MODEL H-223

SPECIFICATIONS

FREQUENCY RANGES:

<table>
<thead>
<tr>
<th>Channel</th>
<th>Channel Frequency (MC)</th>
<th>Video Carrier Frequency (MC)</th>
<th>Audio Carrier Frequency (MC)</th>
<th>Receiver H-F Oscillator Frequency (MC)</th>
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<td>64 - 60</td>
<td>55.25</td>
<td>91.15</td>
<td>81.35</td>
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FINE TUNING RANGE:

Plus or minus 400 kc. on channel 2. Plus or minus 2 kc. on channel 13.

POWER CONSUMPTION: 200 watts

AUDIO POWER OUTPUT:

Undistorted: 1.2 watts
Maximum: 1.5 watts

OPERATING VOLTAGE: 105 to 122 volts, 60 cycles

LOUDSPEAKER:

Type: 5¼" P. N.
Voice Coil Impedance: 3.2 ohms at 400 cycles

RECEIVER ANTENNA INPUT IMPEDANCE: 300 ohms balanced or 72 ohms unbalanced

VIDEO CARRIER INTERMEDIATE FREQUENCY: 26.1 mc.

VIDEO RESPONSE: 3.5 mc.

AUDIO CARRIER INTERMEDIATE FREQUENCY: 4.5 mc.

AUDIO DISCRIMINATOR BAND WIDTH (between peaks): 150 kc.

FOCUS: Magnetic

SWEEP DEFINITION: Magnetic

SCANNING: Interlaced 525 line.

HORIZONTAL SCANNING FREQUENCY: 15,750 CPS

VERTICAL SCANNING FREQUENCY: 60 CPS

FRAME FREQUENCY (picture repetition rate): 30 CPS

HIGH VOLTAGE WARNING

The danger accompanying shock is always present when the receiver is operated outside the cabinet or when the rear cover is removed from the cabinet. Only a person familiar with the precautions to be observed when working with high-voltage equipment should service this receiver.

CATHODE RAY TUBE HANDLING PRECAUTIONS

Shatterproof goggles and heavy gloves should be worn at all times when handling the cathode ray tube. The tube should not be handled in the vicinity of any person not so equipped. When handling the cathode ray tube, always keep it away from the body.

The cathode ray tube bulb, due to its large surface area and high vacuum contained within, is subjected to high air pressure. More than ordinary care is required to prevent shattering the tube. The large end of the bulb, particularly the rim of the viewing surface, must not be scratched, or subjected to more than moderate pressure at any time. If the tube sticks or fails to slip smoothly into place during installation, remove the tube and determine the cause of the trouble - DO NOT FORCE THE TUBE.
INSTALLATION INSTRUCTIONS

TO PREPARE THE RECEIVER FOR OPERATION:
1. Due to the weight of the chassis, the receiver should be lifted by grasping the bottom of the cabinet. Lift the receiver from the carton and place it on an elevated surface such as a bench.
2. Remove the screws that hold the rear cover to the cabinet.
3. Remove the rear cover by sliding it up and then away from the cabinet.
4. Inspect the face of the C.R.T. and the glass window for fingerprints, dust, or other smudges. If the face of the C.R.T. or the inside of the glass window is smudged, it will be necessary to remove the chassis from the cabinet and clean these surfaces. In this event, steps 5 to 8 inclusive, below, should be modified somewhat. Remove all three chassis bolts and square metal plates as in steps 5 and 6. Remove the knobs, disconnect the speaker cord, and then remove the chassis from the cabinet. After cleaning the smudged surfaces, replace the chassis in the cabinet, re-insert the chassis bolts as explained in step 7, connect the speaker cord to the speaker, replace the knobs, and continue with step 9.

5. Move the receiver into such a position that one of the three chassis hold-down bolts on the bottom of the cabinet protrudes over the edge of the bench so as to become accessible.
6. Remove the chassis bolt and the round metal cleat under it.
7. A cloth bag, which accompanies each receiver, contains 3 metal washers and 3 rubber washers. Place first one metal washer and then one rubber washer on the chassis bolt, and re-insert the chassis bolt. Tighten the bolt, just to the point where it can no longer be removed with the fingers.
8. Repeat steps 5, 6, and 7 on the other two chassis bolts.
9. Make certain that the chassis is positioned so that the cathode ray tube is centered with respect to the mask and the control shafts extend sufficiently through the front of the cabinet.
10. Make certain that all tubes are in their sockets and that no damage has occurred in shipment.

11. See that the speaker cord is connected to the chassis.
12. Replace the rear cover.
13. Connect the antenna lead-in to the terminals on the rear of the chassis.
14. Connect the A-C plug to a 105-120 volt 60 cycle A-C outlet.

TO CHECK THE OPERATION OF THE RECEIVER:
1. Rotate the brightness and contrast controls completely counterclockwise.
2. Turn on the receiver by rotating the off-on-volume control clockwise until a click is heard.
3. Rotate the channel selector to the channel number of the desired station.
4. Rotate the volume control clockwise until the sound reaches the desired level.
5. Turn the brightness control clockwise until the raster becomes visible, and check the iron trap magnet adjustment as explained under ADJUSTMENTS. Rotate the brightness control counterclockwise to the point where the retrace lines just disappear.
6. Rotate the contrast control clockwise until a picture appears on the screen.
7. If the picture is moving up or down or quivering, adjust the vertical control until the picture is correctly synchronized vertically.
8. If the picture is twisted diagonally or is not in horizontal sync, adjust the horizontal control.
9. Adjust the fine tuning control for best picture detail.
10. Adjust the contrast control until the correct shades ranging from clear white to intense black are obtained. If necessary, make a slight re-adjustment of the brightness control.
11. Check the operation on all available television stations.
12. If necessary, adjust the linearity, height, width and focus controls as explained under ADJUSTMENTS.

ADJUSTMENTS

FIG. 1 - TOP VIEW OF CATHODE RAY TUBE

A removable panel on the front of the receiver conceals the picture adjustments. This panel, located under the control knobs, can be removed by loosening the two thumb screws that hold the panel in place.

An insulated, long-shank, screwdriver is preferred for making the ring coil and H.V. oscillator adjustments.

ION TRAP MAGNET

CAUTION: When adjusting the ion trap magnets, care should be exercised to avoid breaking the neck of the cathode ray tube.

The ion trap magnet should be oriented approximately as shown in Fig. 1, with the arrow on the magnet pointing toward the large end of the cathode ray tube and the bar magnets lined up with the "flags" inside the neck of the cathode ray tube. Starting from this position, adjust the magnet by rotating it around the neck of the cathode ray tube and moving it forward and backward until the raster is brightest on the screen.

FOCUS COIL

Incorrect centering of the picture or a shadow on one corner of the picture may indicate that the focus coil is in need of adjustment. If only a slight adjustment is required, it can be made by turning the centering adjustment screws. Two of these screws are shown under the label "Centering Adjustments" in Fig. 1, and the third screw is located under the focus coil.

If a major adjustment of the focus coil is required, the procedure is as follows:
1. Turn the centering adjustment screws in or out until the focus coil is positioned at right angles to the neck of the C.R.T. and

FIG. 2 - OPERATING CONTROLS AND ADJUSTMENTS

there is a slight separation between the deflection yoke and the focus coil.

2. Loosen the lock nuts located under the heads of the centering adjustment screws and slide the focus coil up or down or sideways until the picture is correctly centered. Large holes in the focus coil brackets permit this movement of the coil.
3. Tighten the lock nuts while taking care that the screws do not turn during the process.
4. Fine centering adjustments can be made by turning one or more of the centering screws in or out.

NOTE: In some early sets using a P.M. focus coil, an additional adjustment is provided in the form of two wing nuts which hold the focus coil to the mounting plate. In these sets, coarse centering adjustment can be made by loosening the two wing nuts and moving the focus coil in relation to the neck of the tube.

If focusing cannot be accomplished in sets using a P.M. focus coil, it may be necessary to move the coil closer to or further from the deflection yoke by turning the adjusting screws in or out an equal distance. If correct focusing cannot be accomplished in this manner, the H.V. oscillator may require adjustment as described below.

CATHODE RAY TUBE CUSHION

The cushion must fit snugly against the flange of the cathode ray tube in order that the aquadag ground springs will make good contact and the rear of the tube will be supported firmly.

DEFLECTION YOKE

This adjustment controls the angle of the picture with respect to the horizontal. If the
picture is not squared in the picture mask, loosen the wing nut and move it to the left or right so as to rotate the deflection yoke. The picture will tilt to the left or right with the deflection yoke rotation.

FOCUS CONTROL

The focus control (Fig. 2) should be adjusted with the brightness and contrast controls in their normal positions. If correct focusing cannot be obtained, refer above to "FOCUS COIL".

HEIGHT AND VERTICAL LINEARITY

The height adjustment controls the overall height of the picture, while the vertical linearity adjustment governs expansion or contraction of the upper portion only. For this reason, a balance between the two controls is necessary to make the picture symmetrical and fill the mask vertically.

WIDTH

The width adjustment controls the width of the picture. It should be adjusted so the picture fills the mask horizontally. No horizontal linearity adjustment is required.

HIGH VOLTAGE OSCILLATOR

The setting of the high voltage oscillator (C506) determines the voltage applied to the second anode of the C.R.T. To correctly adjust the trimmer:

1. Turn off the receiver and disconnect the high voltage lead from the C.R.T.

2. Connect 9 megohms of resistance between the high voltage lead and the chassis. The 9 megohm resistance should consist of a one-megohm, one-watt resistor connected in series.

3. Connect a kilovoltmeter across the 9 megohm resistance, and make certain that all connections are well insulated.

4. Turn on the receiver and adjust C506 for maximum voltage indication on the meter.

5. Turn off the receiver, disconnect the kilovoltmeter, remove the 9 megohm resistance, and re-connect the high voltage lead to the C.R.T.

HORIZONTAL RINGING COIL

To adjust the horizontal ringing coil, tune in a station, set the horizontal hold control at approximately the middle of its range, adjust the ringing coil (L403) until the picture is properly "locked-in".

CIRCUIT DESCRIPTION -- V-2150-01 CHASSIS

FIG. 23 - "CONVENTIONAL" TV RECEIVER

The following circuit description is based on the assumption that the reader is familiar with standard television principles and practices. The particular circuits described are those included in the Westinghouse Chassis No. V-2150-01. For general television information the reader is referred to one of the several television textbooks on the market.

The function of each circuit component is given in the parts list, and specific components will be mentioned only when necessary for purposes of clarification.

GENERAL

The V-2150-01 chassis utilizes the "common I-F" TV system. As shown in Figs. 23 and 24, this system differs somewhat from the so-called "conventional" system.

In the conventional type TV receiver, the video and audio RF carriers are converted into their respective I-F frequencies in the mixer stage of the R-F tuner. They are then separated, usually at the plate of the mixer or the first I-F stage, and the audio and video components are amplified and detected in separate channels. Every effort is made to keep the audio component from appearing on the grid of the picture tube. This is usually accomplished by the use of traps in the video I-F system and, in some cases, the video amplifier.

With the common I-F system, the audio and video carriers are converted to their respective I-F frequencies in the same manner as in the conventional system. However, the two I-F signals are not separated into different I-F channels at this point. Instead, they are amplified in a common I-F amplifier, and both signals appear at the video detector. Since audio carriers are originally transmitted 4.5 mc. apart, as specified in I.C. standards and this separation is accurately maintained by temperature-controlled crystal oscillators in the transmitter, the two I-F signals appearing at the video detector are separated by exactly 4.5 mc. In addition to the function for which it is named, the video detector serves as a mixer for the two I-F signals. The mixing of the audio I-F carrier with the video I-F carrier produces a 4.5 mc. beat signal that is frequency modulated in accordance with the audio I-F carrier.

The manner in which the 4.5 mc. beat signal is obtained can be likened to the mixer action in the well-known superhet receiver. The incoming video I-F signal serves in lieu of the local oscillator and beats against the incoming audio I-F signal to produce the sum and difference frequencies at the output of the video detector. Since the sum frequency will fall far outside the pass-band of the video amplifier, it can be disregarded. This leaves only the difference frequency of 4.5 mc. to be considered.

After passing through the video amplifier, the 4.5 mc. signal is fed to a 4.5 mc. audio I-F amplifier, which amplifies the signal sufficiently to drive the ratio detector. An audio amplifier raises the output of the ratio detector to a level suitable for exciting the speaker.

R-F TUNER (Fig. 25)

The R-F tuner, consisting of an R-F amplifier, a mixer, and a H-F oscillator, is assembled as a complete unit. Its function is to amplify the received signals and convert the audio and video carriers to the correct intermediate frequencies.

Transformer coupling between the antenna terminals and the R-F amplifier provides a correct impedance match when either a balanced 500 ohm or an unbalanced 72 ohm transmission line is employed. When a balanced 500 ohm line is used, it should be connected to the antenna terminals in the conventional manner; however, if the transmission line is a 72 ohm coaxial cable, the center conductor of the cable should be connected to one of the antenna terminals, and the outer shield should be grounded to the chassis. In addition to providing the correct impedance match between the transmission line and the grid of the H-F amplifier, the transformer presents a high impedance at low frequencies, thereby tending to eliminate interfering, low-frequency signals such as broadcast, etc.
The R-F amplifier grid and plate circuit, along with the mixer grid circuit, are tuned by incremental inductances. As the channel selector switch is rotated toward the higher frequency channel positions, the inductances are progressively shorted and the circuits are resonated to the desired frequency.

The oscillator tuning circuit consists of separate sections that are switched in and out of the circuit as the channel selector switch is rotated. As the name implies, the fine tuning control (C114) provides a fine adjustment of the oscillator frequency and makes it possible to obtain correct tuning despite slight frequency drifts, changes in tube characteristics due to aging, etc.

A 6CA7 tube operating in a modified Colpitts circuit serves as the H-F oscillator. Its output is injected into the mixer grid circuit through C112. Rectification of the oscillator injection voltage in the mixer grid circuit provides part of the bias for the mixer tube, and the remainder of the bias is supplied by a cathode potential.

AC voltage is applied to the grid of the R-F amplifier tube. This voltage controls the gain of the tube and keeps the picture contrast approximately constant under variations in signal strength. In addition, it tends to prevent blocking on very strong signals.

**1-F AMPLIFIER** (Fig. 26)

The V-2150-01 chassis uses a stagger-tuned, impedance-coupled 1-F system. Stagger-tuning provides the required pass-band without resonant inductances that are switched and formers or “M-derived” and other types of filters. The plate load impedances are peaking coils, each of which is tuned to a different frequency. Interstage coupling is obtained through capacitors in a manner similar to that used in resistance-coupled audio amplifiers. Since there are only four tuned circuits in the system—no traps—alignment is relatively simple as compared to the conventional system. AC voltage is applied to the first two stages in order to maintain relatively constant video and audio output under varying signal strengths.

In early production of the V-2150-01 chassis, a trap (L310 and C304) was inserted between the mixer plate and the grid of the first 1-F amplifier. This trap was provided to prevent the H-F oscillator voltage from "leaking through" to the grid of the 1-F tube. In later production, the grid leak was accomplished by changing the length and dress of the mixer plate lead, and the trap was deleted. All stages of the 1-F amplifier have LC isolation networks in their heater circuits. The function of these traps is to prevent interaction between stages and coupling of the 1-F voltages into other stages of the receiver through the heater-cathode capacitance of the tubes and the common heater line.

The 1-F amplifier is designed so that the video 1-F carrier appears at the 50% (6 db) point on the 1-F response curve, while the video 1-F carrier appears at a point 26 db below the video 1-F carrier or at the 2.5% point. As a result, the amplitude of the video 1-F carrier is much less than that of the video 1-F signal entering the video detector. This condition is essential for two reasons: First, the audio 1-F signal must be of very low amplitude at the grid of the C.R.T. in order to prevent picture distortion; and second, the audio 1-F amplitude must be low in comparison with the video 1-F amplitude in order that the characteristics of the 4.5 mc. beat response from the two signals will be determined chiefly by the audio 1-F signals and fluctuations in the video 1-F signal will have less effect upon the 4.5 mc. beat response.

**VIDEO DETECTOR AND AGC** (Fig. 27)

The video detector is a diode type similar to those used in AM receivers. The 1-F signal is applied to one plate of the 6ALS twin-diode tube. On the positive portions of the video 1-F signal, the diode will conduct and current will flow up through the contrast control to the cathode of the diode. This current will develop a voltage across the contrast control, and the voltage will vary with the modulation on the signal. This eliminates the higher-frequency 1-F component by by-passing it to ground. The setting of the contrast control determines the amount of signal that is applied to the grid of the video amplifier which, in turn, determines the voltage amplitude applied to the C.R.T. grid.

At the same time as the video detector is performing the function described in the preceding paragraph, it is serving as a mixer for the video 1-F and audio 1-F signals. The resultant 4.5 mc. frequency-modulated beat signal appears across the contrast control along with the video component.

The other diode section of the 6ALS serves as an AGC rectifier. The 1-F signal is also applied to the plate of this section. On the positive portions of the signal the diode conducts, and current flows down through R325, developing a negative voltage at the junction of R325 and R326. This voltage is applied to the tubes under AGC through a delay network composed of R326 and C315. Each stage under AGC is decoupled from the AGC line by resistor-capacitor networks in order to prevent interaction between stages.

A delay bias of approximately one volt is applied to the cathode of the AGC rectifier by the series dropping resistors R307 and R323. The purpose of this delay bias is to prevent the AGC from becoming operative until the signal strength has reached a predetermined amplitude. This assures maximum sensitivity of the receiver on weak signals.

**FIG. 27 - VIDEO DETECTOR & AGC RECTIFIER**

**FIG. 28 - VIDEO AMPLIFIER**

The video amplifier is a single stage amplifier utilizing direct coupling between the video detector and the control grid of the amplifier. If capacitive coupling were used, the coupling capacitor would have to be large in order to pass the 60 cycle vertical sync pulses. If the capacitor were large enough to pass the sync pulses, the time constant of the AGC network formed by the coupling capacitor and the contrast control, would be too long, and the amplifier would be highly susceptible to noise pulses. The direct coupling method is therefore used to provide better low frequency response and, at the same time, to make the system more immune to noise.

High frequency response is improved by the use of two series peaking coils, L303 and L304. These coils are to limit the output capacity of the 6ALS video detector from the input capacity of the 6ALS amplifier, and to obtain the capacity of the 6ALS amplifier from the input capacity of the C.R.T., so that the capacities are effectively in series rather than in parallel. Since the high frequency response is due to a shunt capacity in the circuit, effectively placing the tube capacities in series—the lowing shunt capacities—gives a high frequency response. A further improvement of high frequency response is afforded by the use of the shunt peaking coil (L304 or L303) and the coupling capacitor (C323). The shunt peaking coil is self resonant at a frequency higher than the highest frequency desired to be passed. As the frequency increases, the load impedance increases, and this tends to compensate for the attenuation caused by the tube and shunt capacity. Therefore the coupling capacitor (C323) provides a high impedance path around the contrast control of the high frequencies and the coupling capacitor (C323) provides a form of high frequency "boost" especially at the lower settings of the contrast control. The series peaking coil (L304) in the plate of the AGC rectifier is bypassed by the resistor (R330) in order to prevent the development of transients that would adversely affect the picture.
The video amplifier is designed to have a sharp cut-off in the vicinity of 3.5 to 4.0 mc, in order to attenuate the badly beat frequency so that it will have no visible effect on the picture. Although the 4.5 mc beat is 60 db below the video response curve and its amplitude is not great enough to have any appreciable effect on the grid of the C.R.T., the signal is still strong enough to excite the grid of the audio I-F amplifier. The attenuation, of the 4.5 mc beat, is further increased by the action of the audio I-F transformer, which is effectively a series-tuned circuit shunting the plate of the video amplifier. This series-tuned circuit provides a low impedance path from the plate of the video amplifier to ground for the 4.5 mc signal, and at the same time sufficient voltage is developed across the audio I-F transformer winding (120) on Fig. 29 to excite the grid of the audio I-F amplifier tube.

**AUDIO CHANNEL (Fig. 29)**

The 4.5 mc signal is taken from the plate of the video amplifier and fed to the audio I-F amplifier. In this stage the signal is amplified to a sufficient level to drive the 40 mc detector. The function and operation of the audio channel is the same as that of an FM receiver except that the I-F frequency is 40 mc rather than 10.7 mc. The reader is referred to one of the several textbooks on the market for information regarding the operation of the ratio detector.

The A.C. power source is applied to the grid of the audio I-F amplifier tube. The diode will conduct during the positive portion of the cycle, and current will flow through R12 and R11 to ground. The current flows a voltage that is negative with respect to ground across these resistors. A portion of the developed voltage is applied to the control grid of a video amplifier, and a portion is applied to the control grid of a voltage divider formed by the three resistors. Greater control over the stage gain is obtained by applying the audio voltage to both grids rather than to the control grid only. The A.C. line is by-passed for R.F by C24 which serves also as part of the A.C. time constant network.
These conditions change, however, during the time of the vertical sync pulses. As shown, the duration of each vertical sync pulse is long enough compared to the time between pulses to charge the capacitors contained in the circuit to a relatively high value during the first pulse, and this charge cannot leak off completely in the short time between pulses. Then when the second pulse comes along, the charge supplied will add to the charge remaining on the capacitors to increase the total charge. Thus the charge will increase with each successive pulse.

During the time of the equalizing pulses following the vertical sync pulses, the pulse duration is again short as compared to the time between pulses. The result is that the charge on C421 decreases in steps. 

By virtue of the low-pass filter characteristics of the network, noise and any other high-frequency components are greatly attenuated, and the output of the network consists essentially of a single pulse correctly timed to trigger the vertical multivibrator.

MULTIVIBRATOR ACTION (Fig. 33)

The "one-shot" type of multivibrator is used in the vertical and horizontal deflection circuits of the V-2150-1 chassis. The operation of the multivibrator is a "free running" oscillator with a single burst of voltage which is used to trigger the vertical multivibrator.

REFERRING TO FIG. 33, WHICH IS A SIMPLIFIED DIAGRAM OF THE VERTICAL MULTIVIBRATOR, Assume that the plate voltage has not yet been applied; under this condition, there will be no charge across C424. When plate voltage is applied, C412 will charge and the polarity will be as indicated in Fig. 33. The heavy current flow required to charge C424 will follow the path indicated by heavy arrows. This current is flowing through R414. When the voltage at the plate of triode A4 reaches a given value, the plate voltage applied to the triode A4. Under these conditions, triode A4 is inoperative because it is held below cut-off. Triode B4 will conduct during this period.

As the charge accumulates on C424, the charging current decreases. This reduces the voltage drop across R414 and R428, and the resultant increase in plate voltage and decrease in bias voltage allows triode A4 to conduct. When triode A4 conducts, its internal resistance is greatly decreased, and C412 will discharge through the path indicated by the dotted arrows. The discharge current flowing through R436 and R404 develops a potential that makes the grid of triode B4 negative with respect to the cathode, and triode B4 will be driven into cut-off. The discharge of C412 will continue along an exponential curve, the only potential applied to the grid of triode B4 being the slowly decaying voltage on R436 until the point is reached where triode B4 will conduct again. When this occurs, the triode B4 cathode current added to the triode A4 cathode current will raise the voltage developed across R436, sufficiently to cut off triode A4. It should be noted that triode B4 will not be cut off at this time because its grid is returned to its cathode rather than to ground. When triode A4 "cuts off", our original starting conditions are obtained, and the cycle will be repeated.

It can be seen that the free-running repetition rate of the oscillator is determined by the charging and discharging rate of C412. The vertical hold control (C406) determines the resistance through which C412 charges and discharges, thus controlling the rate of charge and discharge.

The instantaneous conditions that exist in the circuit are illustrated by Fig. 34. Curves A and B show the voltages at the plates of the triodes while curve C shows the output waveform across R418 and C414. The action of R413 and C414 will be discussed in the context of "VERTICAL DEFLECTION". Fig. 34-B shows the waveform appearing at the grid of triode B4 and illustrates the method of synchronizing the multivibrator with the sync pulse. The solid line shows the curve as it would exist if the oscillator were "free running" at a repetition rate of 59 C.P.S., while the dotted lines show the conditions imposed by the sync pulse. At point A, the grid is held well below cut-off by the charge on C412. As the capacitor gradually discharges, the grid swings up to point B, and the oscillator would be free running. The tube would conduct suddenly at point C. Due to the introduction of the sync pulse, however, the condition is changed somewhat. The sync pulse from the integrating network is applied to the grid of triode A4. This pulse, which is negative in polarity, appears at a time when triode A4 is conducting, and its effect will be to drive triode A4 into cut-off. At the same time, the pulse will be inverted by the phase reversal characteristic of C414 and will apply the grid of triode B4 as a positive pulse. The positive pulse will drive triode B4 into cut-off, and the conduction path of B4 is broken, instead of allowing the non-conduction period to extend to point C as would have occurred if the oscillator were free running. It is thus evident that the free-running frequency of the oscillator must be slightly lower than the sync frequency in order that the multivibrator will "lock-in" with the sync pulses. This condition is obtained when the vertical hold control (C406) is correctly adjusted.

VERTICAL DEFLECTION CIRCUIT (Fig. 35)

The action of the multivibrator was discussed in the preceding section. Referring to Fig. 34-B, it will be noted that the voltage at the plate of triode B4 in the multivibrator is a square wave. This square voltage serves as a switch and controls the charge and discharge of C414 which is connected in series with R418 across the output of the tube. During the period when triode B4 is conducting, the tube is effectively a short circuit through C414 and the voltage across C414 is then at a low value. However, when the tube is driven into cut-off, the full B plus voltage is applied to C414. The capacitor will then charge along an exponential curve until the tube is driven into conduction. As soon as the tube conducts, C414 discharges rapidly. The process of charging and rapid discharge of C414 develops a saw-tooth voltage.

As shown in Fig. 34-C, the output of the multivibrator consists of a sharp spike of negative voltage in addition to the saw-tooth developed across C414. The reduction of the spike of negative voltage is developed across the waveform correction resistor, R418, during the rapid discharge period. The resultant output wave form (Fig. 34-C) is required in order to obtain a saw-tooth of current in the deflection coil. This is necessary because the practical coils contain some resistance in addition to inductance. A saw-tooth of voltage will produce a saw-tooth of current through a resistor, but a square-wave of voltage is required to produce a saw-tooth of current through a pure inductance. Therefore, a composite saw-tooth and square wave is required to produce a saw-tooth of current in a practical coil.

The height control, R401, determines the amount of B plus voltage applied to the charging capacitor, C414. In so doing, it determines the amplitude of the voltage to which the capacitors are charged and the amplitude of the vertical multivibrator output. The output of the multivibrator is coupled to the vertical output tube through C419. From here, the voltage is amplified and applied to the deflection coil through the vertical output transformer. The output transformer serves as an impedance matching device which matches the impedance of the deflection coil to the plate impedance of the output tube. Since the saw-tooth voltage has some curvature due to the exponential charging rate of C414, some means of correction must be used to maintain the saw-tooth shape of the output voltage. This is accomplished by using the vertical linearity control, R402, to adjust the bias on the vertical output tube. At no point on the characteristic curve of the tube, the curvature will be such that the undesirable curve on the applied saw-tooth would impair the performance of the deflection coil as a result of the high percentage content of the saw-tooth voltage; one of the techniques used is to raise the coil into oscillation at its self-resonant frequency.

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FIG. 35 - VERTICAL DEFLECTION CIRCUIT

The purpose of the horizontal AFC circuit is to correct for any fluctuations in the horizontal multivibrator frequency that may be caused by noise, etc. This is accomplished by comparing the phase of the sawtooth output from the horizontal deflection circuits with that of the transmitted sync pulses and deriving a correction voltage that is applied to the horizontal multivibrator.

A portion of the horizontal deflection voltage is fed through C420, R439, and C426 to cathode #5 and plate #7 of the 6AS5 tube. This voltage, which is a square wave at the plates of the 7AS5 tube, is applied to the cathode of diode "A" after passing through C420, R439, and C426. To the cathode #1 of the tube is applied a negative sync pulse from the phase inverter, and to the plate #2 is applied a positive sync pulse that occurs at exactly the same time as the negative pulse applied to cathode #5.

As illustrated in the simplified schematic and waveform #2, the reverse of the preceding conditions obtains during the negative half of the sawtooth. As shown in combined resultant waveform #9, some portions of the currents cancel out instantaneously in R443, while the remaining currents, which have equal areas above and below the zero axis, will average zero. As a result, zero correction voltage is obtained when the multivibrator is correctly synchronized.

Different conditions obtain when the sawtooth lags the sync pulse. As shown by waveform #4, the negative pulse on the cathode of diode "B" arrives at a time when the plate of diode "B" is driven negative by the sawtooth, and the similar potentials do not allow conduction during this period. Thus the current flow in diode "B" is much less than when the deflection circuits are synchronized. However, the current flow in diode "A" (waveform #5) is not much less than when the circuits are synchronized, and the combined resultant as shown in waveform #6 will be predominately negative. The average of the voltage across R443 will then be negative in polarity. This voltage is applied to the grid of the multivibrator as a correction voltage to increase the multivibrator frequency. R438, C408 and C413 (Fig. 36) form a delay network which averages out the D-C fluctuations and tends to make the system immune to noise pulses.

The reverse of the foregoing conditions results when the sawtooth leads the sync pulse. As shown in waveforms #7, #8, and #9, the average output is positive in polarity. The positive voltage obtained thusly is applied to the multivibrator grid in order to decrease the frequency of the multivibrator and restore synchronism.

FIG. 36 - HORIZONTAL AFC

As shown in Fig. 39, the voltage waveform at plate #1 is essentially a sine wave with a superimposed impulse component. The same waveform would appear across the multivibrator output if C427 were not included in the circuit. However, the charge and discharge of C427, as controlled by the multivibrator, produces a sawtooth waveform. This action is described in more detail under "VERTICAL DEFLECTION CIRCUIT." The impulse component on the applied waveform provides the rapid return-to-zero time that is required.

If the frequency of the multivibrator increases in relation to the sync pulse frequency, the AFC circuit will develop a positive output voltage as described in the preceding section. This positive voltage, when applied to the grid of the multivibrator, will increase the plate current of the triode section during its conduction period. This, in turn, will increase the voltage drop across R420, thus decreasing the voltage at the plate (pin #1) during the conduction period. During this period C428, which had previously been charged to the full plate voltage, will discharge through R433 and 4303 until its charge equals the voltage on plate #1. Since C428 must discharge to a lower-than-normal level, its discharge time is longer than when the circuits were synchronized, and the multivibrator frequency will decrease until the circuits are again synchronized.
If the frequency of the multivibrator decreases in relation to the sync pulse frequency, the opposite of the preceding conditions will be obtained.

In addition to the sawtooth developed by the charge and discharge of C427, the output of the multivibrator contains a sharp spike of negative voltage. This voltage is developed across the waveform correction resistor, R422, during the rapid discharge period. An important function of this voltage is to drive the grids of the horizontal output tubes well below cut-off during the retrace time. A pulse of approximately 2500 volts is applied to the plates of the output tubes during the retrace time, and if the grids were not driven well below cut-off, the output tubes or associated components could be damaged by the heavy current that would flow.

The output from the multivibrator is applied to the grids of the horizontal output tubes through C411 and two parasitic suppressors, R412 and R413. The picture width is controlled in the horizontal output stage by varying the B plus applied to the plates of the tubes. The amplitude of the D-C plate voltage determines the amplitude of the sawtooth output to the deflection coils.

The horizontal output is coupled to the high impedance deflection coils, L410 and L411, through the coupling capacitor, C420. Plate voltage is applied to the output tubes through L401 which serves as a plate load impedance.

The function of the 6AK5GT damper circuit is to dampen oscillations that develop in the output circuit during the retrace time. The circuit is allowed to oscillate at its self-resonant frequency over just enough of the cycle to provide a rapid retrace time; then when the polarity of the oscillation changes during the remainder of the cycle, the damper tube conducts and becomes a short circuit to ground for the oscillation. If the oscillation were allowed to persist, erratic deflection would result.

The high voltage power supply utilizes a 6V6/GT tube operating as a tuned-plate, untuned-grid oscillator at approximately 285 kc. A high R-F voltage is developed across the resonant high-voltage coil. This R-F voltage is coupled to the plate of a 1B51GT half-wave rectifier where it is converted to pulsating D-C. Due to the relatively high frequency, filtering is simplified, and an RC filter network composed of C504, R504, and C505 serves to remove the high frequency ripple component from the output. The filtered output of 8500 volts D-C is applied to the second anode of the cathode ray tube.

Filament voltage for the 1B51GT rectifier is obtained through a separate winding on the high voltage R-F coil.

A feature of this type power supply is that personal contact with the high voltage lead will result in de-tuning of the circuit and maximum voltage will not be produced under this condition. Thus the possibility of receiving a lethal shock is greatly reduced. However, extreme care should always be taken when working near high voltage circuits.

LOW VOLTAGE POWER SUPPLY (Fig. 41)

The low voltage power supply is a full-wave rectifier type. In order to handle the relatively large current requirement of the receiver, two 5Y3/GT tubes are employed and their plates are connected in parallel. The rectifier output, approximately 260 volts, is filtered by a single section pi-type network.

Practically all of the current drawn by the receiver flows through the paralleled focus coil and focus control. The current flow through the focus coil is determined by the focus control which shorts some of the current around the coil.

The voltage is divided into various values by dividers and dropping resistors for application to the appropriate circuits in the receiver. These voltages are illustrated in Fig. 41.

ALIGNMENT

TEST EQUIPMENT - To properly service the V-2150-01 chassis, the following test equipment should be available:

1. R-F sweep generator which meets the following requirements:
   a. Frequency range from 18 to 30 mc. with a sweep width of 10 mc.
   b. Output adjustable with at least 100,000 microvolts maximum and a very low minimum.
   c. Output "flat" on all attenuator positions.

2. Cathode-ray oscilloscope, preferably one with a wide band vertical deflection amplifier and a low-capacitance input probe.

3. Signal generator capable of providing output frequencies listed below.
   23.6 mc.: 1st I-F.
   24.1 mc.: 2nd I-F.
   26.1 mc.: 3rd I-F.
   25.5 mc.: 4th I-F.
   4.5 mc.: Audio I-F and ratio detector (the frequency must be extremely accurate, preferably crystal controlled.)
NOTE: The F-F output level on all of the above frequencies should be adjustable with at least 700,000 volts at a very low minimum.

4. Heterodyne frequency meter with crystal calibrator (if the signal generator does not include a crystal calibrator).

5. Electronic voltmeter (vacuum tube voltmeter), preferably one with a high voltage multiplier probe for measurements up to 10,000 volts.

GENERAL INFORMATION - All test equipment and the chassis should be bonded together by short lengths of heavy (1/8 inch) braided copper ribbon. The interconnecting leads should be shielded (2 ohm coaxial cables) and should be as short as possible consistent with ease of making connections. The effectiveness of the bonding can be checked during alignment by placing the hand on the metal chassis or test equipment case. If the response pattern or meter reading changes visibly, the bonding must be improved before the circuits are aligned.

COMMON I-F ALIGNMENT PROCEDURE

1. Rotate the channel selector switch to channel 3.

2. Connect the signal generator to the mixer tube through the coupling device shown in Fig. 42. The device is constructed together with a miniature tube, shielded so that it fits the tube snugly and does not ground to the chassis. A 0.001-mfd capacitor is then soldered to the side of the shield. By sliding the tube shield up or down on the tube, the capacitance between the shield and the tube elements can be varied to obtain additional control of the coupling over that provided by the attenuator in the generator itself. The ground side of the generator output cable should be connected to the receiver chassis.

3. Connect a vacuum tube voltmeter to the video test jack on the receiver chassis, and set the meter to step 5 volt scale.

4. Set the signal generator to 23.6 mc., (unmodulated), and adjust L306 for maximum voltage on the VTM. During this adjustment, keep the signal generator output adjusted so that the VTM reading does not exceed 2 volts.

5. Set the signal generator to 24.1 mc., (unmodulated), and adjust L307 for maximum voltage on the VTM. During this adjustment, keep the signal generator output adjusted so that the VTM reading does not exceed 2 volts.

6. Set the signal generator to 26.1 mc., (unmodulated), and adjust L308 for maximum voltage on the VTM. During this adjustment, keep the signal generator output adjusted so that the VTM reading does not exceed 2 volts.

7. Set the signal generator to 25.5 mc., (unmodulated), and adjust L309 for maximum voltage on the VTM. During this adjustment, keep the signal generator output adjusted so that the VTM reading does not exceed 2 volts.

8. Connect the sweep generator to the mixer tube through the coupling device previously described. The signal generator input to the set must be low in amplitude to avoid distorting the response curve. To reduce the signal generator input accordingly, the signal generator should be loosely coupled to the set by wrapping a few turns of insulated wire around the coupling capacitor “pigtail” and connecting the signal generator to this wire.

9. Connect the vertical input of the oscilloscope to the video test jack through the de-coupling network shown in Fig. 43. The oscilloscope horizontal input should be connected to the sweep output from the sweep generator; turn the sweep control on the oscilloscope to the “X” or “OFF” position.

10. Adjust the sweep generator for a center frequency of 25.3 mc. with a 6 mc. deviation. Adjust the sweep generator output until a setting is found where the pattern on the oscilloscope will not change in amplitude or shape when the contrast control is rotated through its full range.

The oscilloscope pattern obtained should be similar to that shown in Fig. 44. Use the signal generator as a marker to check at the frequencies indicated. If the pattern obtained is not similar to Fig. 44, L306, L307, L308, and L309 should be re-adjusted to produce the correct pattern. The effect of the adjustments will be as follows:

- L306 affects the low frequency side of the curve
- L307 affects the center portion of the curve
- L309 affects the high frequency side of the curve

11. Set the position of the video i-f carrier (26.1 mc.) on the curve.

AUDIO I-F ALIGNMENT PROCEDURE

1. Connect the “high” side of the signal generator to the video test jack through a 0.001-mfd capacitor, and ground the “low” side to the chassis.

2. Connect the vacuum tube voltmeter to the points indicated on the bottom view of the chassis, Fig. 46. The common lead should connect to point “C” and the “high” lead should connect to point “A.” Set the meter on its 5 volt (-12V) scale.

3. Adjust the signal generator to 4.5 mc. (unmodulated). The accuracy of this frequency is very important. If a crystal controlled signal generator is not available, the frequency should be checked using a frequency meter with a crystal calibrator.

4. Adjust L201 and L202 for maximum voltage on the VTM. During this adjustment, keep the signal generator output adjusted so that the VTM reading does not exceed 5 volts.

5. Connect the common lead from the VTM to point “A’” (Fig. 46), and connect the “high” lead to point “B.” Here it is important that the correct capacitance of the VTM are grounded to the receiver chassis; otherwise, point “A’” would be shorted to the chassis through the common lead.

6. Using the same signal generator amplitude and frequency as in step 4, adjust L203 for zero voltage on the VTM. As the adjustment is increased through resonance, the voltage will gradually change from one polarity to the opposite polarity; the point where the voltage is zero is the correct setting.

H-F OSCILLATOR ALIGNMENT PROCEDURE

If the 6C4 i-f, oscillator tube is replaced, the different inter-electrode capacitance of the new tube may change the oscillator frequency enough to necessitate re-alignment of the oscillator.

The oscillator adjusting screws are located on the front of the tuner assembly, and the following procedure should be followed for their adjustment:

1. Remove the chassis from the cabinet and make the connections necessary to receive an on-the-air signal.

2. Set the fine tuning control to the middle of its range, and leave it in this position during the following adjustments.

3. Set the channel selector switch to the highest of the low band (channels 2 through 6) stations operating in your locality.

4. Peak the appropriate oscillator slug for the best picture detail.

5. Repeat step 4 for each progressively lower channel on which a station transmits in your area.

6. Set the channel selector switch to the highest of the high band (channels 7 through 13) stations operating in your locality.

7. Peak the appropriate oscillator slug for the best picture detail.

8. Repeat step 7 for each progressively lower channel in the high band on which a nearby station transmits.

9. Check the previously-made low band adjustments, and if the tuning has changed, repeat steps 3 through 8.
I-F ALIGNMENT CHART

The foregoing written procedure should be studied before using this chart.
Turn the channel selector to channel 3 to avoid undesirable beat response during alignment.

COMMON I-F SECTION

Couple the sweep and marker generators to the mixer tube as shown in Fig. 42.

<table>
<thead>
<tr>
<th>Step</th>
<th>Sweep Gen. Frequency</th>
<th>Marker Gen. Frequency</th>
<th>Remarks</th>
<th>Indicator Connection</th>
<th>Adjust</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Not used</td>
<td>25.6 mc. unmodulated</td>
<td>Keep marker output adjusted so V'TVM reading does not exceed 2 v.</td>
<td>Connect V'TVM to video test jack</td>
<td>L306 for maximum voltage</td>
</tr>
<tr>
<td>2.</td>
<td>Not used</td>
<td>24.1 mc. unmodulated</td>
<td>Same as step 1</td>
<td>Same as step 1</td>
<td>L307 for maximum voltage</td>
</tr>
<tr>
<td>3.</td>
<td>Not used</td>
<td>26.1 mc. unmodulated</td>
<td>Same as step 1</td>
<td>Same as step 1</td>
<td>L308 for maximum voltage</td>
</tr>
<tr>
<td>4.</td>
<td>Not used</td>
<td>25.5 mc. unmodulated</td>
<td>Same as step 1</td>
<td>Same as step 1</td>
<td>L309 for maximum voltage</td>
</tr>
<tr>
<td>5.</td>
<td>25.3 mc. with 6 mc. deviation</td>
<td>Check at: 23.5 mc., 25.8 mc., 25.3 mc., 26.1 mc.</td>
<td>Keep sweep output low enough that response curve is not affected by manipulation of contrast control.</td>
<td>Connect oscilloscope to video test jack; see Fig. 43.</td>
<td>If necessary, adjust L306, L307, L336 and L309 to obtain correct response curve. See Fig. 44</td>
</tr>
</tbody>
</table>

AUDIO I-F SECTION

Connect the signal generator to the video test jack through a .001 mfd mica capacitor.

<table>
<thead>
<tr>
<th>Step</th>
<th>Signal Gen. Frequency</th>
<th>V'TVM Connection</th>
<th>Remarks</th>
<th>Adjust</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>4.5 mc. unmodulated</td>
<td>See Fig. 46. Common lead to point &quot;C&quot; and high lead to point &quot;A&quot;</td>
<td>Use 5 v. (DC) scale on meter. Set sig. gen. output accordingly.</td>
<td>L201 and L202 for maximum voltage</td>
</tr>
<tr>
<td>2.</td>
<td>4.3 mc. unmodulated</td>
<td>See Fig. 46. Common lead to point &quot;A&quot; and high lead to point &quot;B&quot;</td>
<td>Use same sig. gen. output as in step 1.</td>
<td>L203 for zero voltage</td>
</tr>
</tbody>
</table>

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FIG. 47—SCHEMATIC DIAGRAM

IMPORTANT—Since many of the components are very critical, exact duplicates must be used for replacement purposes.