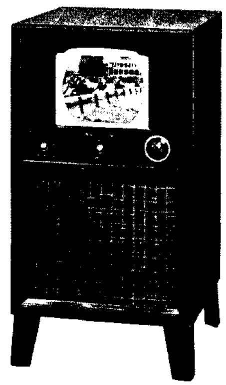
GENERAL

2000 Series



3000 Series

The chassis used in the Model 2000 & 3000 series television receiver is a 16-tube superheterodyne incorporating a number of unusual design features which are described in detail herein. Only three controls are provided for operating the receiver: Volume control; Contrast control; and Station Selector combined with a Fine Tuning control. All other controls are at the back of the cabinet where they are readily accessible because of the small cabinet depth. Each cabinet is styled appealingly and provides a large expanded picture tube mask of latest design in the 10" picture tube Models 2001, 2002, 3001, and 3002; and a similar expanded mask in the 12½" picture tube series Models 2020, 2021, 3030, and 3031. A 4" x 6" oval speaker is mounted on each cabinet to give maximum baffling and excellent tone reproduction.

A newly designed built-in antenna is provided. It is a simple dipole with open triangular shaped end sections mounted on the sides of the cabinet. These sections are used as end-loading for the dipole to give improved low channel performance over that of a simple dipole. Where signals are strong and free of reflection, the built-in antenna can be used successfully. It may improve reception to orient the cabinet or move it a short distance for the best results. When an external antenna is used, the built-in antenna must be disconnected from the antenna terminals.

SPECIFICATIONS

Power Requirements: 117 Volts, 60 cycles AC

Power Consumption: 170 Watts

Chan. No.	Chan. Freq.	Picture Carrier	Sound Carrier	RF Osc. Freq.	Chan. No.	Chan. Freq.	Picture Carrier	Sound Carrier	RF Osc. Freq.
2	54-60	55.25	59.75	81 MC	8	180-186	181.25	185.75	207 MC
3	60-66	61.25	65.75	87 MC	9	186-192	187.25	191.75	213 MC
4	66-72	67.25	71.75	93 MC	10	192-198	193.25	197.75	219 MC
5	76-82	77.25	81.75	103 MC	11	198-204	199.25	203.75	225 MC
6	82-88	83.25	87.75	109 MC	12	204-210	205.25	209.75	231 MC
7	174-180	175.25	179.75	201 MC	13	210-216	211.25	215.75	237 MC

IF Frequencies: Picture Carrier – 25.75 MC
Sound Carrier 21.25 MC

TUBE COMPLEMENT

Tube	Type	Function	Tube	Type	Function
V1	6AG5	RF Amplifier	V9	6AQ5	Audio Output
V2	6J6	Oscillator & Mixer	V10	6AU6	Sync Limiter
V3	6AU6	1st IF	V11	6SN7GT	Vertical Osc, & Output
V4	6AU6	2nd IF	V12	{10BP4} 12LP4	Picture Tube
V5	6AU6	3rd IF	V13	5V4G	Low Voltage Rectifier
V6	6AU6	Video Amplifier	V14	6SN7GT	Horizontal Phase Detector
V7	6AU6	Ratio Detector Drive	V15	6BQ6GT	Hor Osc & Output
V8	6T8	Ratio Detector & 1st Audio	V16	1B3GT	High Voltage Rectifier

Fine Tuning

Plus and minus 300 KC on Channel 2

Plus and minus 1.0 MC on Channel 13

Loudspeaker

4" x 6" PM

Audio Power Output

1.5 Watts, less than 5% distortion

Band Width

Video Amplifier 3.25 MC within 3db

IF Amplifier 3.6 MC within 6db

Band Width (Continued

Antenna input to picture tube 3.25 MC at 6db

Ratio Detector, peak to peak 200 KC

Deflection

Horiz & Vertical — Magnetic

Focus — Magnetic

Scanning — Interlaced, 525 lines

Horiz Freq. — 15750 CPS

Vert Freq. — 60 CPS

Frame Freq. — 30 CPS

TUBE SOCKET MEASUREMENTS

Conditions: Station Selector on Channel 2, Antenna Shorted.
Contrast Control –– Maximum
Volume Control –– Minimum
Brilliance Control – Minimum
All other Controls – Normal
Line Voltage – 117V 60 cycle AC All voltages are DC and measured to chassis with electronic voltmeter.

Total B+ Current = 190 MA
B+ Supply to Tuner = 133 Volts at 21.5 MA
Voltage at Junction of R55 and R54 = 375V
Voltage at Junction of R55 and C348 = 325V

* Assuming 30% efficiency.
** Measured hv using thermal temperature rise of tube.

Tube	Type	Function	1	2	3	4	5	6	7	8	9	10	11	Car.	Plate Dissipation	Screen Gr. Dissipation
V3	6AU6	1st IF	-0.55	0			+132	+133	+0.75						0.925W	0.31W
V4	6AU6	2nd IF	-0.55	0			+135	+136	+0.94						0.9 W	0.365W
V5	6AU6	3rd IF	0	0			+139	+140	+1.03						1.21 W	0.515W
V6	6AU6	Video	-0.65	0			+164	+140	0						0.8 W	0.7 W
V7	6AU6	Ratio Detec Driver	+145	+148	+140	+140	+240	+242	+148						0.69 W	0.405W
V8	6T8	Ratio Detec & Audio	-0.85	-1.4	-0.85			-2.2	0	-0.95	+132				0.2 W	
V9	6AQ5	Audio Output	+132	+140	+140	+140	+365	+360	+132						12.8 W	1.1 W
V10	6AU6	Sync Amplifier	+4.4	+11.5			+107	+110	+11.5							
V11	6SN7GT	Vert Osc & Output	-56	+47	0	0	+310	+11.5							Pin #5 * 1.95 W	
V12	10BP4 12LP4	Picture		+11.5								+325	+140	+7.9KV		
V13	5V4G	Rectifier		+400						+400						
V14	6SN7GT	Phase Detector	0	+295	+14	+1.7	-18	+12							Pin #2 .384W	
V15	6BQ6GT	Hor Osc & Output				+108	-57			0					10.8 W**	2.25 W

With standard test pattern received, Contrast and Brightness controls set for normal picture, the highlight brightness is 15 foot-candles, second anode voltage is 7.1KV, first anode voltage +325V, grid voltage +48V, and cathode voltage +74V.

ALIGNMENT PROCEDURE

CAUTION: Always determine by suitable tests, the causes of unsatisfactory operation before attempting to realign portions of this receiver. Necessity for realignment will, in all cases, be rare.

IF SYSTEM

To align the IF circuits, connect the negative lead of a vacuum tube voltmeter to the video test point through a 47,000 ohm 1/2 watt resistor. Raise the shield from the 6J6 oscillator mixer tube (V2) so that it is not grounded. Connect the high side of a low impedance signal generator to the ungrounded shield. Ground the outer conductor of the signal generator cable to the chassis near the mixer tube. Adjust the tuner to any channel and apply enough signal at 23.1 MC to get an indication of 1.5 volts on the voltmeter. Then proceed according to the following chart.

NOTE: It is possible for some sets to become sufficiently misaligned that signal is too weak to create enough AGC voltage. With no bias, oscillation in the IF may occur. It will, in such cases, be necessary to connect a 1.5 volt dry cell battery between the AGC test point and ground; the test point is placed 1.5 volts negative in respect to ground.

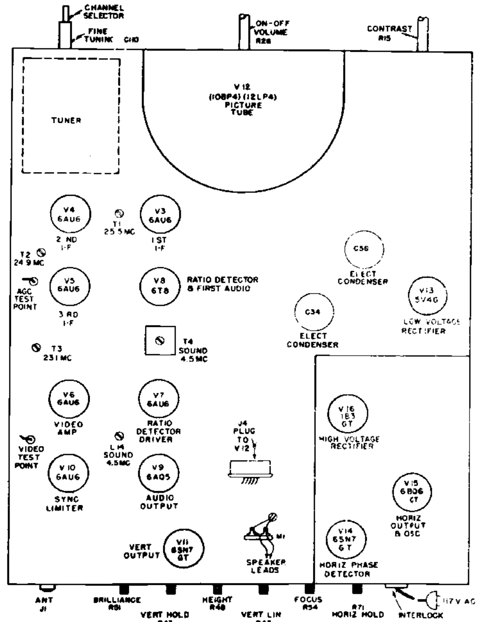


Fig. 1

Before attempting to align set, allow receiver and test equipment to warm up for at least five minutes. For location of all referenced components, see Layout, Fig. 1, the Block Diagram, Fig. 2, and Schematic Diagram, Fig. 19.

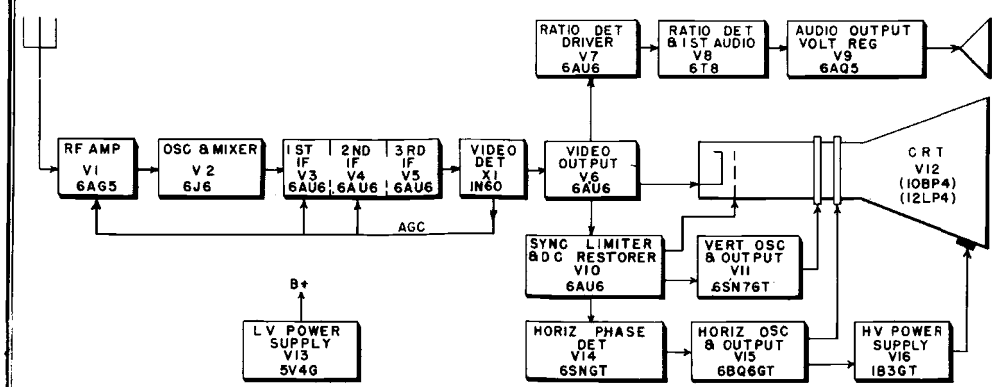


Fig. 2

Generator Freq.	VTVM Connections	Adjustment	Remarks
23.1 MC	To Video Test Point & Ground	T3	Adjust for Max.
24.9 MC	To Video Test Point & Ground	T2	Adjust for Max.
25.5 MC	To Video Test Point & Ground	T1	Adjust for Max.
22.5 MC	To Video Test Point & Ground	L162	Adjust for Max.
21.25 MC	To Video Test Point & Ground	T100	Adjust for Min.

It will be necessary to repeat the procedure to correct for interaction between circuits if the receiver was very far out of alignment.

VISUAL ALIGNMENT OF THE RF AND MIXER STAGES

Connect a RF sweep generator with at least a 10 MC sweep width to the antenna terminals. If the generator output is less than 300 ohms, the pad shown in Fig. 3 must be used. Connect the positive lead

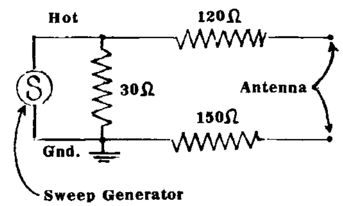


Fig. 3

of a 1.5 V dry cell to chassis ground and the negative lead to the AGC test point. Remove the first IF tube (V3) 6AU6. (This is necessary in order to eliminate AGC action which would interfere with RF alignment.) Attach the high side of the vertical input of an oscilloscope through a 10,000 ohm, 1/4 watt resistor to the RF test point. Connect the horizontal amplifier terminals of the oscilloscope to the oscilloscope sweep voltage terminals of the RF sweep generator. (This is necessary in order to synchronize the oscilloscope sweep with the RF sweep.) Turn the Station Selector to Channel 12. Adjust the sweep generator until it sweeps from 202 MC to 212 MC.

NOTE: If the sweep generator does not supply marker signals at picture and sound carrier frequencies, an external source, such as a CW signal generator, must be used to supply the markers. (For method of marker injection, refer to instructions of manufacturer of sweep generator being used.)

Adjust the frequency of the sweep generator until the response curve is centered on the oscilloscope. Adjust C101, C104, and C106 until the indicated response curve is similar to Fig. 4. Check all other channels

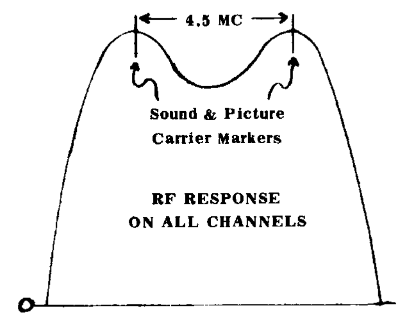


Fig. 4

and readjust C101, C104, and C106 for an optimum response on all twelve channels. Since this completes the RF alignment, replace the first IF tube.

OSCILLATOR ADJUSTMENT

Supply a CW signal to the antenna terminals through the pad shown in Fig. 3. Connect a vacuum tube voltmeter to the video test point. Set the signal generator to the sound carrier frequency of the channel selected. (See chart Set the Fine Tuning control to the center of its range and leave in this position. As it becomes accessible through the hole in the tuner front panel, adjust each oscillator coil slug to produce a sharp dip reading on the VTVM. Repeat procedure for all channels in the same manner. See Fig. 5.

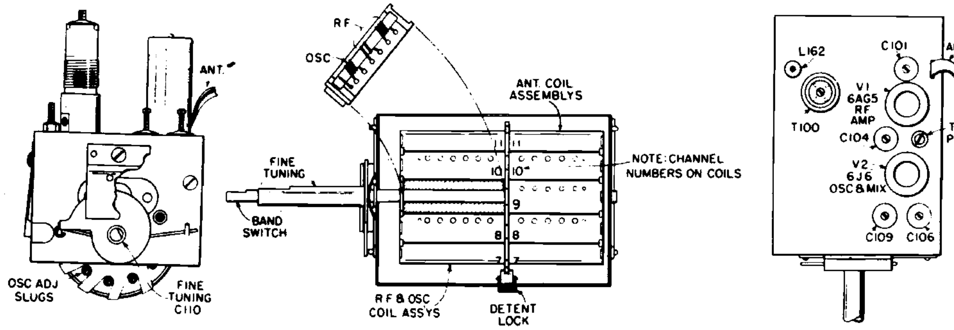


Fig. 5

NOTE: C109 is adjusted at the factory and normally will require no further adjustment in the field. If readjustment does become necessary, it is desirable to adjust C109 on one of the high frequency channels. This is done by setting the oscillator coil in the center of its range. Set the Fine Tuning in the center of its range. Adjust C109 for a sharp dip reading on the vacuum tube voltmeter when connected at the video test point.

SOUND ALIGNMENT

Alignment using AM signal generator and VTVM:

The value of the two 100K resistors connected in step one should be within 1% of each other.

Signal Generator Coupling	*Signal Generator Frequency*	*Connect*	*Adjust*	*Remarks*
High side to Video Test Point. Low side to Chassis.	4.5 MC	Parallel R28 with two 100K Resistors see Fig. 19. DC probe of VTVM to point A. Common lead to chassis.	L14, and L5	Adjust for maximum reading in order given, then repeat.
High side to Video Test Point. Low side to Chassis.	4.5 MC	DC probe of VTVM to point B. Common lead to point A.	L7	Adjust for zero reading at crossover.

CIRCUIT DESCRIPTION

RF SYSTEM

The RF system consists of a rotary turret type tuner. This tuner is made up of a series of strips on which are mounted the coils for each channel. In the event that coils must be replaced, it is a simple matter to remove a strip and snap in a new one. The tuner can be rotated in sequence in either direction. All coils are pre-adjusted, and final overall tuning adjustments are made in the Bendix factory with a sweep generator. Adjustment of the tuner in the field is difficult unless a sweep generator is used; and instructions that are included under *Circuit Alignment* should be followed carefully.

The circuit configuration of the tuner is relatively conventional. A balanced input (nominally 300 ohms impedance) is fed to a center-tapped coil which is coupled to the grid coil of the RF amplifier. The secondary circuit resonant frequency can be changed slightly by adjusting C101. All coils have been matched to a standard, and the correct adjustment of C101 for one channel (after changing RF tubes for example) automatically brings all other channels into tune. C101 can be adjusted most easily on one of the higher frequency channels such as Channel 12.

A 6AG5 pentode RF amplifier (V1) is used. Two overcoupled tuned circuits couple the plate of the RF amplifier to the grid of the mixer (V2). Alignment of these circuits is accomplished by adjustment of C104 and C106. Both circuits are so loaded that the overall response of the RF system is flat over a band width of 11 MC, to within 6 db of the peak response. The secondary load is primarily due to the input loading of the mixer. The mixer grid lead resistance is made up by two resistors (R104 and R105) in series. The junction between these resistors provides a convenient test point for checking the DC voltage developed by the oscillator injection voltage, and for connecting an oscilloscope to examine the response characteristic of the RF system with a sweep generator. A 10,000 ohm resistor should be connected in series with the oscilloscope to avoid adding excessive capacity to the mixer grid circuit.

The mixer tube (V2) is half of a 6J6; the other section of which is used as the local oscillator, which is a Colpitts type. The coils used for the oscillator are provided with an adjustable core which can be set for the correct frequency in each channel from the front of the set. Thus it is possible to set the tuning of each channel with the set in the cabinet merely by removing the selector switch knobs and dial plate. Inductive coupling is used to inject oscillator voltage into the mixer circuit. The DC voltage developed by the injected oscillator signal should be measured at the test point in the mixer grid circuit, and should equal 3 volts minimum in the low channels, and 2.5 volts minimum in the high channels. The vernier tuning provides a frequency coverage ranging from 600 KC on Channel 2, to 2.15 MC on Channel 13.

The output voltage of the mixer (V2) is developed across coil L163. The sound trap, T100, is inductively coupled to L163, and reduces the mixer stage gain approximately 32 decibels at the sound carrier frequency. At this reduced level there will be produced a good 4.5 MC beat note for intercarrier sound when mixed with the picture carrier in the video detector crystal (X1). The output voltage of the mixer is fed to the first IF amplifier (V3) through a series tuned circuit consisting of L162, C114, and associated circuit capacities. The series circuit is tuned to 22.5 MC and is used to prevent the oscillator signal from getting into the IF amplifier.

The whole RF tuning unit can be removed conveniently by disconnecting the four leads coming from the tuner and unfastening the mounting screws holding the unit in place. In addition, the turret can be removed easily merely by removing the two springs retaining the shaft of the tuner in place.

NOTE: *In removing these springs hold the ends firmly, since the springs will snap off with great force.*

IF SYSTEM

A quadruple stagger tuned, three stage amplifier with crystal detector output comprises the IF system. Quadruple stagger tuning is used to achieve the maximum possible gain for the desired bandwidth of 3.6 MC within 6 db.

A unique feature of the IF is the design of the IF transformers. The coils are bifilar wound (two windings interwound) with triple Formex insulated wire. This type of winding approximates unity coupling and gives the effect of a single tuned coil. A number of advantages are derived from such an arrangement. Improved filtering of all plate and grid returns can be achieved as the by-pass condensers can be returned to the same ground as the associated cathode. With the bifilar winding it is possible to keep the time constant in the grid circuit of each amplifier down to a low value. As a result there is no charging of the grid circuit by heavy noise pulses, and picture information is transmitted continuously through the IF system.

Three 6AU6 IF amplifier stages are employed. Unbypassed cathode resistors (R3 and R6) are used in the first two stages to minimize the variation of input capacity with AGC voltage changes. With the values used at 4 volts bias, there is only 0.5 db variation from peak response in picture carrier location.

A 1N60 crystal (X1) is used as the video detector. This is a crystal similar to the 1N34, but one which has been tested dynamically. Improved efficiency has been obtained from the new units. The detector load resistor (R11) is rather small because of the requirements of the video system which will be described later.

Design of the IF system provides for an overall response curve which is flat-topped with a band width of at least 3.6 MC within 6 db. The picture carrier, 25.75 MC, is 6 db down from the peak response; and the band center is approximately 23.95 MC. The sound carrier, 21.25 MC, is attenuated 32 db by the sound IF trap, coil (L164), the secondary of T100.

NOTE: This receiver is like all other high frequency receivers in that its performance can be greatly impaired by altering the lead dress or the location of the grounding points of the component. Therefore, the receiver should not be changed an appreciable amount from its original design in making service replacements.

Two test points are provided for IF checks. One is on the AGC string after the 1.5 megohm filter resistor (R9). This point is used for checking developed AGC voltage and for applying bias potentials when making sweep tests on the RF and IF channels or aligning the IF system. The other test point, at the video detector (X1) output, can be used for several tests: (1) a high impedance DC meter can be used here for checking the voltage developed by the detector; (2) an oscilloscope can be tied to this point for checking the response characteristics of the overall RF and IF systems with a sweep generator; (3) a 4.5 MC signal can be applied for aligning the intercarrier sound channel.

AGC SYSTEM

The AGC action is designed to hold the signal at the video amplifier (V6) grid to a maximum of about 3.5 volts peak to peak, when signals up to 1.0 volt are applied to the antenna terminals. For signal strengths of greater than 1.0 volt at the antenna, it will be necessary to remove the antenna coil section on that channel from the tuner to prevent overloading. Satisfactory reception then can be obtained with as much as 10 volts antenna input signal.

VIDEO SYSTEM

The video system consists of a 6AU6 amplifier (V6) with associated wide band low-pass filters. The output of the detector (X1) is applied to a filter (L3 wound on R16) with sufficient band width to pass 4.5 MC. As a result, the load resistor (R11) must be small to minimize attenuation of the higher video frequencies.

Contrast is controlled by varying the amount of degeneration in the video amplifier (V6) stage. This is done by varying the resistance (R15) in the cathode circuit. A control that has a multiple finger wiper on the resistor element is used to avoid producing a picture with noise streaks when the Contrast is adjusted. Replacements of R15 must be made with the specified Bendix Radio part.

It will be noted that all of the coils in the video system are shunted with damping resistors. The series coils are loaded rather heavily to damp out transients which tend to accentuate picture sharpness, but affect contrast adversely. The design of the video system with the rest of the receiver provides a response characteristic which is fairly flat to 1 MC, is down 3 db at about 2 MC, and is down 6 db at 3.2 MC.

The video stage gain is 27 db measured at 100 KC with the Contrast control set at maximum. Both the intercarrier sound IF (4.5 MC) and the synchronizing information are taken off the plate circuit of the video amplifier (V6). Details of the methods used for obtaining these signals will be presented in subsequent sections. The video signal is applied to the cathode of the picture tube (V12) through 0.2 mfd capacitor (C37) at black positive polarity. The cathode is returned to the Brightness control (R51) through 100,000 ohm resistor (R60). DC restoration for holding black level is accomplished in a rather unusual manner. Two variables are involved — the voltages on both cathode and grid of the picture tube (V12). When a signal is applied to the cathode, it tends to hold white level constant with respect to ground. Examination of the signal voltage on the cathode as observed on a DC connected oscilloscope, will show the white level holding constant and the sync and black level increasing as Contrast is increased. Simultaneously, the output of the video amplifier (V6) is applied to the sync limiter tube (V10) which is biased at approximately 4 volts under no signal conditions. Increases in signal level on the grid of the sync limiter tube (V10) will cause the average plate current to increase, with a resultant DC cathode voltage increase equal in magnitude to about 75% of the applied peak signal voltage. A total of 44,000 ohms (R34 and R35) is in the V10 cathode circuit to produce a DC voltage variation that will be sufficient to approximate the required amount. The cathode resistance is tapped at the center point to give the proper bias for the tube. The 75% ratio was selected so that the net voltage between the grid and cathode of the picture tube (V12) would be representative of the black level voltage at the peak of the blanking pulses. The DC is applied to the picture tube grid simultaneously with the video signal on the cathode. The grid cathode voltage will maintain black level for a wide range of signals. This can be observed by placing a DC connected oscilloscope between grid and cathode.

SOUND SYSTEM

Intercarrier sound reproduction is used. By this method the 4.5 MC beat note between the picture and sound carriers is utilized. The sound carrier has been attenuated 32 db from the peak video level, which is an ideal level for obtaining in the output of the video detector (X1), a 4.5 MC beat frequency which is frequency modulated at the sound frequency rate and contains no appreciable amplitude modulation components.

The sound system consists of a 6AU6 driver amplifier (V7), a 6T8 ratio detector and 1st audio amplifier (V8), and a 6AQ5 audio output amplifier (V9). The 4.5 MC signal is applied to the driver tube (V7) from the tap on an adjustable coil (L14) which is in series with 1.5 mmf condenser (C12) connected to the plate of the video amplifier (V6). The series tuned circuit serves as a trap for attenuating 4.5 MC in the video channel. The small coupling capacitor (C12) minimizes the addition of capacity across the video filter. The grid of the driver tube (V7) is fed from a tap on the coil (L14) to keep the impedance in the grid circuit low enough to eliminate instability due to plate-grid feedback. In addition, loading of the video circuit is also avoided when the driver tube draws grid current upon application of the 4.5 MC signal. Limiting action is obtained in the grid as well as the plate, which with the screen, operates at a low DC potential.

The driver amplifier tube (V7) is connected between +380 volts and +145 volts as part of a voltage regulation system. Details of the operation of the regulation will be discussed in a subsequent section on the power supply. The RC filter network (R21 and C14) between the cathode of V7 and +145 volts, prevents any 4.5 MC signal from getting on the +145 volt string.

A conventional ratio detector circuit is used. The 33 ohm resistor (R24) in series with the coupling link of the detector transformer (T4) stabilizes the impedance presented by the diodes of V8. If this resistor were deleted, the variation in impedance between individual tubes would cause the AM rejection to vary between receivers.

Because of the use of the 6AQ5 output amplifier tube (V9) as part of the voltage regulation system (see Power Supply Block Diagram, Fig. 6), it is possible to DC couple the 1st audio amplifier (V8) to the grid of the output amplifier (V9). About 12 db of negative feedback is provided by the network connected between the speaker voice coil and the cathode of the 1st audio amplifier (V8) to reduce output distortion.

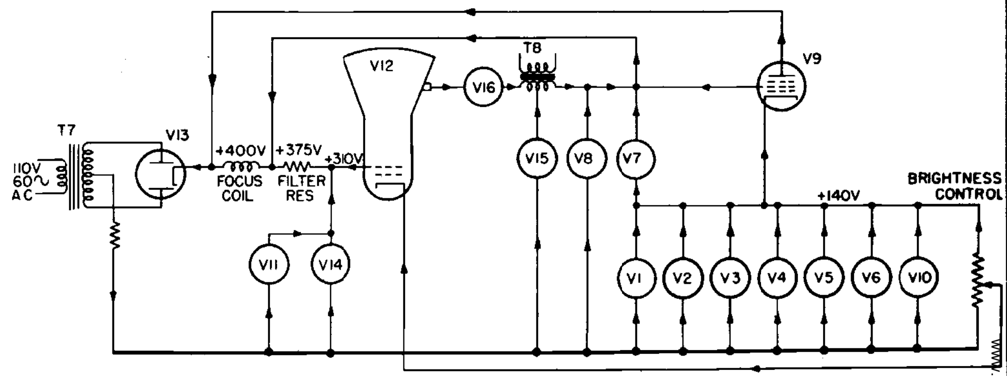


Fig. 6

SYNC SEPARATION

Video signals are applied to the grid of the sync limiter tube (V10) from the plate of the video amplifier tube (V6) through an isolating resistor of 47,000 ohms (R19) and 0.05 mfd capacitor (C11). Isolation between the video amplifier plate circuit and the grid of the sync limiter is required to avoid adding excessive capacity to the video plate circuit which would reduce video band width.

Clipping and limiting is accomplished in both the grid and plate of V10. The grid develops its own bias and the plate is operated at very low DC potential. Approximately one-tenth of this amplitude is fed through an integrating network and a 2000 mmf coupling capacitor (C31) to the vertical oscillator tube (V11A). The full signal amplitude is applied to the horizontal deflection system through a differentiating circuit consisting of C40 and R64.

VERTICAL DEFLECTION SYSTEM

The vertical deflection system consists of a free running multivibrator (V11A and B) which is locked into synchronism by the vertical triggering pulses. The output of the multivibrator (V11) is fed into the vertical deflection coils (L8 and L9) without the use of further amplification. The multivibrator employs both halves of a 6SN7 tube; see V11A and B on the schematic diagram, Fig. 19.

For a discussion of the circuit operation, it will be assumed that no triggering pulses are present. Then, after the circuit operation is understood in the untriggered state, the triggering pulses will be added, and their effect upon operation discussed.

For any linear magnetic deflection system, the waveform of voltage which must be present across the deflection coils (L8 and L9) is as shown in Figure 7 where

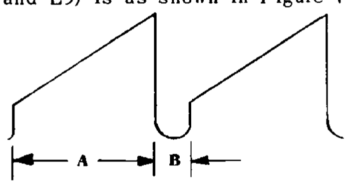


Fig. 7

A is the trace time and B is the retrace time. The procedure for obtaining this waveform is as follows:

If the circuit is thought of as starting from a static condition where both halves of V11 are conducting, it can be seen by the schematic diagram, Fig. 19, that the circuit is very unstable and will readily break into oscillation. For if V11A should have a slight increase of plate current due to "shot effect", "thermal agitation", or any of many possible reasons, the plate voltage of V11A would decrease causing the grid of V11B to be driven in the negative direction. This would, in turn, decrease the plate *current* of V11B causing the plate *voltage* to increase. This would in turn cause the grid of V11A to go in the positive direction, which would further increase the plate current of V11A. The process is cumulative, and V11B is almost instantaneously driven into cutoff. The period of cutoff of V11B is determined by the time constant of the coupling circuit made up by C43–R50, and C33–R42 and R43. When capacitors C43 and C33 change their charge sufficiently to allow V11B to start conducting, V11A is driven almost instantly into cutoff. When V11A again begins conducting, the cycle is repeated.

The circuit constants are so adjusted that the waveform from grid to ground of V11B appears as in Figure 8.

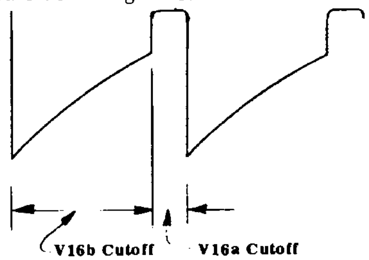


Fig. 8

During the period of time that V11B is cutoff, the waveform at the plate of V11B tries to rise to the full B+ voltage, but C32 and R41 form an integrating circuit which causes the plate voltage waveform to appear as shown in Figure 9.

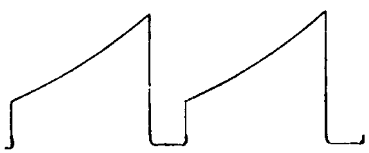


Fig. 9

The waveform of Figure 9 is fed to the grid of V11A which is conducting and capable of amplifying during the trace time. The waveform appearing between plate and ground of V11A is shown in Figure 10.

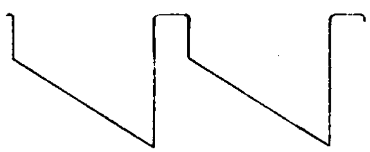


Fig. 10

The waveform appearing between V11B plate and B+ is shown in Figure 11.

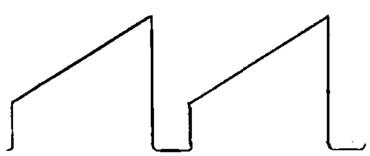


Fig. 11

This is the desired waveform as shown in Figure 7 for the voltage appearing across the deflection coils (L8 and L9).

The effect of the synchronizing pulses can now be discussed. The sync pulses appear at the grid of V11A with a negative polarity. The pulses are amplified by V11A and are fed to the grid of V11B as positive pulses. The effect is shown in Figure 12 which represents the voltage waveform appearing at the grid of V11B.

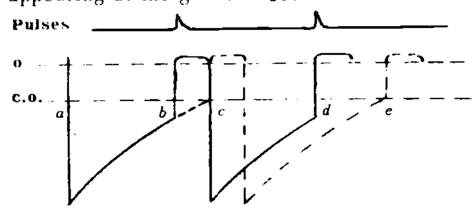


Fig. 12

Without sync pulses V11B would start to conduct at *c* and *e* in their respective cycles; but with the sync pulses, the grid is driven far enough positive at *b* and *d* to cause V11B to conduct and thereby lock the trace in step with the sync pulses.

"Vertical Holding" is obtained by varying R43 which varies the unsynchronized cutoff period of V11B. When R43 is increased, the cutoff period is increased and vice versa. See Figure 13.

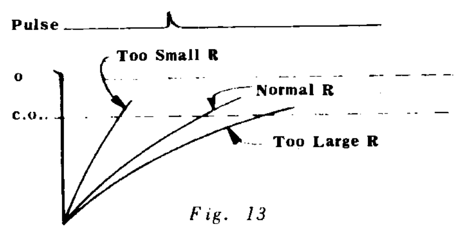


Fig. 13

Figure 13 shows that with the sync pulse as shown, no sync action will occur if R43 is made too large. Similarly, sync action will act on every other cycle if R43 is made sufficiently small. This explains why with too little "Hold", erratic operation takes place; and with too much "Hold" a double image is sometimes observed.

The circuit used in this receiver employs a coupling circuit between V11A and V11B which consists of two R-C networks in cascade, instead of the usual single R-C network. This system makes the vertical sweep circuit much less likely to be triggered by noise and much more smoothly triggered by the sync pulses. The use of cascade coupling circuits causes the grid voltage curve of V11B to cross the cutoff voltage line at a much steeper angle than with a single coupling circuit; see Figure 14.

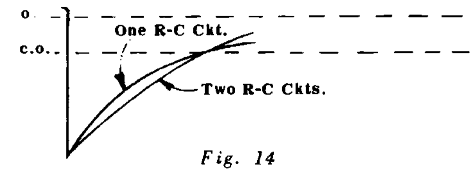


Fig. 14

C42 also helps to prevent the circuit from being triggered by extraneous signals by by-passing the higher frequency signals.

It will be observed that R50 effectively is across the vertical deflection coils (L8 and L9); and it is this resistor which provides the dampening action across the deflection coils during the retrace period.

"Vertical Height" control (R48) is obtained by varying the plate load resistance of V11B which in turn varies the magnitude of the waveform which is fed to V11A.

"Vertical Linearity" (R45) is obtained by varying the bias of V11A which shifts the operating point of the tube up and down its dynamic curve.

NOTE: Vertical Height, Linearity, and Hold controls all interact one upon the other. Therefore they will all have to be adjusted simultaneously for best test pattern.

HORIZONTAL SWEEP SYSTEM

The horizontal sweep system consists of a "beam relaxer" oscillator which is connected directly to the horizontal deflection coils (L10 and L11) and a phase detector tube (V14B) which is used to synchronize the "beam relaxer" oscillator tube (V15).

The horizontal oscillator employs a 6BQ6GT (V15) tube in a "free running oscillator" circuit to supply a linear sweep current through the horizontal deflection coils (L10 and L11).

The synchronizing system used to lock the oscillator in step with the synchronizing pulses employs a 6SN7 tube (V14), in which V14A is used as a sync clipper and phase inverter and V14B as a phase detector.

The discussion of circuit operation will consider, first of all, the operation of the 6BQ6GT oscillator tube and associated circuits in the completely unsynchronized state. This condition would exist if V14 were removed from its socket. Then, the operation will be considered in the synchronized state.

UNSYNCHRONIZED STATE

Assume that the 6BQ6GT oscillator tube (V15) is, at the moment, in the portion of its cycle where there is neither plate nor screen current flow; then, as C44 loses its charge the bias on the tube will decrease (become less negative) to the point where plate current and screen current will be able to flow. Plate current cannot, however, begin flowing in any appreciable magnitude at the first instant because of the effect of the inductance in the plate circuit of the tube. When the tube begins to conduct, the circuit can be thought of as a resistance and inductance placed in series across the power supply; the current flow in an L-R circuit rises gradually as time progresses. The rate of increase is determined by the time constant of the L-R circuit. Therefore, when the 6BQ6GT tube (V15) begins conducting, the magnitude of plate current flow will be small, but the rate of change (from no current at all) of plate current flow will be large. The magnitude of voltage developed across the secondary of T8 (terminals 4 to 6) is directly proportional to the rate of change of plate current in the tube V15. Therefore the moment that plate current begins flowing, point 4 of T8 will swing positive in respect to point 6. This will cause the grid of the 6BQ6GT tube to be swung positive in respect to its cathode. Under this condition heavy plate current would flow if the plate circuit inductance were not impeding the flow. Since the electrons cannot flow to the plate, they flow to the screen grid. As time progresses, the plate current flow increases (almost linearly) which in turn causes the screen current to decrease. As the plate current approaches its maximum value, the rate of change of plate current decreases, and the voltage developed across the secondary of T8 drops to the point where it is no longer great enough to maintain the grid positive in respect to the cathode of the tube. The plate current decreases causing point 4 of T8 to become negative in respect to point 6; the grid of the 6BQ6GT is driven negative in respect to its cathode, cutting off both the plate current and the screen current. During the cut-off period, there is a large pulse of voltage developed across both the primary and the secondary of T8; point 3 swings positive in respect to point 1; and point 4 swings negative in respect to point 6. During the cutoff period, the voltage between screen and ground rises toward the B+ voltage as C45 and C50 increase their charge. The waveforms of voltage appearing between screen and ground, grid and ground, and point 4 to point 6 of T8 are shown for one cycle in Fig. 15A, B, and C.

VOLTAGE BETWEEN SCREEN AND GROUND

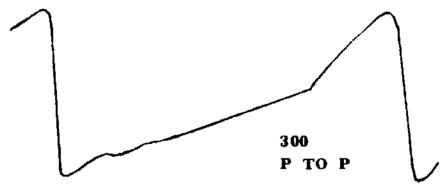


Fig. 15A

VOLTAGE BETWEEN GRID AND GROUND

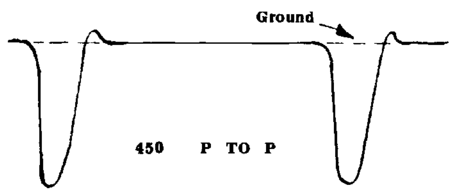


Fig. 15B

VOLTAGE FROM POINT 4 TO POINT 6

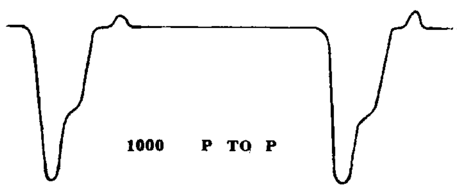


Fig. 15C

The duration of the cutoff period is determined by the time constant of discharge of C44 though the combination of R56, R70, R71, and other associated components, along with the magnitude of bias necessary for cut-off of the 6BQ6GT tube. R71 is the "Horizontal Hold" control and is used to shift the horizontal oscillator frequency. The combination of R59 and C48 is used both as a dampener across the horizontal deflection coils (L10 and L11), and to increase the horizontal linearity.

OPERATION WITH SYNCHRONIZATION

The waveform of voltage existing between screen and ground of the 6BQ6GT is AC coupled to the plate of V14B. This is the only source of voltage for the plate of V14B. The average plate current flow through V14B determines the magnitude of DC across cathode resistor R69 of V14B. The DC across R69 is fed as external bias to the 6BQ6GT oscillator tube (V15). Therefore, since the oscillator frequency is changed by a charge in the oscillator bias, a change in average plate current through V14B will affect the oscillator frequency.

The synchronizing pulses are obtained from the plate of the sync limiter tube (V10) through a differentiating circuit consisting of C40 and R64. The differentiated pulses are both clipped and inverted in V14A.

The waveforms of voltage from plate to ground of V10, grid to ground of V14A, plate to ground of V14A, and cathode to ground of V14A are shown in Fig. 16A through D.

PLATE TO GROUND OF V10

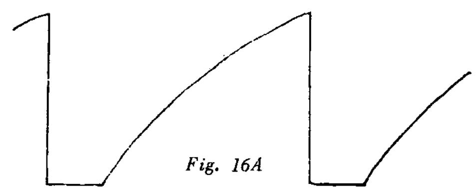


Fig. 16A

GRID TO GROUND OF V14A

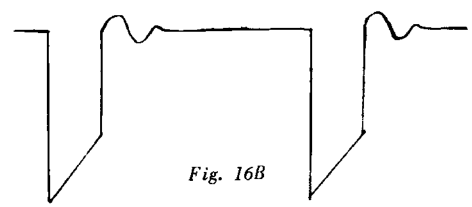


Fig. 16B

PLATE TO GROUND OF V14A

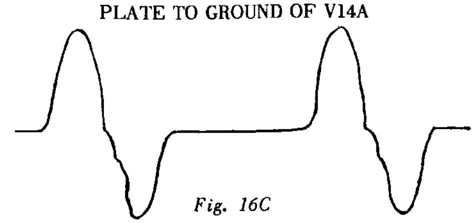


Fig. 16C

CATHODE TO GROUND OF V14A

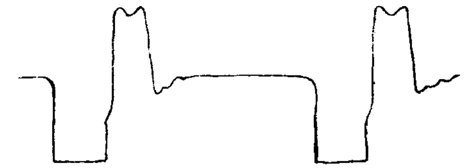


Fig. 16D

The output waveform of voltage present across the secondary of the output transformer (T8) is integrated by R59 and C48. The integrated waveform of voltage present across C48 is coupled to the grid of V14B through R72. The voltage waveform present from plate to ground of V14A is also fed to the grid of V14B through C39. Both the integrated waveform across C48 and the resultant waveform from grid to ground of V14B are shown in Fig. 17A and B.

WAVEFORM ACROSS C48

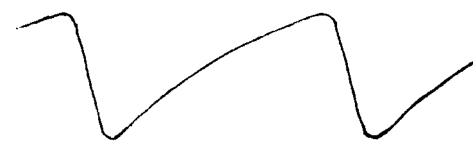


Fig. 17A

WAVEFORM FROM GRID TO GROUND V14B

Fig. 17B

The bias of V14B is controlled by both voltage components appearing between grid and ground of V14B. The synchronizing pulses occur during the time the plate of V14B is positive in respect to ground. The magnitude of average plate current increase when the sync pulse appears, is dependent upon the magnitude of instantaneous plate voltage on V14B; the average being higher for greater plate voltages.

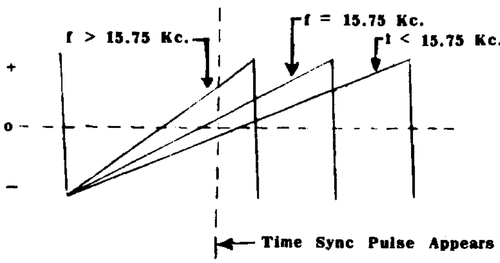


Fig. 18

Fig. 18 indicates the waveform of plate voltage of V14B. This waveform appears for oscillator frequencies equal to, above, and below the correct frequency. From the waveforms it is apparent that the average plate current increases if the oscillator frequency increases, and vice versa.

Therefore, the oscillator bias voltage developed across the V14B cathode resistor R69, increases with an increase in oscillator frequency and decreases with a decrease in oscillator frequency. The frequency of oscillation of the oscillator (V15) will be "pulled" toward the normal horizontal oscillator frequency. The horizontal oscillator (V15) will stabilize when the oscillator frequency is equal to the repetition rate of the sync pulses. C46 with R62 and C47 in the cathode of the phase detector (V14B) provide a long enough time constant to prevent the horizontal oscillator correction voltage from varying at a random noise rate.

POWER SUPPLY

A straight AC transformer power supply (T7) is used. The rectifier (V13) is a 5V4G, which does not heat up faster than the rest of the tubes in the receiver. Consequently there is no high surge voltage during the warm up period and standard rating 450V electrolytic filter capacitors are used.

A block diagram of the power supply is shown in Figure 6, Tubes V7 and V9 in series with the RF and IF amplifiers serve as voltage regulators to maintain a relatively constant voltage supply for the RF and IF stages when the current in those stages varies as a function of signal level. When the current through the RF and IF amplifiers changes, the cathode voltage on V7 and V9 varies accordingly. This causes the impedance of these tubes to change, and the drop across them is maintained approximately at a constant level.

A table of socket voltages and the power dissipation in each tube has been included in the section on *Alignment* of this Manual.

REMOVAL AND INSTALLATION OF PICTURE TUBE

CAUTION: Be sure power cord is removed from receptacle. Wear goggles at any time the picture tube is to be handled.

1. Remove the high voltage lead from the socket on bottom of the picture tube.
2. Remove the tube socket (J4) from the base of the picture tube.
3. Remove the ion trap from the neck of the picture tube, just forward of the tube base.
4. Loosen the machine screw on the left side (viewed from the front) of the picture tube front clamp.
5. Grasp rim of picture tube face and gently pull the tube forward from its mounting. Do not allow the tube to rest on its neck or base and do not attempt to carry or handle the tube holding it only by the neck.
6. To replace the tube reverse the above procedure noting ion trap installation instructions that follow.

PICTURE TUBE COMPONENT ADJUSTMENTS

1. Before placing the socket on the tube base, slide the permanent magnet ion trap on the tube neck with the blackened magnet toward the right (as viewed from the rear). The poles of the magnet nearest the base should be aligned with the 'L' shaped 'flags' welded on the side of the cathode ray gun. When the second anode contact in the tube's glass cone is directly on the bottom, the ion trap magnet will be mounted on the tube in an approximately upright position.
2. Tighten the magnet clamp partially and place the socket on the tube base.
3. Set up a mirror in front of the set so the picture can be observed while working behind the receiver.
4. Loosen the hex nuts on each side of the focus coil, and while observing pattern in mirror, adjust focus coil, forwards or backwards, or tilting it until the pattern is centered in the mask with no shadows evident.
5. After adjusting focus coil, the ion trap should be readjusted. This is done by loosening the knurled nut and with Brilliance control set for a very dim raster, rotate the ion trap axially, forwards and backwards around neck of tube to obtain brightest raster.
6. While holding ion trap, tighten knurled nut, finger-tight.
7. While holding focus coil, tighten the nuts on both sides of coil.
8. Loosen deflection yoke mounting nuts and rotate yoke on the tube neck to produce raster edges parallel to the picture mask edges. Tighten the nuts again.
9. Replace the receiver back cover.

NOTE: For safe shipment the picture tube in each receiver is securely braced and lashed down with fabric tape. Upon unpacking and setting up receiver, it is necessary to remove this fabric shipping tape and adjust picture tube components as outlined above and as directed on an instruction card packaged with each receiver.

REPLACEMENT PARTS LIST

Stock No.	Symbol No.	Description
		ELECTRICAL COMPONENTS
AR0T01	R100-107, T100 C100-115, L100-164	ASSY—RF Tuner with Switch
CC0M00	C2,3,4,5,6,7,14, 15	CAPACITOR—Ceramic Disc .005 mfd Min 450 V
CP2T56	C8,27,36,37,47	CAPACITOR—Paper .2 mfd 220V
CC6A22	C9,40	CAPACITOR—Ceramic 10 mmf 500V
CP2T40	C10	CAPACITOR—Paper .05 mfd 200V
CP4T40	C11,32	CAPACITOR—Paper .05 mfd 400V
CC9A12	C12	CAPACITOR—Ceramic 1.5 mmf 500V
CC0A26	C13	CAPACITOR—Ceramic 22 mmf 500V
CC9M50	C16,20	CAPACITOR—Ceramic .001 mfd Min 500V
CP0M10	C19	CAPACITOR—Paper .001 mfd 10% 120V
CP6T10	C21	CAPACITOR—Paper .001 mfd 600V
CP6T20	C22,29,30,45	CAPACITOR—Paper .006 mfd 600V
CE1D01	C23	CAPACITOR—Electrolytic 10 mfd 50V
CP6T14	C26,33	CAPACITOR—Paper .003 mfd 600V
CP6T12	C28,31	CAPACITOR—Paper .002 mfd 600V
CE3A05	C34a,b,c	CAPACITOR—Electrolytic 80 mfd 450V, 40 mfd 450V, 100 mfd 25V
CP4T51	C35	CAPACITOR—Paper .1 mfd 400V
CE3A06	C38a,b,c	CAPACITOR—Electrolytic 40 mfd 450V, 10 mfd 450V, 100 mfd 200V
CM5A22	C39	CAPACITOR—Mica 100 mmf 500V
CC6A32	C41	CAPACITOR—Ceramic 68 mmf 500V
CP3S10	C42	CAPACITOR—Paper .001 mfd 400V
CP6T36	C43	CAPACITOR—Paper .03 mfd 600V
CM6A38	C44	CAPACITOR—Mica 470 mmf ±10% 500V
CP2T34	C46	CAPACITOR—Paper .02 mfd 200V
CP9S16	C48	CAPACITOR—Paper .004 mfd 85° C 600V
CC9R45	C49	CAPACITOR—Ceramic Disc 500 mmf 10KV
CC6A38	C50	CAPACITOR—Ceramic 220 mmf 500V
RC22A103K	R1,63	RESISTOR—Comp. 10K ±10% ¼W
RC22A681M	R2,21,31,44	RESISTOR—Comp. 680 ohms ¼W
RC22A820K	R3,8	RESISTOR—Comp. 82 ohms ±10% ¼W
RC22A822K	R4,7,39,40,41, 62	RESISTOR—Comp. 8200 ohms ±10% ¼W
RC22A101M	R5,10	RESISTOR—Comp. 100 ohms ¼W

Stock No.	Symbol No.	Description
		ELECTRICAL COMPONENTS—(Continued)
RC22A101K	R6	RESISTOR—Comp. 100 ohms ±10% ¼W
RC22A155M	R9	RESISTOR—Comp. 1.5 meg ¼W
RC22A472K	R11	RESISTOR—Comp. 4700 ohms ±10% ¼W
RC22A105M	R14	RESISTOR—Comp. 1 meg. ¼W
RV0W03	R15	POTENTIOMETER—2000 ohms ±30% 1W (Contrast)
RC24A682K	R18	RESISTOR—Comp. 6800 ohms ±10% 1W
RC22A473M	R19,20,25, 49,64	RESISTOR—Comp. 47K ¼W
RC25A123K	R23	RESISTOR—Comp. 12K ±10% 2W
RC22A330M	R24	RESISTOR—Comp. 33 ohms ¼W
RV0S03	R26,S1	POTENTIOMETER—½ meg. ±30% ¼W (Volume)
RC22A475M	R27	RESISTOR—Comp. 4.7 meg. ¼W
RC22A123K	R28	RESISTOR—Comp. 12K ±10% ¼W
RC22A100M	R29	RESISTOR—Comp. 10 ohms ¼W
RC22A470M	R30	RESISTOR—Comp. 47 ohms ¼W
RC24A154K	R32	RESISTOR—Comp. 150K ±10% 1W
RC22A225M	R33	RESISTOR—Comp. 2.2 meg. ¼W
RC22A223M	R34,35,38	RESISTOR—Comp. 22K ¼W
RC22A184K	R36,57	RESISTOR—Comp. 180K ±10% ¼W
RC22A153M	R37	RESISTOR—Comp. 15K ¼W
RC22A474M	R42	RESISTOR—Comp. 470K ¼W
RV4C08	R43	POTENTIOMETER—1 meg. ±30% ¼W (Vert Hold)
RV0C13	R45	POTENTIOMETER—2500 ohms ±30% ½W (Vert Lin)
RC22A225K	R46	RESISTOR—Comp. 2.2 meg. ±10% ¼W
RC22A335M	R47	RESISTOR—Comp. 3.3 meg. ¼W
RV4C07	R48	POTENTIOMETER—3 meg. ±30% ¼W (Vert Height)
RC22A223J	R50	RESISTOR—Comp. 22K +5% ¼W
RV0C12	R51	POTENTIOMETER—50K ¼W (Brightness)
RW0B12	R52	RESISTOR—Wirewound 100 ohms ±10% 10W
RC25A681K	R53	RESISTOR—Comp. 680 ohms ±10% 2W
RV0W02	R54	POTENTIOMETER—1200 ohms ±10% 2W (Focus)
RC25A472M	R55	RESISTOR—Comp. 4700 ohms 2W
RC22A223K	R56,67	RESISTOR—Comp. 22K ±10% ¼W
RW0B43	R58	RESISTOR—Wirewound 15K ±10% 10W
RW0B29	R59	RESISTOR—Wirewound 3000 ohms ±10% 20W
RC22A104M	R60,70	RESISTOR—Comp. 100K ¼W
RC4T52	R61	RESISTOR—Comp. 680K 2W
RC23A473M	R65	RESISTOR—Comp. 47K ½W
RC22A105K	R68,72	RESISTOR—Comp. 1 meg. ±10% ¼W
RC22A224M	R69	RESISTOR—Comp. 220K ¼W
RV0C14	R71	POTENTIOMETER—250K ±30% ¼W (Hor Hold)
RW0L01	R73	RESISTOR—Wirewound 2.2 ohms ½W
SP4O03		SPEAKER—4 x 6 PM Oval

REPLACEMENT PARTS LIST—Continued

Stock No.	Symbol No.	Description
		ELECTRICAL COMPONENTS—(Continued)
TI0I04	T1	TRANSFORMER—IF Interstage
TI0I05	T2	TRANSFORMER—IF Interstage
TI0D24	T3	TRANSFORMER—IF Output, Detector
TI0D25	T4,L5,6,7, C17,18	TRANSFORMER—Ratio Detector
TA0O22	T5	TRANSFORMER—Audio Output Twist Mtg. (10" Tube)
TA0O23	T5	TRANSFORMER—Audio Output Twist Mtg. (12½" Tube)
TS0V01	T6	TRANSFORMER—Sweep Vertical Output (10" Tube)
TS0V02	T6	TRANSFORMER—Sweep Vertical Output (12½" Tube)
TP0Y01	T7	TRANSFORMER—Power
TS0H02	T8	TRANSFORMER—Hor Output & High Voltage
LC0V04	L1, R12	COIL—Video Peaking
LC0V05	L2, R13	COIL—Video Peaking
LC0V06	L3, R16	COIL—Video Peaking
LC0V07	L4, R17	COIL—Video Peaking
LC0D01	L8,9,10,11	COIL—Deflection Yoke (10" Tube)
LC0D02	L8,9,10,11	COIL—Deflection Yoke (12½" Tube)
LC0F01	L13	COIL—Focus (10" Tube)
LC0F02	L13	COIL—Focus (12½" Tube)
LI0T14	L14	COIL—IF Sound
TI0P01		TRAP—Ion Picture Tube Magnet
1N60	X1	DETECTOR—Crystal
		MECHANICAL COMPONENTS
AC0P01		ASSY—Cord with HV Plate Shield
BT0S01		BOARD—Terminal 11 Lug 2 Mtg.
BT1S03	M1	BOARD—Terminal 1 Lug 1 Mtg.
BT1S05		BOARD—Terminal 1 Lug 1 Mtg.
BT3S06		BOARD—Terminal 3 Lug 1 Mtg.
BT4S06		BOARD—Terminal 4 Lug 1 Mtg.
BT9S00		BOARD—Terminal 9 Lug 2 Mtg.
BT2T03	J1	BOARD—Terminal 2 Lug 2 Mtg. (Ant Conn)
CH0A01		CONNECTOR—Anode HV (10" Tube)
CH0A02		CONNECTOR—Anode HV (12½" Tube)
CL2A13		CORD—AC Line
CR0S00		CUSHION—Slotted Round Rubber .56 x 2.54
CR0S01		CUSHION—Slotted Round Rubber .56 x 3.74
FC0M01		FUSE—Type 3AG .25 Amp.
GC0S00		GASKET—Cork Tube Strap 1/32 x 5/8 x 24¼
GR0S09		GROMMET—Rubber Shockmount Anode Lead 9/16 x 3/8 x 15/64 dia's
GR0S20		GROMMET—Rubber Shockmount Anode Spring 11/32x¼x1/8 dia's
GR0S27		GROMMET—Rubber Shockmount Test Leads 11/32x7/32x3/32 dia's
GR0S28		GASKET—Rubber Focus Coil 1 3/4 x 1/16
GR0S29		GASKET—Rubber Lower Yoke Support 3/8 x 1/8 x 9¾(12½" Tube)
HB1M29		BRACKET—Mtg. RF Tuner
HB1M30		BRACKET—Mtg. Focus Coil & Tube Yoke (10" Tube)
HB1M31		BRACKET—Mtg. Yoke Support (10" Tube)
		MECHANICAL COMPONENTS—(Continued)
HB1M32		BRACKET—Mtg. Focus Coil & Tube Yoke (12½" Tube)
HB1M33		BRACKET—Mtg. Lower Tube Support (12½" Tube)
HH0M01		HOOD—Kinescope Tubing
HN8S02		NUT—Speed #8 Sheet Metal
HN9S02		NUT—Speed, Special
HP0M07		PLATE—Metal Tube Mtg. (12½" Tube)
HR0M03		RING—Kinescope Tube Mtg. (10" Tube)
HR0M04		RETAINER—Metal Kinescope Tube (10" Tube)
HR0M05		RING—Kinescope Tube Mtg. (12½" Tube)
HS1C21		SPRING—Coil Picture Tube Ground
HS0S26		SPRING—Support Anode Lead (10" Tube)
HS0S27		SPRING—Support Anode Lead (12½" Tube)
JR2O13	J2	JACK—Receptacle 2 Contact (Interlock)
PC0M02		PLATE—Metal Cover Tube Ground (12½" Tube)
SO2K01	J4	SOCKET—Tube Kinescope (10" Tube)
SO2K02	J4	SOCKET—Tube Kinescope (12½" Tube)
SO7M15		SOCKET—Tube 7 Prong Min.
SO7M16		SOCKET—Tube 7 Prong Min.
SO7M17		SOCKET—Tube 7 Prong Min.
SO9M00		SOCKET—Tube 9 Prong Min.
SO8S07		SOCKET—Tube Octal
SO8S08		SOCKET—Tube Octal
		CABINET COMPONENTS
BZ0B30		BACK—Cabinet Cover (10" Tube)
BZ0B31		BACK—Cabinet Cover (12½" Tube)
DS0S00		DIAL—Scale, Channel Selector
FP0P00		FRAME—Paper, Picture Tube (10" Mah.)
FP0P01		FRAME—Paper, Picture Tube (10" Oak)
FP0P02		FRAME—Paper, Picture Tube (12½" Mah.)
GZ0S01		GLASS—Safety (10" Tube)
GZ0S02		GLASS—Safety (12½" Tube)
HC0M14		CUP—Metal, Back Cover
HC0S69		CLIP—Spring Safety Glass Retainer (12½" Tube)
HC0S92		CLIP—Spring, Dial Retainer
HC0S93		CLIP—Spring, Control Knob Retainer
HC0S94		CLIP—Spring, Concentric Knob Retainer
KC0B20		KNOB—Control, Contrast Off-On-Volume
KC0B21		KNOB—Control, Fine Tuning
KY0B03		KNOB—Concentric, Channel Selector
HZ0G01		GLIDE—Metal (10" Consolette)
ZW1T02		CABINET—Table Model, Mahogany (2001)
ZW1T03		CABINET—Table Model, Mahogany (2020)
ZW1V00		CABINET—Consolette, Mahogany (3001)
ZW1V01		CABINET—Consolette, Limed Oak (3002)

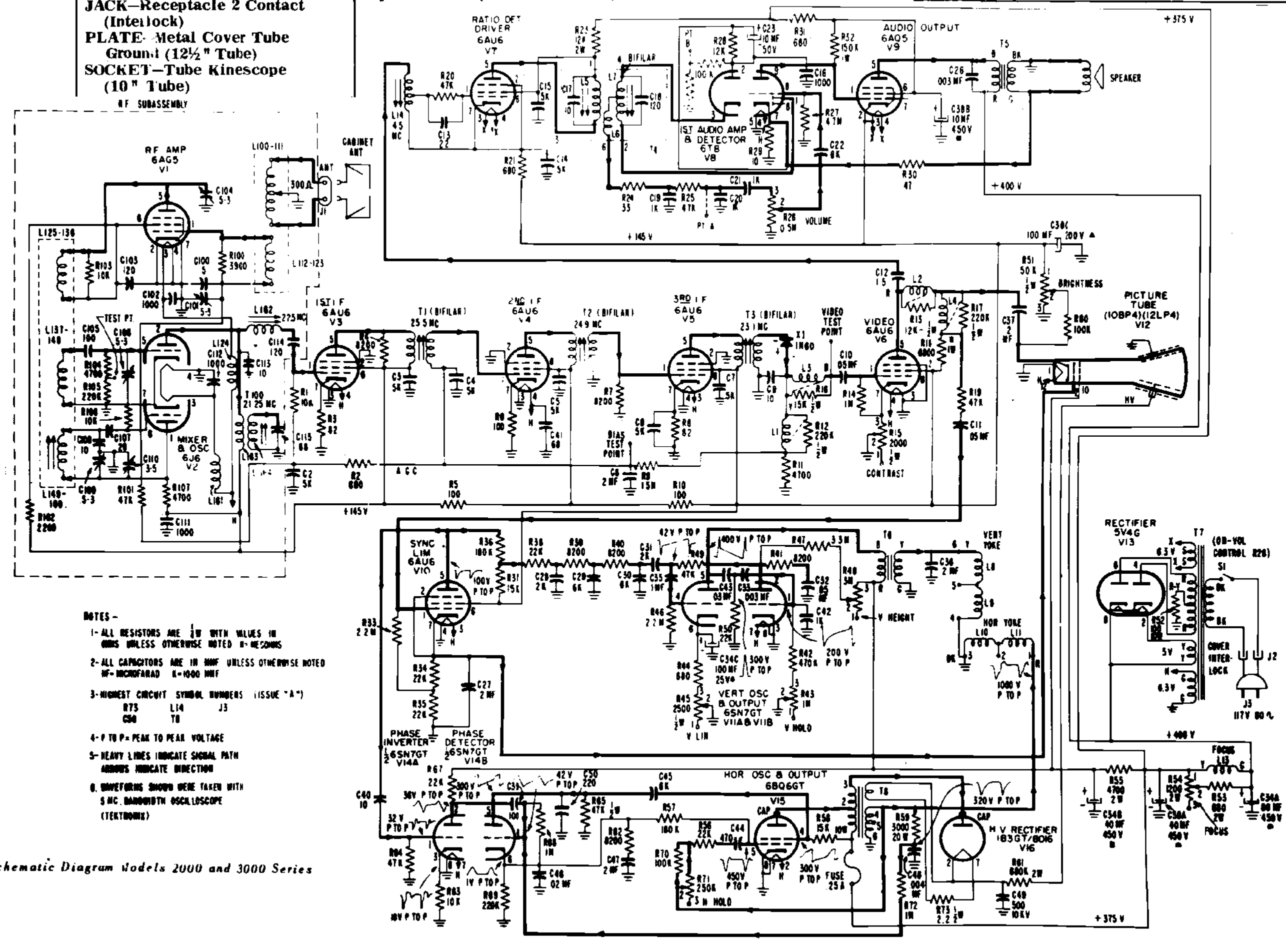


Fig. 19 – Schematic Diagram Models 2000 and 3000 Series