

KS-15512 LIST 4  
VIDEO FREQUENCY OSCILLOSCOPE  
DESCRIPTION

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1. GENERAL

1.01 This issue replaces Issue 2 and is reissued to include minor design changes and circuit modifications to provide the 1958A IRE frequency response characteristic. Marginal arrows indicate the changes made to this section.

1.02 The KS-15512, List 4 oscilloscope is a compact portable instrument designed for waveform analysis and amplitude measurements of video signals encountered in color and monochrome television circuits. This instrument is now rated "Manufacture Discontinued," having been replaced by the KS-15512 — List 5 oscilloscope.

1.03 Modification kits are available for the List 4 oscilloscope to incorporate some of the List 5 features. The List 4 can be modified to the electrical equivalent of the List 5 in which case the schematic diagram of the List 5 will apply. This is covered in Section 103-745-102. Some of the KS-15512, List 4 oscilloscopes which include the 1958A IRE rolloff may be locally designated as List 4A.

1.04 The oscilloscope normally will be used as a terminated device to monitor balanced or unbalanced circuits directly. When used with the test probe, it becomes a high-impedance unbalanced oscilloscope suitable for video measurements.

1.05 The oscilloscope contains an extremely flat, linear, wideband, vertical amplifier and, therefore, can be used for accurate voltage measurements up to and beyond 5 mc.

1.06 The List 4 oscilloscope may also be used as a general purpose instrument in many applications with such features as:

- (a) High sensitivity.
- (b) Excellent synchronizing capability.
- (c) Internal calibrating circuits.
- (d) Wide input voltage range.
- (e) High degree of horizontal expansion.
- (f) Vertical amplifier bandwidth front panel control.

1.07 The KS-15512, List 4 oscilloscope is supplied with a low capacitance, high-impedance input probe, having an attenuation factor of 10 to 1 (20 db), a 10-foot power cable, a pair of side brackets, and hardware for mounting in a standard relay rack.

1.08 While the high-impedance input is available, the capacitance of any cabling or patch cords used to connect the equipment to monitoring jacks may cause significant high-

frequency transmission loss to the transmission path. Consequently, for in-service monitoring of monochrome signals, it is desirable to use a J44103A video monitoring probe with 500-ohm termination (116A adapter and 340D plug) at the monitoring jacks to isolate the monitoring equipment. This monitoring method should not be used on circuits carrying NTSC color signals because bridging of these circuits will cause impairment at high frequencies.

**1.09** Information covering the application of these oscilloscopes in testing a system, or any specific piece of apparatus, is given in the section of the Bell System Practices containing the methods of testing the system or apparatus.

**1.10** General instructions on the maintenance and handling of electronic equipment involving hazardous voltages and cathode ray tubes as contained in Sections 010-110-001 and 010-110-002 should be observed.

## 2. PHYSICAL CHARACTERISTICS

**2.01** A front view of the KS-15512, List 4 oscilloscope is shown in Fig. 1.



**Fig. 1 — KS-15512, List 4 Oscilloscope, Front View**

**2.02** The KS-15512, List 4 oscilloscope is housed in a rugged aluminum carrying case with a removable hinged cover. Two heavy duty suitcase latches fasten the cover to the case. The unit may be carried by means of two leather covered, flexible steel handles mounted on the cover. The case and cover are finished in a smooth, light gray paint. The unit is ventilated by means of louvers in the case.

**2.03** The case is held to the chassis by two captive camlock fasteners which, when opened, permit the chassis to be pulled from the case on supporting slides. Protective covers are placed over components on both sides of the chassis to prevent accidental contact with high-voltage points. The cathode ray tube, enclosed by a mu-metal shield, is removable from the front of the unit. A plexiglass window provides protection against accidental breakage of the cathode ray tube.

**2.04** The front panel consists of the following controls, symmetrically arranged about the 5-inch cathode ray display tube: (See Fig. 2).

- (1) INTENSITY
- (2) FOCUS
- (3) Voltmeter, 0-3 volts peak-to-peak
- (4) CAL VOLTS (calibration control)
- (5) INPUT switch (SIDE, CAL, FRONT  
1:1, 10:1, 100:1)
- (6) IN-1-T, IN-1-R (input jacks)
- (7) IN-2-T, IN-2-R (input jacks)
- (8) BANDWIDTH switch (NARROW,  
1958A IRE, WIDE)
- (9) V GAIN
- (10) H CENT
- (11) V CENT
- (12) FUSE-3A
- (13) SYNC
- (14) FINE FREQUENCY
- (15) SWEEP FREQUENCY range switch  
(EXT, LO and HI)
- (16) SYNC SELECTOR switch (60 CPS,  
+ and -)
- (17) EXT SWEEP input (EXT SWEEP and  
GND)
- (18) POWER ON-OFF switch
- (19) H GAIN

**2.05** On the left side of the case are the power receptacle and side input jacks marked IN-3-T, IN-3-R, IN-4-T and IN-4-R. ASTIGMATISM, LOW FREQ ADJ, HOR TRACK ADJ, and HIGH VOLTAGE ADJ controls are provided inside on the chassis. There are also four attenuator adjustment capacitors and one probe adjustment capacitor.

**2.06** The vertical amplifier components are mounted on a subchassis which can be easily removed for replacement or separate testing purposes.

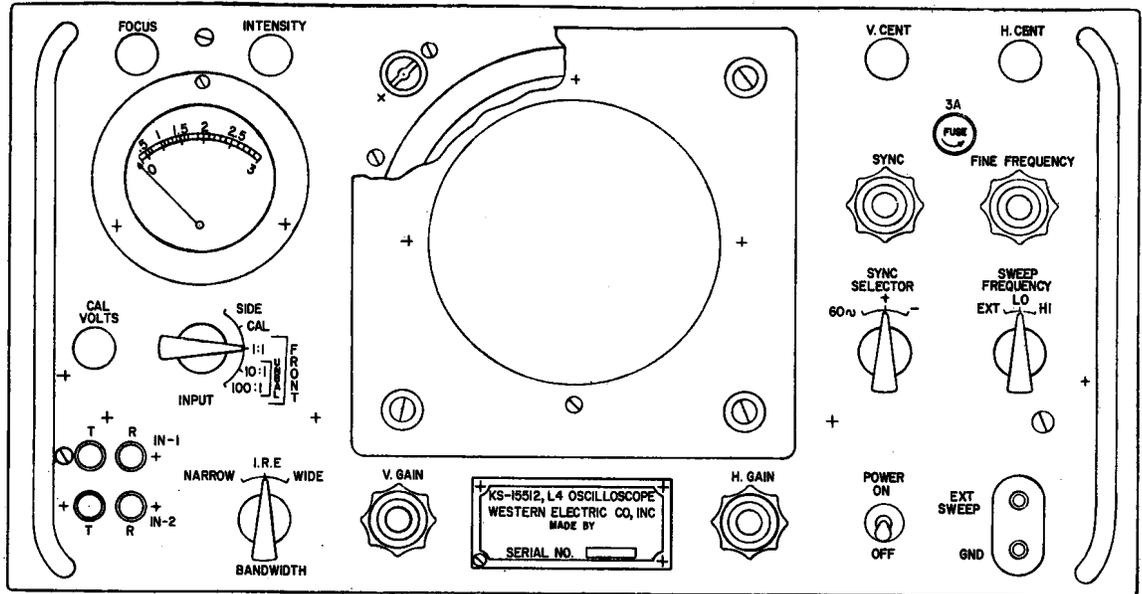


Fig. 2 — KS-15512, List 4 Oscilloscope — Front Panel

**2.07** The heater supply for the vertical amplifier is obtained from a voltage regulating transformer to insure long tube life and stability.

**2.08** Figs. 3 and 4 show the component layouts as viewed from the top and bottom of the List 4 oscilloscope respectively.

**3. TECHNICAL CHARACTERISTICS**

**3.01** The following technical characteristics pertain to the KS-15512, List 4 oscilloscope:

Power Input	105-125 volts 1.8 amperes 50/60 cps
Fuse Protection	3 amperes
Cathode Ray Tube	5UP1
Vertical Amplifier Deflection Sensitivity	NARROW: .020 volt-per-inch 1958A IRE: .200 volt-per-inch WIDE: .200 volt-per-inch

Input Signal Level Range	0.015 to 300 volts peak-to-peak
Input Impedance Vertical Amplifier with probe.	130,000 ohms, 50 mmf 1 megohm, 14 mmf
Horizontal Amplifier (Ext Sweep)	100,000 ohms, 200 mmf
Frequency Response Vertical Amplifier	NARROW 4 db down at 400 kc 1958A IRE 8.8 db down at 2 mc 20 db down at 3.6 mc WIDE 3 db down at 10 mc 3 db down at 35 kc
Horizontal Amplifier	3 db down at 35 kc
Square Wave Response	No tilt at 60 cps
Horizontal Expansion Low-Frequency Sweep	20 tube diameters
High-Frequency Sweep	12 tube diameters
Sweep Frequency Low Range	18 to 80 cps
High Range	4000 to 16,000 cps
Blanking	Trace Blanking Continuous Return

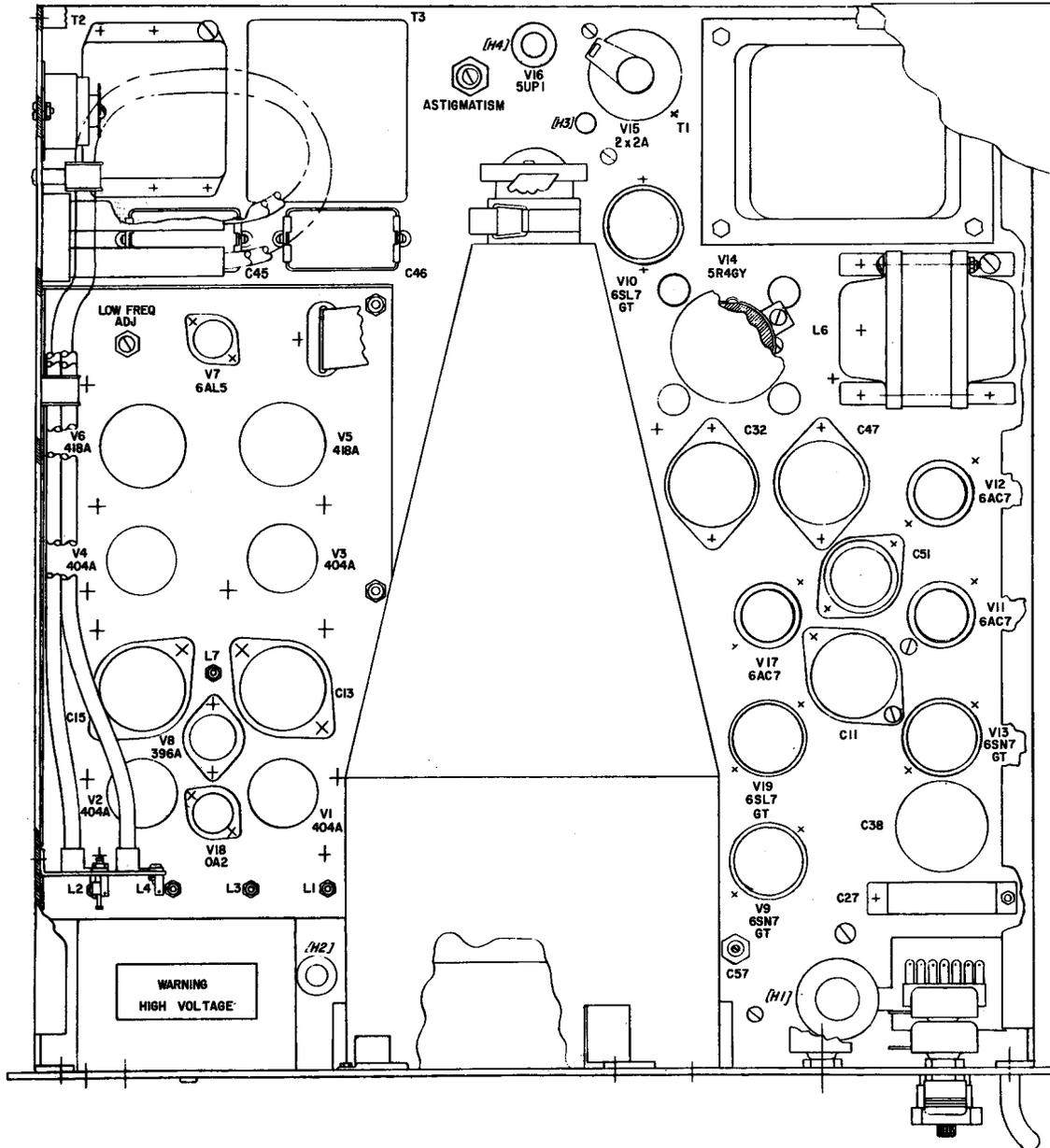


Fig. 3 — KS-15512, List 4 Oscilloscope — Top View

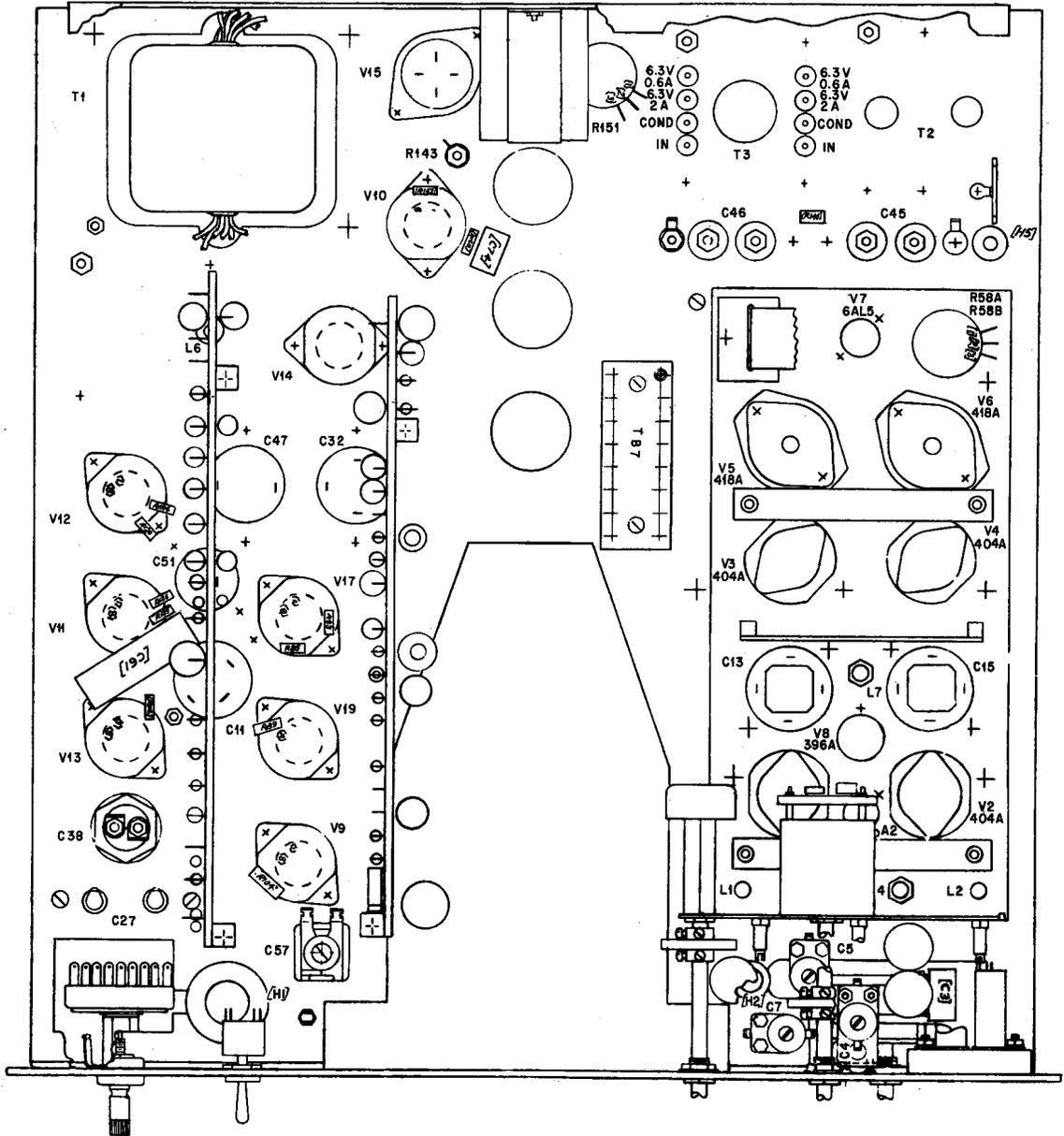


Fig. 4 — KS-15512, List 4 Oscilloscope — Bottom View

4. CIRCUIT DESCRIPTION

(A) Input Circuit and Probe

4.01 The input circuit provides for the connection of signals either balanced or unbalanced. (See Fig. 5.) Multiple jacks are provided for terminating purposes, as indicated in Tables A and B, Paragraph 5.06 (a).

4.02 For continuous monitoring of a circuit where the KS-15512, List 4 oscilloscope is rack mounted, the side input jacks (IN-3 and IN-4) may be permanently connected to the circuit. These jacks may be selected by operating the INPUT switch S1 to SIDE. By operating the switch S1 to 1:1, 10:1, or 100:1, the front panel jacks (IN-1 and IN-2) may be used.

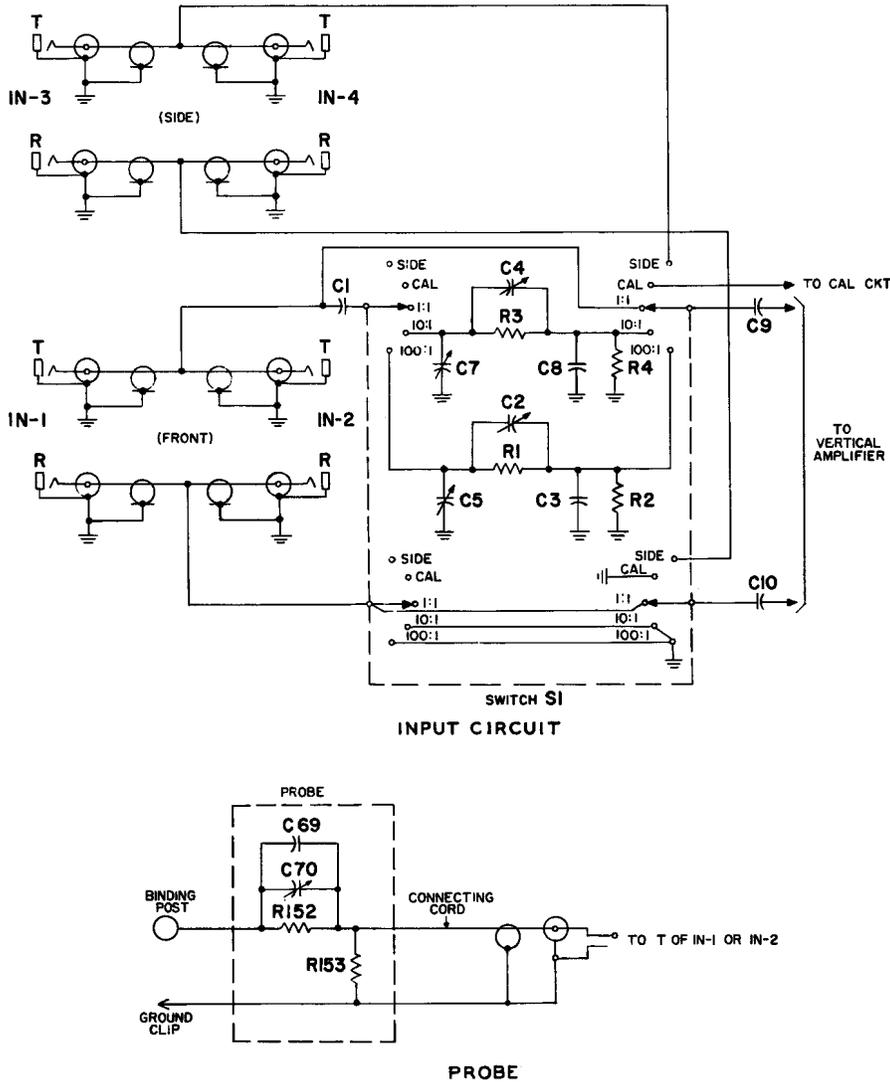


Fig. 5 — List 4 Oscilloscope Input Circuit and Probe

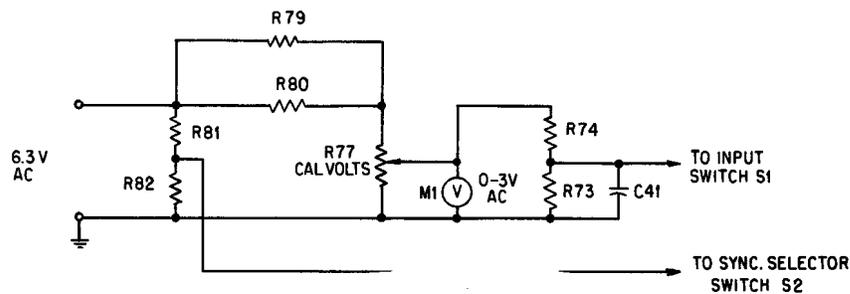


Fig. 6 - 60-Cycle Calibrating Circuit

**4.03** A 20.0 db or 40.0 db pad is inserted in the circuit when switch S1 is operated to 10:1 and 100:1, respectively, for measuring higher voltages and for use with the probe. Trimmer capacitors C4 and C2 are provided to make the loss of these pads constant over the usable bandpass of the oscilloscope. Trimmer capacitors C7 and C5 are provided to make the input capacitance constant on the 1:1, 10:1, and 100:1 switch positions. Thus, when using the probe and adjusting trimmer capacitor C70 for constant loss with frequency on the 1:1 switch position, the probe loss, at all frequencies in the bandpass of the oscilloscope, will remain the same with the switch S1 on 10:1 and 100:1.

#### (B) 60-Cycle Calibrating Circuit

**4.04** The CAL position of switch S1 connects the 60-cycle calibrating voltage to the input of the vertical amplifier. 60 cycles at 6.3 volts is obtained for this purpose from the heater circuit of electron tube V9. The variable source of voltage is obtained from the slider to ground of potentiometer R77 and measured by voltmeter M1. Resistor R79 and R80 limits the voltage that can be obtained across R77 and protects the voltmeter as shown in Fig. 6. Since the voltmeter reads rms voltages, the resistance network R74 and R73 is required to convert to peak-to-peak values.

**4.05** Resistors R81 and R82 form another voltage divider to provide a 60-cycle synchronizing voltage to the horizontal sweep circuits.

#### (C) Vertical Amplifier Input and Sync Separators Cathode Follower

**4.06** As shown in Fig. 7, when an unbalanced signal is fed to electron tube V1 or V2, the stage acts as a cathode coupled phase inverter. For a balanced signal fed simultaneously to V1 and V2, the stage acts as a push-pull amplifier.

**4.07** The V GAIN control, interconnecting the cathodes of V1 and V2, can vary the gain of the vertical amplifier 20 db by changing the amount of cathode degeneration. As the V GAIN control (R-14) is decreased, L1 and L2 become increasingly effective as high-frequency peaking coils for V1 and V2, respectively.

**4.08** The plate load of electron tube V1 (this description applies to V2 also) on the WIDE position of switch S4, consists of resistance R29 in series with R28 and capacitor C15B in parallel. R28 and C15B provide low-frequency compensation. This combination provides maximum bandwidth, as shown in Fig. 8.

**4.09** To provide a transmission characteristic with a 1958A IRE roll-off, capacitors C79, C80 and inductor L13 are connected across the plate load when switch S4 is operated to the 1958A IRE position. This characteristic also is shown in Fig. 8.

**4.10** To use the oscilloscope in conjunction with a J64047A Transmission Measuring System, the bandwidth is modified as shown in Fig. 8, by operating switch S4 to NARROW. This connects capacitor C20 and inductor L3

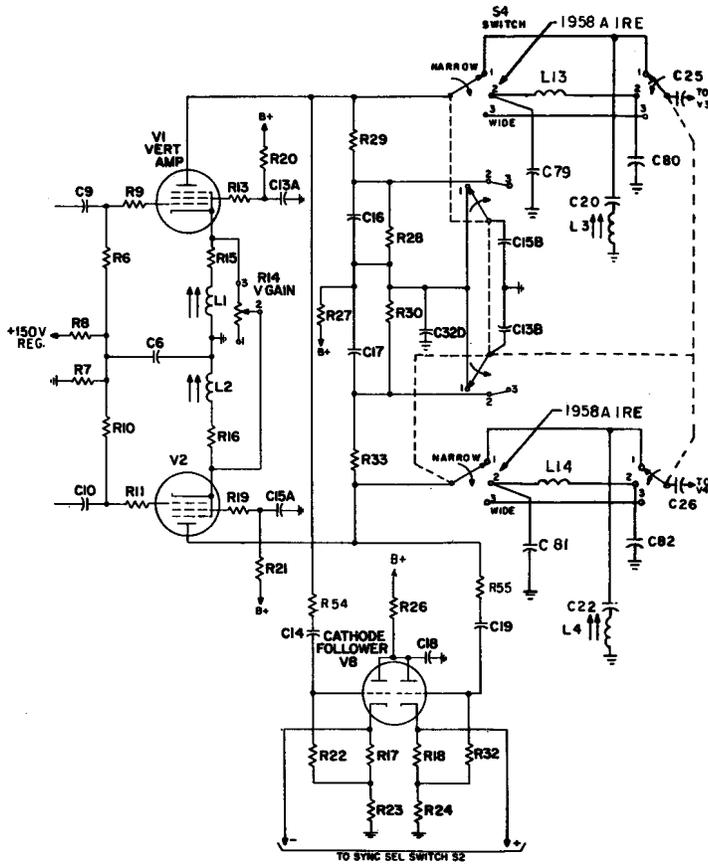


Fig. 7 – Vertical Amplifier and Sync Separator

in series across the plate load. L3 and C20 are tuned to series resonance at 3.579 mc to prevent this burst frequency from interfering with the transmission measurement.

→4.11 In the WIDE and 1958A IRE position of switch S4, the low-frequency compensation is the same, but in the NARROW position capacitor C15B is disconnected from resistor R28 and this resistor in series with R29 forms the plate load, increasing the gain 20 db to permit greater sensitivity. This stage has a maximum midband voltage gain of 16 db on the →WIDE and 1958A IRE switch positions and 36 db on the NARROW switch position.

4.12 The cathode follower, V8, couples two signals 180° out of phase from the vertical amplifier to positions + and - of the three-position SYNC SEL switch S2.

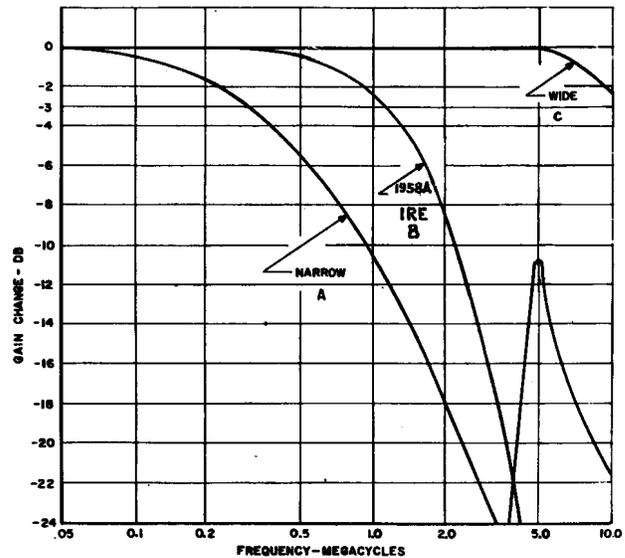


Fig. 8 – Oscilloscope Frequency Response

**(D) Vertical Output Amplifier and DC Setter**

**4.13** The vertical output amplifier consists of a two-stage balanced feed-back amplifier having a forward voltage gain of 30 db and 18 db of voltage feedback, as shown in Fig. 9. To conserve plate current, electron tube V5 is placed in series with V3, and V6 in series with V4. The excess of current required by V5 and V6 over V3 and V4 is obtained by the shunt resistor R45. The cathode potentials of V3 and V4 are considerably above ground, necessitating the voltage divider R45, R38, and R34 to obtain the proper grid bias. These high cathode potentials also require that the heaters of these tubes be fed from a separate heater winding. The proper grid bias for tubes V5 and V6 is obtained by the voltage divider R59 and R61.

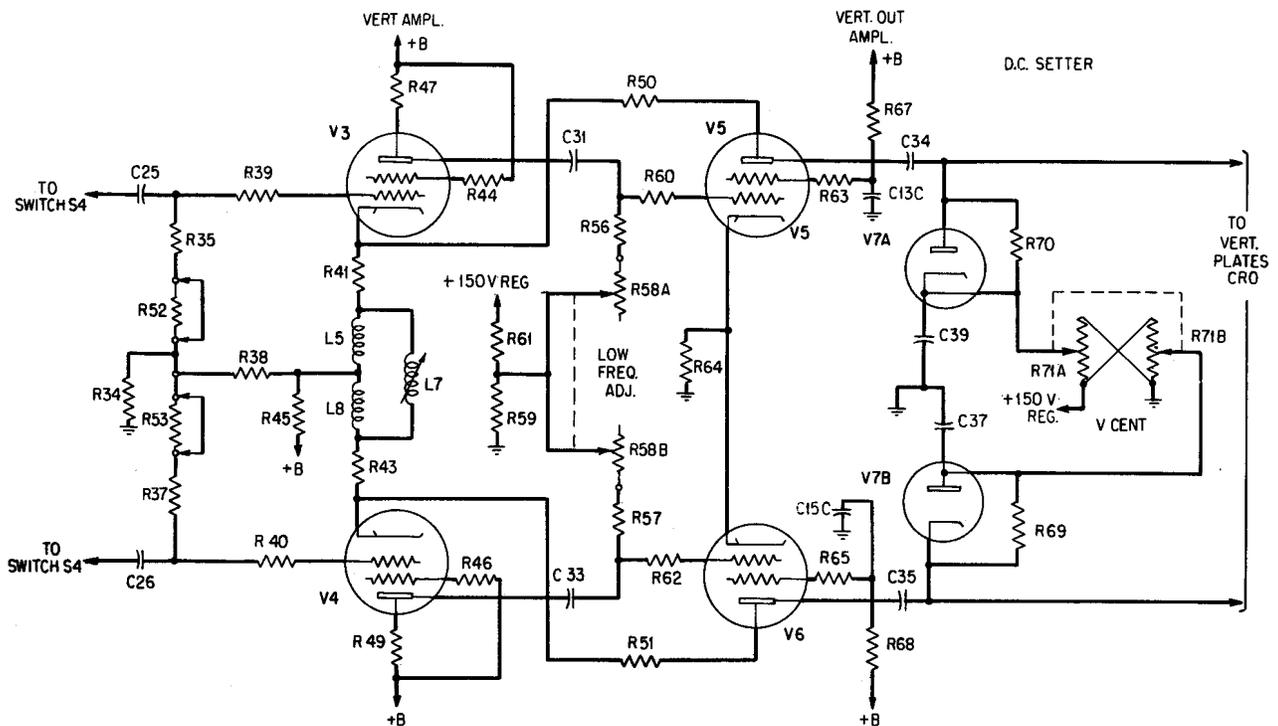
**4.14** Feedback is obtained from the plates of electron tubes V5 and V6 to the cathodes of V3 and V4, respectively, by resistors R50 and R51.

**4.15** High-frequency compensation is made adjustable by a single control, inductor L7. The low-frequency compensation is accomplished by changing the low-frequency phase of the amplifier by adjusting the dual potentiometer R58A and R58B. Additional coarse adjustment is made by removing the straps from resistors R52 and R53.

**4.16** Clamping of the negative going peaks of the signal to the base line for a stable dc reference on the oscilloscope tube is obtained by using the dual diode V7. Vertical centering is obtained by varying the potential of one vertical deflection plate with respect to the other, using the dual voltage potentiometer R71A and R71B.

**(E) Sync Separator Circuit**

**4.17** The dual cathode follower, V8 (Fig. 7), couples two signals, 180° out of phase, from the vertical amplifier to positions 2 and 3 of the SYNC SEL switch S2. The first position



**Fig. 9 – Vertical Output Amplifier and DC Setter**

of the SYNC SEL switch S2 is connected to a 60-cycle voltage source, and in this way positive, negative, or 60-cycle line synchronization may be obtained by the proper positioning of the SYNC SEL switch. The amplifier, V17 of Fig. 10, increases the amplitude of the signal sufficiently to drive the sync separator so that a synchronizing signal will be clipped and separated from the main signal. This clipping is obtained in V19A, which has its cathode grounded. The first synchronizing pulse will cause the tube to draw heavy grid current, and back bias the tube through the drop in the resistor R89. The bias held by C43 will be such that succeeding synchronizing pulses will produce just enough grid current to balance the amount discharged between synchronizing pulses. The pulses are inverted in this stage, and fed into V19B.

**4.18** The cathode follower section of V19, in addition to clipping the negative sync peaks, enables the sync control, R93, to vary the amplitude of the sync signal without materially affecting the rise time of the signal. The vertical integrator network, N1, and the differentiating network, R103 and C53, shape the signal simultaneously. The integrated or differentiated sync pulse may be selected by setting the SWEEP FREQUENCY switch to HI or LO.

#### (F) Sweep Generator

**4.19** Horizontal sweep voltages are developed in the sweep generator tube, a dual triode, V9A and V9B, operated as a cathode coupled, multivibrator. (Fig. 11.) Two basic saw-tooth sweeps of line and frame rates are developed, and may be selected with the SWEEP FREQUENCY switch, S3. These sweep rates are made variable over a reasonable range determined by the FINE FREQUENCY control, R107A and R107B. The output of the sweep generator is from the plate circuit of V9B, through switch S3 to the horizontal amplifier. Sync signals from the sync separator section are coupled selectively to the grid of V9A, through the switch S3. The pulse developed across the cathode resistor R104 as a result of the multivibrator action is used in the return trace blanking circuit. An external sweep signal may be used by switching the SWEEP FREQUENCY switch to EXT, and inserting the signal at the EXT SWEEP jack.

#### (G) Horizontal Amplifier

**4.20** The width of the horizontal sweep can be varied by the H GAIN adjustment, R111, as shown in Fig. 12, which controls the amplitude of the sweep to the phase inverter, V13. The

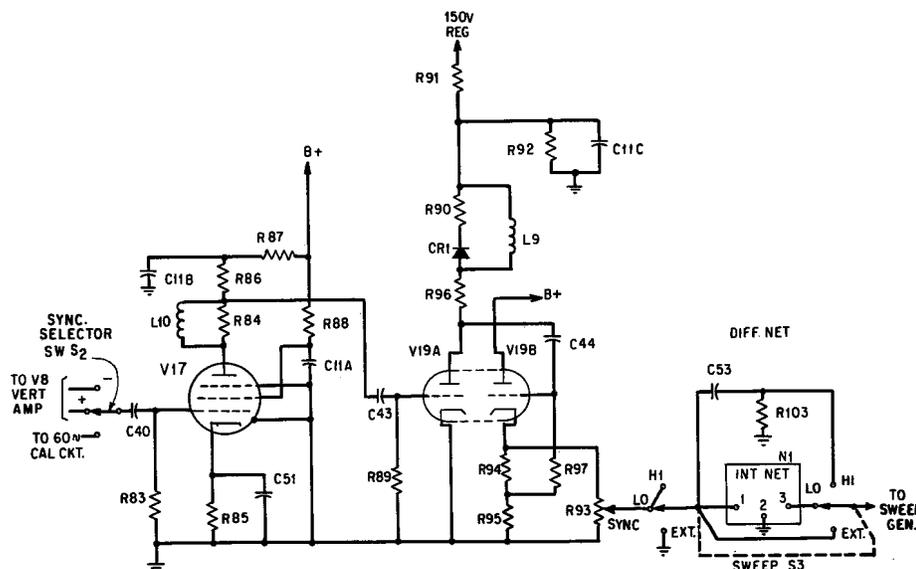


Fig. 10 — Sync Separator Circuit

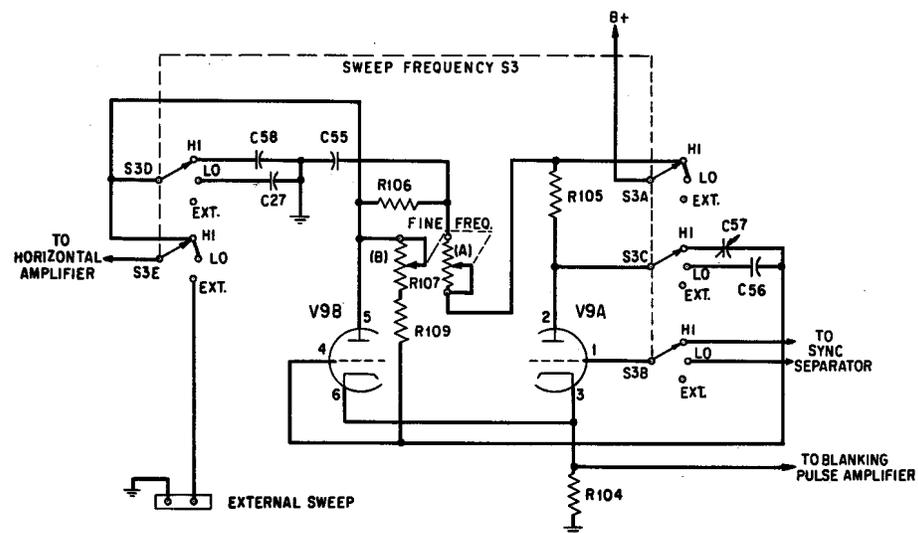


Fig. 11 – Sweep Generator

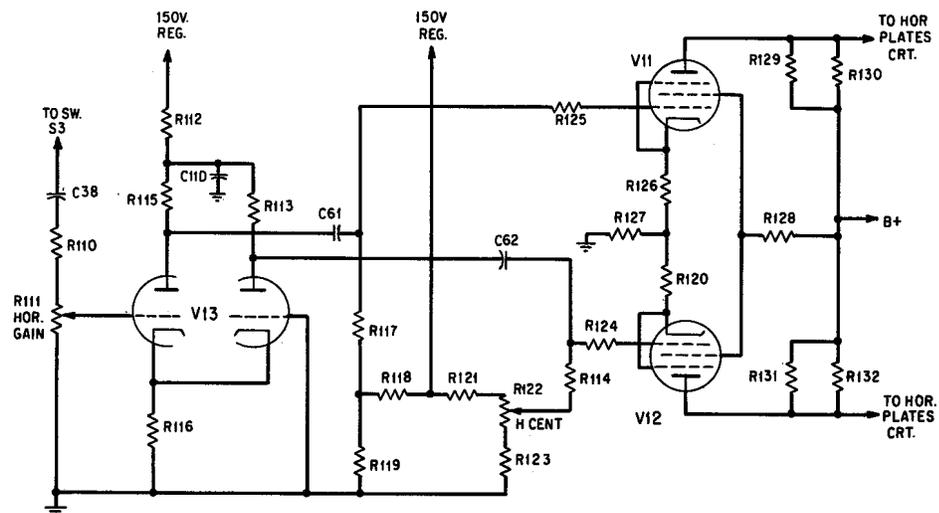


Fig. 12 – Horizontal Amplifier Circuit

phase inverter drives the push-pull amplifier, V11 and V12, whose output is coupled to the horizontal plates of the cathode ray tube.

#### (H) Blanking Amplifier

**4.21** Blanking is accomplished by amplifying the fly-back signal from the cathode of the sweep generator, V9, and inverting it with the blanking pulse amplifier, V10B, Fig. 13. This

negative signal is coupled to the grid of V16, the cathode ray tube, and cuts it off during the sweep retrace time.

#### (I) High-Voltage Regulation

**4.22** The high-voltage regulator tube, V10A, is placed in series with the cathode circuit of the high-voltage rectifier tube, V15, to ground



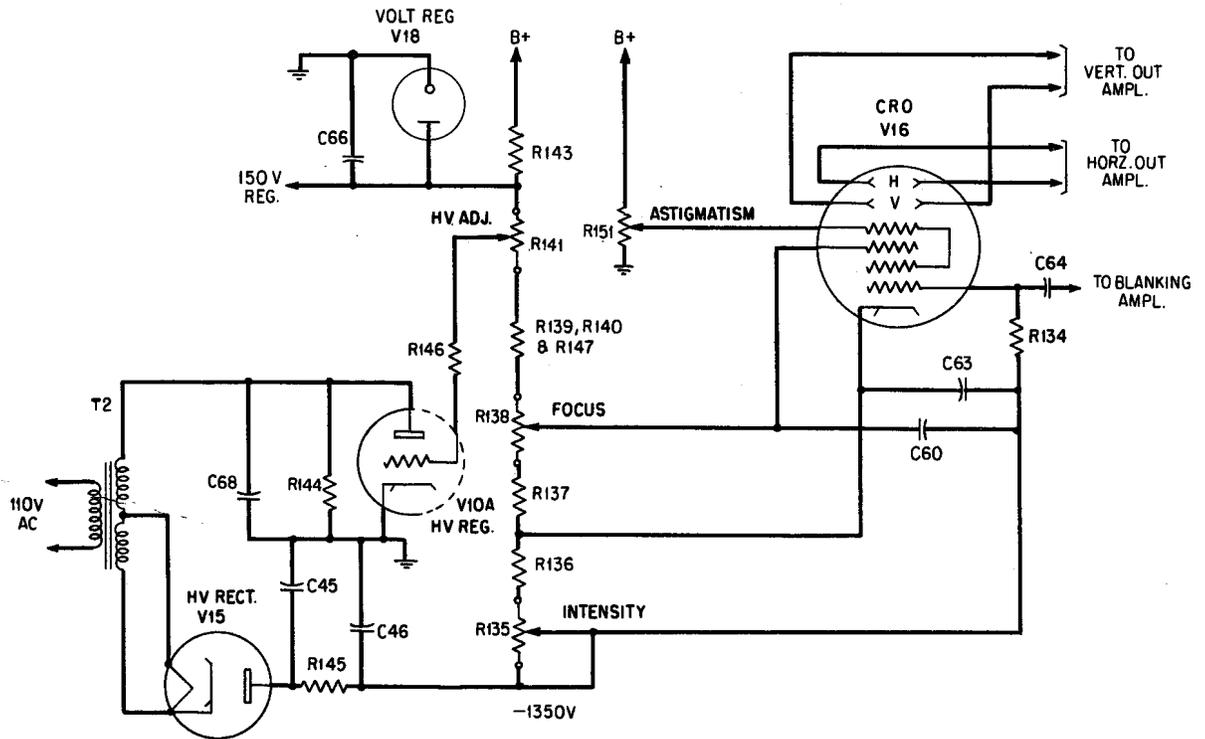


Fig. 14 – Regulated High-Voltage Supply and Cathode Ray Tube Circuit

5.06 Vertical Amplifier — Input Connections and Operations:

(a) Apply signal to desired input jacks. The signal may be balanced or unbalanced; TABLE A and TABLE B indicate the proper terminations and terminating points to be used.

TABLE A

For Side Jacks with INPUT switch in SIDE position.

SIDE JACK CONNECTIONS FOR VARIOUS SIGNAL INPUTS			
JACK DESIGNATION	75 OHMS INPUT UNBALANCED VIDEO		124 OHMS BALANCED VIDEO
	Condition-1 Black Negative Video	Condition-2 Black Positive Video	Condition-3 Balanced Video
IN-3-T IN-3-R IN-4-T IN-4-R	Signal Input Short 75 Ohms Term. Open	Short Signal Input Open 75 Ohms Term.	Black Neg. Black Pos. (124 Ohms (Balanced (Termination

TABLE B

For Front Jacks with INPUT switch in FRONT position.

FRONT JACK CONNECTIONS FOR VARIOUS SIGNAL INPUTS			
JACK DESIGNATION	75 OHMS INPUT UNBALANCED VIDEO		124 OHMS BALANCED VIDEO
	Condition-4* Black Negative Video	Condition-5* Black Positive Video	Condition-6* Balanced Video
IN-1-T IN-1-R IN-2-T IN-2-R	Signal Input Short 75 Ohms Term. Open	Short Signal Input Open 75 Ohms Term.	Black Neg. Black Pos. (124 Ohms (Balanced (Termination

\*Note: Condition 4 may be used with INPUT switch in 1:1, 10:1, or 100:1 position. Condition 4 is also the arrangement when the probe is used, except that the 75-ohm termination is not used. Condition 5 or 6 must be used only with the INPUT switch in the 1:1 position.

(b) For unbalanced inputs, the signal should be applied through a P2BJ type unbalanced coaxial cord or its equivalent. A 368A Plug should be used for the 75-ohm termination, and a 358A Plug (with a bare strap between center conductor and outer shell) should be used as a shorting plug for the proper termination of the multiple input jack arrangement.

(c) For balanced inputs, the signal should be applied through a P3AH type balanced coaxial cord, or its equivalent. A 341F Plug should be used for the 124-ohm (341E for 110-ohm) termination in the multiple input jack arrangement.

(d) Adjust the V GAIN so that the vertical size of the signal displayed is from 1 to 3 inches.

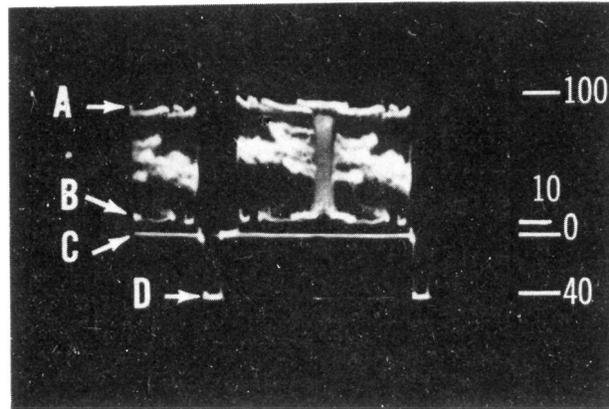


Fig. 15 — Use and Interpretation of IRE Scale

**5.07** Set the BANDWIDTH switch to the proper position. The WIDE band is used for multiburst testing and waveform analysis requiring the widest bandwidth. The 1958A IRE bandwidth follows the curve data of the 1958A IRE specifications. The 1958A IRE response is used when making signal level measurements. The NARROW bandwidth is employed when the oscilloscope is operated in conjunction with the J64047A transmission measuring set, and for measurements requiring high sensitivity. (See Fig. 8 for specific frequency response curves.)

**5.08 Horizontal Sweep — Correct Synchronization and Adjustment:**

(a) **Sync Mode Adjust:** Fig. 15 illustrates the correct sync mode, which shows the H sync pulse occurring at the right-hand end of the sweep. The SYNC and FINE FREQUENCY controls are alternately adjusted until this condition is attained. If the controls are improperly adjusted, synchronization may occur on blanking, which is indicated by the disappearance of the right-hand sync pulse. The sync mode adjustment is applicable to both high- and low-frequency sweep synchronization, i.e., V sync pulses should occur at the right-hand end of the sweep.

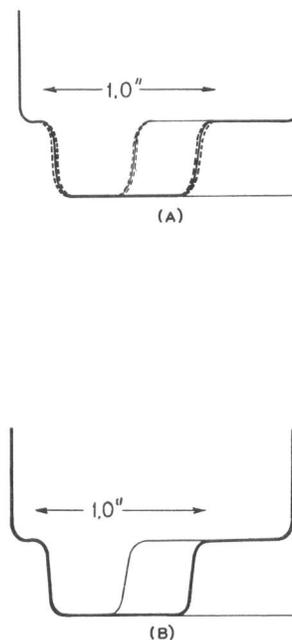


Fig. 16 — Horizontal Sync Pulse Interval

(b) **Low-Frequency Sweep:** When the low-frequency sweep is desired (18 to 80 cps), turn the SWEEP FREQUENCY control to LO, set sync control fully CCW, and adjust the FINE FREQUENCY control until the waveform pattern displayed consists of one or more cycles of the signal and appears to be

moving slowly from right to left. For a television signal observe the polarity of the synchronizing pulses on the screen. If they are positive set SYNC SELECTOR switch to +, or if they are negative set SYNC SELECTOR switch to -. For 60 cycles synchronization set SYNC SELECTOR to 60 cycles. For other input signals the type sync is selected as desired. Rotate the SYNC control clockwise until the waveform pattern suddenly becomes stationary and, therefore, is locked synchronously with the sweep. For best synchronization a minimum of sync should be used.

(c) **High-Frequency Sweep:** When the high-frequency sweep is desired (4000 to 16,000 cps), turn the SWEEP FREQUENCY control to the HI position, and set SYNC control fully CCW. Rotate SYNC control clockwise until pattern becomes stationary. Adjust the FINE FREQUENCY control until the desired number of cycles is displayed. Select the SYNC SELECTOR switch position as described in (b) above. Readjust both SYNC and FINE FREQUENCY control for best synchronization (see Fig. 16) as described in (a), above.

**5.09 Horizontal Sweep—Incorrect Synchronization:** The result of incorrect synchronization is illustrated in Fig. 16A. The leading and trailing edges of the horizontal sync pulse (which are designated by the 1-inch expansion markers) exhibit a considerable degree of jitter. By alternately adjusting the SYNC and FINE FREQUENCY controls, the jitter can be eliminated as shown in Fig. 16B. If the jitter can not be eliminated, examine the incoming signal for the following defects:

- (1) Low-frequency tilt.
- (2) Tilt in the horizontal sync pulses.
- (3) Hum modulation.

In addition, jitter may be caused when observing a TV signal not locked to the local 60-cycle power source. Under these conditions, the jitter will appear to fade in and out, due to the frequency differences in the power sources.

**5.10** Adjust the H GAIN control so that the detail in the center of the waveform display is sufficiently expanded.

**5.11** An external sweep may be connected to this instrument at the terminals marked EXT SWEEP and GND. When an external sweep is used, the SWEEP range switch must be turned to EXT. This sweep may be expanded by means of the H GAIN control.

### **5.12 Amplitude Measurements of Signals:**

#### **(a) General Method:**

(1) Apply the signal voltage as described in Paragraph 5.06 to the oscilloscope and adjust the controls so that an adequate display of the signal is observed on the cathode ray tube.

(2) Using the ruled transparent screen as a scale, note the vertical distance between the extreme amplitude peaks of the signal. **Do not disturb** the V GAIN control after making the measurement.

(3) Turn the INPUT switch to CAL position. (See Fig. 6.)

(4) Adjust the CAL VOLTS control so that the calibration signal (60 cps) displayed is equal in amplitude to the signal as determined by the transparent ruled scale. (Synchronization of the calibrating signal is not necessary.) The reading on the voltmeter scale, multiplied by the input attenuator position (selected in Step 1 of this measurement) determines the signal amplitude in peak-to-peak voltage. For general use in the measurement and comparison of TV signals, the scope should be calibrated in accordance with (c) following so that a 1-volt peak-to-peak signal at the point of observation will span 140 IRE scale divisions.

#### **(b) Scale Interpretation:**

(1) Standardizing the response characteristic and the calibration of the oscilloscope serves to minimize possible differences in interpretation of signal levels. To further insure uniformity in interpreting the oscilloscope indication, the measurement of synchronizing and blanking levels should be observed at a point in the waveform where the voltages representing these levels are

substantially at their steady state value. The longer duration signals of both synchronizing and blanking levels which occur during the horizontal synchronizing interval, are suitable. A representation of the appearance of these portions is shown in Fig. 15, the measurements being made as indicated to minimize errors due to transmission distortion.

(2) In the measurement of composite signals, blanking level may similarly be measured during the horizontal or vertical blanking interval. In measuring picture signal portions, important information bearing signal peaks will be normally held within the 0 to 100 scale range. Certain spurious highlight signals may occasionally be allowed to exceed this range. Where comparison measurements are being made at different points in a transmission system, it is important to insure that identical peaks are being considered.

(3) Measurements made within the IRE standard scale in the above manner will be expressed as in the following illustrative example:

→	White Peak:	92.5 (92.5% of Blanking to Reference White Level)
→	Black Peak:	7.5 (7.5% of Blanking to Reference White Level)
	Synchronizing Level:	40 (40% of Blanking to Reference White Level)

(4) Refer to Fig. 15 for presentation as it would appear on oscilloscope screen.

(5) In measuring oscilloscope deflection levels by means of an external scale, due care must be taken to avoid errors from parallax, centering, shift, etc.

(c) **Oscilloscope Calibration:** In applications requiring the measurement of signals less than 0.5 volt peak-to-peak, the following procedure may be followed:

(1) Turn the INPUT switch to CAL position.

(2) Adjust the CAL VOLTS control so that the voltage read on the ac voltmeter is equal to 0.5 volt.

(3) Next adjust the V GAIN control so that the peak-to-peak amplitude of the displayed calibrating signal is equal to 10 scale divisions. Therefore, each scale division is equal to 0.05 volt. The oscilloscope is now calibrated. **Do not disturb** the V GAIN control.

(4) Turn the INPUT switch to the signal input position and synchronize the frequency of the unknown signal.

(5) Note the peak-to-peak amplitude of the signal in terms of scale divisions on the ruled screen.

(6) To obtain the peak-to-peak voltage of the signal, multiply the number of scale divisions by 0.05.

### 5.13 Procedure for Measurement of Time Intervals of Signal Voltages:

(a) Apply the signal voltage to be measured to the oscilloscope input (as per Paragraph 5.06) and adjust the scope controls so that an adequate synchronized display of the signal is observed on the CRT.

(1) For a low signal frequency as a composite vertical blanking interval measurement, the SWEEP FREQ switch should be set to LO.

(2) For a high signal frequency as a composite horizontal blanking interval measurement, the SWEEP FREQ switch should be set to HI.

(b) Remove the signal voltage and apply a sine wave from a 61B or C Signal Generator or equivalent oscillator to the scope. (For a low-frequency signal, apply a sine wave approximating 10 kc. For a high-frequency signal, apply a sine wave approximating 100 kc.)

quency signal, apply a sine wave approximating 1 mc.) Without readjustment of the FINE FREQUENCY control, lock in the sine-wave display by means of the SYNC control. Adjust the V GAIN control for a sine-wave deflection of about one inch on the scope. Adjust the V CENT control until the lower tips of the sine wave are displayed on the "0" line of the IRE scale on the scope.

(c) Adjust both the H GAIN and H CENT controls until the sine-wave peaks coincide with the small vertical markers on the "0" line of the IRE scale. This then indicates that the vertical markers are calibrated in time according to the horizontal sweep setting, e.g., if the peaks of a 1 mc sine wave fall on every other vertical marker, then a 1 microsecond interval is represented by two divisions or every marker represents a 0.5 microsecond interval. Similarly a 500 kc, 200 kc, 100 microsecond time interval, respectively. every scale marker will indicate 2, 5, 10, and 100 microsecond time interval, respectively.

(d) Without readjustment of the H GAIN control, or the FINE FREQUENCY control, remove the reference sine-wave signal and reinsert the signal voltage. Position the portion of the signal to be measured on the "0" horizontal line and count the number of markers within which the signal falls. Multiply this number by the time interval scale determined in paragraph (c) above. The result yields the time interval of the signal being measured.

*Caution: The horizontal sweep is sufficiently linear for accurate readings over the scale except for the condition where the "LO" sweep is used at low CCW settings of the H GAIN control.*

## 6. SCHEMATIC DIAGRAM AND MAINTENANCE PARTS LIST

6.01 The following is a complete schematic diagram (Fig. 17) and associated maintenance Parts List for the KS-15512, List 4 oscilloscope.



## MAINTENANCE PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
R1	Res. 129K, 1/2W $\pm 1\%$	1	C173A
R2	Res. 1.31K, 1/2W $\pm 1\%$	1	C173A
R3	Res. 117K, 1/2W $\pm 1\%$	1	C173A
R4	Res. 14.4K, 1/2W $\pm 1\%$	1	C173A
R5	Not used		
R6	Res. 130K, 1/2W $\pm 5\%$	2	EB
R7	Res. 33K, 1/2W $\pm 1\%$	1	C173A
R8	Res. 68K, 1/2W $\pm 1\%$	1	C173A
R9	Res. 240, 1/2W $\pm 5\%$	2	EB
R10	Res. 130K, 1/2W $\pm 5\%$	2	EB
R11	Res. 240, 1/2W $\pm 5\%$	2	EB
R12	Not used		
R13	Res. 47, 1/2W $\pm 10\%$	2	EB
R14	Res. 2500, 2W Pot	2	JB2521 w/P3200 Shaft
R15	Res. 2610, 2W $\pm 1\%$ w/insulated caps	3	S25
R16	Res. 2610, 2W $\pm 1\%$ w/insulated caps	3	S25
R17	Res. 470, 1/2W $\pm 10\%$	2	EB
R18	Res. 470, 1/2W $\pm 10\%$	2	EB
R19	Res. 47, 1/2W $\pm 10\%$	2	EB
R20	Res. 27K, 1W $\pm 10\%$	2	GB
R21	Res. 27K, 1W $\pm 10\%$	2	GB
R22	Res. 1 Meg. 1/2W $\pm 10\%$	2	EB
R23	Res. 1000, 1/2W $\pm 10\%$	2	EB
R24	Res. 1/2W $\pm 10\%$	2	EB
R25	Not used		
R26	Res. 5100, 1W $\pm 5\%$	2	GB
R27	Res. 2000, 5W	4	27E
R28	Res. 4590, 2W $\pm 1\%$ w/insulated end caps	3	S25
R29	Res. 430, 1/2W $\pm 1\%$	1	C173A
R30	Res. 4590, 2W $\pm 1\%$ w/insulated end caps	3	S25
R31	Not used		
R32	Res. 1 Meg. 1/2W $\pm 10\%$	2	EB
R33	Res. 430, 1/2W $\pm 1\%$	1	C173A
R34	Res. 200K, 1/2W $\pm 1\%$	1	C173A
R35	Res. 43K, 1/2W $\pm 5\%$	2	EB
R36	Not used		
R37	Res. 43K, 1/2W $\pm 5\%$	2	EB
R38	Res. 2200, 1/2W $\pm 1\%$	1	C173A
R39	Res. 130, 1/2W $\pm 5\%$	2	EB
R40	Res. 130, 1/2W $\pm 5\%$	2	EB

**Note:** All resistance values are in ohms.

## MAINTENANCE PARTS LIST (Contd)

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
R41	Res. 27, 1/2W $\pm 1\%$	1	C173A
R42	Not used		
R43	Res. 27, 1/2W $\pm 1\%$	1	C173A
R44	Res. 47, 1/2W $\pm 10\%$	2	EB
R45	Res. 2500, 10W NON-IND	5	Type NIT
R46	Res. 47, 1/2W $\pm 10\%$	2	EB
R47	Res. 1000, 1/2W $\pm 1\%$	1	C173A
R48	Not used		
R49	Res. 1000, 1/2W $\pm 1\%$	1	C173A
R50	Res. 1500, 4W $\pm 1\%$	3	S30
R51	Res. 1500, 4W $\pm 1\%$ w/insulated end caps	3	S30
R52	Res. 22K, 1/2W $\pm 5\%$	2	EB
R53	Res. 22K, 1/2W $\pm 5\%$	2	EB
R54	Res. 330, 1/2W $\pm 5\%$	2	EB
R55	Res. 330, 1/2W $\pm 5\%$	2	EB
R56	Res. 30K, 1/2W $\pm 5\%$	2	EB
R57	Res. 30K, 1/2W $\pm 5\%$	2	EB
R58	Res. 100K, 2W Dual Pot	2	JJU1041 w/SD2040 Shaft
R59	Res. 9770, 1/2W $\pm 1\%$	1	C173A
R60	Res. 100, 1/2W $\pm 10\%$	2	EB
R61	Res. .178 Meg. 1/2W $\pm 1\%$	1	C173A
R62	Res. 100, 1/2W $\pm 10\%$	2	EB
R63	Res. 47, 1/2W $\pm 10\%$	2	EB
R64	Res. 80, 2W $\pm 1\%$ w/insulated end caps	3	S25
R65	Res. 47, 1/2W $\pm 10\%$	2	EB
R66	Not used		
R67	Res. 10K, 5W	4	27E
R68	Res. 10K, 5W	4	27E
R69	Res. 4.7 Meg. 1/2W $\pm 10\%$	2	EB
R70	Res. 4.7 Meg. 1/2W $\pm 10\%$	2	EB
R71	Res. 0.5 Meg. 2W Dual Pot	2	JJU5041 w/P3048 Shaft
R72	Not used		
R73	Res. 5500, 1/2W $\pm 1\%$	1	C173A
R74	Res. 10K, 1/2W $\pm 1\%$	1	C173A
R75	Not used		
R76	Not used		
R77	Res. 50, WW Pot Lin Taper 3/8" Bush, 3/4" Shaft	11	A43-50
R78	Not used		
R79	Res. 27, 1/2W $\pm 10\%$	2	EB

**Note:** All resistance values are in ohms.

## MAINTENANCE PARTS LIST (Contd)

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
R80	Res. 27, 1/2W $\pm 10\%$	2	EB
R81	Res. 1000, 1/2W $\pm 10\%$	2	EB
R82	Res. 100, 1/2W $\pm 10\%$	2	EB
R83	Res. 1 Meg. 1/2W $\pm 10\%$	2	EB
R84	Res. 33K, 1/2W $\pm 10\%$	2	EB
R85	Res. 180, 1/2W $\pm 10\%$	2	EB
R86	Res. 5600, 1W $\pm 5\%$	2	GB
R87	Res. 5600, 1W $\pm 5\%$	2	GB
R88	Res. 68K, 2W $\pm 10\%$	2	HB
R89	Res. 4.7 Meg. 1/2W $\pm 10\%$	2	EB
R90	Res. 1000, 1/2W $\pm 10\%$	2	EB
R91	Res. 33K, 2W $\pm 10\%$	2	HB
R92	Res. 33K, 2W $\pm 10\%$	2	HB
R93	Res. 5K, 2W Pot	2	JU5021 w/P3048 Shaft
R94	Res. 3.3K, 1/2W $\pm 5\%$	2	EB
R95	Res. 8200, 1/2W $\pm 10\%$	2	EB
R96	Res. 10K, 1/2W $\pm 10\%$	2	EB
R97	Res. 470K, 1/2W $\pm 10\%$	2	EB
R98	Not used		
R99	Not used		
R100	Not used		
R101	Not used		
R102	Not used		
R103	Res. 4.7K, 1/2W $\pm 5\%$	2	EB
R104	Res. 1200, 1W $\pm 10\%$	2	GB
R105	Res. 39K, 1/2W $\pm 10\%$	2	EB
R106	Res. 100K, 1/2W $\pm 10\%$	2	EB
R107	Res. Pot, .5 Meg. 2W Dual	2	JJU5041 w/P3048 Shaft
R108	Not used		
R109	Res. 100K, 1/2W $\pm 10\%$	2	EB
R110	Res. 47K, 1/2W $\pm 10\%$	2	EB
R111	Res. Pot, 50K 2W	2	JU5031 w/P3048 Shaft
R112	Res. 2200, 1/2W $\pm 10\%$	2	EB
R113	Res. 75K, 1/2W $\pm 5\%$	2	EB
R114	Res. 1.0 Meg. 1/2W $\pm 10\%$	2	EB
R115	Res. 39K, 1/2W $\pm 10\%$	2	EB
R116	Res. 5100, 1/2W $\pm 5\%$	2	EB
R117	Res. 1.0 Meg. 1/2W $\pm 10\%$	2	EB
R118	Res. 100K, 1W $\pm 5\%$	2	GB
R119	Res. 47K, 1/2W $\pm 5\%$	2	EB
R120	Res. 150, 1/2W $\pm 5\%$	2	EB
R121	Res. 100K, 1W $\pm 5\%$	2	EB

**Note:** All resistance values are in ohms.

## MAINTENANCE PARTS LIST (Contd)

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
R122	Res. 50K, 2W Pot 3600° rotation, 1/2" split bushing with knurled nut, shaft extended 1/2" beyond bushing	29	HA-100-F
R123	Res. 33K, 1/2W ±5%	2	EB
R124	Res. 47, 1/2W ±10%	2	EB
R125	Res. 47, 1/2W ±10%	2	EB
R126	Res. 150, 1/2W ±5%	2	EB
R127	Res. 6.8K, 1/2W ±5%	2	EB
R128	Res. 47K, 2W ±10%	2	HB
R129	Res. 68K, 2W ±10%	2	HB
R130	Res. 68K, 2W ±10%	2	HB
R131	Res. 68K, 2W ±10%	2	HB
R132	Res. 68K, 2W ±10%	2	HB
R133	Not used		
R134	Res. 4.7 Meg. 1/2W ±10%	2	EB
R135	Res. 100K, 2W Pot	2	JU1041 w/SD3040 Shaft
R136	Res. 33K, 1/2W ±10%	2	EB
R137	Res. 330K, 1W ±10%	2	GB
R138	Res. 500K, 2W Pot	2	JU5041 w/SD2024 Shaft
R139	Res. 330K, 1W ±10%	2	GB
R140	Res. 330K, 1W ±10%	2	GB
R141	Res. 250K, 2W Pot	2	JU2541 w/SD3040 Shaft
R142	Res. 1Meg. 1/2W ±10%	2	EB
R143	Res. 6K, 10W ±5%	2	HB
R144	Res. 4.7 Meg. 1/2W ±10%	2	EB
R145	Res. 330K, 1W ±10%	2	GB
R146	Res. 100K, 1/2W ±10%	2	EB
R147	Res. 270K, 1W ±10%	2	GB
R148	Not used		
R149	Res. 47K, 1/2W ±10%	2	EB
R150	Res. 1.0 Meg. 1/2W ±5%	2	EB
R151	Res. 0.5 Meg. 2W Pot	2	JU5041 w/P2024 Shaft
R152	Res. 910K, 1/2W ±5% Deposited Carbon	7	DCC
R153	Res. 470K, 1/2W ±5% Deposited Carbon	7	DCC

**Note:** All resistance values are in ohms.

## MAINTENANCE PARTS LIST (Contd)

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
C1	Cap. 1.0 $\mu$ f $\pm$ 10%, 400V, 0.750" Dia x 2-1/8" Lgth	8	620M
C2	Cap. 1.5-7 $\mu$ f, Var. Ceramic	9	TS2A - 1.5
C3	Cap. 750 $\mu$ f, 500V $\pm$ 5%	10	CM20E751J
C4	Cap. 5-20 $\mu$ f, Var. Ceramic	9	TS2A-5
C5	Cap. 7-45 $\mu$ f, Var. Ceramic	9	TS2A-7
C6	Cap. 1.0 $\mu$ f, 150V (Tantalum)	16	102D44
C7	Cap. 5-20 $\mu$ f, Var. Ceramic	9	TS2A-5
C8	Cap. 51 $\mu$ f, 500V $\pm$ 5%	10	CM-15-E-510-J
C9	Cap. 1.0 $\mu$ f $\pm$ 10% 400 V, 0.750" Dia x 2-1/8" Lgth	8	620M
C10	Cap. 1.0 $\mu$ f, $\pm$ 10% 400 V 0.750" Dia x 2-1/8" Lgth	8	620M
C11	Cap. 4 x 20 $\mu$ f, 450 V	4	TVL 4763
C12	Not used		
C13	Cap. 3 x 40 $\mu$ f, 450 V	4	TVL-3787
C14	Cap. 0.01 $\mu$ f, 600V, Discap.	12	MD103
C15	Cap. 3 x 40 $\mu$ f, 450 V	4	TVL-3787
C16	Cap. 51 $\mu$ f $\pm$ 10%	10	DM-15-510J
C17	Cap. 51 $\mu$ f $\pm$ 10%	10	DM-15-510J
C18	Cap. 0.01 $\mu$ f, 600 V Discap.	12	MD103
C19	Cap. 0.01 $\mu$ f, 600 V Discap.	12	MD103
C20	Cap. 22 $\mu$ f $\pm$ 5%	10	CM-15-C-220-J
C21	Not used		
C22	Cap. 22 $\mu$ f $\pm$ 5%	10	CM-15-C-220-J
C23	Not used		
C24	Not used		
C25	Cap. 1 $\mu$ f, 200 V $\pm$ 10% 0.60" Dia x 1-5/8" Lgth	8	620M
C26	Cap. 1.0 $\mu$ f, 200 V $\pm$ 10% 0.60" Dia x 1-5/8" Lgth	8	620M
C27	Cap. 1.0 $\mu$ f, 600V Channel Type, Case CP65	4	PN86
C28	Cap. 0.01 $\mu$ f, 600V, Discap.	12	MD103
C29	Cap. 0.01 $\mu$ f, 600V, Discap.	12	MD103
C30	Not used		
C31	Cap. 0.25 $\mu$ f, 400 V, $\pm$ 10% 0.550" Dia x 1-3/8" Lgth	8	620M
C32	Cap. 4 x 20 $\mu$ f, 450 V	4	TVL 4763
C33	Cap. 0.25 $\mu$ f, 400 V, $\pm$ 10% 0.550" Dia x 1-3/8 Lgth	8	620M
C34	Cap. 0.1 $\mu$ f, 400 V $\pm$ 10% 0.450" Dia x 1-1/8" Lgth	8	620M
C35	Cap. 0.1 $\mu$ f, 400V $\pm$ 10% 0.450" Dia x 1-1/8" Lgth	8	620M

## MAINTENANCE PARTS LIST (Contd)

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
C36	Not used		
C37	Cap. 0.1 $\mu$ f, 400V $\pm$ 10% 0.450" Dia x 1-1/8" Lgth	8	620M
C38	Cap. 4 $\mu$ f, 600 V	4	06P3
C39	Cap. 0.1 $\mu$ f, 400 V $\pm$ 10% 0.450" Dia x 1-1/8" Lgth	8	620M
C40	Cap. 0.1 $\mu$ f, 200V	16	330201
C41	Cap. 0.01 $\mu$ f, 200V	16	330211
C42	Not used		
C43	Cap. 0.1 $\mu$ f, 400 V	16	330401
C44	Cap. 0.1 $\mu$ f, 400 V	16	330401
C45	Cap. 0.5 $\mu$ f, 2KV	17	TJU 20005
C46	Cap. 0.5 $\mu$ f, 2KV	17	TJU 20005
C47	Cap. 4 x 20 $\mu$ f, 450 V	4	TVL 4763
C48	Not used		
C49	Not used		
C50	Not used		
C51	Cap. 1000 $\mu$ f, 6 V Electrolytic	4	DFP
C52	Not used		
C53	Cap. 68 $\mu$ f, 500 V $\pm$ 10% Mica Half Post	10	CM20A680K
C54	Not used		
C55	Cap. 12 $\mu$ f, 450 V	17	BR1245A
C56	Cap. 0.1 $\mu$ f, 400 V	16	330401
C57	Cap. 190-760 $\mu$ f	10	305
C58	Cap. 6800 $\mu$ f, 500 V $\pm$ 10% Mica Half Post	10	CM35A682K
C59	Not used		
C60	Cap. 0.01 $\mu$ f, 1000 V	4	10TM-S1
C61	Cap. 0.25 $\mu$ f, 400V $\pm$ 10%	16	3302025
C62	Cap. 0.25 $\mu$ f, 400V $\pm$ 10%	16	3302025
C63	Cap. 0.25 $\mu$ f, 200 V	16	3302025
C64	Cap. 0.05 $\mu$ f, 2000 V	20	OT467
C65	Cap. 0.01 $\mu$ f, 600 V	16	330611
C66	Cap. 0.1 $\mu$ f, 400V	16	330401
C67	Cap. 0.01 $\mu$ f, 600 V	16	330611
C68	Cap. 0.1 $\mu$ f, 1000V	16	330601
C69	Cap. 12 $\mu$ f, $\pm$ 5%	21	Type N-450
C70	Cap. 1-8 $\mu$ f, Tub. Trimmer	9	532-10
C71	Cap. 0.25 $\mu$ f, 200V	16	3302025
C72	Not used		
C73	Cap. .015 $\mu$ f, 600V	19	P88
C74	Cap. 39 $\mu$ f, 500V	10	CM20A 390K
C75	Cap. 1 $\mu$ f Voltage Optional Part of T3, Matched with T3	8	620M

## MAINTENANCE PARTS LIST (Contd)

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
C76	Cap. 47 $\mu\text{f}$ , 500 V $\pm 5\%$	10	CM15E470J
C77	Cap. 12 $\mu\text{f}$ , 450 V	17	BR1245A
C78	Cap. 150 $\mu\text{f}$ , 500 V $\pm 5\%$	10	CM15E151J
C79	Cap. 68 $\mu\text{f}$ , 500 V 5%	10	CM15E680J
C80*	Cap. 450 $\mu\text{f}$ , 500V 5%	10	
C81	Cap. 68 $\mu\text{f}$ , 500 V 5%	10	CM15E680J
C82*	Cap. 450 $\mu\text{f}$ , 500 V 5%	10	
V1	Electron Tube 404A	24	
V2	Electron Tube 404A	24	
V3	Electron Tube 404A	24	
V4	Electron Tube 404A	24	
V5	Electron Tube 418A	24	
V6	Electron Tube 418A	24	
V7	Electron Tube 6AL5	26, 27 or 28	
V8	Electron Tube 396A	24	
V9	Electron Tube 6SN7-GT	26, 27 or 28	
V10	Electron Tube 6SL7-GT	26, 27 or 28	
V11	Electron Tube 6AC7	26, 27 or 28	
V12	Electron Tube 6AC7	26, 27 or 28	
V13	Electron Tube 6SN7-GT	26, 27 or 28	
V14	Electron Tube 5R4-GY	26, 27 or 28	
V15	Electron Tube 2X2-A	26, 27 or 28	
V16	Electron Tube 5UP1, CRT	26, or 28	
V17	Electron Tube 6AC7	26, 27 or 28	
V18	Electron Tube OA2	26, 27 or 28	
V19	Electron Tube 6SL7-GT	26, 27 or 28	
CR1**	Varistor	27	1N34A
S1	Switch	12	PA-024-1223
S2	Switch	12	1P3T
S3	Switch	20	3263J
S4	Switch Assembly	12	PA-024-1181
S5	Switch	22	8370K7
L1	Inductor 45-100 $\mu\text{h}$	13	B-934120-2
L2	Inductor 45-100 $\mu\text{h}$	13	B-934120-2
L3	Inductor 33-70 $\mu\text{h}$	13	B-934120-1
L4	Inductor 33-70 $\mu\text{h}$	13	B-934120-1
L5	Inductor 7.5 $\mu\text{h}$ $\pm 5\%$	7	CLA
L6	Inductor 7 h	14	1912
L7	Inductor .47-1.0 $\mu\text{h}$	13	B-934015
L8	Inductor 7.5 $\mu\text{h}$ $\pm 5\%$	7	CLA
L9	Inductor 6.7 mh	13	B-934014

\*Made with a DM-19-251 250  $\mu\text{f}$  5% and a DM-19-201 200 $\mu\text{f}$  5%

\*\*Avoid overheating diode while soldering by holding pigtail with the long nose pliers at a point between diode and source of heat.

## MAINTENANCE PARTS LIST (Contd)

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
L10	Inductor 1 mh	13	B-934929
L11	Not Used		
L12	Not Used		
L13	Inductor 41 $\mu$ h $\pm$ 5%	15	Sample 4327
L14	Inductor 41 $\mu$ h $\pm$ 5%	15	Sample 4327
T1	Transformer Power	13	B-934012
T2	Transformer H. V.	30	22161-A
T3	Transformer Fil. matched with Cap. C75	31	W6916
M1	Meter 0-3 V (AC)	6	476
F1	Fuse, 3 AMP	23	AGC-3
J1	Jack	24	470C
J2	Jack	24	470C
J3	Jack	24	470C
J4	Jack	24	470C
J5	Jack	24	477B
J6	Jack	24	477B
J7	Jack	24	477B
J8	Jack	24	477B
J9	Not used		
J10	Receptacle	25	7486
P5	Plug	24	358A
W1	Cord Assembly	24	ED63656-01 G1
N1	Network	12	PC101

## LIST OF MANUFACTURERS

MFR. CODE NO.	MANUFACTURER
1	Mepco Inc.
2	Allen-Bradley Co.
3	Corning Glass Works
4	Sprague Electric Co.
5	Ward-Leonard Electric Co.
6	Weston Electrical Instrument Corp.
7	International Resistance Co.
8	Good-All
9	Erie Resistor Corp.
10	Arco Electronics
11	Clarostat Mfg. Co.
12	Centralab Div. Globe-Union Inc.
13	Manufacturer of oscilloscope
14	Sterling Transformer Corp.
15	Jeffers Electronics Inc.
16	Sangamo Electric Co.
17	Cornell-Dubilier Elec. Corp.
18	El Menco
19	Aerovox Corp.
20	P. R. Mallory & Co.
21	Mucon Corp.
22	Cutler-Hammer Inc.
23	Bussmann Mfg. Co.
24	Western Electric Co., Inc.
25	Harvey Hubbell
26	Radio Corporation of America
27	Sylvania
28	General Electric Co.
29	Circuit Instruments, Inc.
30	Chicago Std. Trans. Corp.
31	Raytheon Mfg. Co.