voltages at the points stipulated in a and c, with the line voltage at 125 VAC and the TEST LOAD switch on LO LOAD. Check the ripple voltage again, with the line voltage at 105 VAC and the TEST LOAD switch on HI LOAD. The Ripple voltage shall not exceed 10 millivolts at any test point.

Nomenclature	Part or Model No.	Application	Range	Accuracy
Square Wave Generator	Type 107 (Tektronix)	High Frequency peaking	400 KC to 1 MC; rise time 3 millimicrosec.	
Time Mark Generator	Model 180A (Tektronix)			
Test Oscillator	Model 650A (Hewlett Packard)			
Constant Amplitude Signal Generator	Model 190B (Tektronix)		350 KC to 50 MC; 40 milli-volts to 10 volts peak-to-peak.	±2% from 350 KC to 30 MC; ±5% 30 MC to 50 MC.
Differential Voltmeter	Model 801 (John Fluke)			
Multimeter	Simpson 260			
AF-RF Voltmeter	Model 314 (Ballantine)			
Plug-in Preamplifier	LA-265-L (Lavoie)			
Gain Adjust Adapter	Type EP53A (Tektronix)			
Oscilloscope	LA-265 (Lavoie)	A Shop standard, general purpose		
Test Load	TU-2 (Tektronix)			
Type P Plug-in	Tektronix			
Adjustable Line Voltage Autotransformer	Variac W10			
AC Voltmeter (150V)	Weston 433			
Square Wave Generator	Model 211 (Hewlett-Packard)			
Wheatstone Resistance Bridge	Industrial Instruments			

Figure 7-1. *Test Equipment Required for Calibration*

7-8. AMPLITUDE CALIBRATOR ADJUSTMENT. Proceed as follows:

a. Set AMPLITUDE CALIBRATOR control to off position.

b. Connect Model 801 differential voltmeter to the *Cal Test Point (see figure 7-2).*

c. Adjust the Cal Adj (see figure 7-2) for exactly 100 volts dc.

d. After setting the Cal. Adj. potentiometer, remove tube V875 and connect a differential voltmeter, Model 801 to the CAL. OUT connector. Measure the DC output voltage at the ten AMPLITUDE CALIBRATOR knob settings from .1 volt to 100 volts. The voltage reading shall correspond to the knob settings within ±3%.

e. Replace tube V875. Remove differential voltmeter and connect the shop standard oscilloscope in its places. Check output at remaining eight AMPLITUDE CALIBRATION knob settings (.2 to 50 millivolts). Note symmetry of calibrator waveform.

7-9. HIGH VOLTAGE POWER SUPPLY ADJUSTMENT. Proceed as follows:

a. Connect Simpson 260 multimeter to the high voltage test point (see figure 7-3).

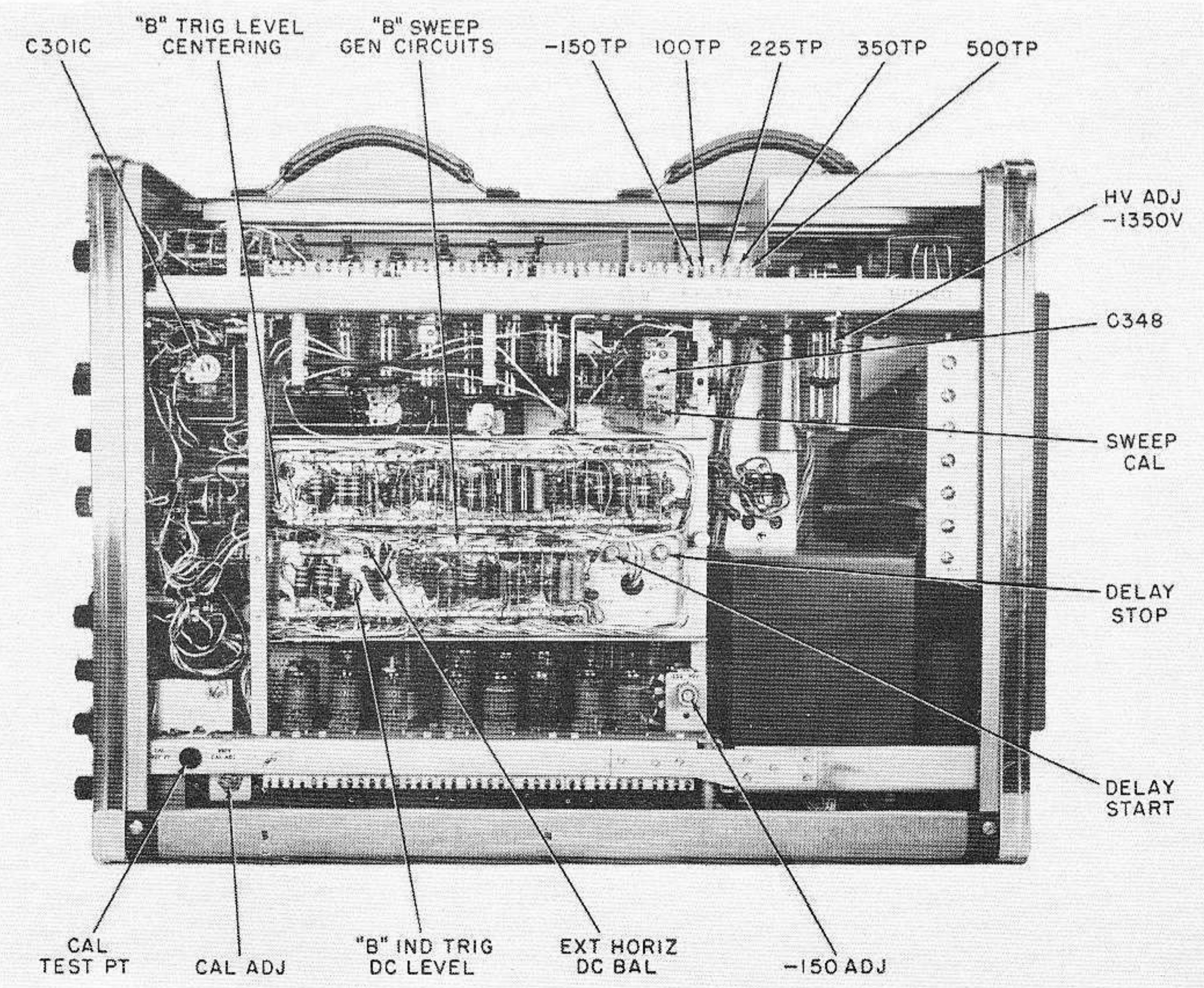


Figure 7-2. Oscilloscope Right Side View

b. Adjust the H.V. Adj. for exactly -1350 volts dc (see figure 7-2).

7-10. CRT ADJUSTMENT. Perform this adjustment if the crt has been replaced, or the trace does not line up with the graticule. Proceed as follows:
a. Remove any vertical input signal.
b. Loosen crt clamp (see figure 5-2).
c. Turn TIME BASE A TRIGGER MODE switch to AUTO.
d. Position the trace directly behind the center graticule marking.
e. Rotate the crt in its shield until the trace and graticule marker are in-line, and push crt forward against light filter.
f. Tighten crt clamps.

7-11. CRT GEOMETRY ADJUSTMENT. Proceed as follows:
a. Set front panel TIME BASE A controls as indicated:

HORIZONTAL DISPLAY	A
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
TIME/CM	.5 MILLISEC
VOLTS/CM	.05
VARIABLE	CALIBRATED (full clockwise).

b. Connect CAL. OUT connector to INPUT connector using test lead.
c. Adjust VERTICAL POSITION control and AMPLITUDE CALIBRATOR control so display covers entire graticule.
d. Adjust Geometry potentiometer (see figure 7-4) for straight vertical lines, running parallel to the right and left edges of the graticule.

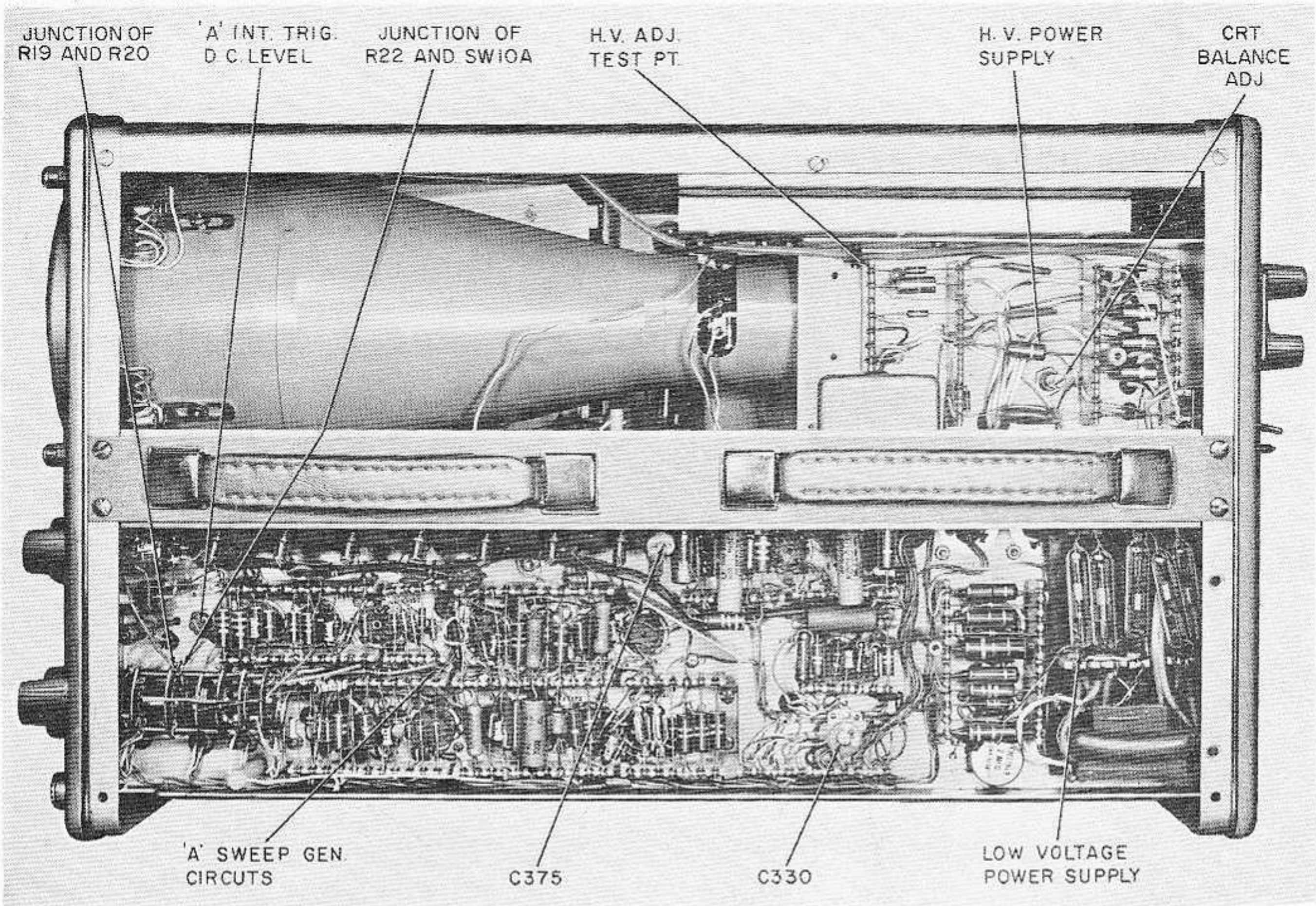


Figure 7-3. Oscilloscope Top View

e. Adjust CRT bal for optimum focus over entire screen (see figure 7-3).
f. Remove test lead.

7-12. TIME BASE A TRIGGERING LEVEL ADJUSTMENT. Proceed as follows:

HORIZONTAL DISPLAY	A
TRIGGERING MODE	DC
TRIGGER SLOPE	+INT
TRIGGERING LEVEL	0
STABILITY	full counterclockwise (not PRESET)

b. Connect Simpson 260 multimeter between junction of R19 and R20 (see figure 7-3) to ground.
c. Rotate the TRIGGERING LEVEL control for a minimum reading; control shall be at 0 position when multimeter indicates minimum reading. If not, loosen setscrew, and reposition control to 0 position.

7-13. TIME BASE A TRIGGER LEVEL CENTERING AND TRIGGER SENSITIVITY ADJUSTMENT. Proceed as follows:
a. Set oscilloscope controls as indicated:

TRIGGERING MODE	AC
TRIGGER SLOPE	-EXT
TIME/CM	.5 MILLISEC
AMPLITUDE CALIBRATOR	1 VOLT

b. Ground the junction of resistor R19 and R20.
c. Set Trig. Sens. potentiometer (see figure 7-4) to mid-position.
d. Connect CAL. OUT connector to "A" TRIGGER INPUT connector using test lead.
e. Set shop standard oscilloscope controls as indicated:

VOLTS	.5
TIME/CM	.5 MILLISEC

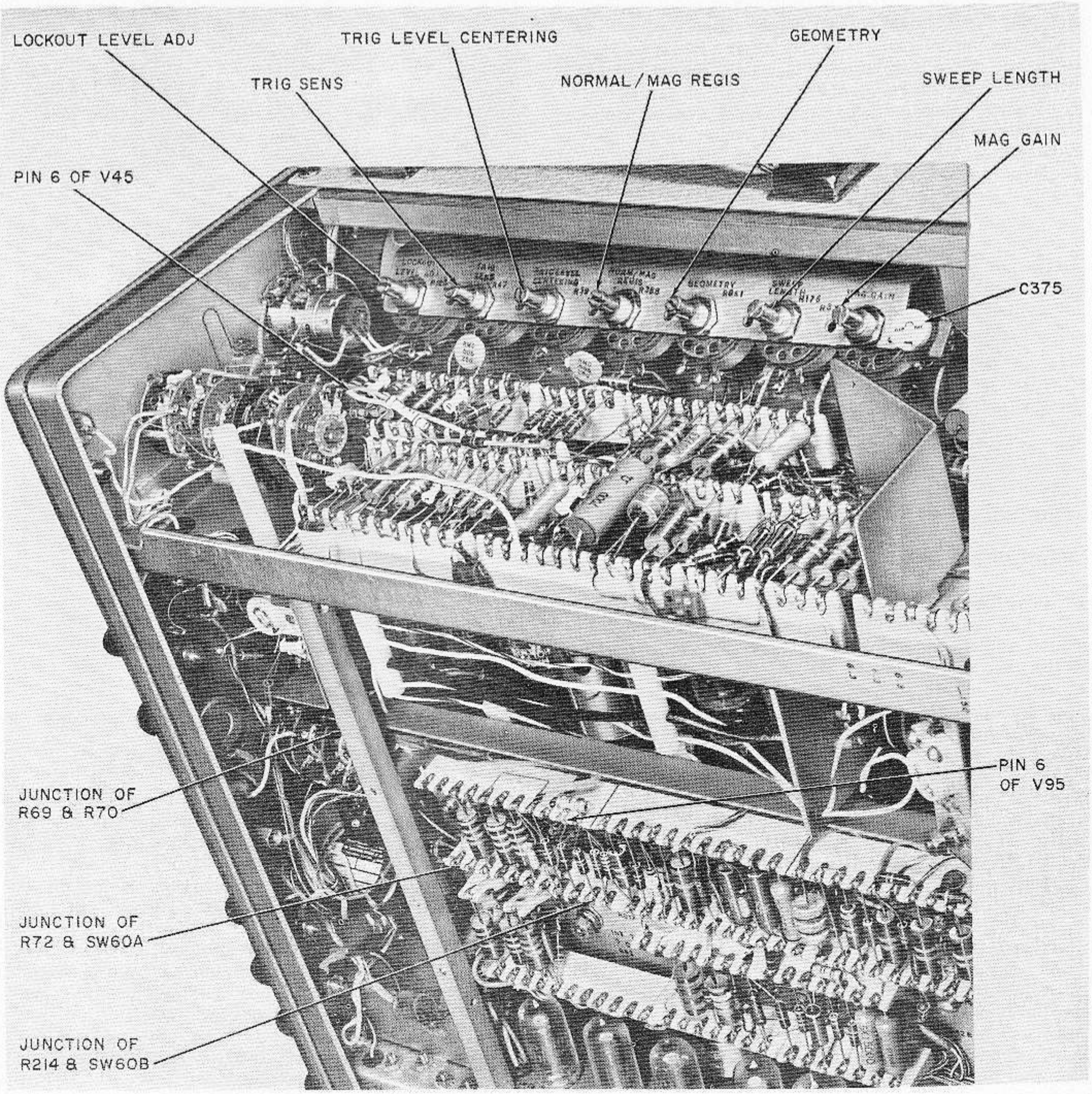


Figure 7-4. Calibration Points

f. Using 10X attenuator probe connected to shop standard oscilloscope, connect probe tip to pin 6 of tube V45 (see figure 7-4) on oscilloscope being calibrated.
g. Adjust the Trig. Level Centering potentiometer (see figure 7-4) to the exact center of the area which provides a square wave of approximately 1.5 cm on the shop standard oscilloscope.
h. Change AMPLITUDE CALIBRATOR to .2, and adjust the Trig. Sens potentiometer (see figure 7-4) clockwise until square wave is again visible on shop standard. Carefully adjust Trig. Sens potentiometer to the position where square wave is jitter-free.
i. Slightly readjust both Trig. Level Centering and Trig Sens potentiometers for best response on shop standard.
j. Remove all connections.

Note

Do not rotate Trig. Sens potentiometer any further clockwise than is necessary to obtain stable triggering.

7-14. A INTERNAL TRIGGERING DC LEVEL ADJUSTMENT. Proceed as follows:
a. Set the oscilloscope controls as indicated:

STABILITY	clockwise (free running sweep)
TRIGGER SLOPE	-INT
TRIGGERING MODE	DC

b. Position the sweep trace to the center of the graticule, and connect the Simpson 260 multimeter between ground and the junction of resistor R22 and switch SW10A (see figure 7-3).
c. Set the multimeter on its lowest range which provides an on-scale reading, and adjust the Int. Trig. DC Level Adj (see figure 7-3) for exactly zero volts.

7-15. 'A' PRESET ADJUSTMENT. Proceed as follows:
a. Set the TIME BASE A TRIGGERING MODE control to AC, the TRIGGER SLOPE control at +LINE, and the STABILITY control full counterclockwise until it clicks. Then turn the PRESET ADJUST potentiometer full clockwise.
b. Connect the Simpson 260 multimeter using a dc function, to the wiper arm of the PRESET ADJUST potentiometer (see figure 7-5).
c. Rotate the PRESET ADJUST potentiometer clockwise until a trace appears, and note the meter indecation.
d. Continue rotating the PRESET ADJUST clockwise until the trace brightens; again note the meter indication.
e. Set the PRESET ADJUST potentiometer mid-way between the two extreme meter readings obtained in steps c and d.

7-16. TIME BASE B TRIGGERING LEVEL ADJUSTMENT.
a. Set the oscilloscope controls as indicated:

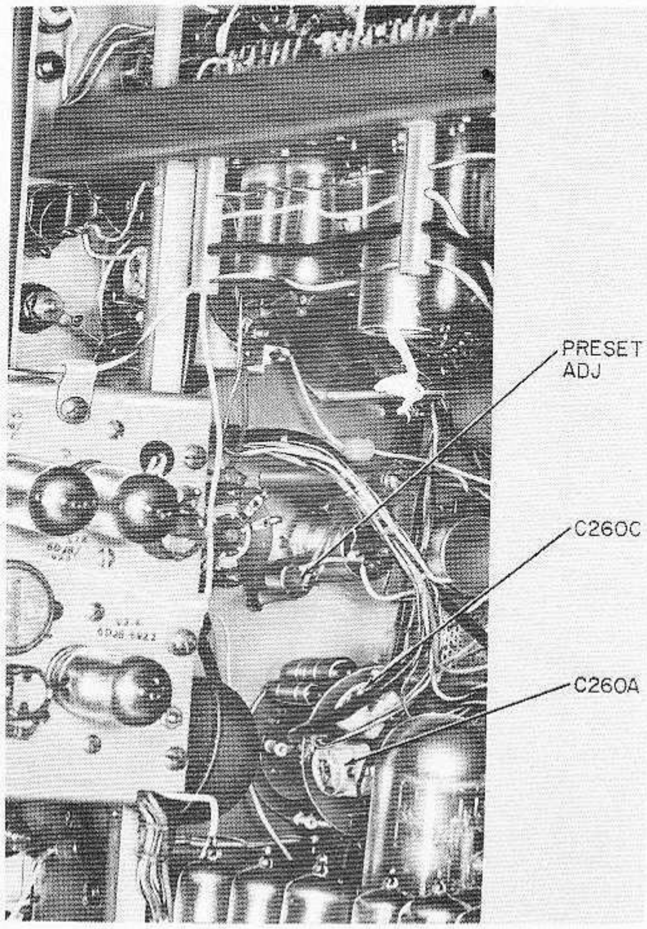


Figure 7-5. Time Base B Sweep Speed Calibration Points

HORIZONTAL DISPLAY	B
TRIGGERING MODE	DC
TRIGGER SLOPE	+INT
TRIGGERING LEVEL	0
STABILITY	full counterclockwise (not PRESET)

b. Connect the Simpson 260 multimeter to the junction of resistors R69 and R70 (see figure 7-4), and ground.
c. Rotate the TRIGGERING LEVEL control for a minimum reading: control shall be at 0 position when multimeter indicates minimum reading. If not, loosen setscrew, and reposition control to 0 position.

7-17. B INTERNAL TRIGGERING DC LEVEL ADJUSTMENT. Proceed as follows:
a. Set oscilloscope controls as indicated:

STABILITY	clockwise (free running sweep)
TRIGGER SLOPE	-INT
TRIGGERING MODE	DC

b. Position the sweep trace to the center of the graticule, and connect the Simpson 260 multimeter between ground and the junction of resistor R72 and switch SW60A (see figure 7-4).
c. Set multimeter on its lowest scale which provides an on-scale reading, and adjust the 'B' Int Trig DC Level (see figure 7-2) for exactly zero volts.

7-18. B TRIGGER LEVEL CENTERING ADJUSTMENT. Proceed as follows:
a. Set the oscilloscope as indicated:

TRIGGERING MODE	AC
TRIGGER SLOPE	-EXT
AMPLITUDE CALIBRATOR	.2

b. Ground the junction of resistors R69 and R70.
c. Connect CAL. OUT connector to 'B' TRIGGER INPUT connector using test lead.
d. Set shop standard oscilloscope controls as indicated:

VOLTS/CM	.5
TIME/CM	.5 MILLISEC

e. Using 10X attenuator probe connected to shop standard oscilloscope, connect probe tip to pin 6 of tube V95 on oscilloscope being calibrated.
f. Adjust the Trig. Level Centering potentiometer (see figure 7-2) to the exact center of area which provides a square wave of approximately 1.5 cm on the shop standard oscilloscope.
g. Rotate the TRIGGER SLOPE control back and forth between +EXT and -EXT, and readjust the Trig. Level Centering potentiometer for a completely stable display in both positions.

7-19. B PRESET ADJUSTMENT. Proceed as follows:
a. Set TIME BASE B TRIGGERING MODE control to AC, TRIGGER SLOPE AT +LINE and STABILITY control full counterclockwise until it clicks. Then turn "B" PRESET ADJUST potentiometer full counterclockwise.
b. Connect the Simpson 260 multimeter using a dc function, to the wiper arm of the 'B' PRESET ADJUST potentiometer.
c. Rotate the PRESET ADJUST potentiometer clockwise until a trace appears on the crt, and note the meter indication.
d. Continue rotating clockwise until the trace brightens; again note the indication.
e. Set the PRESET ADJUST potentiometer mid-way between the two extreme meter readings obtained in steps c and d.

7-20. 5X MAGNIFICATION GAIN ADJUSTMENT. Proceed as follows:
a. Set the oscilloscope controls as indicated:

HORIZONTAL DISPLAY	B
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
5X MAGNIFIER	ON
VOLTS/CM	2
TIME/CM	1 MILLISEC

b. Connect one millisecond and 100 microsecond markers from the time mark generator to the INPUT connector, adjust controls for a stable display.
c. Adjust the Mag. Gain potentiometer (see figure 7-4) to display a one millisecond marker every five cm, and two 100 microsecond markers every cm.

7-21. 5X MAGNIFIER ALIGN ADJUSTMENT. Proceed as follows:
a. Leave controls as set in the previous paragraph.
b. Using HORIZONTAL POSITION control, set the first time mark under the center graticule mark.
c. Set 5X MAGNIFIER control to OFF position and adjust the Norm/Mag. Regis potentiometer (see figure 7-4) so the first time mark is aligned with the center graticule mark again.

7-22. EXTERNAL HORIZONTAL DC BALANCE ADJUSTMENT. Proceed as follows:
a. Set the oscilloscope controls as indicated:

HORIZONTAL DISPLAY	EXT 1X
A STABILITY	Full clockwise

b. Connect the test lead between the A SAWTOOTH binding post and the INPUT connector.
c. Rotate the HORIZONTAL POSITION control so the vertical trace is aligned with the left-most graticule mark.
d. Adjust the Ext. Horiz DC Bal potentiometer (see figure 7-2) so that no horizontal shift occurs when the VARIABLE 10-1 control is rotated.

7-23. EXTERNAL HORIZONTAL INPUT COMPENSATION ADJUSTMENT. Proceed as follows:
a. Set the oscilloscope controls as indicated:

HORIZONTAL DISPLAY	EXT X1
"A" TRIGGER SLOPE	-EXT
"A" TIME/CM	1 MILLISEC
VOLTS/CM	10
AMPLITUDE CALIBRATOR	.5

b. Connect the test lead between the A SAWTOOTH binding post, and the INPUT connector.

c. Connect the CAL. OUT connector to both the HORIZ INPUT binding post and A TRIGGER INPUT connector.
d. Adjust the A STABILITY and TRIGGERING LEVEL controls for a stable square-wave.
e. Adjust variable capacitor C330 (see figure 7-3) for optimum square-wave display.
f. Set HORIZONTAL DISPLAY control to EXT X10, and increase the AMPLITUDE CALIBRATOR setting to 5.
g. Adjust variable capacitor C301C (see figure 7-2) for optimum square-wave flat top.

7-24. SWEEP ADJUSTMENT. Proceed as follows:
a. Set the oscilloscope controls as indicated:

HORIZONTAL DISPLAY	B
TIME/CM	1 MILLISEC
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
5X MAGNIFIER	OFF
VOLTS/CM	2

b. Connect 1 millisecond markers from Model 180A time mark generator to the INPUT connector, and adjust TIME BASE B controls for a stable display.
c. Adjust the Adjust Sweep Cal. potentiometer (see figure 7-2) for one time mark each centimeter.
d. Leave time mark generator connected.

7-25. SWEEP A TO SWEEP B ADJUSTMENT. Proceed as follows:
a. Set oscilloscope controls as indicated:

HORIZONTAL DISPLAY	A
TIME/CM	1 MILLISEC
VARIABLE	CALIBRATED

b. Adjust TIME BASE A controls for a stable display.
c. Adjust potentiometer R160Z (see figure 7-6) for one time mark each centimeter.

7-26. SWEEP A LENGTH ADJUSTMENT. Proceed as follows:
a. Leave controls as set in previous paragraph.
b. Adjust the Sweep Length potentiometer (see figure 7-4) for a sweep deflection of 10.5 centimeters.

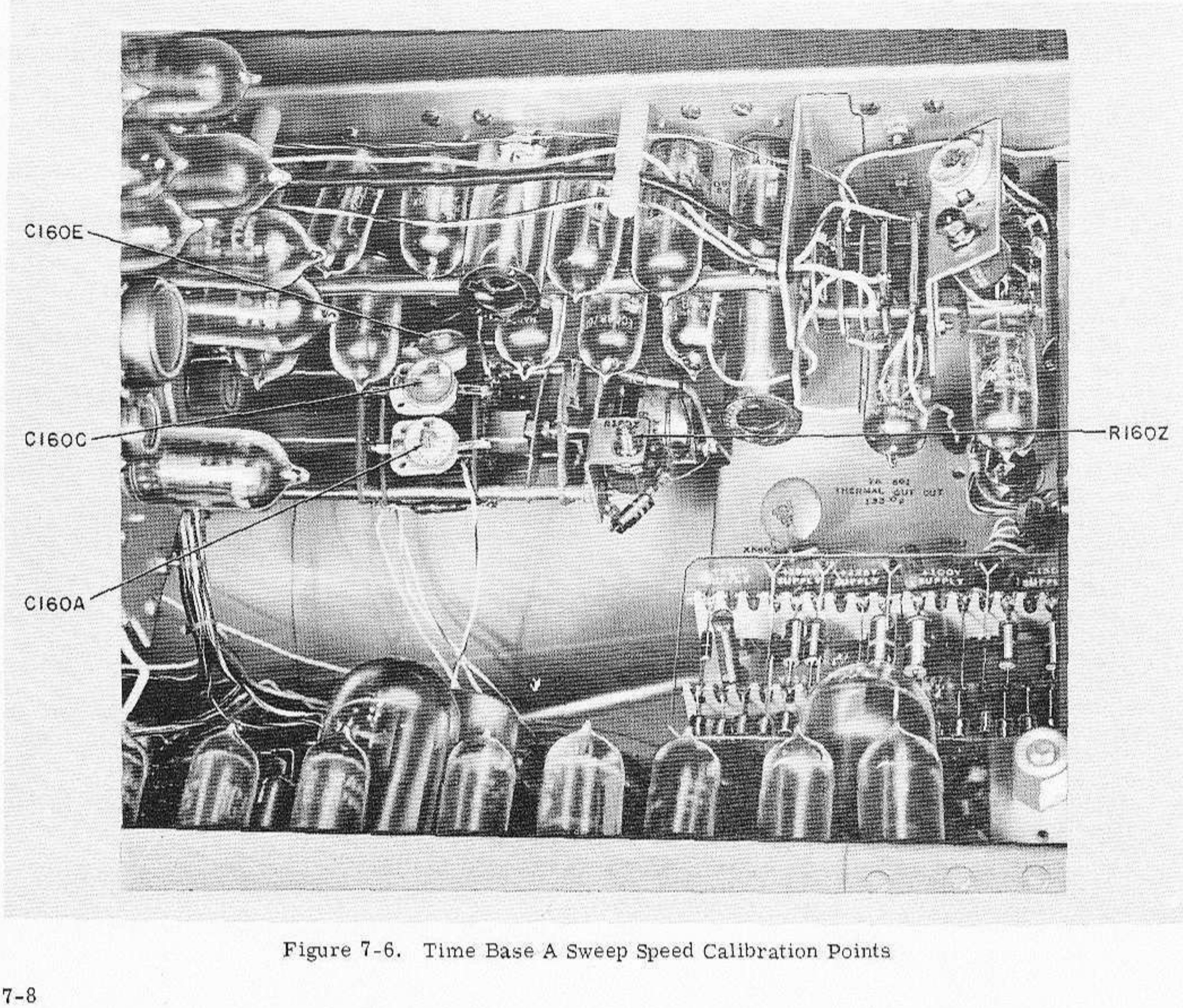


Figure 7-6. Time Base A Sweep Speed Calibration Points

7-27. TIME BASE A SWEEP SPEED ADJUSTMENT. Proceed as follows:
a. Set oscilloscope controls as indicated:

HORIZONTAL DISPLAY	A
TIME/CM	.1 MILLISEC
VARIABLE	CALIBRATED

b. Connect 10 microsecond markers from time mark generator to the INPUT connector and adjust TIME BASE A controls for a stable display.
c. Rotate 5X MAGNIFIER to ON position.
d. Using HORIZONTAL POSITION control, place first time mark under center graticule marking.
e. Rotate TIME/CM control to 50 usec and note any horizontal shift in time marker; if any occurs, adjust variable capacitor C330 (see figure 7-3) until first time marker on both the .1 MILLISEC and 50 usec positions of the TIME/CM control occur at the same position.
f. Rotate 5X MAGNIFIER control to OFF.
g. Set TIME/CM control to positions indicated, adjusting time mark generator as indicated, and adjust associated variable capacitor (see figure 7-6) as outlined in figure 7-7.

7-28. DELAY START AND STOP ADJUSTMENT. Proceed as follows:
a. Set HORIZONTAL DISPLAY control at 'B' INTENSIFIED BY 'A'.
b. Connect 500 microsecond markers from time mark generator to INPUT connector.
c. Set TIME BASE A and B TIME/CM controls at 50 usec and .5 MILLISEC respectively.
d. Rotate A STABILITY control full clockwise, adjust TIME BASE B controls for stable triggering.
e. Set the DELAY-TIME MULTIPLIER control at 1.00.
f. Adjust the Delay Start potentiometer (see figure 7-2) so the brightened portion of the sweep trace starts at the first time mark (one centimeter from the start of the trace).
g. Set the DELAY-TIME MULTIPLIER control at 9.00 and adjust the Delay Stop potentiometer (see figure 7-2) so the brightened portion of the sweep trace starts at the ninth time mark (nine centimeters from the start of trace).
h. Repeat steps e through g until a satisfactory setting is obtained.
i. Set the DELAY-TIME MULTIPLIER control at 1.00, and the HORIZONTAL DISPLAY control at 'A' DEL'D by 'B'.
j. Adjust the Delay Start control so that the leading edge of the time mark is at the start of the trace.
k. Set the DELAY-TIME MULTIPLIER control at 9.00 and adjust the Delay Stop control until the leading edge of the time mark is at the start of the trace.

7-29. TIME BASE B SWEEP SPEED ADJUSTMENTS. Proceed as follows:
a. Set the HORIZONTAL DISPLAY control at 'B' INTENSIFIED BY 'A'.
b. Set the TIME BASE A and B TIME/CM controls at 5 usec and 50 usec respectively.
c. Connect 50 microsecond time markers from the time mark generator to the INPUT connector.
d. Adjust the TIME BASE B control for a stable display, and the A STABILITY control fully clockwise.
e. Adjust the DELAY-TIME MULTIPLIER control to place the brightened portion of the sweep trace at the first marker (one centimeter from the start of the trace).
f. Set the HORIZONTAL DISPLAY at 'A' DEL'D by 'B', and adjust the DELAY-TIME MULTIPLIER control so the leading edge of the time marker is at the start of the sweep trace, note the DELAY-TIME MULTIPLIER setting.
g. Adjust the DELAY-TIME MULTIPLIER control for a setting 8.00 higher than the setting noted in step f.
h. Adjust variable capacitor C260C (see figure 7-5) until the leading edge of the ninth time marker is at the start of the sweep trace.

TIME/CM	Time Mark Generator	Adjustment	Display
10 usec	10 microsec.	C160E	one mkr/cm
.1 usec (5XMAG)	50MC**	*C160A (for time) C375 (for linearity)	one cycle/cm
.1 usec	10 MC	C348 (for time)	one cycle/cm
1 usec	1 microsec.	C160C	one mkr/cm

Note: *C375 only affects the first part of the display. Timing adjustments should be made between the first and ninth centimeter lines of the graticule.
**Set TRIGGER SLOPE on EXT-. Obtain 1 usec marker from time mark generator and connect to TRIGGER INPUT connector. This provides synchronization to view the 50 MC signal.

Figure 7-7. Sweep Speed Adjustments

i. Repeat the procedure described in steps a through h with the TIME BASE A TIME/CM control set at .5 usec, the B TIME/CM control set at 5 usec, and 5 microsecond markers connected to the INPUT connector. Adjust variable capacitor C260A (see figure 7-5). If alignment cannot be accomplished, refer to paragraph 6-8.

7-30. LOCKOUT LEVEL ADJUSTMENT. Proceed as follows:
a. Set the HORIZONTAL DISPLAY control at 'A' DEL'D BY 'B', the TIME BASE B STABILITY control full clockwise, and the A TIME/CM control at .1 MILLISEC.
b. Slowly adjust the A STABILITY control until the sweep just appears.
c. Connect the shop standard oscilloscope using a 10X attenuator probe to pin 3 of tube V133, using dc coupling.
d. Adjust the shop standard oscilloscope controls for a vertical display of four centimeters.
e. Adjust the Lockout Level potentiometer (see figure 7-4) until the square-wave portion of the displayed waveform is 1.4 centimeters high.

Note

The A STABILITY control must be checked periodically to ensure that it is just at the point of a free running sweep. At the completion of the adjustment, the square-wave shall be 1.4 centimeters, and the sawtooth 2.6 centimeters in amplitude.

7-31. VERTICAL GAIN ADJUSTMENT. Proceed as follows:
a. Set the TU-2 Test Load to 250:1 and the AMPLITUDE CALIBRATOR output to 100 volts.
b. Set the Gain Adj. potentiometer (see figure 7-8) for exactly four centimeters vertical deflection.

7-32. DC SHIFT ADJUSTMENT. Proceed as follows:
a. Remove TU-2 Test Load from oscilloscope and install LA-265-L preamplifier.
b. Connect the square-wave generator Model 211A to the preamplifier input, and adjust the generator for a one cycle square-wave output.
c. Adjust the oscilloscope sweep controls to display several cycles of the one cycle square-wave.
d. Set the amplitude for four centimeters of vertical deflection.
e. Adjust DC SHIFT ADJ. potentiometer (R1091) to remove any upward or downward slope on the flat top of the square-wave.

7-33. DELAY LINE AND HIGH FREQUENCY COMPENSATION ADJUSTMENT.

7-34. GENERAL. Before attempting to alter the present adjustment of the delay line, the necessity for readjustment, and areas where it is required should be carefully determined as described in the following paragraphs.

7-35. EXTENT OF ADJUSTMENT REQUIRED. Using a type L, or K, plug-in preamplifier apply a 400 kc input square wave from Square Wage Generator, Tektronix 107, display a square wave of 3 centimeters amplitude at the sweep rate to be stipulated, and check the following display characteristics. (See figure 7-13.)
a. Top Slope. Set the sweep TIME/CM switch to 5 usec. Obtain a stable display, and observe the top of the waveform. There should be no upward or downward slope anywhere along the top. If slopes exist they are a collective effect of all delay line capacitors.
b. Bumpiness on Top Portion. Set the sweep TIME/CM switch to .2 usec. Obtain a stable display. Observe the top portion of the square wave immediately following the rise. If fairly long duration bumps occur, it indicates misadjustment of a group of capacitors in the delay line. Short bumps at random intervals indicate general delay line misadjustment, see figure 7-13 (5). A short duration bump would indicate a single misadjusted capacitor. Bumps occurring at regular rhythmic intervals can be due to amplifier high frequency compensators and would not require delay line adjustment, see figure 7-13 (2). An upward or downward step from the leading edge to the termination bump indicates a misadjusted reverse plate line termination, figure 7-13 (4).
c. Rise. Set the sweep TIME/CM switch to .1 usec and observe the leading edge of the displayed waveform. The waveform should be a sharp cornered step with no overshoot, undershoot wrinkles or bumps in this section. If a roll-off (undershoot) is observed, see figure 7-13 (1) and (3) it may be due to misadjustment of the delay line capacitors nearest the CRT or the inductors following between the delay line and the deflection plates. It can also be caused by insufficient high frequency peaking in the vertical amplifier or an amplifier tube with low GM. Overshoot and ringing can be caused by a mistuned delay line, or an overcompensated input amplifier or cathode interface on one of the amplifier tubes, see figure 7-13 (6).

7-36. ADJUSTMENT. After analyzing the three basic characteristics of the waveform as described in paragraph 7-35, the technician should first check any other possible trouble source mentioned before attempting to adjust the delay line. The following is a complete delay line adjustment procedure followed by vertical amplifier high frequency compensation. If the trouble appears to be high frequency compensation, these adjustments should be tried before adjusting the delay line.

CAUTION

In adjusting the delay line, observe the displayed waveform very carefully to note changes occurring in any part of the display as a result of the adjustment in process. While one bump is being eliminated, another distortion may be created in a different portion of the display. It is easy for the entire procedure to get completely out of control in this manner. Never turn an adjustment without first noting the effect of a slight touch. In many cases only a small fraction of a turn is required at strategic points to restore normal operation.

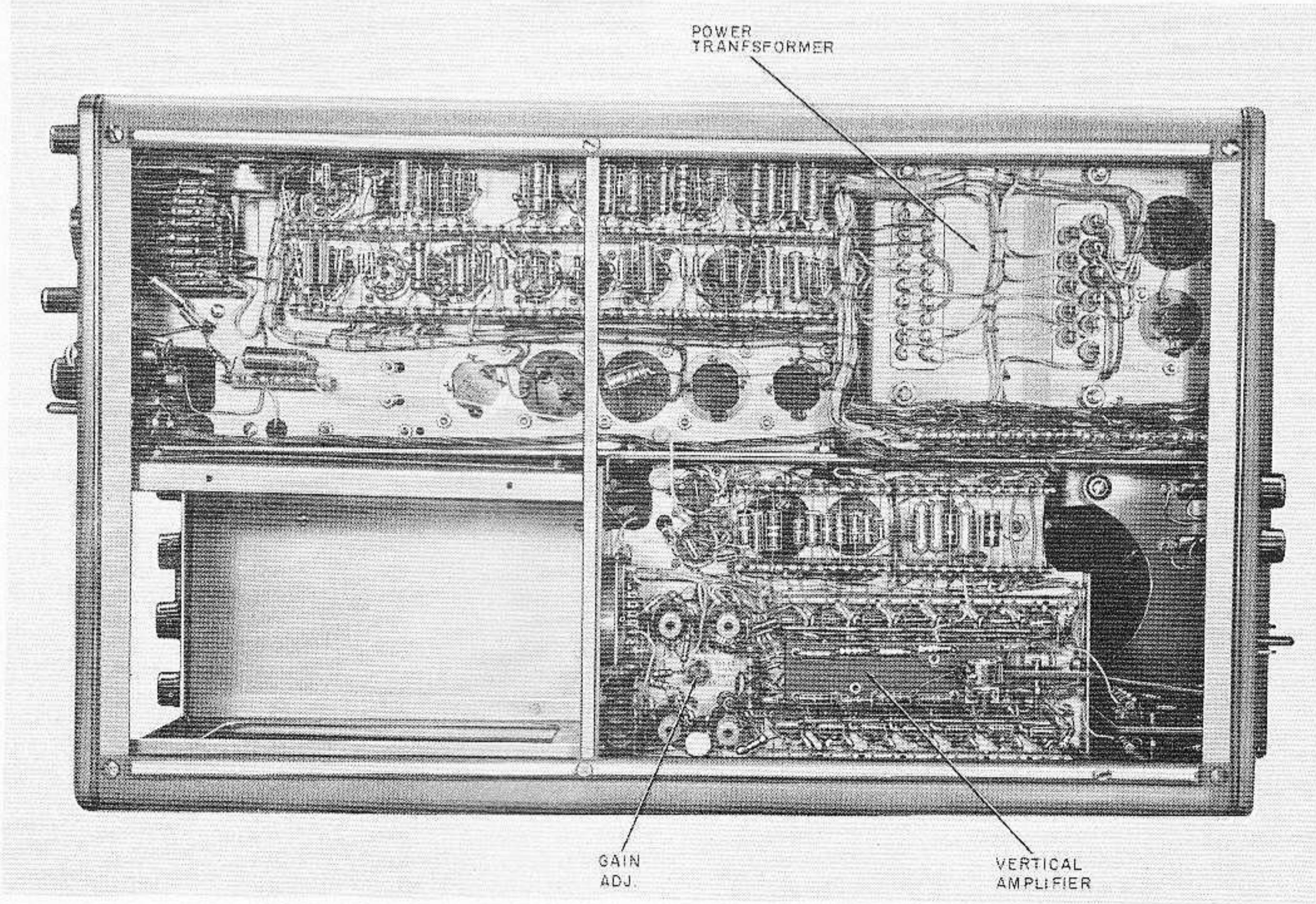


Figure 7-8. Oscilloscope Bottom View

7-37. If the operator has not considerable experience in delay line adjustments, error will be avoided by turning the slugs on the inductors in the vertical amplifier and at the CRT end of the delay line, so that they are just out of the coils. (Flash a light through the forms to locate this position.) This adjustment will produce a roll-off in the leading edge of the display, but will decrease the effect of the inductors during the delay line adjustment. After the delay line has been adjusted the slugs can be returned to their proper position. Before starting adjustment, note that a properly adjusted line will generally have all screws about equal height (about 3/8 inch) above the capacitor body.

a. Flattening the Top. With the oscilloscope power OFF, adjust the termination network as follows:

(1) With multimeter Simpson 260, or equivalent, measure the resistance across the extremes of resistors R1030 through R1035 in series, and adjust potentiometer R1043 to obtain a reading of 620 ohms.

(2) Turn on oscilloscope with L head inserted and adjust vertical amplitude to 3 centimeters.

(3) Set TIME/CM switch to 5 usec and obtain a stable sweep.

(4) Progressing in the direction of the CRT touch up each capacitor so as to level the display. When a good average level is attained, set TIME/CM switch to 2 usec and repeat procedure. After proper adjustment the bumps should not exceed a trace width in amplitude. If an upward or downward step from the leading edge to the termination bump persists after these adjustments it may indicate resistive unbalance in the termination.

b. Removing the Bumps. Proceed as follows:

(1) Set TIME/CM switch to .5 usec, and obtain a stable display.

(2) Starting at the end of the delay line furthest from the CRT, proceed to the first group of 5 delay line capacitors and touch up adjustments to smooth the portion of the trace which they effect.

(3) Set TIME/CM switch to 5 usec and check that the level of the display has remained the same.

(4) Set TIME/CM switch to .5 usec and continue adjustments, proceeding towards the CRT, touching up the capacitors in groups of 4 or 5, each time checking the level.

(5) After all sections have been adjusted, repeat the procedure with the TIME/CM switch at .02 usec. Extreme care and a very light touch should be used in this final adjustment to prevent the possibility of ruining the adjustment already achieved.

c. Restoring High Frequency Compensation. The square corner of the display should now be restored by means of the high frequency compensation. Proceed as follows:

(1) Set TIME/CM switch to .2 usec and adjust the display to provide a good view of the leading edge of the waveform.

(2) Carefully adjust the vertical amplifier inductors and those at the end of the delay line, a pair at a time, to square off the leading edge. The setting of each inductor in the pair should be approximately the same.

(3) Check that display level is maintained and no bumps are introduced by these adjustments. It may be necessary to touch up the adjustment of the last few delay line capacitors near the CRT to finalize the squaring of the display.

d. Measure Rise Time. Upon completion of all adjustments, the rise time of the main vertical amplifier should be measured. This is accomplished as follows:

(1) Using a type P plug-in unit, adjust display amplitude to 3 centimeters and set the TIME/CM switch to .1 usec.

(2) The rise time should be no greater than 10 nanosec. Overshoot shall not exceed 2-1/2%.

7-38. FINAL TESTING AFTER CALIBRATION.

7-39. GENERAL. The following paragraphs describe tests to determine the serviceability of an oscilloscope after calibration. If a partial calibration has been performed, it is only necessary to perform the tests associated. If a complete calibration has been performed, all tests shall be made to determine serviceability.

7-40. VOLTAGE AND RIPPLE TEST. Proceed as follows:

a. Set oscilloscope controls as follows:

INTENSITY	full counterclockwise
HORIZONTAL DISPLAY	A
TRIGGERING MODE (A and B)	AC
TRIGGER SLOPE (A and B)	+INT
STABILITY (A and B)	Counterclockwise (not PRESET)
TIME/CM	.5 MILLISEC
VARIABLE	Clockwise (CALIBRATED)
CALIBRATOR	OFF

Preamplifier

AC/DC	DC
VOLTS/CM	.05
VARIABLE	Clockwise (CALIBRATED)

b. Using Differential Voltmeter, measure the dc voltage at the test points shown in figure 7-9. (See figure 7-2 for the physical locations.) Voltages shall be within the tolerances listed.

Test Point	Voltage Tolerance	Maximum Ripple
-150 VDC	-147 to -153 VDC	0.01 V P-P
+100 VDC	98 to 102 VDC	0.01 V P-P
+225 VDC	220 to 230 VDC	0.01 V P-P
+350 VDC	343 to 357 VDC	0.01 V P-P
+500 VDC	490 to 510 VDC	0.01 V P-P

Figure 7-9. Voltage Tolerance and Ripple

c. With both sweeps non-operating, using shop standard oscilloscope and preamplifier, measure ripple voltage at each of the test points listed in figure 7-9. Maximum ripple shall not exceed the values listed.

d. Using suitable range on multimeter, measure voltage between high voltage test point (see figure 7-3) and ground. Voltage shall be -1350 volts ±3%.

7-41. BEAM CONTROLS. With both sweeps non-operating and no signal input, check operation of the controls as follows:

a. INTENSITY Control - Rotation shall adjust the beam from extinguished to full brilliance.

b. FOCUS and ASTIGMATISM controls - Check that proper adjustment will provide a clear, sharply defined spot.

c. VERTICAL POSITION control and indicator lamp - Check that control is capable of positioning the beam vertically over the 4 centimeter calibrated portion. Check that appropriate vertical indicator lamp is illuminated when the beam moves off center.

d. HORIZONTAL POSITION control - Set HORIZONTAL DISPLAY to EXT. Check that control is capable of positioning the beam horizontally to the extreme edge of the screen in both directions. Check that appropriate horizontal indicator lamp is illuminated when the beam moves off center.

e. BRILLIANCE - Set the 'A' TIME/CM switch to 1 millisec and STABILITY fully clockwise. Advance INTENSITY control to observe trace. Trace should be extinguished with INTENSITY control fully counterclockwise, and should begin to appear at approximately half rotation.

f. H. V. REGULATION - Using the VARIAC, vary the line voltage input between 105 and 125 VAC. The brilliance should remain the same and there shall be no evidence of blooming.

7-42. AMPLITUDE CALIBRATOR. Using the Differential Voltmeter, check the amplitude calibrator output accuracy as follows:

a. Remove tube V875 from its socket.

b. Connect differential voltmeter to the front panel CAL. OUT connector.

c. Measure dc output voltage with each of the following AMPLITUDE CALIBRATOR knob settings - 100 VOLTS, 5 VOLTS, .2 VOLTS and .1 VOLTS. These measurements verify the accuracy of the divider chain, and the 1000:1 (millivolt) divider. The voltage accuracy shall be ±3%.

7-43. VERTICAL RISETIME. Proceed as follows:
a. Connect Type 107 Square-wave Generator output to vertical INPUT connector.
b. Set generator frequency to approximately 1 megacycle.
c. Set TRIGGER SLOPE to +, adjust sweep controls to display a single square-wave on the crt. Adjust square-wave generator and VOLTS/CM control for 4 cm vertical deflection.
d. Observe leading edge. The risetime from 10% to 90% point shall be 10 nanosec (millimicrosec) or less. Overshoot shall not exceed 2.5%.

7-44. VERTICAL AMPLIFIER BALANCE CHECK. Proceed as follows:
a. Insert TU-2 load unit.
b. Short the vertical deflection plates of the CRT together, to determine electrical center.
c. Remove short and position trace at this point.
d. Using shorting strap (see figure 6-13) jumper grid lines of 6DK6 stages together.
e. Connect a lead from +225 volt output of TU-2 to cathodes of each pair of 6DK6 tubes in order, beginning with the last pair toward the rear of the oscilloscope. Unbalance should not exceed 2mm in the 6DK6 stages.
f. Continue forward to the 6DJ8 stage and check balance by jumpering together the plates of the 12BY7's. Unbalance shall not exceed 1 cm in the 6DJ8 stage.
g. Check 12BY7 stage by pressing zero reference button on Test Load TU-2. Unbalance should not exceed 1 cm and overall amplifier unbalance should not exceed 1.5 cm. If unbalance is found in any stage, restore balance by replacement or transposition of tubes. Follow the same order in which the balance was checked.

7-45. VERTICAL COMPRESSION CHECK. Perform this check as follows:
a. Display 2 cm of amplitude calibrator signal with trace vertically centered on screen.
b. Move trace to upper and lower extremes of the graticule.
c. Expansion or compression should not exceed .5 mm.

7-46. BANDPASS CHECK. The purpose of this check is to ascertain whether the oscilloscope is providing a uniform output over a frequency range of 500 KC to 30 MC.

7-47. Perform this check as follows:
a. Install a Type L (or K) plug-in and apply a 500 KC signal from the Constant Amplitude Signal Generator Model 190 to its input.
b. Set ATTENUATOR and SIGNAL LEVEL for 4 cm vertical deflection.
c. Increase frequency of signal generator to 30 mc. Vertical deflection should be no less than 2.8 cm.

7-48. LOW FREQUENCY RESPONSE CHECK. Proceed as follows:
a. Connect Square Wave Generator Model 211 to INPUT.
b. Set generator frequency to 10 cps, ATTENUATOR and SIGNAL LEVEL for 3 cm vertical deflection.
c. Set sweep TIME/CM switch to 20 MILLISEC and adjust for a stable display.
d. Square wave should be of good quality with no slope or drop.

7-49. TRIGGER SWEEPS A AND B INTERNAL SENSITIVITY. Proceed as follows:
a. Set oscilloscope controls as indicated:

HORIZONTAL DISPLAY	A
A and B TRIGGERING MODE	AC
A and B TRIGGER SLOPE	+INT
A and B TIME/CM	2 USEC
AC - DC	AC
VOLTS/CM	.1
VARIABLE	CALIBRATED

Note

Controls shall remain at these settings for remainder of tests unless otherwise stated.

b. Connect output of Test Oscillator to INPUT connector. Set generator frequency to 1 megacycle.
c. Adjust output of Test Oscillator to obtain 2 millimeters of vertical deflection. Adjustment of the STABILITY and TRIGGERING LEVEL controls shall produce a stable display.
d. Set HORIZONTAL DISPLAY control to B. Repeat test as in steps b and c.

7-50. TRIGGER SWEEPS A AND B EXTERNAL SENSITIVITY. Proceed as follows:
a. Set HORIZONTAL DISPLAY control to A and A TRIGGER SLOPE TO +EXT.
b. Increase output amplitude of Constant Amplitude Generator 10 V P-P; adjustment of the STABILITY and TRIGGERING LEVEL controls shall produce a stable display.
c. Decrease output amplitude of Constant Amplitude Generator to .2 v P-P; adjustment of the STABILITY AND TRIGGERING LEVEL controls shall produce a stable display.

7-51. + AND - SLOPE TEST. Proceed as follows:
a. Set A TIME/CM control to .1 MILLISEC.
b. With test oscillator at 10 KC, obtain a stable 1 cm display. (A TRIGGER SLOPE at -EXT.) The leading portion of the first cycle displayed shall have a positive slope.
c. Switch the TRIGGER SLOPE control to -EXT position; at the moment of switching, a "turnover" of 180 degree phase shift shall result in the displayed signal and the leading portion of the first cycle displayed shall have a negative slope.

7-52. TRIGGER MODES TEST.

7-53. AUTOMATIC TRIGGERING. Proceed as follows:

Note

The LA-265A Oscilloscope sweep will free-run in the AUTO mode without a triggering signal. The sweep will free-run in any other mode, at the selected sweep rate, by advancing the STABILITY control beyond the normal triggering position.

a. Using T connectors, connect AMPLITUDE CALIBRATOR output to vertical INPUT and TRIGGER INPUT TIME BASE A and TRIGGER INPUT TIME BASE B jacks. Set VOLT/CM to 1 and AMPLITUDE CALIBRATOR to .2 VOLTS.
b. Set HORIZONTAL DISPLAY knob to A, TRIGGER MODE to AUTO, TRIGGER SLOPE to + or - INT and TIME/CM switch to 1 MILLISEC. A stable display should be obtained without adjustment of the TRIGGERING LEVEL control.
c. Repeat b to check the "B" trigger, with HORIZONTAL DISPLAY on B and sweep controls as set for A.
d. Repeat steps b and c with the TRIGGER SLOPE on + or - EXT.

7-54. DC TRIGGERING. Proceed as follows:
a. With AMPLITUDE CALIBRATOR and sweep controls set as in paragraph 7-53 a and b, switch TRIGGER MODE to DC. A stable display should result from adjustment of the STABILITY and TRIGGERING LEVEL controls.

Note

In the DC MODE the VERTICAL POSITION and TRIGGERING LEVEL controls will be interactive.

b. Repeat step a with HORIZONTAL DISPLAY on B and B sweep controls set correspondingly.
c. Repeat steps a and b with the TRIGGER SLOPE at + or - EXT.

7-55. AC TRIGGERING. Repeat paragraph 7-54 steps a through c with TRIGGER MODE switch set to AC. Rotate TRIGGER SLOPE switch to opposite polarity. A 180° phase shift in the displayed signal shall result.

7-56. AC LOW FREQUENCY REJECT MODE. Repeat step 7-54 a with TRIGGER MODE switch at AC LF REJECT. Repeat this check with the TRIGGER SLOPE at + or - EXT.

7-57. HIGH FREQUENCY SYNCHRONIZATION TRIGGERING. Proceed as follows:
a. Set A TRIGGERING MODE to HF SYNC, A TIME/CM to .1 USEC, and TRIGGER SLOPE to + or - INT.
b. Connect Constant Amplitude Signal Generator to INPUT Connector. Set frequency to 30 megacycles and adjust amplitude to obtain 2 centimeters of vertical deflection.
c. Adjustment of the STABILITY control shall result in a stable display.

7-58. CALIBRATED SWEEP RATES TEST.

7-59. TIME BASE A. Proceed as follows:
a. Set Oscilloscope controls as indicated:

HORIZONTAL DISPLAY	A
A TIME/CM	.1 usec
TRIGGERING MODE	AC
TRIGGER SLOPE	EXT-
5X Magnifier	ON

b. Connect 50 Megacycle output from Time Mark generator to Input connector. Connect 1 usec output from Time Mark generator to Time Base A Trigger Input.
c. Set VOLTS/CM controls for convenient vertical deflection and the A triggering controls for a stable display.
d. The display shall be 1 time mark per horizontal division (cm). The leading edge of the first cycle shall be lined up with the first centimeter division, the leading edge of the last cycle shall not be offset from the ninth centimeter division by an amount greater than ±3%.
e. Set Triggering Mode switch to + Int. Set 5X Magnifier to Off. Remove connection from Time Mark generator to Trigger Input, connection to vertical Input should remain. Set Time Mark generator output to 10 Megacycle. The display shall be as stipulated in d above.
f. Check the remaining 24 sweep speeds using the Time Mark Generator outputs as listed in figure 7-10. Adjust the VOLTS/CM and triggering controls for a convenient and stable display in each case. The display for each sweep rate shall be listed in figure 7-10. The accuracy of each sweep rate shall be ±3%, determined from the first to the ninth centimeter graticule lines as in step d.

7-60. A VARIABLE TIME/CM CONTROL CHECK. Proceed as follows:
a. Set A TIME/CM to 1 MILLISEC and VARIABLE control to CALIBRATED.
b. Display 5 millisec markers from Time Mark Generator. These should be 1 marker each 5 cm.
c. Rotate VARIABLE CONTROL fully counter clockwise. Markers should be displayed 1 marker each 2 cm or less. UNCALIBRATED neon lamp shall light.

7-61. TIME BASE B. Proceed as follows:
a. Set Oscilloscope controls as indicated:

HORIZONTAL DISPLAY	B
B TIME/CM	2 USEC
B TRIGGERING MODE	AC
B TRIGGER SLOPE	+INT
5X MAGNIFIER	OFF

b. Connect Time Mark Generator output to INPUT connector. Set Std. Freq. selector knob to 1 Mc.
c. Set VOLTS/CM controls for convenient vertical deflection, and the B triggering controls for convenient and stable display.
d. The display shall be 2 cycles per horizontal division (cm). The leading edge of the first cycle shall be lined up with the first centimeter division, the leading edge of the next to the last cycle shall not be offset from the ninth centimeter division by an amount greater than ±3%.
e. Check the remaining 17 sweep speeds using the Time Mark Generator outputs listed in figure 7-11. The accuracy of each sweep rate shall be ±3%, determined from the first to the ninth centimeter graticule lines as in step d.

7-62. B SWEEP LENGTH CHECK. Perform this check as follows:
a. Set B TIME/CM switch to .5 MILLISEC and STABILITY for a free running sweep.
b. Check that the B LENGTH control limits are from 3.2 to 3.8 cm minimum to 10.2 to 10.8 maximum.

7-63. SWEEP MAGNIFICATION TEST. Proceed as follows:
a. Set Oscilloscope controls as indicated:

HORIZONTAL DISPLAY	B
B TRIGGERING MODE	AC
B TRIGGERING SLOPE	+INT
B TIME/CM	1 MILLISEC
5X MAGNIFIER	ON
VOLTS/CM	2

b. Connect Time Mark Generator output to INPUT connector. Set Time Mark Generator for 1 Millisec and 100 microsecond time marks.
c. Adjust VOLTS/CM and triggering controls for convenient and stable display.
d. The display shall be 1 large marker every five divisions (cm) and 2 small markers every one division (cm). Position display to observe linearity on both ends.

7-64. DELAY SWEEP TESTS.

7-65. "B" INTENSIFIED BY "A". Proceed as follows:
a. Set oscilloscope controls as indicated:

HORIZONTAL DISPLAY	A
A TIME/CM	50 USEC
A VARIABLE	CALIBRATED
B STABILITY	PRESET
B TIME/CM	.5 MILLISEC
B LENGTH	10 CM
DELAY TIME MULTIPLIER	1.0
A and B TRIGGERING MODE	AC
A and B TRIGGERING SLOPE	+ or - INT

b. Connect the Time Mark Generator output to the INPUT connector. Set generator for 500 usec markers.
c. Adjust VOLTS/CM control and A TRIGGERING LEVEL for a convenient and stable display. Two time marks shall be displayed; position them to align the leading edge of the first mark (one centimeter from the start of trace) with the first centimeter division from the left edge of the scope face.
d. Set HORIZONTAL DISPLAY control to 'B' Intensified by 'A', and A STABILITY fully clockwise (free running).
e. Adjust B TRIGGERING LEVEL for a stable display. The start of the delayed portion of the sweep shall now be indicated by an intensified trace for the delayed sweep duration. With the DELAY-TIME-MULTIPLIER set at 1, the first mark shall be intensified, starting with its leading edge. With the DELAY-TIME-MULTIPLIER set at 9, the ninth time mark shall be displayed in an identical manner.

7-66. 'A' DELAYED BY 'B' DELAY TIME MULTIPLIER LINEARITY. Proceed as follows:
a. Set HORIZONTAL DISPLAY control to 'A' DEL'D by 'B'.
b. Display signal as in paragraph 7-65.
c. Check DELAY TIME MULTIPLIER at each major division from 1.00 to 9.00. The error shall not exceed two minor divisions.

7-67. 'A' DELAYED BY 'B' JITTER CHECK. Proceed with this check as follows:
a. Set oscilloscope controls as indicated:

B TIME/CM	1 MILLISEC
A TIME/CM	1 USEC
HORIZONTAL DISPLAY	B INTENSIFIED BY A

b. Connect the Time Mark Generator to the INPUT connector, and set for 1 millisecond markers.
c. Set the DELAY-TIME-MULTIPLIER to 1.00, so the brightened portion of the sweep coincides with the first marker.
d. Set the HORIZONTAL DISPLAY control to 'A' DEL'D BY 'B'. The horizontal jitter in the observed marker shall not exceed 3mm.
e. Repeat step d and observe the ninth marker. The horizontal jitter observed shall not exceed 5mm.

7-68. EXTERNAL HORIZONTAL INPUT DEFLECTION FACTOR CHECK. Proceed as follows:
a. Set oscilloscope controls as indicated:

HORIZONTAL DISPLAY	EXT X1
'A' STABILITY	fully clockwise
AMPLITUDE CALIBRATOR	.2 VOLTS
VARIABLE 10-1	fully clockwise

Sweep Time	.1 usec (5X MAG)	.1 usec	.2 usec	.5 usec	1 usec	2 usec	5 usec	10 usec	20 usec	50 usec	.1 Msec	.2 Msec	.5 Msec
Time Mark Interval	50 Mc	10 Mc	10 Mc	1 usec	1 usec	1 usec	5 usec	10 usec	10 usec	50 usec	100 usec	100 usec	500 usec
Display	1 cm	1 cm	2 cm	1/2 cm	1 cm	2 cm	1 cm	1 cm	2 cm	1 cm	1 cm	2 cm	1 cm

Sweep Time	1 Msec	2 Msec	5 Msec	10 Msec	20 Msec	50 Msec	.1 sec	.2 sec	.5 sec	1 sec	2 sec	5 sec
Time Mark Interval	1 Msec	1 Msec	5 Msec	10 Msec	10 Msec	50 Msec	100 Msec	100 Msec	500 Msec	1 sec	1 sec	5 sec
Display	1 cm	2 cm	1 cm	1 cm	2 cm	1 cm	1 cm	2 cm	1 cm	1 cm	2 cm	1 cm

Figure 7-10. Time Base A Sweep Rate Checks

Sweep Time	2 usec	5 usec	10 usec	20 usec	50 usec	.1 Msec	.2 Msec	.5 Msec	1 Msec	2 Msec	5 Msec	10 Msec	20 Msec	50 Msec	.1 sec	.2 sec	.5 sec	1 sec
Time Mark Inter-val	1 usec	5 usec	10 usec	10 usec	50 usec	100 usec	100 usec	500 usec	1 Msec	1 Msec	5 Msec	10 Msec	10 Msec	50 Msec	100 Msec	100 Msec	500 Msec	1 sec
Dis-play	2 cm	1 cm	1 cm	2 cm	1 cm	1 cm	2 cm	1 cm	1 cm	2 cm	1 cm	1 cm	2 cm	1 cm	1 cm	2 cm	1 cm	1 cm

Figure 7-11. Time Base B Sweep Rate Checks

b. Connect CAL. OUT to HORIZ. INPUT. At least one cm of horizontal deflection should result.

c. Increase AMPLITUDE CALIBRATOR to 2 VOLTS and set VARIABLE 10-1 for 10 cm of horizontal deflection.

d. Set HORIZONTAL DISPLAY to EXT X10. Horizontal deflection shall be 1 cm ±2%.

7-69. ALTERNATE TRACE CIRCUITRY CHECK. Proceed with this check as follows:

a. Switch TU-2 Test Load NORMAL-DUAL TRACE switch to DUAL TRACE and ALTERNATE-CHOPPED switch to ALTERNATE position. Check for dual trace with HORIZONTAL DISPLAY on A and then on B.

b. Set ALTERNATE-CHOPPED switch to CHOPPED.

c. Set switch on rear of oscilloscope to DUAL-TRACE CHOPPED BLANKING. Check for absence of switching transients on both A and B sweeps.

7-70. OUTPUT WAVEFORMS TEST. Proceed as follows:

a. Using a calibrated oscilloscope, check amplitudes at +GATE A and +GATE B output binding posts, with appropriate sweep running. Minimum output at each shall be 20 volts.

b. Check output at SAWTOOTH A binding post. The minimum sawtooth amplitude shall be 140 volts.

NOTE

The following waveforms were obtained using a 400 Kc, 3 nanosecond risetime square wave from the Tektronix Type 107 Generator. A type L preamplifier was used in the oscilloscope.

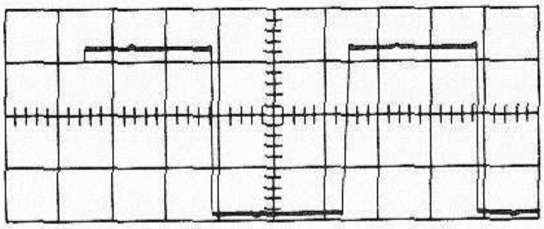
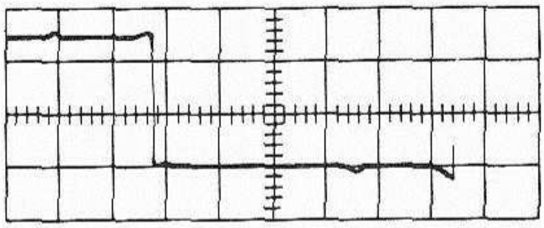
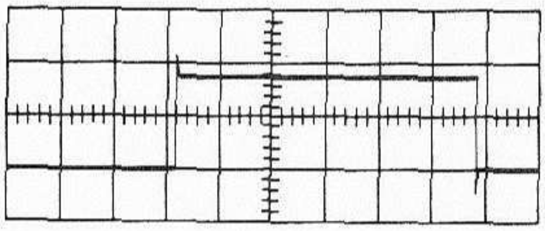
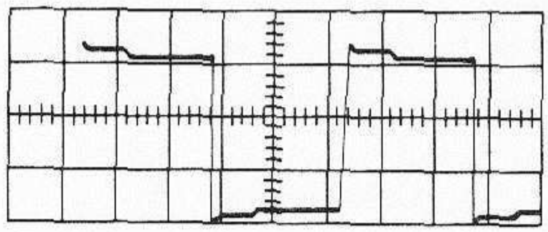
Waveform No.	Waveform Display	Sweep Rate Used	Waveform
1	Undershoot of leading edge. Capacitors at end of delay line maladjusted.	.5 usec	
2	Overshoot with bumps and wrinkles.' Defective distributed amplifier tube.	.2 usec	
3	Overshoot of leading edge. Capacitors at CRT end of delay line maladjusted.	.2 usec	
4	Downward step. Plate line reverse termination maladjusted (R1043).	.5 usec	

Figure 7-12. Delay Line Adjustment Waveforms (Sheet 1 of 2)

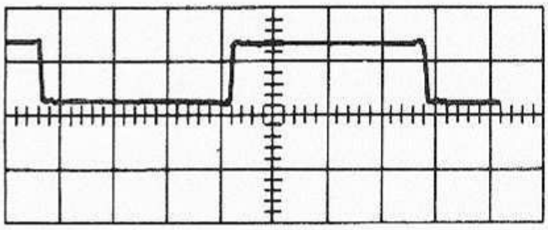
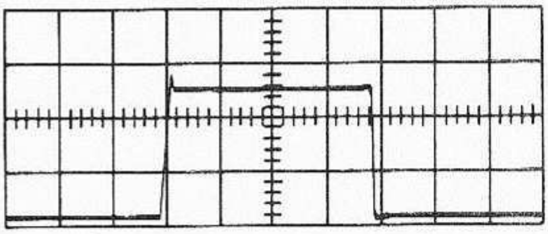
Waveform No.	Waveform Display	Sweep Rate Used	Waveform
5	Short duration bumps at random intervals on top. General delay line maladjustment.	.4 usec (approx)	
6	Ringing on leading edge. Maladjusted peaking coils.	.4 usec (approx)	

Figure 7-12. Delay Line Adjustment Waveforms (Sheet 2 of 2)