KS-15512 LIST 5
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 This section provides information pertaining to the KS-15512, List 5 oscilloscope. For similar information regarding the KS-15512, List 1, List 2, List 3 and List 4 oscilloscopes reference should be made to other sections in this division of Bell System Practices. Some of the KS-15512, List 5 oscilloscopes which include the 1958A IRE rolloff may be locally designated as List 5A. The technical information in this section may not necessarily apply to List 4 oscilloscopes which have been modified to List 5.

1.03 The KS-15512, List 5 oscilloscope is a compact portable instrument intended primarily for wave-form analysis and amplitude measurements of video signals encountered in color and monochrome television transmission circuits. It employs a 5-inch cathode-ray tube.

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, general purpose oscilloscope suitable for video measurements.

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

1.06 The List 5 oscilloscope includes all the major features of the List 4 instrument, and in addition provides:

(a) A camera mount bezel together with added front panel bracing.

(b) Scale illumination controlled by a rheostat associated with the POWER switch.

(c) Improved linearity and stability and increased expansion of the normal horizontal sweep and in addition, a special sweep for detailed examination of special test signals inserted in the first three horizontal lines of a standard television picture at the field frequency rate (30 cps). The special sweep is made available by use of the NORMAL — SPECIAL SWEEP push button provided on the front panel of the instrument.

(d) A single knob ten-turn HORIZONTAL CENTERING control on the front panel with increased centering range allowing examination of the ends of the expanded sweep trace without sweep distortion.

(e) An ASTIGMATISM control located on the front panel.

(f) A coaxial jack in place of the former EXTERNAL SWEEP binding posts.

(g) Shock mounting of the cathode-ray tube.

1.07 The List 5 oscilloscope may also be used as a general purpose instrument in many applications because of its high sensitivity, excellent synchronizing capability, precision calibrating circuits, wide input voltage range, and high degree of horizontal expansion. For standardization of frequency response interpretation of television signals, the bandwidth of the vertical amplifier can be set by a front panel control.

1.08 The KS-15512, List 5 oscilloscope is supplied with a low capacitance, high-impedance input probe having an attenuation factor of 10 to 1 (20 db down), a polarized 10-foot power cable, and mounting brackets for mounting flush with the face of a duct-type relay rack or in a ED-92677-01 mobile cabinet.

1.09 While the high-impedance input is available, the capacitance of any cabling or patch cords used to connect to equipment monitoring jacks may cause significant high-frequency transmission loss in the transmission path. Consequently, in bridged connections for in-service monitoring, 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.

1.10 Information covering the application of this oscilloscope in testing a system or any specific piece of apparatus is given in the

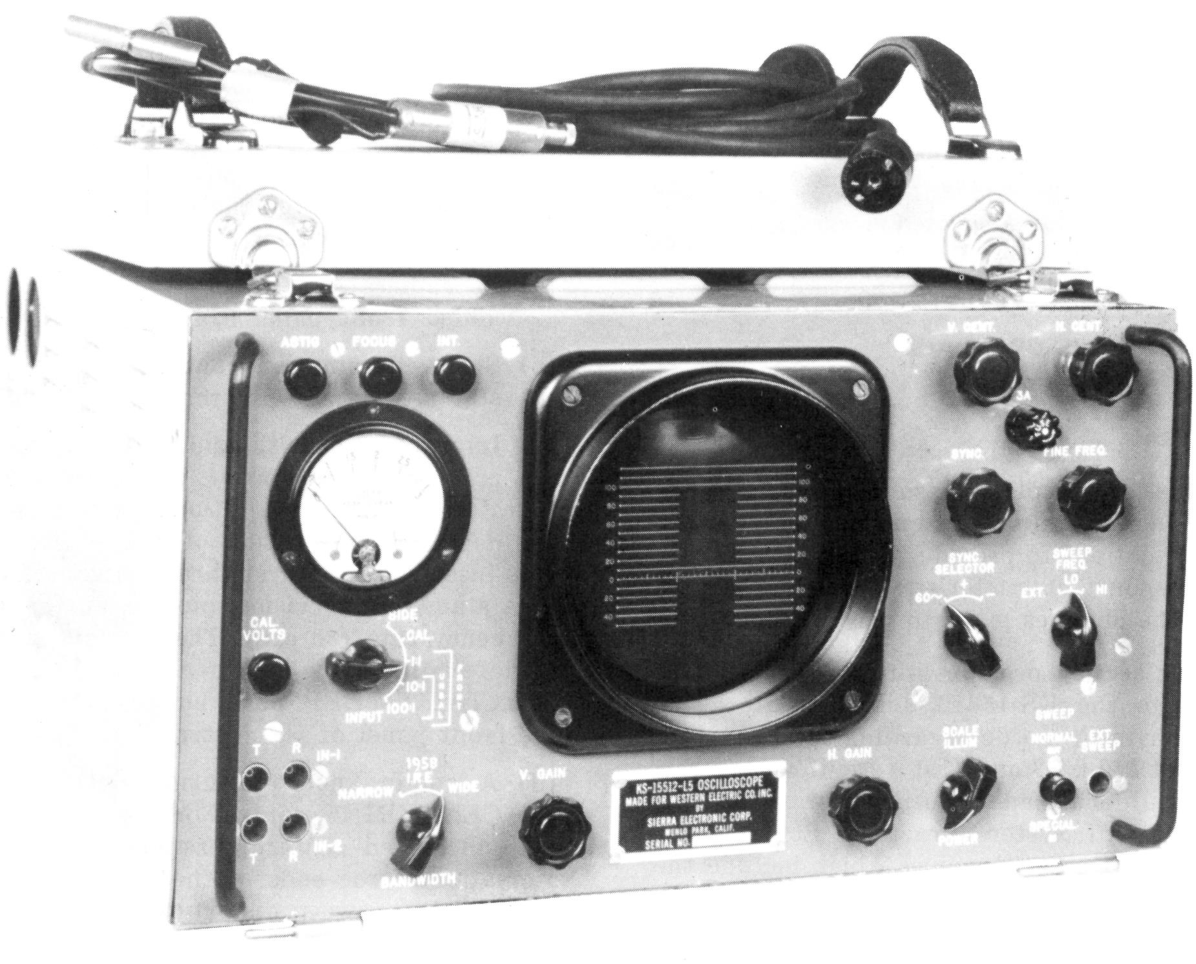


Fig. 1 — KS-15512, List 5 Oscilloscope

section of the Bell System Practices containing the methods of testing the system or apparatus.

1.11 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 The KS-15512, List 5 oscilloscope is illustrated in Figs. 1 to 3 which show the front view and the top and bottom views with cover removed.

2.02 The KS-15512, List 5 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 unit is ventilated by means of louvers in the side and top of 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 free 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 plexiglas 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:

(1) INT (Intensity)

(2) FOCUS

(3) ASTIG.

(4) Voltmeter, 0-3 volts peak-to-peak

(5) INPUT switch (SIDE, CAL., FRONT / 1:1,10:1,100:1)

(6) CAL VOLTS

(7) IN-1-T, IN-1-R (input jacks)

(8) IN-2-T, IN-2-R (input jacks)

(9) BANDWIDTH switch (NARROW, 1958A IRE, WIDE) ←

Fig. 2 — Oscilloscope, KS-15512, List 5 Top Internal View

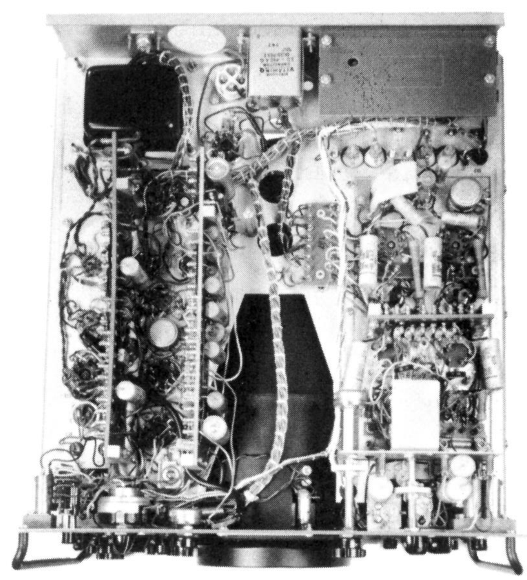


Fig. 3 — Oscilloscope, KS-15512, List 5, Bottom Internal View

(10) V GAIN

(11) H CENT

(12) V CENT

(13) FUSE — 3A

(14) SYNC

(15) FINE FREQ

(16) SWEEP FREQ range switch (EXT, LO, HI)

(17) SYNC SELECTOR switch (60~, +, −)

(18) EXT. SWEEP (input jack)

(19) SWEEP push button (NORMAL OUT, SPECIAL IN)

(20) POWER switch and SCALE ILLUM.

(21) H GAIN

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. +185 VOLT ADJ., LOW FREQ. ADJ., HOR. TRACK ADJ., and HIGH VOLTAGE ADJ. controls are provided on the chassis. There are also four attenuator adjustment capacitors, three compensation coils, and one probe adjustment capacitor.

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

2.06 The heater supply for the vertical amplifier is obtained from a voltage regulated transformer, to insure long tube life and stability.

3. TECHNICAL CHARACTERISTICS

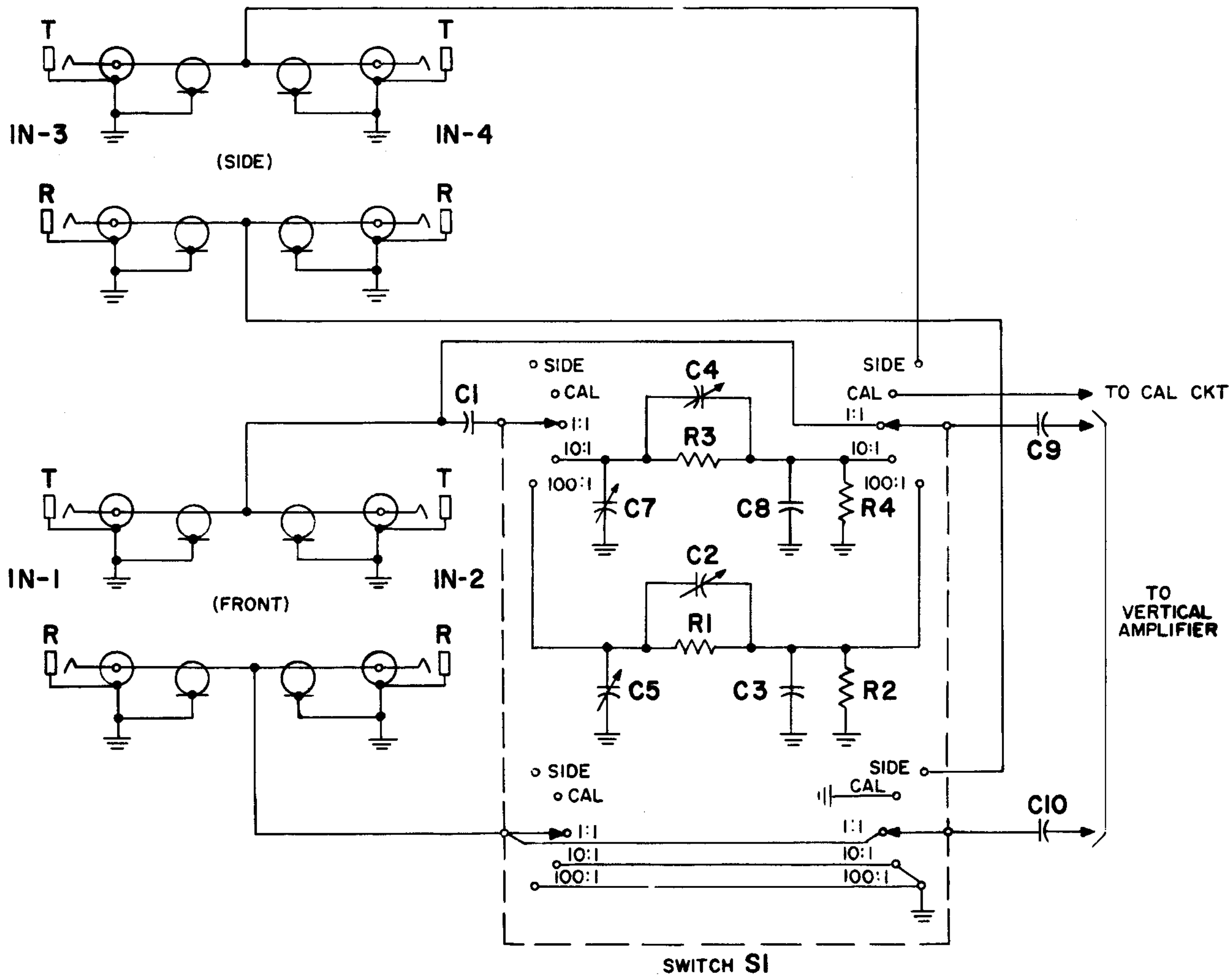
3.01 The following technical characteristics pertain to the KS-15512, List 5 oscilloscope:

Power Input	105-125 volts 1.9 amperes 50/60 cps
Fuse Protection	3 Amperes
Cathode-Ray Tube	5UP1
Vertical Amplifier Deflection → Sensitivity	NARROW: .015 volt per inch 1958A IRE: .150 volt per inch WIDE: .150 volt per inch
Input Signal Level Range	0.015 to 300 volts peak-to-peak
Input Impedance	
Vertical	130,000 ohms 50 μμf
Amplifier with probe	1 Megohm, 14 μμf
Horizontal Amplifier (External Sweep)	100,000 ohms, 200 μμf
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
Horizontal Amplifier	3 db down at 35 kc
Square Wave → Response	No tilt at 60 cycles (WIDE or 1958A IRE)
Horizontal Expansion	
Normal Low-Frequency Sweep	24 tube diam.
Normal High-Frequency Sweep	12 tube diam.
Special Sweep	6 times expansion of the normal sweep in tube diams.
Sweep Frequency	
Low Range	18 to 80 cps
High Range	4,000 to 16,000 cps
Blanking	Continuous Return Trace Blanking

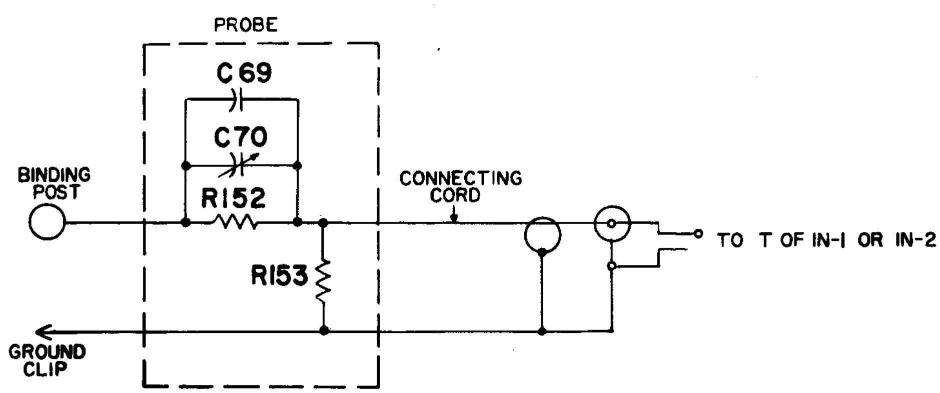
4. CIRCUIT DESCRIPTION

4.01 ***(A) Input Circuit and Probe:*** (See Fig. 4) The input circuit provides for the connection of signals either balanced or unbalanced. When the circuit to be observed is unbalanced, the corresponding (R) jack is shorted. Multiple jacks are provided for terminating purposes.

4.02 For continuous monitoring of a circuit, where the List 5 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 switch



INPUT CIRCUIT



PROBE

Fig. 4 — KS-15512, List 5 Oscilloscope Input Circuit and Probe

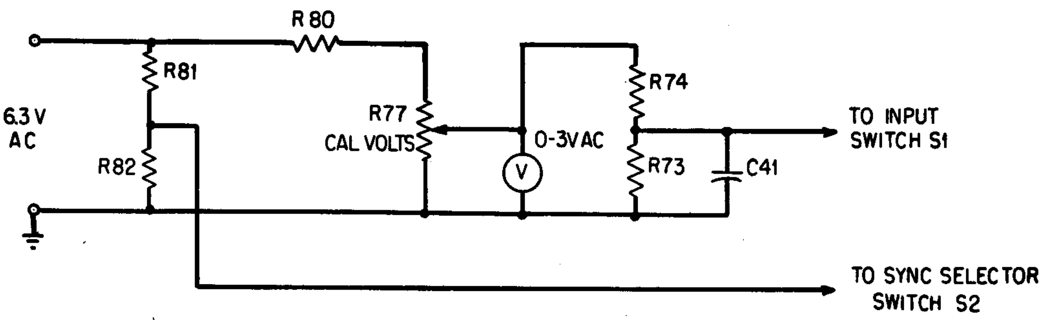


Fig. 5 — KS-15512, List 5 Oscilloscope 60-Cycle Calibrating Circuit

S1 to SIDE. By operating switch S1 to 1:1, 10:1, or 100:1 the front panel jacks (IN-1 or IN-2) may be used.

4.03 A 20.0 and 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 band pass 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 band pass of the oscilloscope, will remain the same with the switch S1 on 10:1 and 100:1.

4.04 ***(B) 60-Cycle Calibrating Circuit:*** (See Fig. 5) 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 (Fig. 10). The variable source of voltage is obtained from the slider to ground of potentiometer R77 and measured by voltmeter M1. Resistor R80 limits the voltage that can be obtained across R77 and protects the voltmeter. Since the voltmeter reads rms voltages, the resistance potentiometer R74 and R73 (in parallel with the input resistance of the oscilloscope) 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.

4.06 ***(C) Vertical Amplifier Input and Sync Separators Cathode Follower:*** (See Fig. 6) If 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 electron tubes V1 and V2, the stage acts as a push-pull amplifier.

4.07 The V GAIN control, R14, connecting the cathode of V1 to the cathode of V2 varies the gain more than 20 db by changing the amount of cathode degeneration. As R14 decreases, inductors L1 and L2 become increasingly effective as high-frequency compensation inductors 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 resistor R29 in series with R28 and capacitor C15B in parallel. R28 and C15B provide low-frequency compensation. This combination provides for maximum bandwidth, as shown in Fig. 7.

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 is also shown in Fig. 7.

4.10 To use the oscilloscope in conjunction with a J64047A Transmission Measuring System, the bandwidth is modified as shown in Fig. 7, by operating switch S4 to NARROW. This connects capacitor C20 and inductor L3 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.

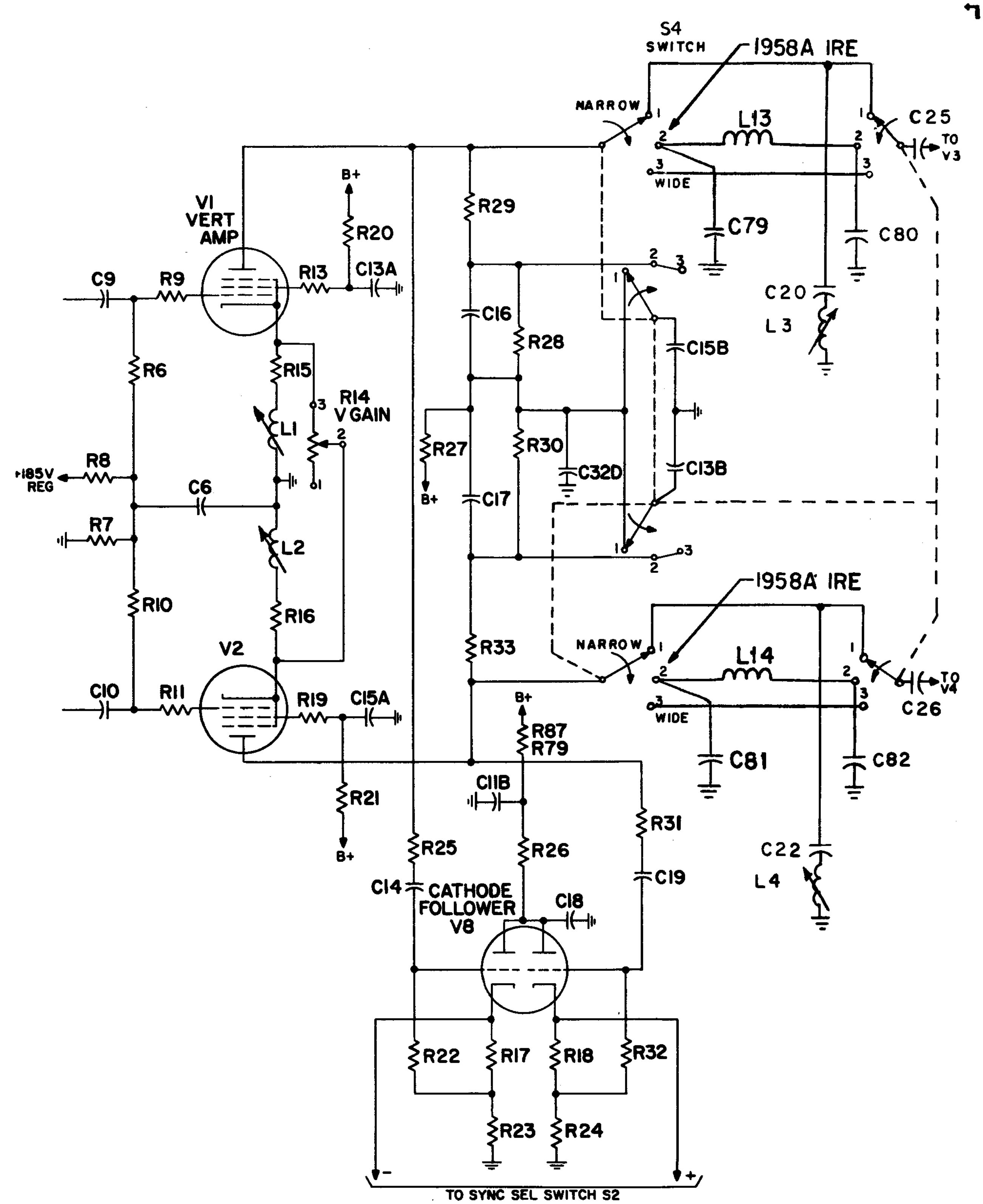


Fig. 6 — KS-15512, List 5 Oscilloscope Vertical Amplifier Input and Sync Separator Cathode Follower Circuits

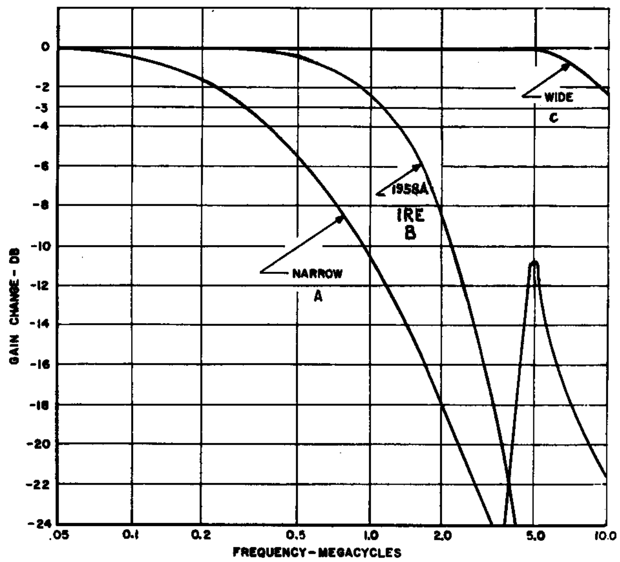


Fig. 7 — KS-15512, List 5 Oscilloscope Video Frequency Response

4.11 In the WIDE and 1958A IRE positions 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. The gain of 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 dual 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.

4.13 ***(D) Vertical Output Amplifier and DC Setter:*** (See Fig. 8) The vertical output amplifier consists of a two-stage balanced feedback amplifier having a forward voltage gain of 30 db and 18 db of voltage feedback. To conserve plate current electron tube V5 is placed in

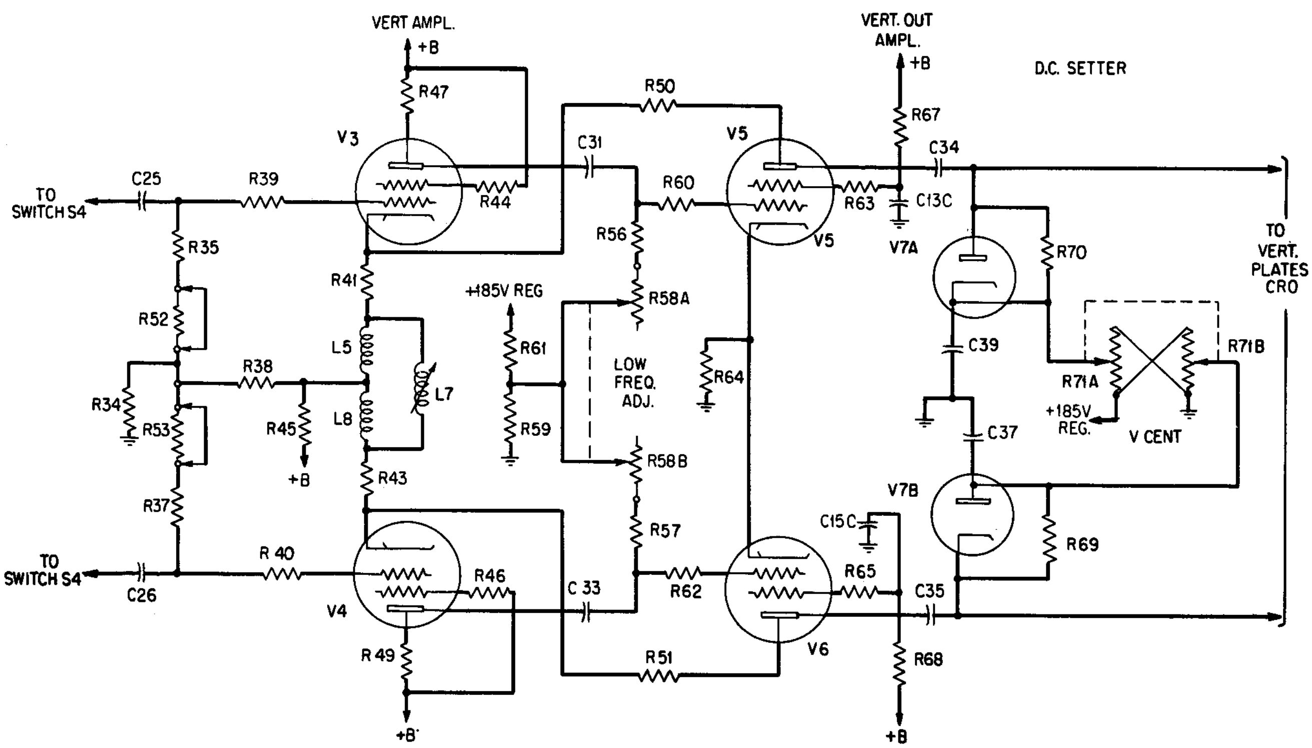


Fig. 8 — KS-15512, List 5 Oscilloscope Vertical Output Amplifier Circuit and DC Setter

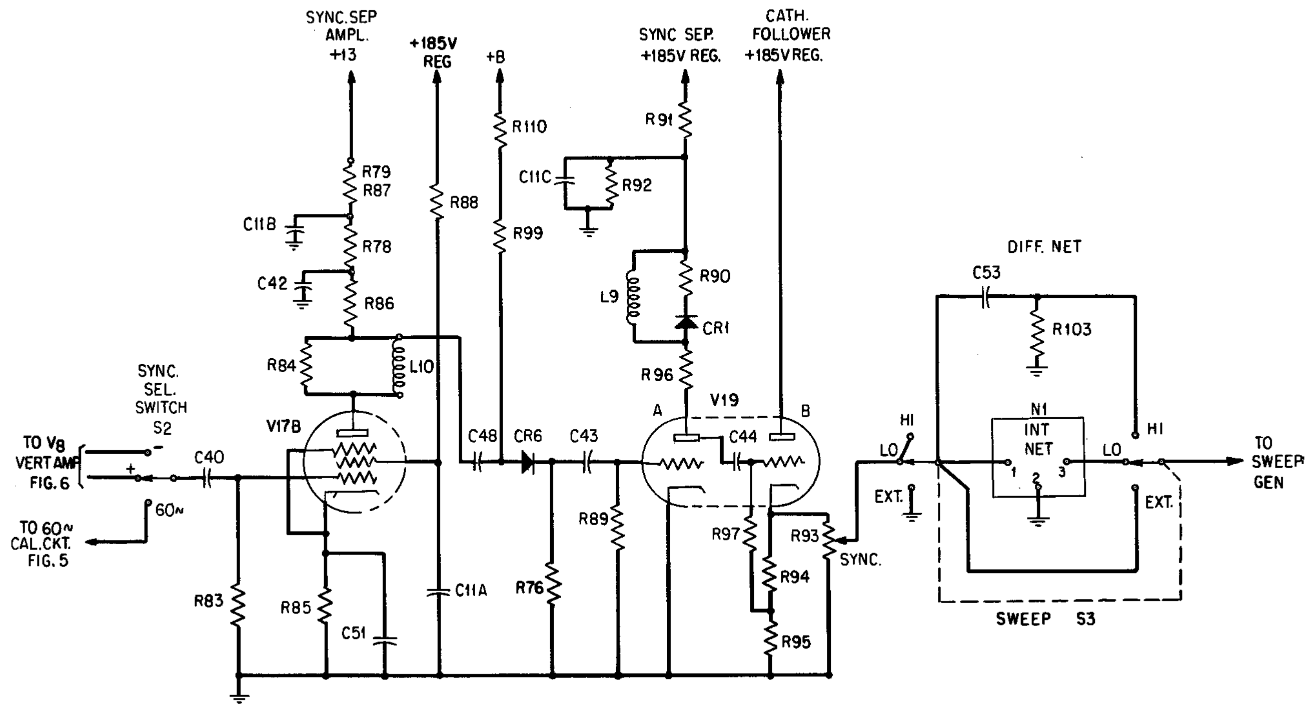


Fig. 9 — KS-15512, List 5 Oscilloscope Sync Separator Circuit

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 separated 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 R58. 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 deflective plate with respect to the other using the dual voltage potentiometer R71.

4.17 ***(E) Sync Separator Circuit:*** (See Fig. 9) Incoming signals from the vertical amplifier are selected for proper synchronizing phase by the SYNC SEL switch S2. (With the switch in the 60-cycle position, a portion of the ac heater voltage from the calibrating circuit is obtained for synchronization purposes.) The signal is amplified and inverted in the amplifier stage V17B which is conventionally biased. The signal is partially clipped of its video information by the biased varistor CR6. Biasing of this varistor is accomplished by the divider R110, R99, R76 along with the forward resistance of CR6. Additional clipping is obtained in the A Section of electron tube V19A which has its cathode grounded. The first synchronizing pulse will

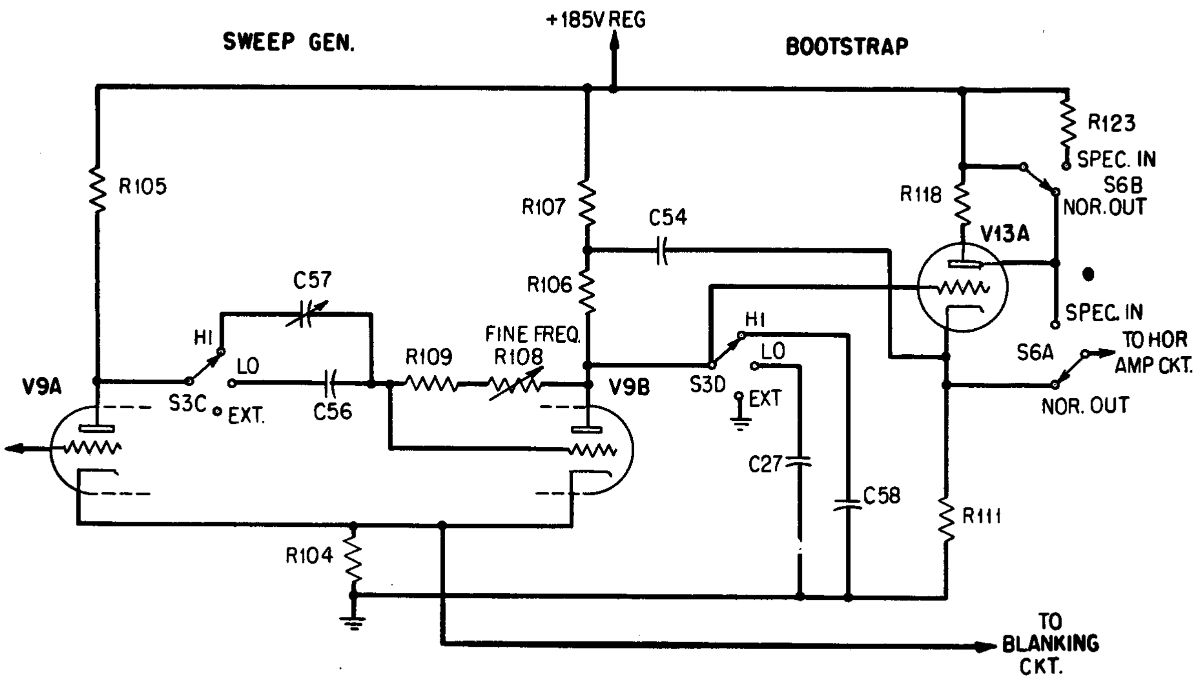


Fig. 10 — KS-15512, List 5 Oscilloscope Sweep Generator

cause the tube to draw heavy grid current and back bias the tube through the drop in 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 the cathode follower electron tube V19B. Further clipping is obtained in this stage and pulses taken from the cathode will be of the same phase but now at low-impedance level. This allows a synchronizing control R93 to be used where the position of the slider does not affect the shape of the pulses.

4.18 The synchronizing pulses are then fed both to the differentiating network, C53 and R103, and the integrating network, N1. Here the horizontal pulses are differentiated for proper synchronization of the sweep generator when a line display is desired and the vertical pulses integrated for synchronization where the field display is wanted. Selection of the desired display is obtained by operating the SWEEP switch S3 to HI or LO.

4.19 ***(F) Sweep Generator:*** (See Fig. 10) The sweep generator, electron tube V9A and V9B is a conventional type cathode coupled multivibrator. The time constants of the coupling circuits between the A and B Sections of V9 determine the frequency with a variable resistor R108 providing the required adjustment of frequency range. Variable capacitor C57 is provided so that the sweep generator when locked for a field display (LO) can be adjusted to automatically lock in for a line display when the SWEEP switch S3 is operated to HI.

4.20 The saw-tooth is formed in a conventional manner where C58 or C27 is charged to +185 volts through R106 and R107 when V9B is cut off and discharges through V9B when this tube is saturated.

4.21 Electron tube V13A is a bootstrap type circuit for linearizing the sweep saw-tooth. Voltages differing in phase are applied to the grid and cathode of V13A from the plate circuit of V9B and any deviation from linearity is cancelled out. This permits over-all sweep

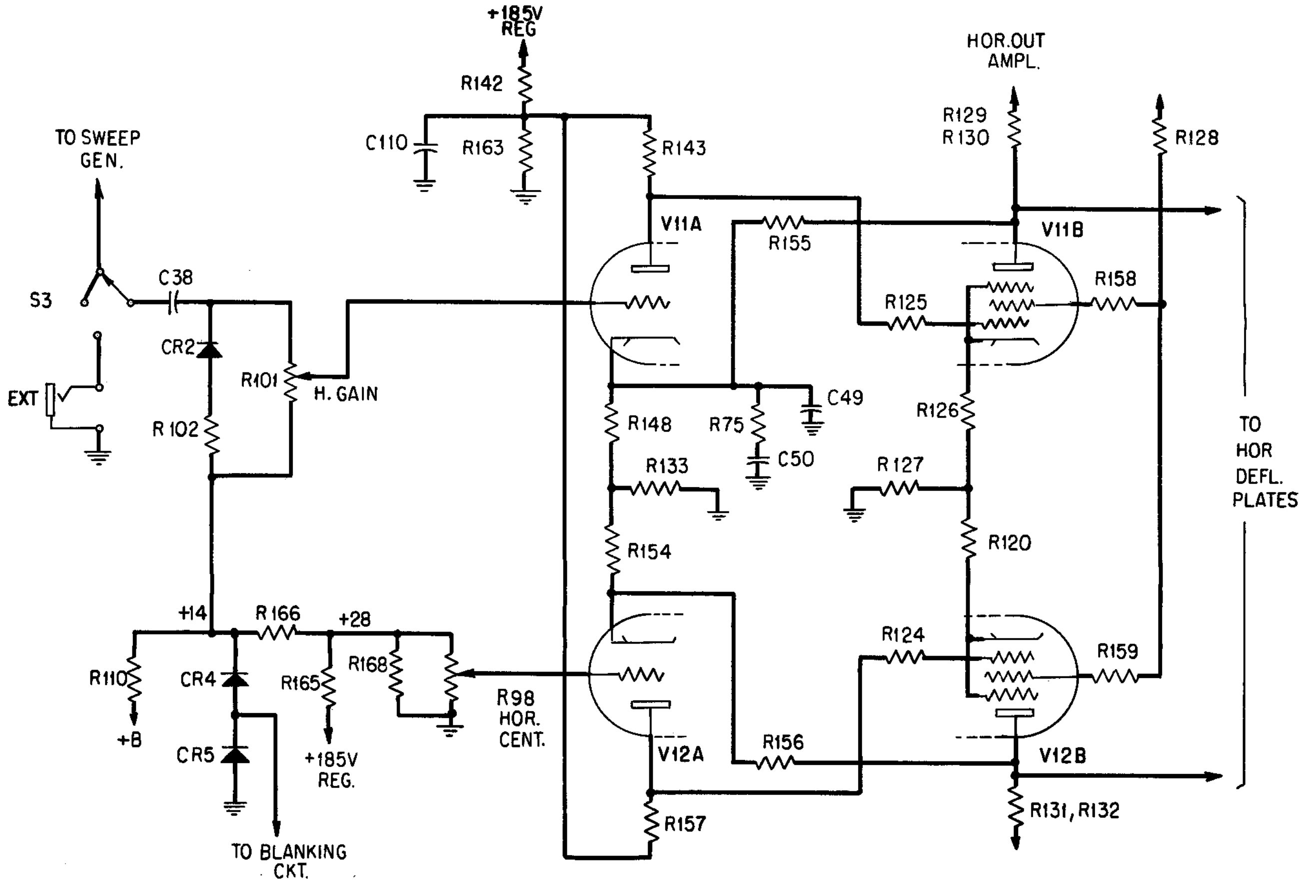


Fig. 11 — KS-15512, List 5 Oscilloscope Horizontal Amplifier Circuit

linearity of better than 95%. For NORMAL-OUT position of SWEEP selector switch S6 the saw-tooth from the cathode is fed to the horizontal amplifiers (see Fig. 11) while for the SPECIAL-IN position the inverted saw-tooth from the plate is used.

4.22 ***(G) Horizontal Amplifier:*** (See Fig. 11) The horizontal amplifier consists of a 2 stage phase-inverter dc coupled amplifier with a large amount of feedback for stability. The signal whose amplitude is controlled by the H GAIN control is fed into electron tube V11A and is amplified and directly coupled to the grid of V11B. V11B further amplifies the signal which is then directly coupled from its plate to one of the horizontal deflecting plates. A portion of the signal is fed back from the plate of V11B to the cathode of V11A through resistor R155.

4.23 The signal applied to V11A from the sweep generator is coupled to tube V12A through the common cathode resistor R133 and the resulting saw-tooth at the plate of V12A is 180° out of phase with that at the plate of V11A. Similar action as described in Paragraph 4.21 takes place and the phase inverted saw-tooth is applied to the other horizontal deflecting plate of the CR tube for balanced deflection.

4.24 Since the amplifier is dc coupled, any change in grid potential of V12A with respect to V11A will be magnified and the dc potential difference of the horizontal deflecting plates will be great. This large change in deflecting plate potential with relatively small change in input grid potentials is used to provide the large centering control range. This puts a strict requirement on the stability of the dc potentials

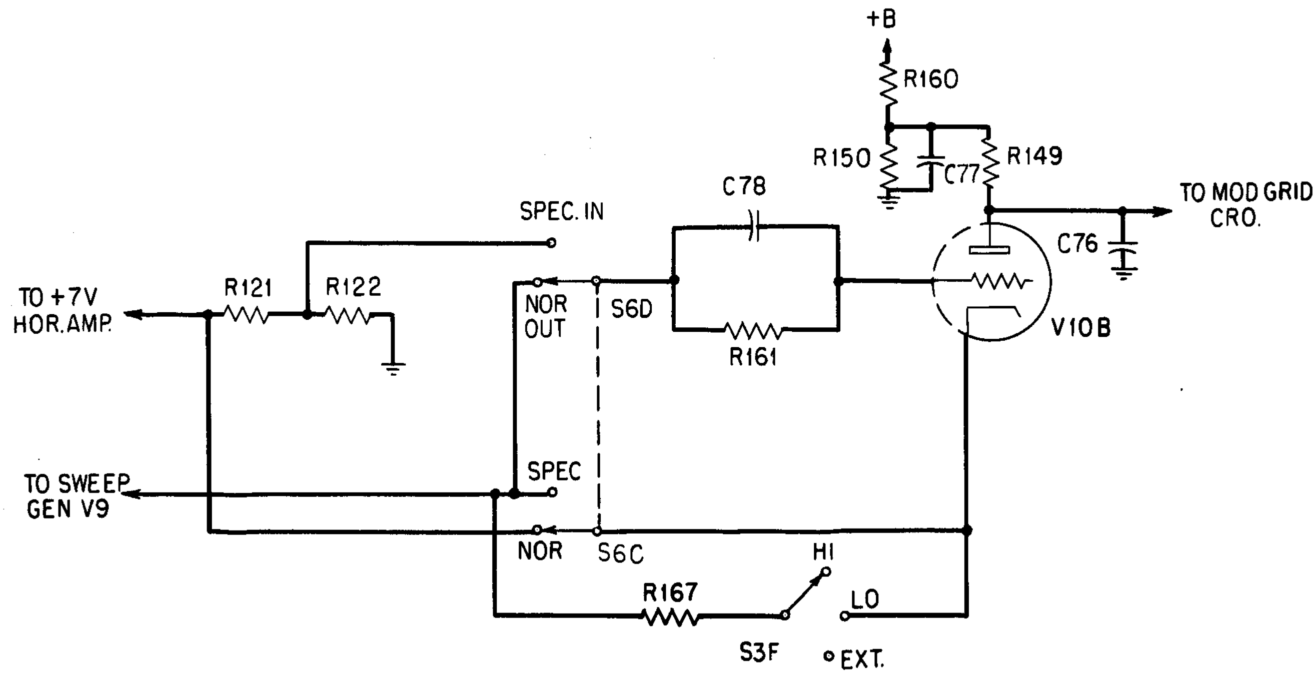


Fig. 12 — KS-15512, List 5 Oscilloscope Blanking Amplifier Circuit

applied to these grids. Matched varistors CR4 and CR5 are used as a voltage reference for the grid voltage of V11A. To break down the varistors the voltage from the regulated 185 volts would normally be used. This is partially done through resistors R165 and R166. The current required at breakdown of these varistors is more than is available for this purpose from the 185-volt regulated supply. The remaining current required is obtained from the B supply through R110. The junction R165 and R166 is held constant at 28 volts and the grid of V12A can be varied from 0 to 28 volts with the HOR CENT Control (R98). Therefore the grid voltage of V12A can be varied ±14 volts with respect to the grid voltage of V11A.

4.25 ***(H) Blanking Amplifier:*** (See Fig. 12) Normally where blanking is used on an oscilloscope, the slow charging portion of the saw-tooth is used as the sweep and the fast discharging portion which would be the retrace is blanked by taking a pulse generated at the time of the discharge by the sweep generator and using this pulse to drive the grid of the CR tube to cutoff. With the SWEEP switch S6 operated to NORMAL-OUT, the positive pulse from the cathodes of V9 is applied to the grid of the blanking amplifier V10B where it is inverted and amplified. The amplified negative pulses are applied to the grid of the CR tube to cut it off during the retrace interval. Cathode bias for V10B is obtained from one of the matched varistors.

4.26 For the SPECIAL-IN position of SWEEP switch, S6, where the lines immediately following the blanking interval on a field display are to be greatly expanded, the retrace portion of the saw-tooth is used as a sweep and the slow charging portion of the saw-tooth is blanked. During normal sweep the slow charging portion of the saw-tooth scans left to right on the CR tube and the retrace portion scans right to left. In order to obtain left to right scanning in both the NORMAL-OUT and SPECIAL-IN positions the saw-tooth feed to the horizontal amplifier is taken from the cathode of V13A for the NORMAL-OUT position and the inverted saw-tooth from the plate of V13A for the SPECIAL-IN position. The blanking pulse as for the NORMAL-OUT position is taken from the cathode of V9 but is now fed into the cathode of the blanking amplifier V10B where

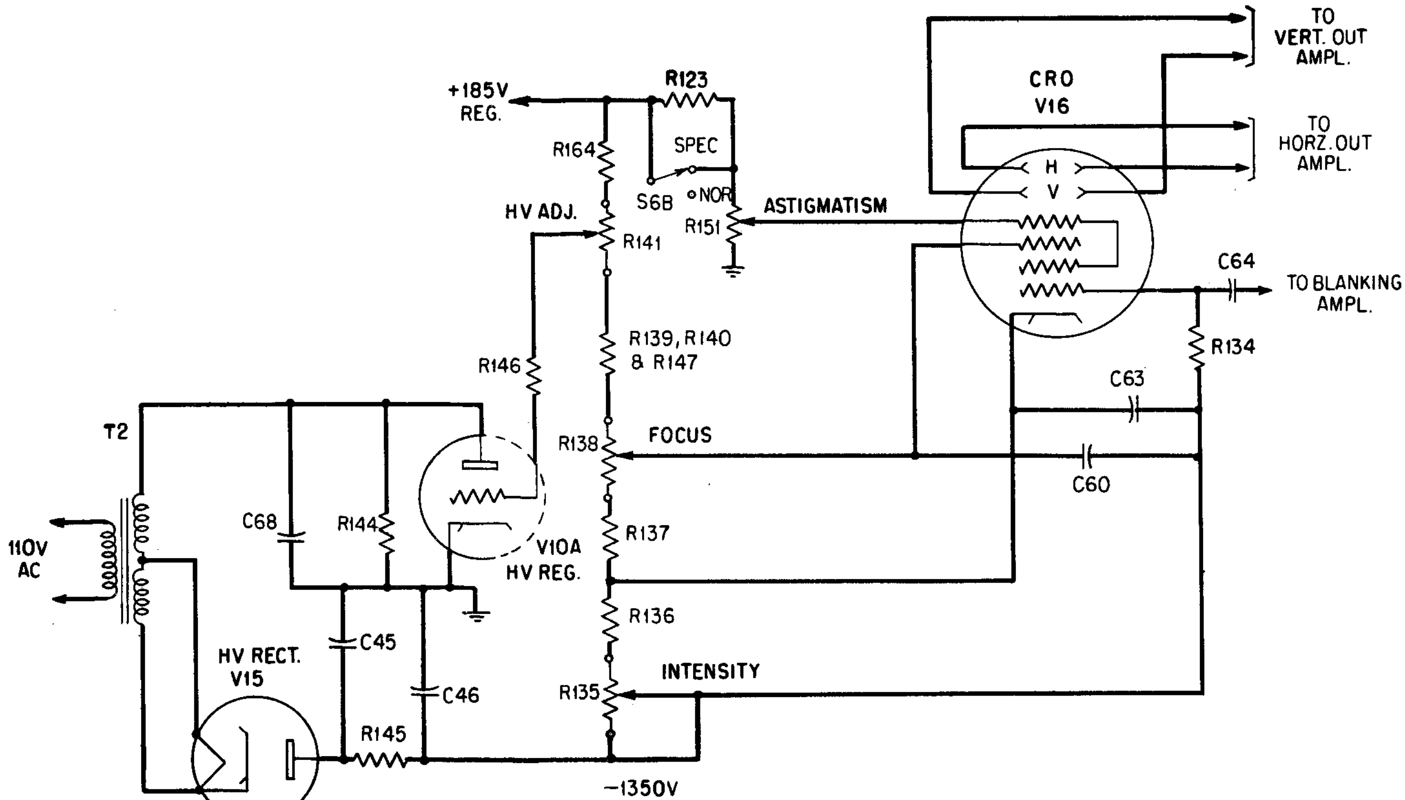


Fig. 13 — KS-15512, List 5 Oscilloscope Regulated High-Voltage Supply and Cathode-Ray Tube Circuit

amplification occurs but no phase inversion. Bias potential for the grid of V10B is obtained from a portion of the voltage across one of the matched varistors in the grid circuit of the horizontal amplifier tube V12A through the voltage divider, R121 and R122.

4.27 ***(I) High-Voltage Supply:*** (See Fig. 13) The CR tube V16 requires 1500 volts for proper operation and this voltage is derived from the high-voltage rectifier, a regulating ← tube and the 185-volt regulated supply. The ← voltages for the cathode, grid, focusing anode, and second anode are derived from a voltage divider R164, R141, R139, R140, R147, R138, R137, R136 and R135 across these supplies. The intensity and focus are made variable for the sharpest display. In addition, to improve the focus over the entire display an astigmatism control has been made available to bring the second anode potential to the average of the deflecting plate voltages. With the SWEEP switch on SPECIAL-IN this voltage can be adjusted to 185 volts above ground.

4.28 The high-voltage rectifier is a standard half-wave rectifier. A regulating tube V10A shunts this supply and acts as a variable resistive load across the rectifier. Any change in rectifier output or current drawn by the CR tube will change the grid bias of this tube causing its resistance to change so as to maintain the voltage determined by the setting of the HV ADJ control constant.

4.29 ***(J) +B and 185V Regulated Power Supplies:*** (See Fig. 14) The +B supply is a conventional nonregulated full-wave rectifier filtered by C32, L6 and C47 and furnishes 330 volts at the output of this filter.

4.30 The 185-volt regulated rectifier consists of V13B as a series tube, V17A as the feed-back tube and V18 as the voltage reference

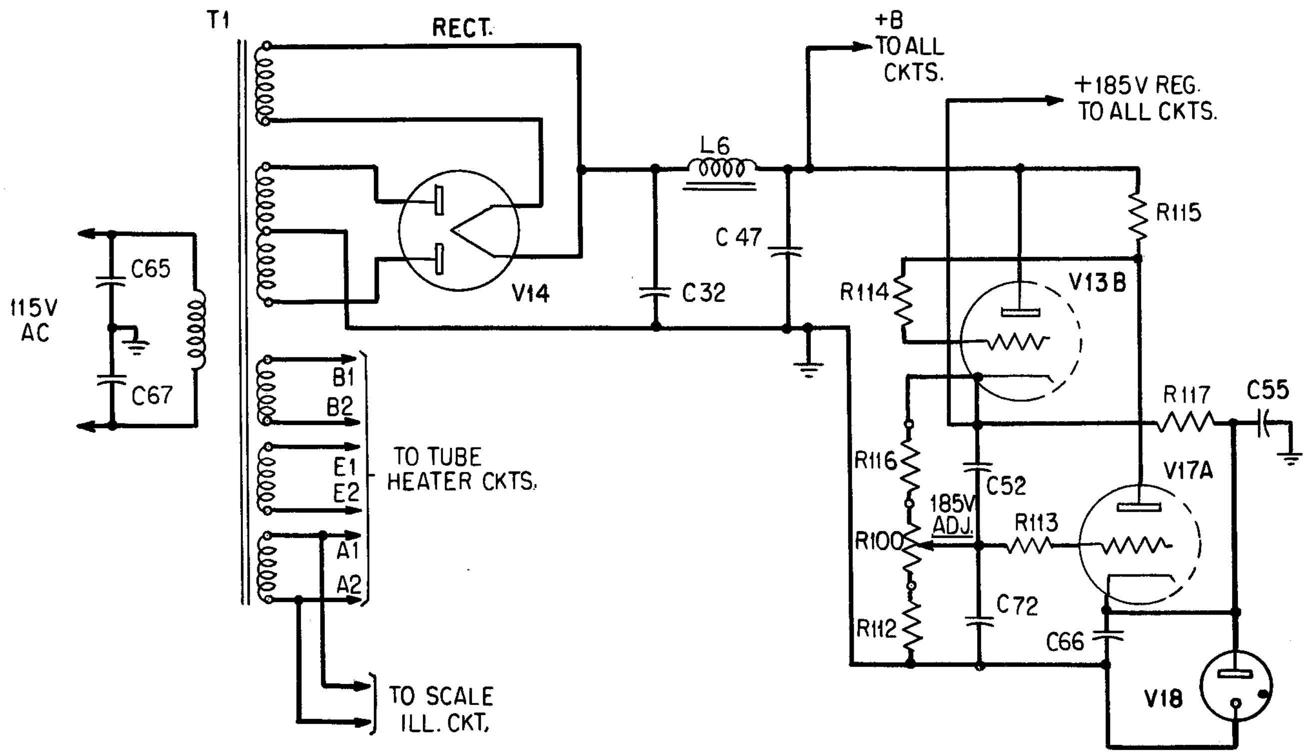


Fig. 14 — KS-15512, List 5 Oscilloscope +B and +185V Regulated Supplies

tube. Resistor R117 is the starting current limiting resistor for V18. The action of the rectifier is as follows. If the B supply voltage increases, the voltage on the grid of V13B increases causing more current to flow through the tube. This increase in tube current increases the voltage on the grid of V17A whose cathode voltage is kept constant by V18. Increasing the grid voltage of V17A allows more plate current to flow. This in turn drops the plate voltage of V17A through the increased drop in resistor R115. Since the grid of the series tube V13B is tied to the plate of V17A, this voltage will also decrease, maintaining the voltage out of its cathode constant at 185 volts. The rectifier voltage is set to 185 volts by adjustment of the 185V ADJ control R100.

5. OPERATION

5.01 Connect the power cable to the power receptacle located on the left side of the unit, and connect the other end to a 115-volt, 50/60 cps power outlet suitable for a three-bladed polarized power plug with a ground post.

CAUTION:

1. ***Do not substitute a nongrounding plug.***
2. ***Do not use in a nongrounded receptacle without the use of an approved adapter which has been grounded through its pigtail.***

5.02 Turn POWER switch CW until it snaps on. Set the V. GAIN control to the maximum counterclockwise position with power on, in order to eliminate pickup while adjusting the oscilloscope, and turn the SWEEP FREQUENCY range switch to HI position. Turn the INPUT switch to 1:1 position. Press SWEEP switch to NORMAL-OUT position.

5.03 Adjust the V. CENT control so as to position the trace along the vertical axis at a convenient point; adjust the H. GAIN con-

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	Signal Input	Short	Black Neg.
IN-3-R	Short	Signal Input	Black Pos.
IN-4-T	75 Ohms Term.	Open	124 Ohms Balanced Termination (IN-4-T and IN-4-R)
IN-4-R	Open	75 Ohms Term.	

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	Signal Input	Short	Black Neg.
IN-1-R	Short	Signal Input	Black Pos.
IN-2-T	75 Ohms Term.	Open	124 Ohms Balanced Termination (IN-2-T and IN-2-R)
IN-2-R	Open	75 Ohms Term.	

Note:* Condition 4 may be used with INPUT switch in 1:1, 10:1, or 100:1 position. Condition 5 or 6 must be used ***only* with the INPUT switch in the ***1:1 position.*** This is also true when using the probe, with which no 75-ohm termination is used.

trol so that the length of the trace is completely displayed on the cathode-ray tube.

5.04 Adjust the H. CENT control so as to position the trace along the horizontal axis at a convenient point. Readjust the H. GAIN control so that the length of the trace is approximately equal to the diameter of the tube.

5.05 Adjust the FOCUS and ASTIG. controls for the sharpest and most distinct trace. Then adjust the INTENSITY control for desired brightness of trace. It may be necessary to refocus after adjusting the intensity.

5.06 ***Vertical Amplifier: Input Connections and Operation:***

(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.

(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 bare strap between center conductor and shell) should be used as a shorting plug for the proper termination of the multiple input jack arrangement.

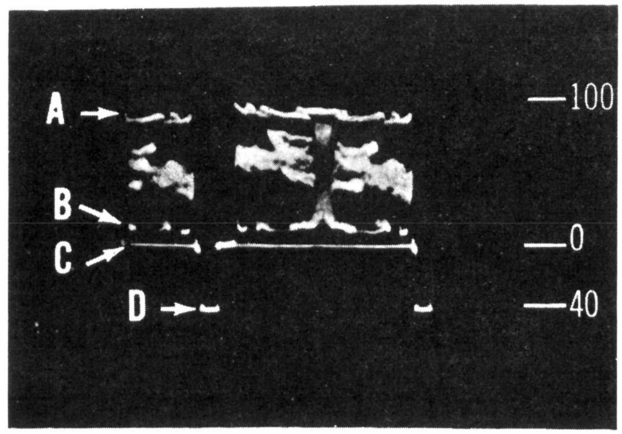
(c) For balanced inputs, the signal should be applied through a P3AH-type balanced coaxial cord, or its equivalent. A 341F Plug should be used for the 124-ohm termination in the multiple input arrangement.

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

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 and 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. 7 for specific frequency response curves).

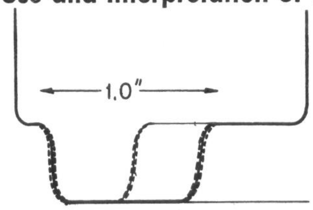
5.08 ***Normal Horizontal Sweep: Synchronization and Adjustment:***

(a) ***Sync. Mode Adjust:*** Fig. 15 illustrates the correct sync mode, which shows the H. sync pulse occurring at the right-hand side of the sweep. The SYNC and FINE FREQ controls are alternately adjusted until this condition is attained. If the controls are im-



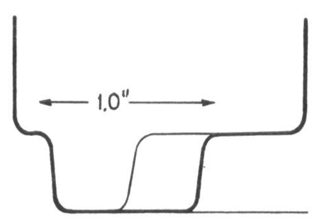
A. Measure White Peak Here
B. Measure Black Peak Here
C. Measure Blanking Level Here
D. Measure Sync Level Here

Fig. 15 — Use and Interpretation of IRE Scale



(A)

Incorrect Synchronization Adjustment or Jitter in TV Synchronizing Signal



(B)

Correct Synchronization Adjustment and no Jitter in TV Signal

Fig. 16 — Horizontal Sync Pulse Interval

properly 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.

(b) ***Low-Frequency Sync. Adjust:*** To examine the alternate Vertical interval, reduce the horizontal size to 3 inches. Turn the SYNC control slowly counterclockwise until the trace starts to slip slowly from right to left. When the Vertical interval (which had previously been locked in at the right side of the display) approaches the center, quickly rotate the SYNC control clockwise so that the display is again synchronized. The alternate interval is now at the center of the picture, and its complete Vertical period may be examined.

(c) ***High-Frequency Sweep:*** When the high-frequency sweep is desired (4,000 to 16,000 cps), turn the SWEEP FREQ control to the HI position, and set SYNC control fully counterclockwise. Rotate SYNC control clockwise until pattern becomes stationary. Adjust the FINE FREQ control until the desired number of cycles is displayed. Select the SYNC SELECTOR switch position as described in Paragraph 5.09 (b). Readjust both SYNC and FINE FREQ controls for best synchronism. (See Figs. 15 and 16.) Adjust the H. GAIN control so that the detail in the waveform is sufficiently expanded.

(d) ***Horizontal Sweep: Incorrect Synchronization:*** The result of incorrect synchronism 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 FREQ controls, the jitter may be eliminated, as shown in Fig. 16B.

If the jitter cannot 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 television 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.

5.09 (a) ***Low-Frequency Sync. Adjust:*** To examine the Vertical interval of a television signal, synchronize as described in (b), displaying two Vertical fields. Rotate the H. GAIN control clockwise for the desired expansion, and recenter.

(b) ***Low-Frequency Sweep:*** When the low-frequency sweep is desired (18 to 80 cps), turn the SWEEP FREQ control to LO, set SYNC control fully CCW, and adjust the FINE FREQ 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.

5.10 *Special Horizontal Sweep:*

(a) The purpose of the Special Sweep is to offer an expanded view of the special test signals inserted in the vertical synchronizing interval. To observe this signal, synchronize the normal low-frequency sweep as outlined in Paragraph 5.09. Press the SWEEP push button into the SPECIAL-IN position. The special sweep will automatically synchronize. Expand the sweep to the desired horizontal width, and position the test signal to be observed to the center of the CRT. Alternately adjust the FOCUS and ASTIG. controls for the sharpest focus.

(b) To examine the test signal following the alternate interlaced Vertical interval, reposition the display so that the last equalizing pulse and first horizontal pulse in the Vertical Blanking interval may be observed. The period between them will be that of two equalizing pulses or two horizontal synchronizing pulses. Rotate the SYNC control fully counterclockwise, and then clockwise, until the trace is again locked in. Note the period between the equalizing and horizontal pulses. It should be the alternate of the period previously observed. If it is not, repeat the above SYNC control operation until the proper time interval appears. The test signal may now be examined.

5.11 An external sweep may be connected to this instrument at the EXT. SWEEP receptacle. 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) Rotate the SCALE ILLUM. control clockwise until the scale is lighted to the desired intensity.

(3) Using the scale, note the vertical distance between the extreme amplitude peaks of the signal. ***DO NOT DISTURB*** the V. GAIN control after making the measurement.

(4) Turn the INPUT switch to CAL. position. (See Fig. 5.)

(5) 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 television 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 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 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.

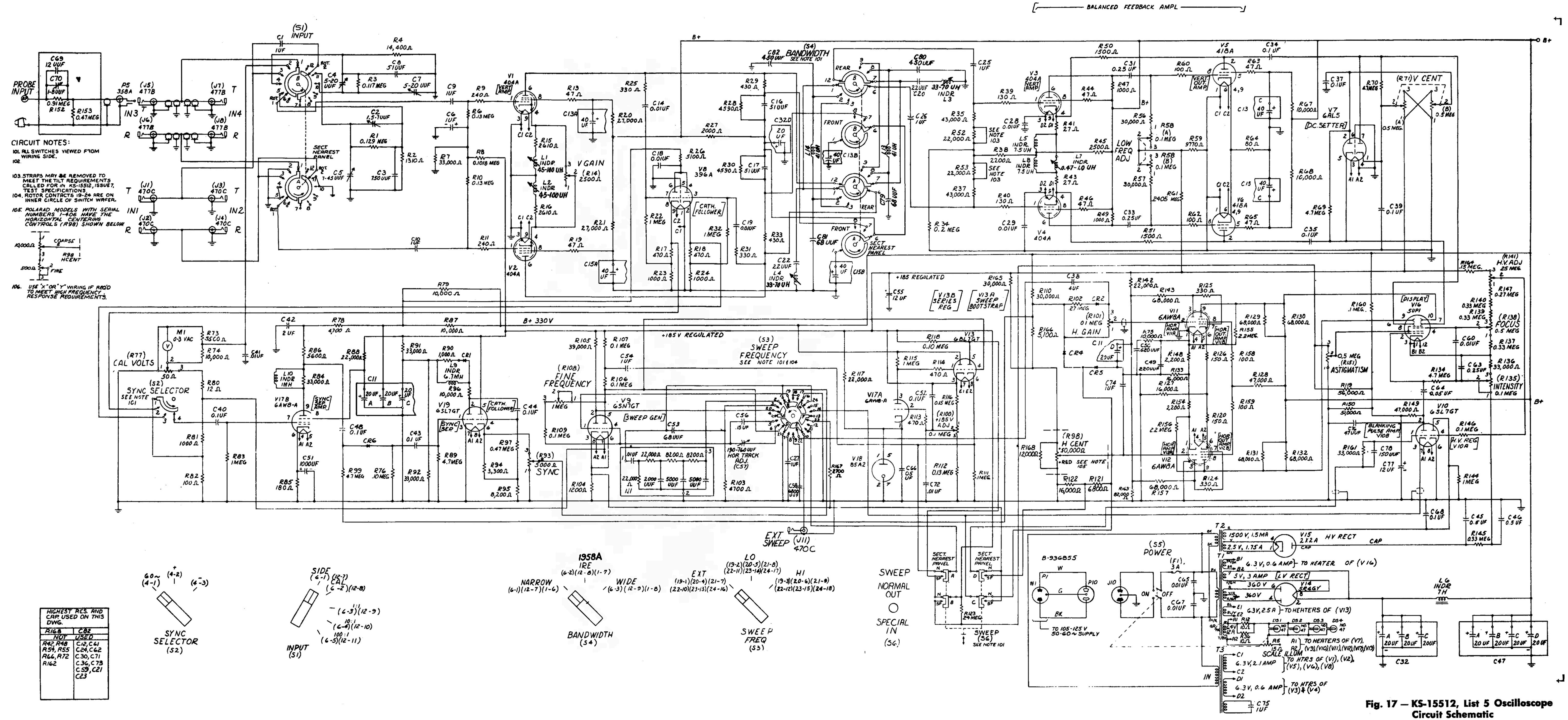
(b) Remove the signal voltage and apply a sine wave from a 61B or C Signal Generator or equivalent oscillator to the scope. (For a low-frequency signal, apply a sine wave approximately 10 kc. For a high-frequency signal, apply a sine wave approximating 1 mc.) Without readjustment of the FINE FREQUENCY 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 1 inch on the scope. Adjust the V. CENT. Control until the lower tips of the sine wave are displayed on the "O" 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 "O" 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 vertical marker, then each space represents a 1 microsecond interval; if each sine-wave peak is set to fall on every second 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 kc and 10 kc sine wave positioned on the scale markers will indicate a 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. Reference the portion of the signal to be measured on the "O" 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 voltage being measured.

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 5 oscilloscope.



CIRCUIT NOTES:

101. ALL SWITCHES VIEWED FROM WIRING SIDE.

102.

103. STRAPS MAY BE REMOVED TO MEET THE TILT REQUIREMENTS CALLED FOR IN KS-15512, ISSUE 7, TEST SPECIFICATIONS.

104. ROTOR CONTACTS 19-24 ARE ON INNER CIRCLE OF SWITCH WAFER.

105. POLARAD MODELS WITH SERIAL NUMBERS 1-406 HAVE THE HORIZONTAL CENTERING CONTROLS (R98) SHOWN BELOW

106. USE "X" OR "Y" WIRING IF REQ'D TO MEET HIGH FREQUENCY RESPONSE REQUIREMENTS.

HIGHEST RES. AND CAP. USED ON THIS DWG.	
R168	C82
NOT USED	
R42, R48 R54, R55 R66, R72 R162	C12, C61 C24, C62 C30, C71 C36, C73 C59, C21 C23

Fig. 17 — KS-15512, List 5 Oscilloscope Circuit Schematic

MAINTENANCE PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
R1	Res. 129K, 1/2W ±1%	1	C173A
R2	Res. 1.31K, 1/2W ±1%	1	C173A
R3	Res. 117K, 1/2W ±1%	1	C173A
R4	Res. 14.4K, 1/2W ±1%	1	C173A
R5	Res. 15, 4W Pot with DPST Switch attached	11	CM19541
R6	Res. 130K, 1/2W ±5%	2	EB
R7	Res. 33K, 1/2W ±1%	1	C173A
R8	Res. 101.8K, 1/2W ±1%	1	C173A
R9	Res. 240, 1/2W ±5%	2	EB
R10	Res. 130K, 1/2W ±5%	2	EB
R11	Res. 240, 1/2W ±5%	2	EB
R12	Res. 10, 1W ±10%	2	GB
R13	Res. 47, 1/2W ±10%	2	EB
R14	Res. 2500, 2W Pot "B" Taper 3/8" Bush 2" Overall Shaft	2	JB2521 w/P3200 Shaft
R15	Res. 2610, 2W ±1% w/insulated caps	3	S25
R16	Res. 2610, 2W ±1% w/insulated caps	3	S25
R17	Res. 470, 1/2W ±10%	2	EB
R18	Res. 470, 1/2W ±10%	2	EB
R19	Res. 47, 1/2W ±10%	2	EB
R20	Res. 27K, 1W ±10%	2	GB
R21	Res. 27K, 1W ±10%	2	GB
R22	Res. 1 Meg. 1/2W ±10%	2	EB
R23	Res. 1000, 1/2W ±10%	2	EB
R24	Res. 1000, 1/2W ±10%	2	EB
R25	Res. 330, 1/2W ±5%	2	EB
R26	Res. 5100, 1W ±5%	2	GB
R27	Res. 2000, 5W	4	27E
R28	Res. 4590, 2W ±1% w/insulated end caps	3	S25
R29	Res. 430, 1/2W ±1%	1	C173A
R30	Res. 4590, 2W ±1% w/insulated end caps	3	S25
R31	Res. 330, 1/2W ±5%	2	EB
R32	Res. 1 Meg. 1/2W ±10%	2	EB
R33	Res. 430, 1/2W ±1%	1	C173A
R34	Res. 200K, 1/2W ±1%	1	C173A
R35	Res. 43K, 1/2W ±5%	2	EB
R36	Res. 10, 1W ±10%	2	GB
R37	Res. 43K, 1/2W ±5%	2	EB
R38	Res. 2200, 1/2W ±1%	1	C173A
R39	Res. 130, 1/2W ±5%	2	EB

Note: All resistance values are in ohms.

MAINTENANCE PARTS LIST (cont'd)

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
R40	Res. 130, 1/2W ±5%	2	EB
R41	Res. 27, 1/2W ±1%	1	C173A
R42	Not used		
R43	Res. 27, 1/2W ±1%	1	C173A
R44	Res. 47, 1/2W ±10%	2	EB
→ R45	Res. 2500, 10W NON-IND	5	Type NIT
R46	Res. 47, 1/2W ±10%	2	EB
R47	Res. 1000, 1/2W ±1%	1	C173A
R48	Not used		
R49	Res. 1000, 1/2W ±1%	1	C173A
R50	Res. 1500, 4W ±1% w/insulated end caps	3	S30
R51	Res. 1500, 4W ±1% w/insulated end caps	3	S30
R52	Res. 22K, 1/2W ±5%	2	EB
R53	Res. 22K, 1/2W ±5%	2	EB
R54	Not used		
R55	Not used		
R56	Res. 30K, 1/2W ±5%	2	EB
R57	Res. 30K, 1/2W ±5%	2	EB
R58	Res. 100K, 2W Dual Pot Lin Taper 1/4" Bush 5/8" slot shaft	2	JJU1041 w/SD2040 Shaft
R59	Res. 9770, 1/2W ±1%	1	C173A
R60	Res. 100, 1/2W ±10%	2	EB
R61	Res. 240.5K, 1/2W ±1%	1	C173A
R62	Res. 100, 1/2W ±10%	2	EB
R63	Res. 47, 1/2W ±10%	2	EB
R64	Res. 80, 2W ±1% w/insulated end cap	3	S25
R65	Res. 47, 1/2W ±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 ±10%	2	EB
R70	Res. 417 Meg. 1/2W ±10%	2	EB
R71	Res. 0.5 Meg. 2W Dual Pot Lin Taper 3/8" Bush 3/4" Shaft	2	JJU5041 w/P3048 Shaft
R72	Not used		
R73	Res. 5500, 1/2W ±1%	1	C173A
R74	Res. 10K, 1/2W ±1%	1	C173A
R75	Res. 10K, 1/2W ±5%	2	EB
R76	Res. 100K, 1/2W ±5%	2	EB
R77	Res. 50, WW Pot Lin Taper 3/8" Bush, 3/4" Shaft	11	A43-50

Note: All resistance values are in ohms.

MAINTENANCE PARTS LIST (cont'd)

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
R78	Res. 4700, 1W ±10%	2	GB
R79	Res. 10K, 2W ±10%	2	HB
R80	Res. 12, 1W ±10%	2	GB
R81	Res. 1000, 1/2W ±10%	2	EB
R82	Res. 100, 1/2W ±10%	2	EB
R83	Res. 1 Meg. 1/2W ±10%	2	EB
R84	Res. 33K, 1/2W ±10%	2	EB
R85	Res. 180, 1/2W ±10%	2	EB
R86	Res. 5600, 1W ±5%	2	GB
R87	Res. 10K, 2W ±10%	2	HB
R88	Res. 22K, 2W ±5%	2	HB
R89	Res. 4.7 Meg. 1/2W ±10%	2	EB
R90	Res. 1000, 1/2W ±10%	2	EB
R91	Res. 33K, 2W ±10%	2	HB
R92	Res. 33K, 2W ±10%	2	HB
R93	Res. 5K, 2W Pot 3/8" Bush 3/4" Shaft Lin Taper	2	JU5021 w/P3048 Shaft
R94	Res. 3.3K, 1/2W ±5%	2	EB
R95	Res. 8200, 1/2W ±10%	2	EB
R96	Res. 10K, 1/2W ±10%	2	EB
R97	Res. 470K, 1/2W ±10%	2	EB
R98	Res. Pot, 50K, 2W, 3600° rotation 1/2" split bushing with knurled nut, shaft extending 1/2" beyond bushing	13	HA-100F
R99	Res. 4.7 Meg. 1/2W ±10%	2	EB
R100	Res. Pot, 100K, 2W 3/8" Bush, 5/8" Slotted Shaft, Lin Taper	2	JU1041 w/SD3040 Shaft
R101	Res. Pot, 100K, 2W 3/8" Bush 3/4" Shaft, Lin Taper	2	JU1041 w/P3048 Shaft
R102	Res. 270K, 1/2W ±10%	2	EB
R103	Res. 4.7K, 1/2W ±5%	2	EB
R104	Res. 1200, 1W ±10%	2	GB
R105	Res. 39K, 1/2W ±10%	2	EB
R106	Res. 100K, 1/2W ±10%	2	EB
R107	Res. 100K, 1/2W ±10%	2	EB
R108	Res. Pot, 1 Meg. 2W 3/8" Bush, 3/4" Shaft Lin Taper	2	JU1051 w/P3048 Shaft
R109	Res. 100K, 1/2W ±10%	2	EB
R110	Res. 30K, 10W	5	10F
R111	Res. 100K, 1/2W ±10%	2	EB
R112	Res. 130K, 1/2W ±5%	2	EB
R113	Res. 470, 1/2W ±10%	2	EB

Note: All resistance values are in ohms.

MAINTENANCE PARTS LIST (cont'd)

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
R114	Res. 470, 1/2W ±10%	2	EB
R115	Res. 1 Meg. 1/2W ±10%	2	EB
R116	Res. 150K, 1/2W ±10%	2	EB
R117	Res. 22K, 2W ±10%	2	HB
R118	Res. 100K, 1W ±10%	2	GB
R119	Res. 56K, 1/2W ±10%	2	EB
R120	Res. 150, 1/2W ±5%	2	EB
R121	Res. 6800, 1/2W ±5%	2	EB
R122	Res. 16K, 1/2W ±5%	2	EB
R123	Res. 240K 1/2W ±5%	2	EB
R124	Res. 330, 1/2W ±5%	2	EB
R125	Res. 330, 1/2W ±5%	2	EB
R126	Res. 150, 1/2W ±5%	2	EB
R127	Res. 16K, 2W ±5%	2	HB
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	Res. 16K, 1/2W ±5%	2	EB
R134	Res. 4.7 Meg. 1/2W ±10%	2	EB
R135	Res. 100K, 2W Pot Lin Taper 3/8″ Bush, 5/8″ Slotted Shaft	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 Lin Taper 3/8″ Bush, 5/8″ Slotted Shaft	2	JU5041 w/SD3040 Shaft
R139	Res. 330K, 1W ±10%	2	GB
R140	Res. 330K, 1W ±10%	2	GB
R141	Res. 250K, 2W Pot Lin Taper 3/8″ Bush, 5/8″ Slotted Shaft	2	JU2541 w/SD3040 Shaft
R142	Res. 22K, 1/2W ±5%	2	EB
R143	Res. 68K, 1/2W ±5%	2	EB
R144	Res. 1 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	Res. 2200, 1/2W ±5%	2	EB
R149	Res. 47K, 1/2W ±10%	2	EB
R150	Res. 51K, 1/2W ±5%	2	EB
R151	Res. 0.5 Meg. 2W Pot 3/8″ Bush, 3/4″ Slotted Shaft, Lin Taper	2	JU5041 w/P3048 Shaft

Note: All resistance values are in ohms.

MAINTENANCE PARTS LIST (cont'd)

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
R152	Res. 910K, 1/2W ±1% Deposited Carbon	7	DCC
R153	Res. 470K, 1/2W ±1% Deposited Carbon	7	DCC
R154	Res. 2200, 1/2W ±5%	2	EB
R155	Res. 2.2 Meg. 1/2W ±5%	2	EB
R156	Res. 2.2 Meg. 1/2W ±5%	2	EB
R157	Res. 68K, 1/2W ±5%	2	EB
R158	Res. 100, 1/2W ±10%	2	EB
R159	Res. 100, 1/2W ±10%	2	EB
R160	Res. 100K, 1/2W ±10%	2	EB
R161	Res. 33K, 1/2W ±10%	2	EB
R162	Not used		
R163	Res. 82K, 1/2W ±5%	2	EB
R164	Res. 150K, 1W ±10%	2	GB
R165	Res. WW, 30K, 5W ±5%	4	KT
R166	Res. 5100, 1/2W ±5%	2	EB
R167	Res. 2700, 1/2W ±5%	2	EB
R168	Res. 1200, 1/2W ±5%	2	EB
C1	Cap. 1.0 μf ±10%, 400V, 0.750″ Dia x 2-1/8″ Lgth	8	620M
C2	Cap. 1.5-7 μμf, Var. Ceramic	9	TS2A - 1.5
C3	Cap. 750 μμf, 500V ±5%	10	CM-20-E-751-J
C4	Cap. 5-20 μμf, Var. Ceramic	9	TS2A-5
C5	Cap. 7-45 μμf, Var. Ceramic	9	TS2A-7
C6	Cap. 1.0 μf, 150V (Tantalum)	16	#102D44 ←
C7	Cap. 5-20 μμf, Var. Ceramic	9	TS2A-5
C8	Cap. 51 μμf, 500V ±5%	10	CM-15-E-510-J
C9	Cap. 1.0 μf ±10% 400V, 0.750″ Dia x 2-1/8″ Lgth	8	620M
C10	Cap. 1.0μf, ±10% 400 V, 0.750″ Dia x 2-1/8″ Lgth	8	620M
C11	Cap. 4 x 20 μf, 450 V	4	TVL 4763
C12	Not used		
C13	Cap. 3 x 40 μf, 450 V	4	TVL 3787
C14	Cap. 0.01 μf, 600V, Discap.	12	MD103
C15	Cap. 3 x 40 μf, 450 V	4	TVL 3787
C16	Cap. 51 μμf ±5%	10	DM-15-510J
C17	Cap. 51 μμf ±5%	10	DM-15-510J
C18	Cap. 0.01 μf, 600 V Discap.	12	MD103
C19	Cap. 0.01 μf, 600 V Discap.	12	MD103
C20	Cap. 22 μμf ±5%	10	CM-15-C-220-J
C21	Not used		←
C22	Cap. 22 μμf ±5%	10	CM-15-C-220-J
C23	Not used		←
C24	Not used		

Note: All resistance values are in ohms.

MAINTENANCE PARTS LIST (cont'd)

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
C25	Cap. 1 μf, 200 V ±10% 0.60″ Dia x 1-5/8″ Lgth	8	620M
C26	Cap. 1.0 μf, 200 V ±10% 0.60″ Dia x 1-5/8″ Lgth	8	620M
C27	Cap. 1.0 μf, 600V Channel Type, Case CP65	4	PN86
C28	Cap. 0.01 μf, 600V, Discap.	12	MD103
C29	Cap. 0.01 μf, 600V, Discap.	12	MD103
C30	Not used		
C31	Cap. 0.25 μf, 400 V, ±10% 0.550″ Dia x 1-3/8″ Lgth	8	620M
C32	Cap. 4 x 20 μf, 450 V	4	TVL 4763
C33	Cap. 0.25 μf, 400 V, ±10% 0.550″ Dia x 1-3/8″ Lgth	8	620M
C34	Cap. 0.1 μf, 400 V ±10% 0.450″ Dia x 1-1/8″ Lgth	8	620M
C35	Cap. 0.1 μf, 400V ±10% 0.450″ Dia x 1-1/8″ Lgth	8	620M
C36	Not used		
C37	Cap. 0.1 μf, 400V ±10% 0.450″ Dia x 1-1/8″ Lgth	8	620M
C38	Cap. 4 μf, 600 V	4	06P3
C39	Cap. 0.1 μf, 400 V ±10% 0.450″ Dia x 1-1/8″ Lgth	8	620M
C40	Cap. 0.1 μf, 200V	16	330201
C41	Cap. 0.01 μf, 200V	16	330211
C42	Cap. 2 μf, 450 V	17	BR245
C43	Cap. 0.1 μf, 400 V	16	330401
C44	Cap. 0.1 μf, 400 V	16	330401
C45	Cap. 0.5 μf, 2KV	17	TJU 20005
C46	Cap. 0.5 μf, 2KV	17	TJU 20005
C47	Cap. 4 x 20 μf, 450 V	4	TVL 4763
C48	Cap. 0.1 μf, 400 V	16	330401
C49	Cap. 220 μμf, 500 V ±5%	10	CM-15-E-221J
C50	Cap. 620 μμf, 500 V ±5%	10	CM-20-A-621J
C51	Cap. 1000 μf, 6 V Electrolytic	4	DFP
C52	Cap. 0.1 μf, 200 V	16	330201
C53	Cap. 68 μμf, 500 V ±10% Mica Half Post	10	CM20A-680K
C54	Cap. 1 μf, 200 V ±10%	8	620M
C55	Cap. 12 μf, 450 V	17	BR1245A
C56	Cap. 0.15 μf, 400 V	16	3304015
C57	Cap. 190-760 μμf	18	305
C58	Cap. 6800 μμf, 500 V ±10% Mica Half Post	10	CM35A682K
C59	Not used		
C60	Cap. 0.01 μf, 1000 V	4	10TM-S1
C61	Not used		

MAINTENANCE PARTS LIST (cont'd)

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
C62	Not used		
C63	Cap. 0.25 μf, 200 V	16	3302025
C64	Cap. 0.05 μf, 2000 V	20	OT467
C65	Cap. 0.01 μf, 600 V	16	330611
C66	Cap. 0.05 μf, 200V	16	330215
C67	Cap. 0.01 μf, 600 V	16	330611
C68	Cap. 0.1 μf, 1000 V	16	330601
C69	Cap. 12 μμf ±5%	21	Type N-450
C70	Cap. 1-8 μμf, Tub. Trimmer	9	532-10
C71	Not used		
C72	Cap. 0.01 μf, 600 V	12	MD103
C73	Not used		
C74	Cap. 1 μf, 200 V ±10%	8	620M
C75	Cap. 1 μf Voltage Optional Part of T3, Matched with T3		
C76	Cap. 47 μμf, 500 V ±5%	10	CM15E470J
C77	Cap. 12 μf, 450 V	17	BR1245A
C78	Cap. 150 μμf, 500 V ±5%	10	CM15E151J
C79	Cap. 68 μμf, 500 V 5%	10	CM 15-E680J
C80	Cap. 450 μμf, 500 V 5%*	10	
C81	Cap. 68 μμf, 500 V 5%	10	CM 15-E680J
C82	Cap. 450 μμf, 500 V 5%*	10	
V1	Electron Tube 404A	23	
V2	Electron Tube 404A	23	
V3	Electron Tube 404A	23	
V4	Electron Tube 404A	23	
V5	Electron Tube 418A	23	
V6	Electron Tube 418A	23	
V7	Electron Tube 6AL5	27, 28 or 32	
V8	Electron Tube 396A	23	
V9	Electron Tube 6SN7-GT	27, 28 or 32	
V10	Electron Tube 6SL7-GT	27, 28 or 32	
V11	Electron Tube 6AW8-A	27, 28 or 32	
V12	Electron Tube 6AW8-A	27, 28	
V13	Electron Tube 6BL7-GT	27, 28	
V14	Electron Tube 5R4-GY	27, 28 or 32	
V15	Electron Tube 2X2-A	27, 28 or 32	
V16	Electron Tube 5UP1, CRT	27 or 32	
V17	Electron Tube 6AW8-A	27, 28	
V18	Electron Tube 85A2/OG3**	29	
V19	Electron Tube 6SL7-GT	27, 28 or 32	
CR1***	Varistor	28	1N34A
CR2***	Varistor	25	1N482
CR3	Not used		
CR4***	Varistor } MATCHED PAIR	25	SV3005
CR5***	Varistor } MATCHED PAIR	25	SV3005
CR6***	Varistor	25	1N482

*Made with a DM-19-251 250 μμf 5% and a DM-19-201 200 μμf 5%

**Temporary replacement part — RCA Type 5651

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

MAINTENANCE PARTS LIST (cont'd)

CIRCUIT SYMBOL	DESCRIPTION	MFR.	MFR. DESIGNATION
S1	Switch	12	PA024-1223
S2	Switch	12	PA201-067
S3	Switch	20	3263J
→ S4	Switch assembly	12	PA024-1181
S5	Switch (PART OF R5)		
S6	Switch	26	170
L1	Inductor 45-100 μh	33	B-934120-2
L2	Inductor 45-100 μh	33	B-934120-2
L3	Inductor 33-70 μh	33	B-934120-1
L4	Inductor 33-70 μh	33	B-934120-1
L5	Inductor 7.5 μh ±5%	7	CLA
L6	Inductor 7 h	14	1912
→ L7	Inductor .47-1.0 μh	33	B-934015
L8	Inductor 7.5 μh ±5%	7	CLA
L9	Inductor 6.7 mh	33	B-934014
L10	Inductor 1 mh	33	B-934929
L11	Not used		
L12	Not used		
L13	Inductor 41 μh ±5%	15	4327 (sample)
L14	Inductor 41 μh ±5%	15	4327 (sample)
T1	Transformer Power	30	24606
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	22	AGC-3
J1	Jack	23	470C
J2	Jack	23	470C
J3	Jack	23	470C
J4	Jack	23	470C
J5	Jack	23	477B
J6	Jack	23	477B
J7	Jack	23	477B
J8	Jack	23	477B
J10	Receptacle	24	7486
J11	Jack	23	470C
P5	Plug	23	358A
W1	Cord Assembly	33	ED63656-01 G1
N1	Network	12	PC101

TABLE C

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	Circuit Instruments Inc.
14	Sterling Transformer Corp.
15	Jeffers Electronics Inc.
16	Sangamo Electric Co.
17	Cornell-Dublier Elec. Corp.
18	El Menco
19	Aerovox Corp.
20	P. R. Mallory & Co.
21	Mucon Corp.
22	Bussmann Mfg. Co.
23	Western Electric Co., Inc.
24	Harvey Hubbell
25	Transitron
26	Oak Mfg. Co.
27	Radio Corporation of America
28	Sylvania
29	Mullard, England (Can be obtained from Amperex Electronic Corporation, Hicksville, N. Y.)
30	Chicago Std. Trns. Corp.
31	Raytheon Mfg. Co.
32	General Electric Co.
33	Manufacturer of oscilloscope