INSTALLATION AND OPERATING INSTRUCTIONS

RECEIVER LOCATION

The receiver may be placed anywhere in the room, but for greatest satisfaction it should be located:

1. Away from any bright light that may fall directly on the screen or be reflected from it; this includes windows and lamps. Some illumination in the room, off to one side, is desirable, however, to prevent eye-strain.

2. To provide comfortable viewing and ease of operation.

3. At least one-inch away from a wall to allow for cabinet ventilation. This is very important.

ANTENNAS

The choice of a television antenna depends entirely on the location of the receiver with respect to all television stations transmitting antennas in the area. Maximum pick-up is obtained when the receiving antenna is directly in line of sight with the transmitting antennas.

"Bilt-In-Tenna" All receivers using the TS-88 series television chassis are equipped with the Motorola "Bilt-In-Tenna", mounted inside the cabinet, for use in good signal areas.

When this antenna is used, the following precautions should be observed for best reception:

1. Operation to get maximum performance and satisfactory pictures from the "Bilt-In-Tenna", ample signals from the television station must be present at the location of the receiver. Normally, the strength of the signals will vary throughout the room in which the receiver is located. For this reason, better pictures will be obtained if the receiver is tried in all possible locations in the viewing room and is then placed where the best pictures are received from all stations. Avoid large metallic objects such as, radiators, metal panels, etc.

2. Lamps, vases and metallic objects, when placed on top of the receiver, may affect the efficiency of the "Bilt-In-Tenna".

TV ANTENNA - Television chassis TS-88 contains 9 tubes plus a 14" rectangular picture tube. The picture, sound, and scanning circuits, together with a selenium rectifier-voltage doubler "B" supply are contained on a single chassis.

TV TUNING RANGE - Channels 2 through 13

TV IF FREQUENCY -

Channels 2, 3, 4, 5, 6, 7, 12 & 13: sound - 21.9 mc; picture - 26.4 mc

Channels 8, 9 & 10: sound - 27.3 mc; picture - 22.8 mc

ANTENNAS - table model: TA-6 "Bilt-In-Tenna" console; TA-4 "Bilt-In-Tenna", Provision for connection of an external antenna in both cases.

TV ANTENNA IMPEDANCE - 300 ohms

POWER SUPPLY - 117 volts, 60 cycle AC current only

HIGH VOLTAGE WARNING

Operation of this receiver, outside its cabinet or with covers removed, involves a shock hazard from the power supplies. No work should be attempted on this receiver by anyone not thoroughly familiar with the precautions necessary when working on high voltage equipment.

CATHODE RAY PICTURE TUBE HANDLING PRECAUTIONS

Extreme care must be used in handling the picture tube. The tube is highly evacuated and, due to its large size, is subjected to a considerable atmospheric pressure. The handler should wear safety goggles and gloves for protection. Avoid nicking or scratching the glass by rough contact with other objects.

Before removing glass tubes, discharge the capacitor formed by the inner and outer aquadag coatings on the tube by aborting the anode contact on the side of the tube to the outer surface with a well insulated piece of wire.

RECEIVER ANTENNA CONNECTION

The antenna lead-in to the television receiver is connected to the two screws of the terminal strip, in line of sight with the radio. Disconnect the "Bilt-In-Tenna" leads from the terminal strip before attaching an external antenna lead-in. Sometimes, reversing the lead-in connections at the receiver may improve picture quality and overall performance.

OPERATING CONTROLS

There are two dual controls, consisting of a small and a large knob each, on the front panel of the receiver. The function of each control is marked on the front panel, the "circle" indicating the large knob, and the "dot" indicating the small knob. See Figure 1 for front panel control functions.
SERVICE ADJUSTMENTS

The receiver is completely adjusted at the factory, so normally none other than the front panel control operating instructions need be followed in putting the receiver to operation. However, to provide for any misalignment of the service controls, due to handling, the following instructions are in order. See Figure 2 for location of the service adjustment controls.

FOCUS CONTROL

The FOCUS control should be adjusted until the fine horizontal line structure of the raster is clearly visible over the picture area. The control should be tuned through the correct point several times so that optimum focus is obtained.

CENTERING

By means of a lever extending from the focus coil, thru the rear screen, the focus coil can be shifted to center the picture in its mask.

VERTICAL SIZE AND VERTICAL LINEARITY

Adjust the VERTICAL SIZE control until the picture fills the mask vertically. Adjust the VERTICAL LINEARITY control for best overall vertical linearity. Adjustment of the VERTICAL SIZE control will require a realignment of the VERTICAL LINEARITY control and possibly of the VERTI- cal HOLD control. Center picture with the centering lever on the focus coil.

HORIZONTAL SIZE

Adjust the HORIZONTAL SIZE lever until the picture fills the mask horizontally. Center picture with the centering lever.

HORIZONTAL HOLD ADJUSTMENT

The HORIZONTAL HOLD control should have a sync range of approximately 180°. If the control is too critical, adjust as follows:

1. Short out HORIZONTAL OSCILLATOR coil L-23. This may be done with the chassis in the cabinet by shorting pins 3 and 8 of the test socket on chassis rear.
2. With the centering lever, move the picture to the left so that the right edge of the raster can be seen. Adjust the HORIZONTAL HOLD control to about the middle of its range and note the width of the blanking pulse. (The blanking pulse appears as a gray bar at the right edge of the picture area.)
3. Remove shorts from HORIZONTAL OSCILLATOR coil.
4. Adjust HORIZONTAL OSCILLATOR coil until the same amount of blanking pulse can be seen as was noted in step 2.

VERTICAL HOLD ADJUSTMENT

Adjust the VERTICAL HOLD control for the center of the vertical sync lock-in range.

BRIGHTNESS

Adjust the BRIGHTNESS control, in combination with the CONTRAST control for the most pleasing picture. Keep the brilliance slightly below maximum, however, in order to protect the fluorescent screen of the picture tube and to prevent poor picture detail.

ADJUSTMENT OF ION TRAP

Under conditions of rough shipment, it is possible for the ion trap to become misaligned. To prevent serious damage to the picture tube, the following method of adjustment should be used. See Figure 3.

The magnet should be placed on the neck of the tube in the direction indicated by the marking on the magnet (usually an arrow which points toward the picture tube screen) so that the stronger magnet of the double magnet type or the only magnet in the single magnet type is positioned over the internal poles which are mounted on the gun structure. Adjust the BRIGHTNESS control for low intensity and move the magnet a short distance forward and backward at the same time rotating the thumbscrew with the tip of the index finger. In obtaining the brightest raster, the ion trap magnet has tube moved more than 1/4" from the gun pole pieces; the magnet is probably weak and a new magnet should be tried. Never correct for a shadowed raster with the ion trap magnet if such correction results in decreased brightness. The ion trap magnet must always be adjusted for maximum brightness and, if shadows occur at this setting, they should be eliminated by adjusting the focus and deflection coils as explained under "Focus Coil and Deflection Yoke Adjustment".

CAUTION: Keep brightness control at low intensity until ion trap is properly set.

A mirror placed in front of the receiver will aid in making this adjustment.

DEFLECTION YOKE ADJUSTMENT

If the deflection yoke shifts, the picture will be tilted. To correct, loosen the thumbscrew on top of the deflection yoke and rotate yoke until the picture is straight. Before tightening the thumbscrew, make certain that the deflection yoke is as far forward as possible.

If the yoke support and the picture tube have shifted in transit or, for any reason, these parts have been removed and replaced, it is best to do a complete job of repositioning. See Figure 3. The starting point is the position of the picture tube. It should be adjusted so that the distance from the center of the tube to the front edge of the chassis is 1". The clamp on the front of the tube should then be tightened. The picture tube rear support bracket positioning adjustment screws should be loose enough to permit sliding the bracket forward until the rubber cushion fits snugly up against the flare of the tube. Loosen the yoke adjustment thumbscrew and push the yoke up against the flare of the tube. CAUTION: Do not use force in sliding the bracket up. If too much force is used, a strain will be placed on the neck of the tube when the support bracket positioning adjustment screws are tightened. Also the yoke may be forced out of position. The opening in the yoke should be concentric with the neck of the tube.

FOCUS COIL

The focus coil should be positioned so that it is spaced 1/4" from the deflection yoke when parallel with the yoke. The opening in the focus coil should be concentric with the neck of the tube. The spacing should be adjusted before the front of the picture tube is clamped down because it is necessary to remove the tube to change the position of the focus coil. Its position is changed by choice of location of the coil mounting studs in the scrollop holes on the top and bottom of the coil mounting bracket. The opening in the focus coil can be made concentric with the neck of the tube by loosening the nuts on the studs which support the focus coil bracket and turning the studs with a screwdriver in the slots provided. The studs are eccentric and move the coil both vertically and horizontally. They should be used only to center the neck of the tube in the opening of the coil.

TEST SOCKET

A test socket is provided on the rear of the chassis which allows adjustment of the horizontal oscillator and checking of sensitivity without removing chassis from cabinet. See Figure 2 for socket connections.
ALIGNMENT

6. Peak T-3 primary (top core) for maximum reading on meter.

7. Move the meter and decoupling resistor from C-60 to junction of R-44 (533k) and lead to volume control.

8. Adjust T-3 secondary (bottom core) for zero response on 2.5V scale of meter. This corresponds to the cross-over point on the FM detector curve. If desired, the symmetry of the curve may be checked by tuning the signal generator 25 kc above and below 4.5 mc and noting the plus and minus voltage produced, reversing the meter connections as necessary. For proper balance of the ratio detector system, the voltage in each direction should be approximately equal. If not, check the tuning of L-26 and the primary & secondary of the ratio detector. If necessary, replace the ratio detector tube V-9 (6AL5). It is desirable to calibrate the generator on a station signal. This may be done by nulling the secondary on a station signal and then connecting the generator and tuning it to produce the same null without touching the trimmers in the set.

NOTE: As the adjustments are brought to resonance, it is advisable to reduce signal generator output to prevent overloading.

With a 10,000 microvolt signal into the grid of the video amplifier tube, with the contrast control turned fully clockwise, and the focus control at center of range, the voltages read from one side of capacitor C-60 should be greater than 5.0 V.

4.5 MC TRAP ALIGNMENT

1. Connect the high side of the signal generator through a 1000 mfd capacitor to the grid (pin 1) of the video amplifier tube V-7 (6AH6), and the low side to B-.

2. Connect the voltmeter and germanium crystal rectifier, as shown in Figure 5, between the cathode of the picture tube (yellow lead) and B-.

3. With the signal generator accurately set at 4.5 mc and maximum output, adjust trap L-18 for minimum reading on the meter.

4. AM SIGNAL GENERATOR: Accurately calibrated at 4.5 mc (Optional) Adjustable output

5. DC Meter: Low range electronic voltmeter

6. Procedure:

   Refer to Figure 4 for location of adjustments.

   1. If possible, it is desirable to align the audio section from an actual station signal, since the 4.5 mc alignment frequency will be exact. The fine tuning trimmer should be turned off the station slightly, to prevent overloading the ratio detector.

   2. If a signal generator is used, tune it accurately to 4.5 mc, and adjust the output to approximately 10,000 microvolts. Connect the high side of the signal generator through a 1000 mfd capacitor to the grid (pin 1) of the video amplifier tube V-7 (6AH6), and the low side to B-.

   3. The following applies whether the station signal or signal generator is used.

   a. From either side of capacitor C-60 (10 mf), connect an electronic voltmeter to B- decoupled thru 9K ohms.

   b. Place the contrast control for maximum gain (fully clockwise).

   c. Peak L-26 for maximum reading on meter.

   d. Peak T-3 for maximum reading on meter.

   e. 10. Adjust the 3rd IF plate transformer, T-2, to provide a flatter top or symmetrical response curve.

   f. 11. Reset the traps (steps 6 & 7) and again check the IF for proper response.

   NOTE: It is suggested that the bias be removed for accurate resetting of the traps.

   g. With bias applied, connect the sweep between the grid (pin 2) of the mixer tube V-2A (12AT7) and B-.

   h. Disconnect the trimmer, C-14, in LC circuit in the grid of the mixer tube, and connect the trimmer through a 10,000 mfd ceramic disc type to B-.

   i. Bring both cores of the mixer transformer, T-1, simultaneously from the outside towards the center. The half-way markers should be 24,6 mc and 22,9 mc (Figure 7).

   NOTE: In aligning the three IF coils, each coil is adjusted individually, but when adjusting the primary and secondary of the mixer transformer, the adjustments should be made simultaneously. The important point to keep in mind is to obtain a flat response curve with as much gain as possible. The sides of the curve should be straight and as steep as possible. Simultaneous adjustment of the primary and secondary is the easiest way to obtain this result. The transformer by itself is in effect tuned for the same pass band as the three staggered circuits. See Figure 7. The main difference in the overall wave form should be that the sides of the overall wave are steeper. Constant use of the 60% markers (22,9 mc and 26,4 mc) should be reset to, since it is absolutely necessary to obtain the proper curve. A slight dip (not exceeding 10%) is permissible in the mixer transformer response curve.

BANDWIDTH

The bandwidth may be determined by connecting an AM generator to the mixer grid. With the generator frequency at 24,6 mc, adjust the output for 1 volt reading on a VTVM connected at the plate (pin 2) of the video detector tube V-6 (6AL5) and B-.

Now, by tuning either side of 24,6 mc and noting the frequencies at which the VTVM again reads 1 volt, the 6 db bandwidth points are indicated.

REGENERATION CHECK

After the above IF and mixer transformer alignment has been made, a check for regeneration in the IF amplifier strip should be made. This is done by removing the bias battery and observing the output response curve on the oscilloscope as taken between the picture tube cathode and B-. The bandwidth may be increased by the removal of about 0.2 mc, and the regeneration will be marked down to more than 0.2 mc. Set the contrast control to maximum gain. Decrease the input until the output signal shows a marked decrease. Any regeneration present will be indicated by sharp peaks on the overall response curve. The oscillator should be stopped, as described above, during this procedure.

CAUTION: Do not inject too much marker signal.

MIXER LC ADJUSTMENT

Reconnect bias removed for regeneration check. Reconnect bias removed for regeneration check. Reconnect bias removed for regeneration check. Reconnect bias removed for regeneration check.
FIGURE 4. TUBE & ALIGNMENT ADJUSTMENT LOCATIONS

Place trimmer C-14 in LC circuit of mixer grid or remove 10,000 mfd ceramic between trimmer and B-. Adjust the trimmer so it is tuned to the center of the mixer response curve. This is indicated by observing the effect of the LC circuit on the mixer response. Increasing the capacity of the trimmer and bringing the LC circuit from above the IF range into the IF range, it will be noted that the mixer curve will pull down on the high side, then straightens out at the LC circuit approaches the middle of the range, and pull down on the low side as the LC circuit approaches the low end of the IF range. The proper tuning point is that point at which the mixer curve straightsens out. In effect, the LC circuit is similar to a jack coil when it is within the IF range.

CAUTION: Tuning the LC circuit very low will cause oscillation.

FIGURE 5. ELECTRONIC VOLTOMETER CONNECTIONS

FIGURE 6. IF RESPONSE CURVE

FIGURE 7. OVERALL RESPONSE CURVE FROM MIXER

FIGURE 8. BOTTOM VIEW OF CHASSIS
IF SENSITIVITY MEASUREMENTS

1. Remove the battery bias from last IF tube grid.
2. Connect an AM signal generator, set at 24.6 mc, through a blocking capacitor of 5000 mfd between B- and the grid (pin 1) of the last IF tube V-3 (6A6U).
3. Connect an electronic voltmeter across the video detector load resistor R-28 (5600). Both leads from the meter should be decoupled with 100K ohm resistors.
4. Set the contrast control for maximum sensitivity.
5. Stop the oscillator tube by disconnecting resistor R-10 (1000) from plate (pin 6) of V-28 (12AT7).
6. The signal required to produce 1 volt (negative) above contact potential on the meter should be less than 125 microvolts.

Mixer & IF Stages

The preliminary preparations are the same as for checking the sensitivity of the IF stages except:
1. Connect the AM signal generator, set at 24.6 mc, through a 5000 mfd capacitor between B- and the grid (pin 2) of the mixer tube V-28 (12AT7).
2. The signal required to produce 1 volt (negative) above contact potential on the meter should be less than 125 microvolts.

OSCILLATOR, ANTENNA AND RF ALIGNMENT

NOTE: The IF must be aligned before the RF section can be properly phased.

Equipment Required:

1. Sweep Generator: Frequency range 40-220 mc; 10 mc sweep width
2. Output constant and adjustable
3. Adjustable markers/markers should be calibrated occasionally by checking against an accurate signal generator.

Oscilloscope: Preferably one with a calibrated input attenuator.

Signal Generator: Frequency range 40 to 220 mc

If the sensitivity measurements are as follows:

FREQUENCY CHART

<table>
<thead>
<tr>
<th>Channel</th>
<th>Frequency</th>
<th>Picture</th>
<th>Sound</th>
<th>Oscillator</th>
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</thead>
<tbody>
<tr>
<td>2</td>
<td>54-60</td>
<td>55,25</td>
<td>60,75</td>
<td>61,65</td>
</tr>
<tr>
<td>3</td>
<td>60-66</td>
<td>61,25</td>
<td>65,75</td>
<td>67,75</td>
</tr>
<tr>
<td>4</td>
<td>66-72</td>
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<td>71,75</td>
<td>73,65</td>
</tr>
<tr>
<td>5</td>
<td>70-76</td>
<td>71,25</td>
<td>75,75</td>
<td>77,65</td>
</tr>
<tr>
<td>6</td>
<td>76-82</td>
<td>77,25</td>
<td>81,75</td>
<td>83,65</td>
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<tr>
<td>7</td>
<td>82-88</td>
<td>83,25</td>
<td>87,75</td>
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<tr>
<td>8</td>
<td>88-94</td>
<td>87,25</td>
<td>91,75</td>
<td>93,45</td>
</tr>
<tr>
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<td>100-106</td>
<td>101,25</td>
<td>105,75</td>
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<tr>
<td>12</td>
<td>106-112</td>
<td>107,25</td>
<td>111,75</td>
<td>113,45</td>
</tr>
<tr>
<td>13</td>
<td>112-118</td>
<td>113,25</td>
<td>117,75</td>
<td>119,45</td>
</tr>
</tbody>
</table>

ANTENNA & RF ALIGNMENT PROCEDURE

1. Remove high voltage generator tube V-17 (6VQ6GT) from its socket and stop the oscillator by disconnecting R-10 (1000) from plate (pin 6) of V-28 (12AT7).
2. Connect the sweep generator across the antenna terminals on the chassis with the antenna lead-in removed.
3. The line from the sweep generator should be as short as possible.
4. Connect the oscilloscope through a decoupling resistor of 150,000 ohms between the cathode (pin 5) of the mixer tube V-28 (12AT7) and B-.
5. Short out the AGC circuit with a clip lead from the AGC bus to B-.

NOTE: Before aligning the oscillator section, make certain that the 3.3 microhenry choke in the mixer grid is dressed away from the 2 mmf capacitor tied to same grid.

17. Turn sweep generator and station selector switch to channel 6.
18. Adjust channel 6 oscillator coil (L-4E, Figure 9) so that the sound marker falls into the 21.9 mc trap dip in the response curve.
19. Turn generator and station selector to channel 9 with the fine tuning shaft slot still in the horizontal position.
20. Spread or compress the 3-turn coil located in the center of the oscillator plate (L-4M, Figure 9) so that the sound marker for channel 9 falls into the 27.3 mc trap dip in the response curve. As the oscillator is turned below the center on channels 7, 8, and 10 the 27.3 mc trap will be in the same position as the 21.9 mc trap in step 9.
21. Repeat steps 6, 7, 8, and 9.
22. Turn generator and station selector to channel 13.
23. Turn fine tuning trimmer so that the sound marker for channel 13 falls into the 21.9 mc trap dip of response curve. The slot in the fine tuning shaft should not move more than 30 degrees from the horizontal position to accomplish this (each number on the station selector knob represents 30 degrees).
24. If more than a 30 degree change in fine tuning trimmer was needed in step 14, adjust channel 13 oscillator coil (L-7) by spreading or compressing until the 30 degree requirement is met.

NOTE: Each adjustment of channel 13 oscillator coil (L-7) will necessitate a rechecking of the oscillator trimmer on channel 12 as per steps 6, 7, 8, and 9.

16. Check channels 12, 11, 10, 9, 8, and 7 by noting whether the fine tuning trimmer can drop the sound marker for each channel in the trap dip by a 30 degree rotation. If the fine tuning shaft does not meet the 30 degree requirement, a compromise must be made by resetting channel 9 or 12, whichever is closer to the channel in question.

Example: 1) If channel 11 does not meet the 30 degree requirement, return station selector and generator to channel 12 and tone ceramic trimmer toward channel 11 (trimmer frequencies lowered by tightening screw). This will tend to move channel 12 sound marker out of the trap dip, but this may be compensated for by the fine tuning trimmer. Do not adjust trimmer any more than is necessary to get the channel in question back within the 30 degree requirement.

2) If channel 10 does not meet the 30 degree requirement, move station selector to generator to channel 9 and tune the 3-turn coil (L-4M, Figure 9) toward channel 10 (coil freemay be raised by spreading turns). Keep the output low enough to show no evidence of limiting in the overall response curve.

NOTE: To calibrate the scope, connect it across the 6.3 volt filament, if the peak-to-peak amplitude on the screen will then be approximately 18V (6.3 x 2).

4. Tone signal generator to video carrier frequency of the channel being checked. Generator signal should be 30% modulated at 400 cycles. The signal from the generator to produce 20 volts peak-to-peak at picture tube cathode should be less than 25 microvolts on channels 2 to 6 and less than 75 microvolts on channels 7 to 11.

CIRCUIT DESCRIPTION

LOW VOLTAGE POWER SUPPLY

The low voltage power supply (Figure 12) provides plate voltage for all tubes except the high voltage applied to the second anode of the picture tube. The heater transformers supply heater voltage to all tubes except the RF rectifier, which is energized by horizontal sweep current.

One low voltage secondary of T-7, the step-down filament transformer, supplies filament voltage to all tubes except the audio driver-limiter (V-8), the vertical output tube (V-14), and the horizontal damping diode (V-18). Since the damping diode (V-18) develops a high voltage pulse at its cathode, and its cathode is tied to the filament to prevent breakdown in the tube, it is necessary to provide a separate low-capacity, well-insulated transformer (T-8) to heat this filament. The vertical output tube V-14 (2SL6GT) requires a 25 volt filament supply and, hence, is provided with a separate 25 volt tap on the transformer. In earlier production chassis, the audio driver-limiter (V-8) had its cathode connected to a B plus point of about 120 volts. In order to keep the heater to cathode difference of potential low, it was necessary to provide a separate filament winding for this tube. This tube's cathode is now returned to B- but, since the separate winding is still supplied on present production transformers, it is still used for V-8 and in late sets also for V-20.

The B plus plate supply uses a voltage doubler, R-103 is a limiting resistor to protect the rectifiers from initial current surges and also serves as a fuse in case of B plus shorts. When the polarity of the applied 117 volt AC is such as to make the side of the line connected to R-103 negative, E-2 will conduct and charge C-109 (300 mf) to peak line voltage. On the next alternation, E-1 will conduct and the voltage applied to it is now the peak line voltage plus the peak charge stored in C-109. This results in a charge of about 270 volts on C-115 (100 mf). The speaker grid is used as a filter choke. The focus coil and the resistor network, which controls the current thru it, act also as a voltage divider to supply plate and screen voltages to several tubes, as shown in Figure 12.

Another voltage divider from B plus to B-, consisting of R-76 (1 meg) and the potentiometer, R-77 (1 meg) provides a variable bias on the cathode of the picture tube, to serve as a brightness control.

THE RF TUNER

Antenna Input

Figure 13 is a simplified schematic of the tuner.

The antenna input coil, L-1, couples the balanced line to the single ended input circuit for the RF tube, V-1. Optimum antenna coupling for all channels is obtained by the coupling coils L-33A, L-33B, L-33C, and the coupling leads on channel positions B, 10, and 12 of switch wafer S-1A. These can be considered the primary of the antenna transformer. The secondary, or tuned grid circuit, includes also the continuous, tapped coil mounted on wafer S-1B for the low channels (2-6) and the stapled metal plate in series with the coil for the high channels (7-13). The purpose of the antenna coil, coupling leads, and secondary circuit, is to match the 300 ohm impedance of the transmission line from the antenna to the input impedance of the RF amplifier grid circuit and to tune this circuit for the channel selected. Referring to Figure 13, it will be seen that the switch, in progressing from channel 1 to channel 13, shorts out the unused portion of the secondary winding or stamped metal plate. The bandwidth of channels 1 thru 13 is about 8 mc. The stamped metal plate is carefully designed so that with this bandwidth alignment adjustment is needed on the high channels. The individual coil sections on the low channels, however, may be tuned by adding or compressing them, as outlined in the alignment procedure.

RF Amplifier

The grid of the RF amplifier V-1 (6CG6) is returned to the AGC bus thru L-5 and a by-pass capacitor (C-5). The plate load of this tube consists of another tapped coil for the high channels mounted, in this case, on switch wafer S-1C. Here again, the switch progressively shorts out the unused sections of the inductance in tuning from channel 1 to 13. In this case, however, a trimmer C-6 and a choke L-6 are provided to center the high channel response while the low channel coils may be tuned by expansion or compression.

The Mixer

The mixer uses 1/2 of V-2 (12AT7). C-13 (8 mm) couples the RF amplifier output to the mixer grid. Oscillator injection is accomplished by C-15 (2 mm). L-8 and C-14 form a series resonant circuit tuned to the center of the IF response, to prevent interaction between the IF and the mixer input.

The Oscillator

The oscillator uses the other half of V-2 (12AT7) in a Colpitts circuit. Here again, the tuning inductance consists of the tapped coil for the low channels and the stamped metal plate for the high channels mounted on wafer S-1E. L-7 and C-42 are provided to set the center frequency in the high channels while the low channels are aligned by shading or
compressing the individual coil sections. C-11 is provided as a fine tuning control for customer use. The oscillator operates above the RF on the low channels and below the RF on the high channels except that in later production the circuit was modified to avoid interference by operating the oscillator on the high side for channels 11, 12 and 13.

**IF AMPLIFIER**

The IF amplifier uses two 6AG6 tubes and one 6A5G tube. Figure 16 is the schematic of the IF amplifier. T-1 couples the mixer plate to the first IF grid. Coupling between primary and secondary, which are individually slug-tuned, is fixed and is designed for proper bandwidth. The plate choke L-10, of the 1st IF tube V-3 (6A16), is coupled to the grid coil, L-11, of the 2nd IF tube V-4 (6A5G) thru C-27 (320 mfd). At IF frequencies, the impedance of C-27 is negligible and for all practical purposes, L-10 and L-11 can be considered as being in parallel, L-11 being slug-tuned. A similar method is used between the 2nd and 3rd IF tubes, the 3rd IF plate is coupled to the detector by T-2, a unity coupled transformer. The IF circuits are stagger-tuned for proper bandwidth as explained in the Alignment Instructions. L-12 and L-14 are separately tuned trap windings on IF coil forms L-11 and L-15, respectively. Together with C-28 and C-35, they form absorption type trap circuits which steepen the high and low skirts of the IF response for better picture quality and stabilize the audio response with intercarrier sound.

Decoupling has been used not only in the plate supply and AGC circuits, but also in the filament circuits to prevent regeneration.

**THE VIDEO DETECTOR**

One-half of V-6 (6A5L) is used as the video detector. Figure 15 is a schematic of the video detector. Since for noise limiting purposes it is desirable to apply a signal with negative going sync pulses to the grid of the video amplifier, the detector load R-26 (5600) is placed in the plate circuit of the diode, L-29, L-27 and C-42, form a low pass filter to keep IF frequencies off the grid of the video amplifier.

Since this circuit operates on the intercarrier sound system, the detector heterodynes the video and sound IF frequencies, and produces the 4.5 mc beat frequency which becomes the new audio IF frequency. The negative DC voltage developed at this point R-26 (5600) will be a function of carrier level. This voltage is fed to the AGC bus thru R-25 (15 meg) and controls the gain of the RF and 1st and 2nd IF amplifiers.

**THE VIDEO AMPLIFIER**

The video amplifier V-7 (6AT6) not only amplifies the video signal but also the 4.5 megacycle audio IF beat. Figure 16 is a schematic of the video amplifier. In its plate circuit, this beat is separated from the video signal and fed to the grid circuit of the audio driver-limiting tube V-8 (6A5D) by C-49 (2.2 mfd) and L-20, the sound take-off coil. The 4.5 mc trap, L-18 and C-30, is a parallel resonant circuit which, when properly tuned, offers a high impedance to this frequency, to prevent its reaching the picture tube.

By applying a negative signal to the grid of the video ampli-
The vertical scanning system is shown in Figure 19, combined with an oscillograph. It will be noted that the scanning occurs in synchronism with the external horizontal scanning. The transverse stabilization used in this system is almost identical with that described in the foregoing paragraphs, where the linear sweep is introduced. In this case, the horizontal sweep is introduced as the plate to the sweep tube, and the horizontal deflection is applied to the grid of the horizontal deflection tube. The sweep tube also has a similar signal applied to its grid, and the resultant electron beam energizes the shadow mask. This mask is then deflected by the deflection yoke into the right-hand picture frame, where it forms the image upon the cathode-ray tube. The vertical deflection coils are placed around the picture frame to cause the image to be deflected in the vertical direction. The vertical deflection coils are wound in the picture frame in such a way as to form a spiral, which causes the image to be deflected downward as the electron beam is deflected upward. The vertical deflection is then applied to the grid of the vertical deflection tube, which deflects the electron beam in the vertical direction. The vertical deflection is then applied to the grid of the vertical deflection tube, which deflects the electron beam in the vertical direction. The vertical deflection is then applied to the grid of the vertical deflection tube, which deflects the electron beam in the vertical direction.
It can be seen that if this grid is returned to a point which varies in potential with frequency of the multivibrator, it would be possible to make this variation a means of frequency control. Assume that the grid of "A" in Figure 20 is made more positive. This causes the bias of "B" to increase because of the increased drop across the common cathode resistor R-89. Capacitor C-87 will now discharge for a longer time before "B" conducts, thereby decreasing the frequency of oscillation. If the grid were made more negative, the bias across the common cathode resistor would be less and C-87 would discharge for less time before "B" started to conduct, thereby increasing the frequency.

Figure 18 is a simplified schematic of the clipper and phase detector circuits. The phase detector V-15 (6AL5) is so connected that a comparison of the phase of the incoming sync pulses and a sawtooth wave applied to the horizontal output system is made. A positive sync pulse from the plate of the second clipper V-12 (6SN7) is fed through C-87 [001] to the plate of diode "A" of V-15. A negative sync pulse from the cathode of V-12 is applied through C-68 [000] to the cathode of diode "B" of V-15. A sawtooth, derived from the integration of a pulse in the horizontal output circuit, is applied to the grid of diode "A" at the same instant that the negative pulse is applied to the cathode of diode "B", the negative sawtooth is applied to the plate of diode "B", which is tied together and returned to B thru R-83 (6JX6). The load for diodes "A" and "B" consists of resistors R-84 (10k) and R-81 (1k) whose junction returns to the high side of the grid resistor R-82 of the first horizontal multivibrator tube V-16 (6SN7). The voltage applied to the two diodes will be a function of the amplitude of the sawtooth, the amplitude of the sync pulses and the phase relationship between the pulses and the sawtooth.

The sawtooth, whose phase and frequency are a function of the multivibrator’s phase and frequency, is operating in the middle of the lock-in range, the sync pulse will occur in the center of the region, see Figure 22. Since the horizontal sync pulses have an amplitude of from 6 to 8 volts while the sawtooth amplitude is about two volts. The RC time constant in the pulse input circuit to the diodes is long enough to maintain an average pulse voltage of 6 to 8 volts for two or three horizontal lines. This means that in the "on" frequency condition shown in Figure 22, the diodes conduct only on the pulses and since these are equal in amplitude and develop voltages of opposite polarity across R-82 in the first multivibrator grid circuit, as shown in Figure 22, no control voltage is applied to the grid of V-16.

If the oscillator tends to decrease in frequency, with respect to the sync pulses, the phase relationship shown in Figure 22(b) exists at the diodes. The phase of the sawtooth has now shifted so that at the same instant that the pulse is applied to the plate of diode "A", the negative sawtooth is applied to its cathode, so that only the shaded portion of the pulse causes conduction of diode "A". Diode "B", however, still conducts on the total amplitude of the negative pulse applied to its cathode aided by the positive sawtooth applied to its plate at the same time. Since current flow thru diode "A" makes the grid end of R-82 negative, with respect to B, the decreased current flow, caused by the sawtooth voltage (diode "A", results in a more positive voltage across R-82, applying a more positive voltage to the grid of V-16 which, as we have seen, results in decreasing the oscillator’s frequency.

If the oscillator tends to increase in frequency, with respect to the sync pulses, the phase relationship shown in Figure 22(a) exists at the diodes. The phase of the sawtooth has now shifted so that at the same instant that the pulse is applied to the plate of diode "A", the negative sawtooth is applied to its cathode, so that only the shaded portion of the pulse causes conduction. Diode "A", however, conducts on the total amplitude of the positive pulse applied to its plate, aided by the negative sawtooth applied to its cathode at the same time. Since current flow thru diode "A" makes the grid end of R-82 positive, with respect to B, the decreased current flow thru diode "A" results in a less (more negative) voltage to the grid of V-16 which, as we have seen, results in increasing the oscillator frequency.

The Horizontal Output System

The combination sawtooth and pulse waveform developed across C-88 (680) and R-93 (150k) by the multivibrator circuit is fed to the grid of the horizontal output tube V-17 (6SN7). Figure 20 is a simplified schematic of the horizontal output system. It will be noted that in this system an autotransformer is used. In the horizontal scan, it is necessary that the sawtooth included in about 7 microseconds. In order to accomplish reversal of current in the iductance of the output transformer and the yoke in this short time, it is necessary to make this circuit resonant at such a frequency that the half cycle time will equal 7 microseconds.

Because only by shock exciting each circuit into oscillation will the circuit be recharged in the time allowed. This circuit is made resonant by the inductance of the output transformer and yoke, the distributed capacity and the tube capacity. Bearing this in mind, the operation can be explained as follows. Referring to Figure 22(a), assume that the voltage on the grid of the output tube is increasing, point "a", the grid is now being made less negative and the output tube starts to draw current which is supplied from B plus thru the damping diode. When point "b" is reached on the grid waveform, the output tube is suddenly cut off because its grid has been made highly negative (point "c" on the grid waveform). With the tube cut off, the resonant plate load is undamped and the circuit is shocked into oscillation. The reversal of current through the output inductance produces a positive pulse voltage which makes the cathode of the damping diode "V-17" (6SN7) more positive, with respect to its plate; therefore, it cannot conduct. C-92 (100) is placed across the diode to provide a low impedance for the oscillatory current. If the damping diode V-18 were not present, this oscillation would continue and would flow in the output transformer as shown in Figure 22(b). In order to insure a linear trace, however, this oscillation must be stopped and the damping diode serves this purpose. When the current nears its maximum negative value, the polarity and amplitude of the voltage pulse on the damping diode is such that its plate becomes positive, with respect to its cathode, so that the tube conducts heavily and loads the circuit sufficiently to prevent continuation of the oscillation. The current then follows the decay curve shown in Figure 22(c). At the time "d" in Figure 22(c), the voltage at the grid of the output tube has become less than cut off (point "a") in Figure 22(a), the tube again demands current. The rising current in the tube results in superimposing the waveform "e" in Figure 22(c) on the current flow already in the output transformer due to the decaying current which resulted from the damping diode. Combination of these two results currents in the linear trace current indicated at "f" in Figure 22(a), which is a composite waveform of the entire action. During the peak condensation of the damping diode, C-93 (1.0 charge), and its polarity is such that when the output tube calls for current the charge on the condenser will be in series with the B plus supply so that the voltage at the output tube plate is raised from the 250 volt B plus supply to about 475 volts by this so-called "bootstrap" voltage. When the grid voltage waveform of the output tube again reaches point "b" of Figure 22(b), the tube is cut off and another cycle starts.

In order to properly match the yoke inductance to the required output inductance of the tube, the yoke is connected to a tap on the transformer winding which is connected to an autotransformer of this section. The positive pulse of voltage at this tap is coupled to the yoke thru C-94 (0.05) and results in a sawtooth of current thru the yoke. It will be remembered that a portion of this pulse is also fed to the phase detector for the AFC action thru R-86 and R-87.

The small additional winding, terminal which is connected to chassis ground while the other terminal is connected to B thru C-94 (0.05) is used to cancel the pulse of voltage which is placed on the chassis by induction from the output transformer. By connecting this winding in such a way as to place a pulse of suitable amplitude on the chassis 180° out of phase with the induced voltage, cancellation of the induced voltage will take place.

High Voltage

To take advantage of the large voltage pulse developed across the output inductance by the heavy current flow caused by the retrace oscillation, the plate winding is made the primary of an auto-transformer whose step-up ratio is such as to develop pulses of about 14 kv at its high end. These pulses are rectified by V-19 (13B) and the resulting DC is applied to the second anode of the picture tube. The filament voltage for the 13B rectifier is obtained from an additional winding on the output transformer.

Controls

L-23 is the coil of the sine wave generating circuit in the horizontal multivibrator circuit and should be tuned to 19,700 cycles as explained in the service instructions.

R-91 is the horizontal hold control which can be adjusted for correct frequency operation of the multivibrator.

L-24, paralleling a small portion of the output choke controls, to a small degree, the inductance of the choke and acts as a size control.
## REPLACEMENT PARTS LIST

**NOTE:** When ordering parts, specify model number in addition to part number and description of part.

### CHASSIS 38-20 ELECTRICAL PARTS

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<tr>
<th>Ref.</th>
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