Television

Servicing Course

New Edition

PRACTICAL TELEVISION TRAINING FOR HOME-STUDY

THEORY

PRACTICE   EXPERIENCE

Prepared under the direction of

M. N. BEITMAN

SUPREME PUBLICATIONS

PRICE **$3**

Television

Servicing Course

Compiled by

M. N. BEITMAN

Introduction

This course is designed to help you get into television servicing in the minimum of time. This course-book contains all the material you need to master TV repair work. You should have a working knowledge of radio servicing, but you need not be an expert in radio. Since many circuits and components are common to both radio and TV applications, you will now learn a great many facts that puzzled you when you studied radio servicing.

This is not just another book, but a practical course designed for home-study and tested on other students to guarantee you success. It is an effective course; written by practical technician-engineers, using examples of actual jobs, prepared with the cooperation of leading electronic manufacturers in America.

It is a revolutionary type of training since it teaches you first how to make the easiest type of TV repairs. Since the easiest TV repairs are also most often found on service calls, you are ready to make money after the very first lesson. And with every lesson, you learn more to know how to handle every kind of trouble found in all makes of TV sets.

Every electronic repair is two-fold in nature. One, the fault must be found, and, two, it must be repaired. It is easier to find TV faults than radio faults! This surprising statement is true because not only can you use the same type of instruments for both radio and TV work to aid you in fault finding, but in television service you have the picture itself giving you direct suggestions as to what may be wrong. Yes, the picture tube acts as a visual instrument always connected and spelling out its story of where the trouble may lie.

And so we begin our study of television not with the theory of the transmitted signal or explanation of special circuits, but with observed faults on the picture tube, what they mean, and how to make needed adjustments and repairs to eliminate such faults.

TEST PATTERN

A test pattern of the type illustrated is broadcast for a short time before a television program begins. When the receiver is correctly adjusted the pattern is clear and steady and in the center of the screen with five distinct shades discernible, black, dark gray, medium gray, light gray and white.
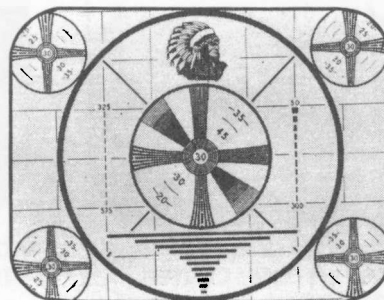
MIS-ADJUSTED CONTROLS
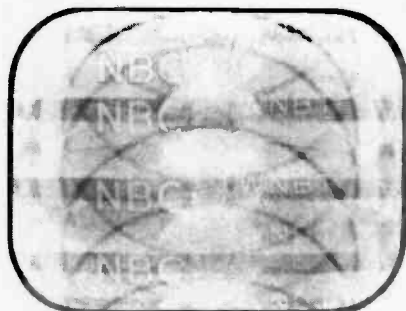
VERTICAL MOVEMENT
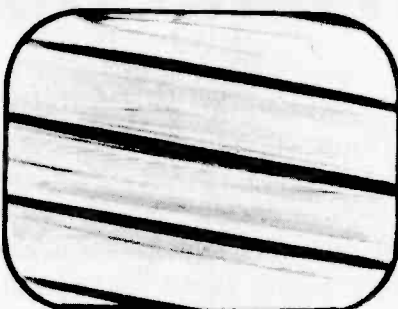
HORIZONTAL MOVEMENT

SOUND BARS
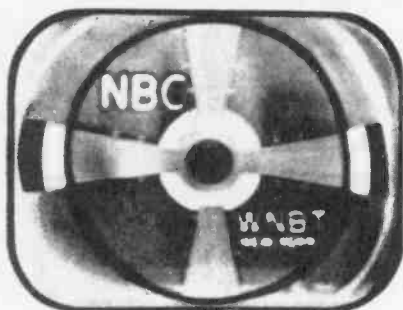
FOCUS CONTROL
REQUIRES ADJUSTMENT

FOCUS COIL & ION TRAP
MAGNET REQUIRES ADJUSTMENT

VERTICAL CENTERING CONTROL
REQUIRES ADJUSTMENT
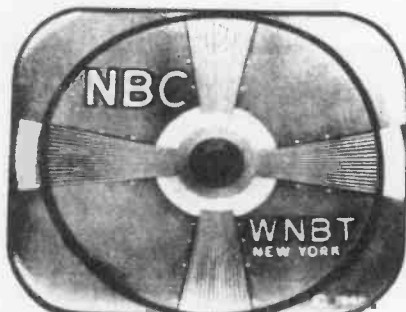
WIDTH CONTROL
REQUIRES ADJUSTMENT
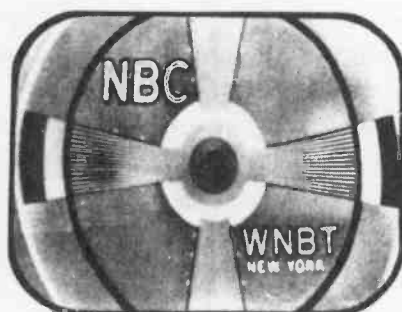
HEIGHT CONTROL
REQUIRES ADJUSTMENT
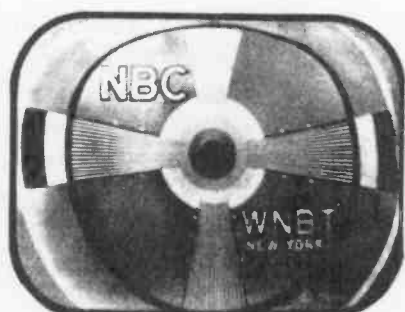
VERTICAL LINEARITY CONTROL
REQUIRES ADJUSTMENT

HUM IN VIDEO AND SYNC.
(PATTERN OFF CENTER
TO SHOW EDGE OF RASTER.)

HORIZONTAL CENTERING CON-
TROL REQUIRES ADJUSTMENT
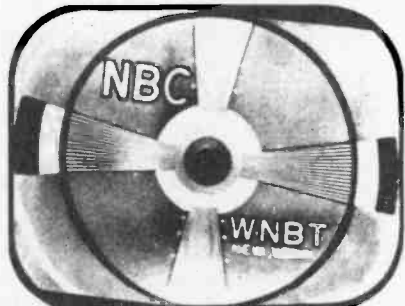
DEFLECTION YOKE
REQUIRES ADJUSTMENT

LESSON 1

SIMPLE ADJUSTMENTS TO CORRECT POOR PICTURES

Some faults are caused simply by poor adjustment of front or rear controls or the natural aging of parts, requiring resetting of some of these adjustment controls. Many of such faults are illustrated on the page at left. Other faults require actual repairs or more complex adjustment calling for chassis removal from cabinet. But to understand such picture faults is to know what section (or perhaps even what tube or component) is at fault. First we will consider adjustment-type faults and their repair. Since this course is made up of practical material, factory supplied in many instances, much of the material on adjusting TV sets is reprinted from data released by leading manufacturers for use by TV servicemen in the field.

A raster or "lighted" screen may be reproduced by having all controls correctly set, but having the tuning control positioned on a channel not transmitting. Some of the tests we will suggest will require 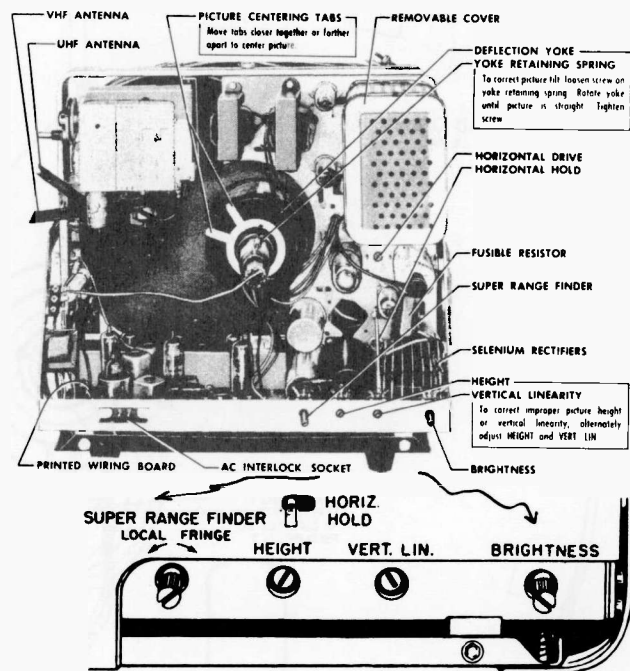the observation of a raster. Majority of adjustments should be made while a pattern is being received. If you have a choice of two stations transmitting a pattern, use the one that comes in poorer. In making adjustments for the worse received station, you know that the others will be satisfactory. Certain of the adjustments may be made with a regular picture received from a station, but where linearity is involved you must have a pattern or a bar generator which will be described under test equipment lesson.

VHF ANTENNA
UHF ANTENNA
PICTURE CENTERING TABS — Move tabs closer together or further apart to center picture
REMOVABLE COVER
DEFLECTION YOKE
YOKE RETAINING SPRING — To correct picture tilt loosen screw on yoke retaining spring. Rotate yoke until picture is straight. Tighten screw
HORIZONTAL DRIVE
HORIZONTAL HOLD
FUSIBLE RESISTOR
SUPER RANGE FINDER
SELENIUM RECTIFIERS
HEIGHT
VERTICAL LINEARITY — To correct improper picture height or vertical linearity, alternately adjust HEIGHT and VERT LIN
BRIGHTNESS
PRINTED WIRING BOARD
AC INTERLOCK SOCKET

SUPER RANGE FINDER
LOCAL FRINGE
HORIZ. HOLD
HEIGHT   VERT. LIN.   BRIGHTNESS

If you believe from picture observation that adjustments are at fault, familiarize yourself with the location of every front and rear control of the set you are called on to service. Rear controls, of course, include those in rear and top of the chassis as well as those placed around the

neck of the cathode ray tube. Place a mirror in front of the picture tube to help you see results taking place while you are making adjustments on the rear controls. Now you are ready to make needed adjustments. But first let us review what each control does.

The action of controls is similar in majority of sets while their location may be marked on the chassis or found by their appearance. On the previous page is a photograph of a recent Admiral set showing rear adjustments. Below is a rear view of a GE receiver of horizontal construction, showing rear controls and tube adjustments. In general when you change any of these controls, the results will be observed in viewing the picture, and if incorrect you will be able to readjust back to the original position. Make all these adjustments gradually and watch results; in this way it will be easy to prevent errors.
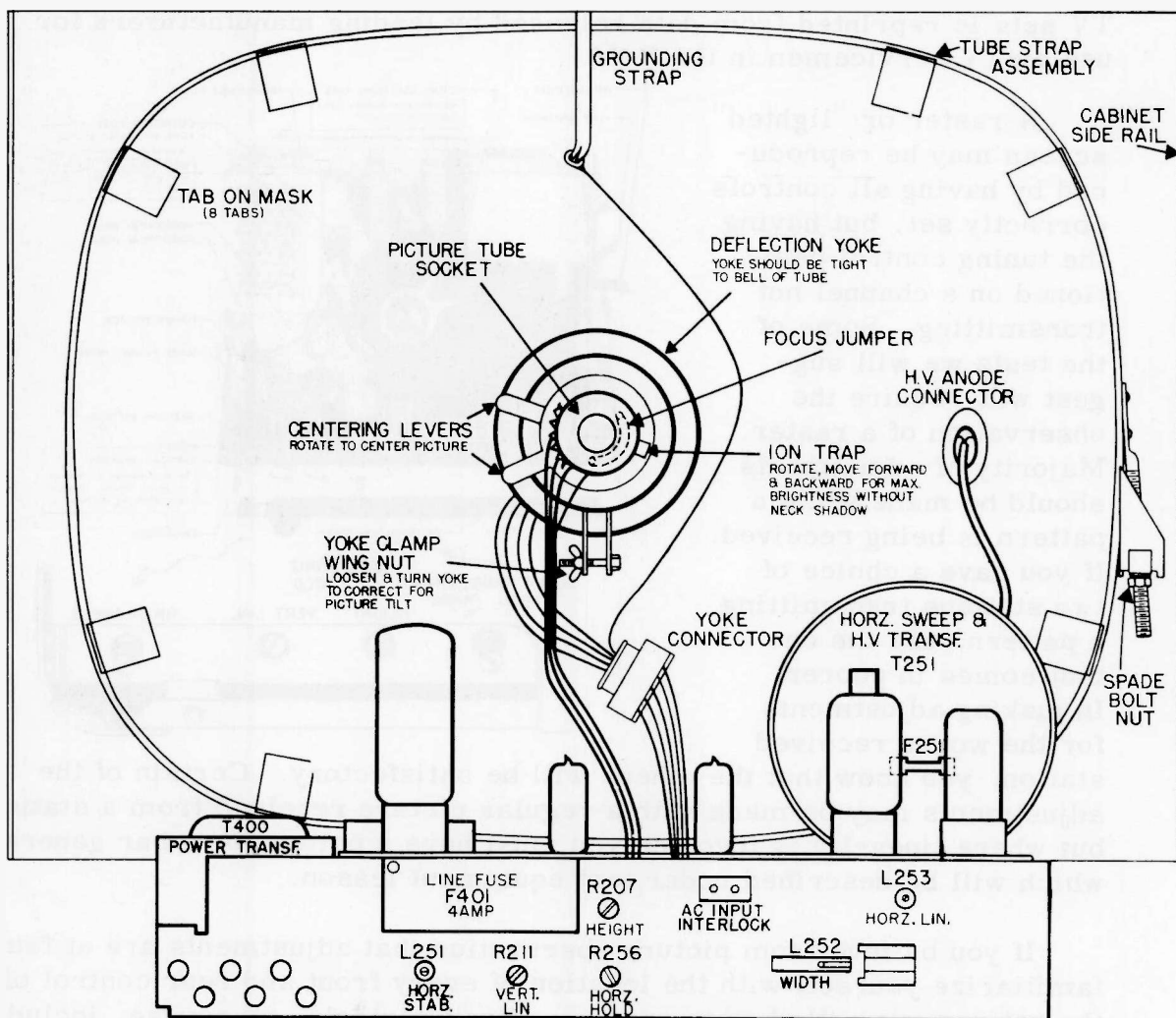
Chassis and Picture Tube Assembly, Rear View

On this page and on page 8 are presented additional photographs of various faults that you may find on television sets you will service. These are presented through the co-operation and courtesy of the Admiral Corp. It is very important for the TV serviceman to be able to diagnose picture faults correctly and to know when such corrections call for a simple adjustment, or are due to received interference, or are due to a real fault in the receiver itself.
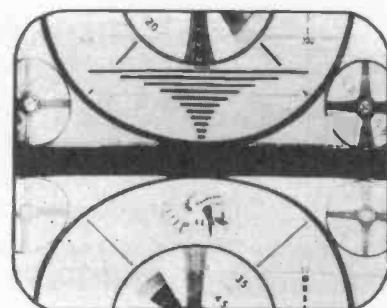
Figure 4. Vertical movement; adjust VERTICAL control.
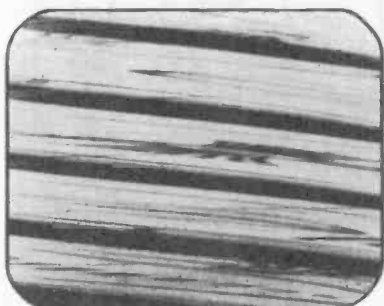
Figure 5. Horizontal movement; adjust HORIZONTAL control.
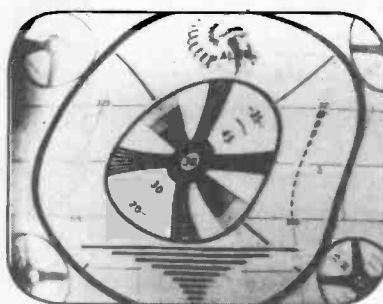
Figure 6. Excessive contrast; turn CONTRAST to the left.
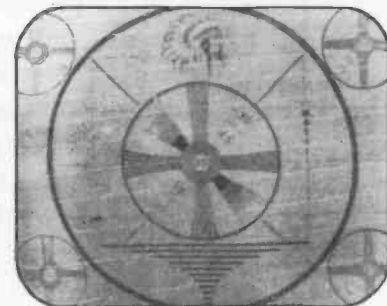
Figure 7. Insufficient contrast, readjust CONTRAST and BRIGHTNESS.
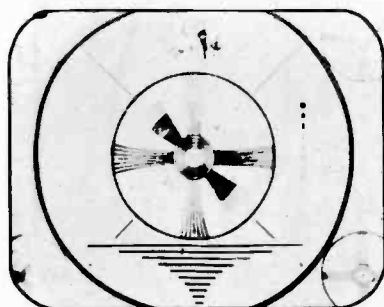
Figure 8. Excessive brightness; turn BRIGHTNESS to the left.
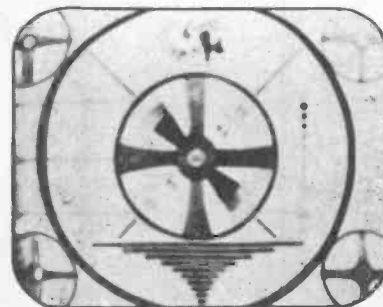
Figure 9. Improper focus; adjust FOCUS control.
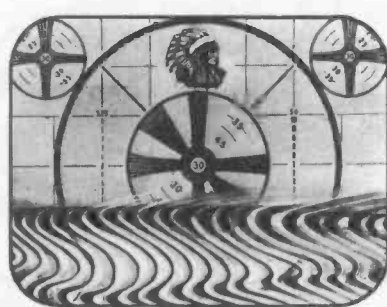
Figure 10. Interference from electronic medical equipment.
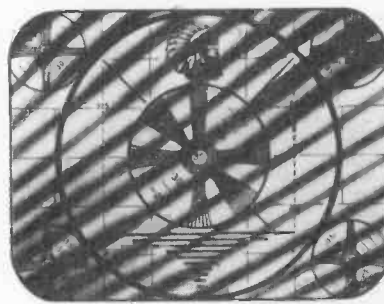
Figure 11. Short wave transmitter interference.
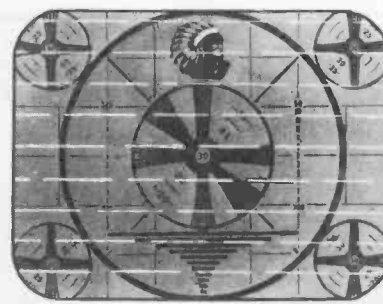
Figure 12. Automobile ignition interference.
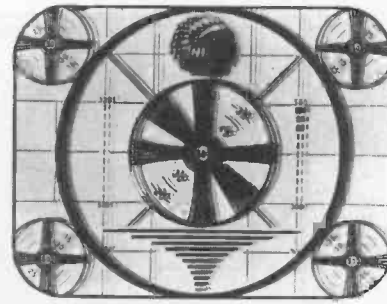
Figure 13. "Ghosts".

Static and man-made interference can be heard on a standard broadcast receiver. They are also visible on the picture tube screen of a television receiver and may result in unsatisfactory television reception. Some common interference conditions are illustrated in Figures 10 to 13.

Some of the adjustments have an effect on the entire picture, and we will talk about these at first. Sets that use an electromagnetic focus coil have their picture centered by tilting this coil. Some mechanical means is provided near the mounting of this coil for the purpose of this adjustment. Since the focus coil is placed around the neck of the cathode ray picture tube with not very much clearance, care must be taken in carrying out this adjustment and at no time should the coil actually touch the glass of the tube. If you are able to slip a thin cardboard between the coil and tube neck at several points around the neck, there is enough clearance for safety. You should keep in mind that high voltage is present and care should be taken in working on a set while it is in operating condition.
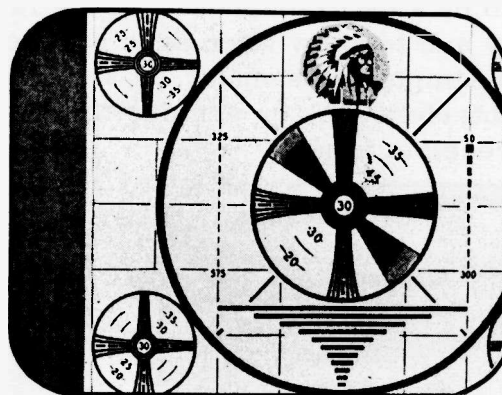
Fig. 16. Picture Too Far to Right or Left; Adjust Mechanical Position of Focus Coil
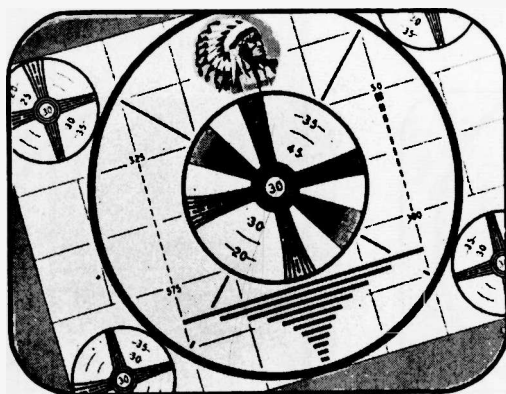
Fig. 17. Picture Tilted; Adjust Electromagnetic Deflection Coil
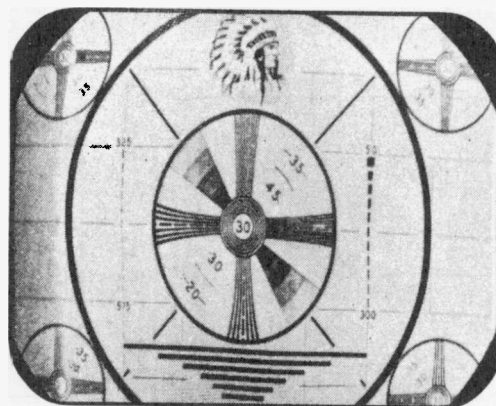
Fig. 19. Too Much Height; Adjust HEIGHT Control
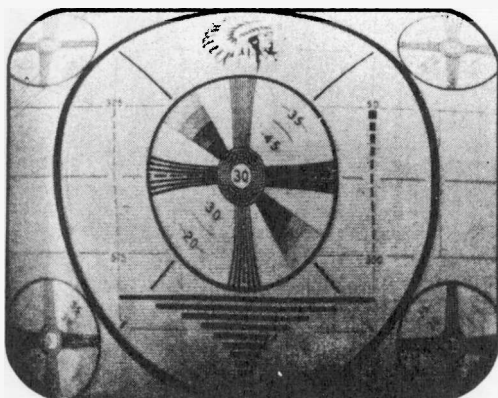
Fig. 21. Non-Linear Vertically; Adjust VERT. LIN. Control
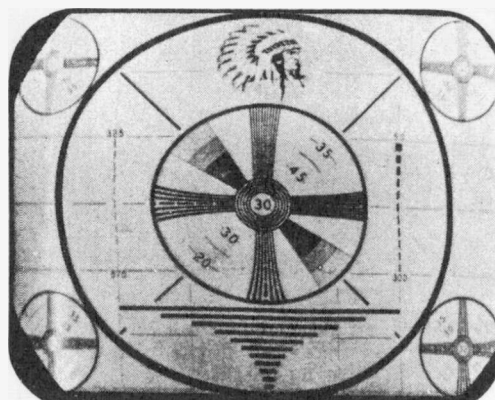
Fig. 22. Non-Linear Horizontally; Adjust HOR. DRIVE Control

When this centering adjustment is carried out, the mirror you have placed in front of the picture tube will permit you to observe the result of your action at all times. This mirror is a must when you are working on the rear controls. Without a mirror you would have to walk to the front of the set each time you make a minor change in any of the rear adjustments.

In case the focus coil is of the PM type (using a fixed piece of magnet instead of electromagnetic coil), screws are loosened and the coil pushed slightly sideways or up an down for this adjustment. The adjustment of actual focus (effecting sharpness and clarity of picture) is done by turning a set screw in the magnet assembly of the PM type focus, or by a means of a front or rear focus adjustment provided in sets with electromagnetic focus arrangement.

In case the entire picture is tilted (on a slant), rotating electromagnetic deflection coils will rectify this fault. This adjustment also is of mechanical nature and from the illustrations included you can see how this is done. Following this general explanation of adjustments, there are presented a number of factory released instructions on such practical adjustments for popular sets of various types and this material will be of especial aid to you.

Although there are sets using cathode ray tubes that do not require ion traps, the majority of sets you will service have a single or a double ion trap (also called a beam bender). An ion trap is placed on the tube neck near the socket end and does not have any electrical connection with the set. The function of the ion trap is to deflect electrons towards the face of the tube where the picture is formed, and it has a great effect on the permanent brightness of the picture. The ion trap is adjusted by very slightly rotating it around the neck of the tube and moving it forward or backwards a fraction of an inch. This adjustment is carried with a raster, picture, or pattern visible on the screen. The ion trap is moved about until the brightest picture results with a given setting of the front controls. In case the brightest picture adjustment produces shadows in one or more corners, a slight additional movement will usually eliminate such shadows.

The ability of the synchronising circuits to lock in step with pulses supplied as a part of the transmitted signal, can be observed in the end result as a steady picture (not rolling or broken). When the picture is broken up into a series of slant lines and forms, slanting either to the left or right, the horizontal sync control will stop this action and lock the circuits of the set in step with the incoming signal. Similarly, the movement of the picture up or down, sometimes in two or more parts, is stopped by an adjustment of the vertical sync control on the front panel. You as a user of television, undoubtedly, are familiar with these adjustments

which are basic and simplest. Because these sync adjustments have to be made from time to time, their controls are placed on the front along with tuning and other operating controls.

Now there are times that all the action of the front sync controls will not correct the fault, or, after each correction, it is only a matter of minutes before another adjustment is needed. In such instances there is some definite fault with the circuits and a more serious type of adjustment is needed. Methods for carrying out such tests and repairs will be presented in a more advanced lesson.

A television picture is non-linear when parts are spread out or condensed in a manner not originally transmitted. Considerable linearity distortion may be present before it can be detected by observing a scene of a usual television program. Therefore, linearity adjustments should be made while a pattern is being transmitted. Such adjustments may be made also with the help of a bar generator.

The linearity adjustments should be made to have the center of the pattern equally spaced from the left and right edges of the mask (ends of visible picture). And the center should also be equally spaced from top and bottom edges of the picture. Initially the picture is centered with the adjustment of the focus coil, and a readjustment may be in order after some corrections are made with linearity controls. The guide to linearity is the appearance of the inner circle and the appearance of the outer circle which should touch the mask at top and bottom. These circles should be as true round as they can be made with linearity adjustments.

Vertical height adjustment spreads the picture up and down almost evenly, while vertical linearity has a greater effect on the upper part of the pattern and is used to bring the two into equal balance. These controls have some effect on each other, and both should be adjusted a little at a time for best vertical linearity.

Horizontal drive control has a greater effect on the left side of the picture. It should be adjusted together with the width control to give proper linearity in width. Because of associated circuits, better results will be secured in the operation of the set if the drive control is advanced as far as possible consistent with acceptable width linearity.

Linearity controls should be adjusted for one station and tested on others that may be operating in the locality. Sometimes it is impossible to make these adjustments best for all stations received and a compromise adjustment will be in order.

It is proper to add a word about tuning. Some sets are turned to wanted channel and then adjusted with the fine tuning control. Others may be continuously tuned -- the same knob used for turning to another channel and

adjusting for best results. In older sets and all others using separate I.F. stages, tuning is done for loudest sound like a radio set and the picture will be correct with such a setting. In inter-carrier type sets, tuning is carried out for best picture and sound and set at a point where the resulting picture and sound are acceptable. In such sets it is not practical to get brightest picture and loudest sound with the same setting and some compromise is in order.

The contrast and brightness controls are adjusted for a pleasing picture of acceptable tones that suggest true relationship of colors that are present in the scene being televised. Since it is the contrast control that is adjusted for difference in signal strength or changes in line voltage, in some sets you may find the brightness control placed in the rear.

Dust deposits on the viewing surface of the cathode ray tube, as well as on the surfaces of the mask or protective glass. The front of the mask is easily cleaned by the housewife and is not a source of trouble. The amount of dust deposited on the inside surface of the mask and on the front of the picture tube can be of surprise to you. In many sets electrostatic action adds to the process of dust accumulation. On every service job, you should clean these surfaces. On some sets, the mask may be removed from the front and the cleaning task is very simple. Other sets call for the removal of the chassis, but you may have the chassis out anyway for the purpose of carrying out your repair work.

The material that follows will give you practical instructions on making the adjustments we have discussed. This material has been selected for presentation because it is easy to follow and is applicable not only to the group of sets for which it was prepared but to hundreds of additional models of many different manufacturers. Study this material with care.

The first practical material applies to older TV sets and is presented on pages 12 through 14. While this is elementary material, it must be clearly understood in order to follow explanations in the more advanced lessons that come later.
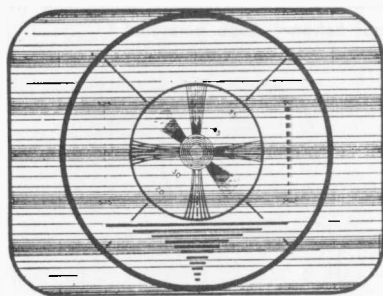
Fig. 2—SOUND INTERFERENCE
CAUSED BY INCORRECT TUNING
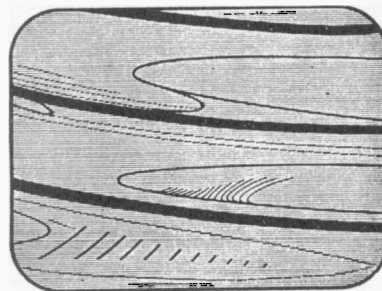
Fig. 3—HORIZONTAL MOVEMENT
ADJUST HORIZ. HOLD CONTROL

Fig. 1

This knob is for decorative purposes only.

FINE TUNING CONTROL

Use to tune in station after "Channel Selector" is set to desired channel. See next section for complete description of tuning procedure.

ON-OFF SWITCH & VOLUME CONTROL

Use to turn receiver on or off and to adjust for desired sound volume.

HORIZONTAL HOLD CONTROL

Adjust so that picture is stationary and does not move horizontally or break up into black and white streaks.

BRIGHTNESS CONTROL

Adjust for picture brilliance. Re-adjust after setting "Contrast" control.

CONTRAST CONTROL

Adjust to receive picture and obtain correct contrast between light and dark shades.

CHANNEL SELECTOR (front knob)

Set knob so that desired channel designation appears in illuminated opening. Then use Fine Tuning control to tune in station.

The various controls on the receiver may be divided into two classes, Operating and Pre-set. Operating controls are those which control program selection as well as sound and picture quality and their functions are indicated in Fig. 1.

There are nine Pre-set controls, four of which are located at the back of the chassis (see Figure 18). Four controls are accessible by removing the Name Plate located directly above the Operating controls. Access to the "Auxiliary Fine Tuning" screw can be gained by removing the "Channel Selector" and "Fine Tuning" knobs.

1. **ADJUST ION TRAP**—If screen remains dark or is only dimly illuminated when "Brightness" control is turned clockwise, the ion trap may require adjustment.

   The ion trap is located on the neck of the picture tube as shown in Figure 18 and consists of a magnet held in position by metal bands.

   Rotate the entire trap assembly while sliding it back and forth until picture tube screen is illuminated to maximum brilliance. Reduce "Brightness" control setting and repeat this operation to assure accurate positioning of ion trap.

2. **AUXILIARY FINE TUNING ADJUSTMENT**—If it is found that the tuning range of the "Fine Tuning" control is inadequate to permit correct tuning of a station in its assigned channel, then adjustment of the "Auxiliary Fine Tuning" screw will be necessary. This special screw is accessible after removal of the "Channel Selector" and "Fine Tuning" knobs. They may be removed by merely pulling them forward.
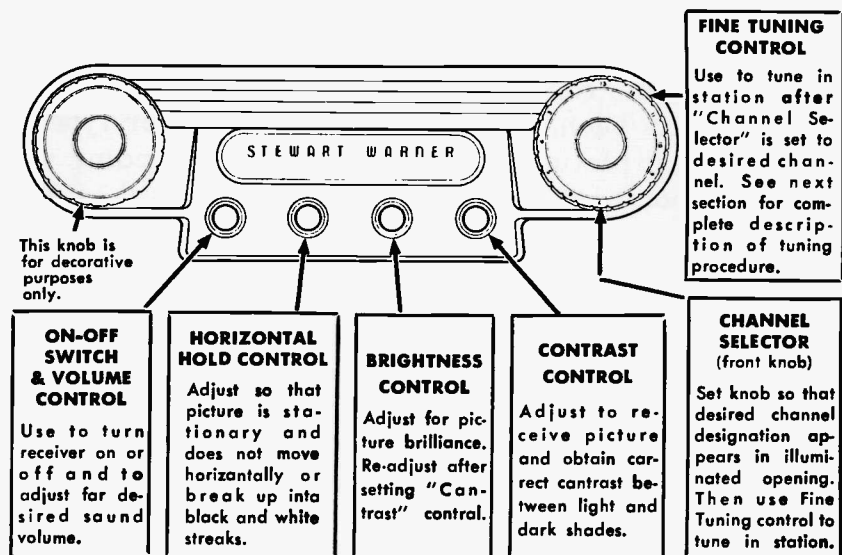
Adjustment of the "Auxiliary Fine Tuning" screw may now be undertaken in accordance with the following procedure.

a. Set "Channel Selector" to desired channel; then remove this knob.

b. Set "Fine Tuning" knob to the center of its range; then remove this knob. The flat portion of the main tuning shaft (outer brass shaft) should now be in the uppermost position. Note the location of the "Auxiliary Fine Tuning" adjustment screw on receiver chassis —see Fig. 14.

c. Using a thin screwdriver (preferably non-metallic), adjust the setting of "Auxiliary Fine Tuning" screw for correct tuning of the desired television station—**CAUTION: Do not attempt to rotate this screw more than two full turns in either direction, as further rotation may release it from the thread clip within the tuning mechanism and the coil for that channel (located in R.F. Tuner Unit) would then have to be removed in order to restore the screw to the correct position.** If a metal screwdriver is used, detuning occurs when the screwdriver is removed but it will be noted that this degree of detuning can now be compensated by resetting the "Fine Tuning" control (brass shaft). Thus the range of the "Fine Tuning" control (after knob is replaced on the shaft) will be adequate to tune in the station.

d. This completes the adjustment of the "Auxiliary Fine Tuning" screw for one channel. Identical screws are provided on each channel and they are all accessible thru the same opening in the tuning mechanism as each successively moves into position when the "Channel Selector" knob is rotated.
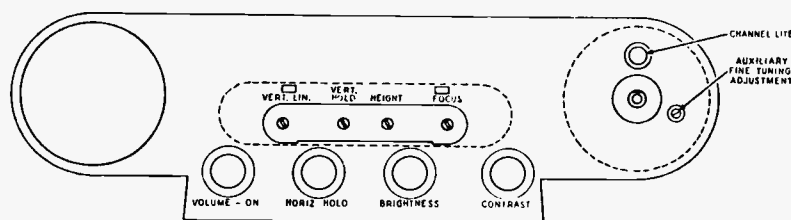
Fig. 14—LOCATION OF PRE-SET CONTROLS

3. **HORIZONTAL HOLD**—Should the picture appear to move horizontally across the screen or break up into a series of light and dark streaks as shown in Figure 3, adjust the "Horizontal Hold" control until the picture remains stationary.

If this control must be rotated to the end of its range for proper "locking" action, then it will be necessary to reset the position of the "Horizontal Lock" control (see Figure 18 for location). Adjustment is accomplished by first setting the "Horizontal Hold" control in the middle of its range and then changing the setting of the "Horizontal Lock" control until picture locks in horizontally.

4. **VERTICAL HOLD**—Should the picture appear to roll by in a vertical direction or cause multiple vertical images as shown in Figure 15, it will be necessary to adjust the "Vert. Hold" control located behind the Name Plate (see Figure 14).

After this adjustment is made, reduce contrast until picture is barely visible and check setting of "Vertical Hold" control for proper picture synchronization.
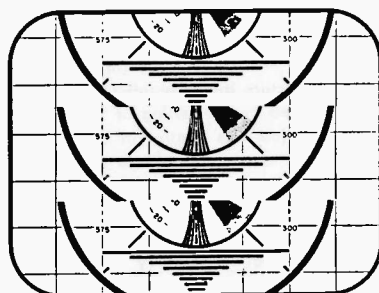
Fig. 15—VERTICAL MOVEMENT; ADJUST VERTICAL HOLD CONTROL

5. **INITIAL FOCUS**—Adjust the "Focus" control, located behind Name Plate, until picture is clearly defined.

Fuzzy picture may also be due to reproduction of poor quality film when station is televising a motion picture. Incorrect tuning of receiver produces a similar effect.
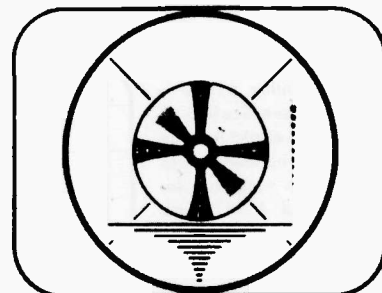
Fig. 16—BLURRED APPEARANCE; ADJUST FOCUS CONTROL

6. **STRAIGHTENING TILTED RASTER**—If the pattern should appear on the screen in a tilted position as shown in Figure 17, loosen the deflection yoke locking screw (see Figure 18) and rotate the yoke sufficiently to correct this condition.
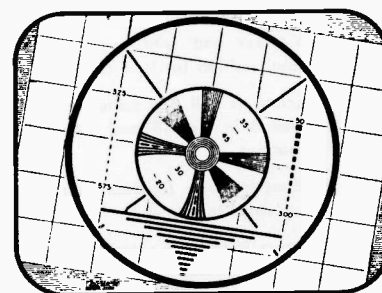
Fig. 17—TILTED PICTURE; ADJUST YOKE POSITION

ION TRAP ASSEMBLY

STRAP ASSEMBLY

PICTURE TUBE 16TP4 or 16RP4

YOKE LOCKING WING SCREW
Loosen this screw if repositioning of yoke is necessary

CENTERING MAGNET ASSEMBLY

DEFLECTION YOKE

R.F. TUNER UNIT

FOCUS COIL
"RED"—High Field Strength
"GREEN"—Low Field Strength

POWER TRANSFORMER

ANTENNA TERMINALS

SPEAKER
508157—For model 9106-A
508174—For model 9106-B

HIGH VOLTAGE POWER SUPPLY COMPARTMENT

WIDTH CONTROL

FUSE ¼ AMP., 250 VOLT
Located inside High Voltage Power Supply Compartment

HORIZONTAL DRIVE CONTROL

HORIZONTAL LINEARITY CONTROL

HORIZONTAL LOCK CONTROL
for Horizontal Sync. "Flywheel" Circuit
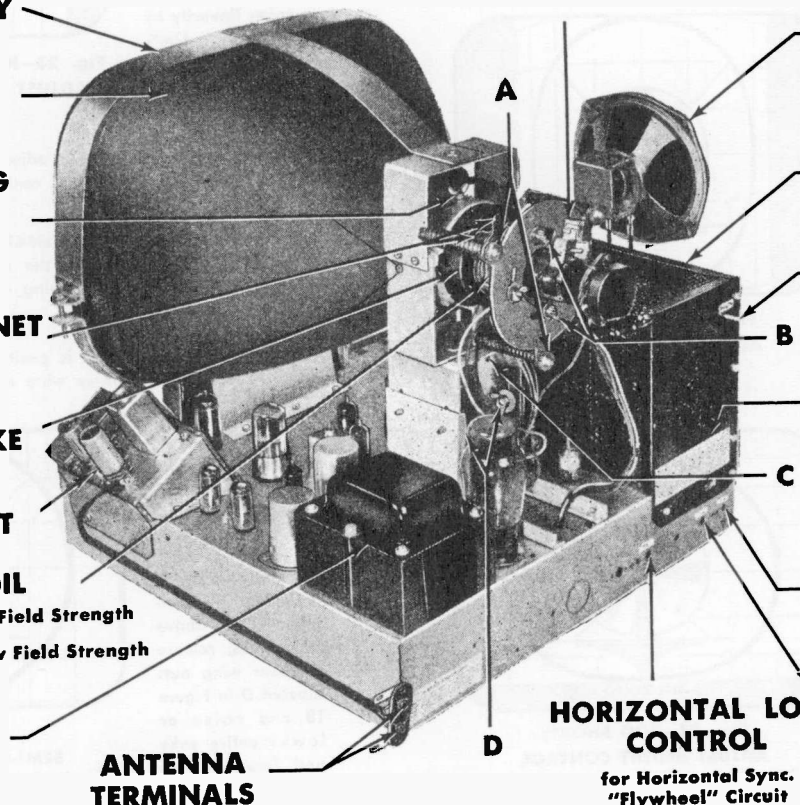
Fig. 18—CHASSIS AND PICTURE TUBE ASSEMBLY

7. **CENTERING:** To center the test pattern on the screen, proceed as follows:

   a. Make sure focus coil mounting plate is perpendicular to neck of picture tube by adjustment of three wing nuts labeled A in Figure 18.

Fig. 19—OFF CENTER; ADJUST FOCUS COIL POSITION

   b. Rotate the two magnets in the centering magnet assembly (see Fig. 18). These magnets may be adjusted by grasping the cardboard "ears" attached to each magnet and rotating the magnets with respect to each other and with respect to the picture tube. Adjust the magnet position for best centering of the test pattern.

   c. If picture is still not centered, loosen four focus coil wing nuts labeled B in Fig. 18 and rotate focus coil for best centering of test pattern.

   d. Readjust ion trap for maximum brightness on picture tube screen as explained in step #1.

   e. If picture is still not centered, position focus coil by adjusting the three nuts labeled A in Fig. 18.

In event picture cannot be centered by above procedures, release the four wing nuts labeled D in Fig. 18 and raise or lower entire yoke and focus coil assembly so that focus coil can be repositioned vertically with respect to the tube neck.

8. **WIDTH** — Control of picture size in the horizontal direction is accomplished by means of the "Width" control located on the rear of H. V. power supply (see Fig. 18). If abnormally low line voltage makes it difficult to obtain sufficient picture width when using the "Width" control, then changing the setting of the "Horizontal Drive" control may be helpful.

Fig. 20—TOO NARROW; ADJUST WIDTH CONTROL

9. **HEIGHT** — Control of picture size in the vertical direction is accomplished by means of the "Height" control located behind the Name Plate. Height and width adjustments should be checked for all transmitting stations to be sure that picture properly fills the viewing area. It may be necessary to change the setting of the "Height" control after the "Vertical Linearity" control is adjusted.

Fig. 21—TOO SHORT; ADJUST HEIGHT CONTROL

10. **VERTICAL LINEARITY** — Improper vertical linearity causes the circular test pattern to appear condensed on the upper edge of the screen and extended on the lower edge or vice versa. This effect is illustrated in Figure 22. Adjust for proper linearity by using "Vert. Lin." control located behind Name Plate.
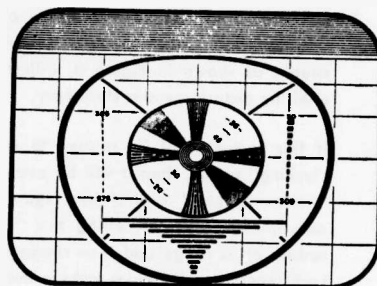
Fig. 22—VERTICAL DISTORTION; ADJUST VERTICAL LINEARITY

11. **HORIZONTAL DRIVE** — The "Horizontal Drive" control located at rear of chassis (see Fig. 18) should be rotated clockwise to the point where any white (or black) vertical lines near the left side of the picture are eliminated. As width and linearity of the picture are affected by the setting of "Horiz. Drive" control, it will be necessary to adjust this control in conjunction with the Horiz. Linearity and Width controls to obtain desired picture width and linearity.

12. **HORIZONTAL LINEARITY** — Improper horizontal linearity causes the circular test pattern to appear condensed on the right edge of the screen and extended on the left edge or vice versa. This effect is illustrated in Figure 23. Adjust for proper linearity by using "Horiz. Lin." control located at rear of chassis (see Figure 18). In event that proper horizontal

Fig. 23—HORIZONTAL DISTORTION; ADJUST HORIZONTAL LINEARITY CONTROL

linearity cannot be obtained by adjusting this control, then change the setting of the "Horiz. Drive" control.

13. **ELIMINATING SEMI-CIRCULAR SHADOW** — This shadow is caused by the electron stream striking the neck of the tube and it can generally be corrected by applying one or a combination of the following procedures:

   a. Make sure deflection yoke is positioned as far forward as possible by loosening the three wing nuts labeled C in Fig. 18.

   b. Reposition the focus coil by readjusting the three nuts labeled A in Fig. 18 to shift the coil forward.

   c. In event neck shading cannot be eliminated by the above procedures, release the four wing nuts labeled D in Figure 18 and raise or lower entire yoke and focus coil assembly so that

Fig. 24 SEMI-CIRCULAR SHADOW

focus coil can be repositioned vertically with respect to the tube neck.
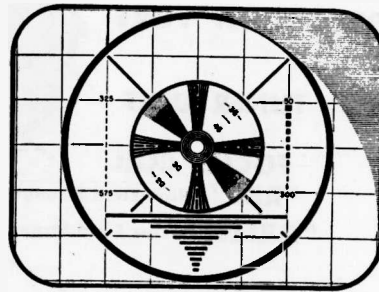
SERVICE ADJUSTMENTS FOR DU MONT TELESET
MODEL RA-109A
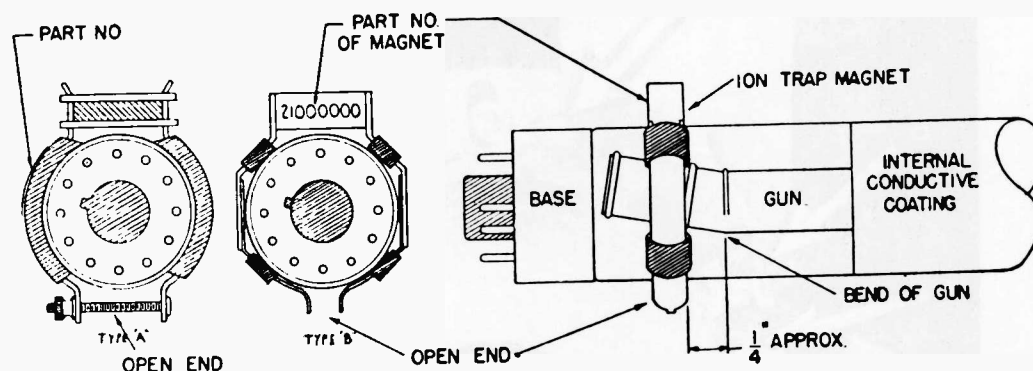
Types of ion-trap magnets used. (Thumbscrew of Type A should be tightened by hand only — do not use tools.)

ION-TRAP MAGNET ADJUSTMENT
(See Adjoining Illustrations)

NOTE: Accurate setting of the ion-trap magnet is highly important to insure optimum performance and normal life of the picture tube. The procedure should be carried out as rapidly as possible, to prevent damage to picture tube, and is not to be used as a picture positioning or screen coverage adjustment.

1. Start with the magnet about ½" from the base of the tube.
2. Keep the Brightness Control at the lowest possible setting that will allow adjustment of the magnet.
3. Adjust the magnet by rotating it on the neck of the tube and sliding it back and forth for maximum illumination. Correct positioning of the magnet results in a decrease in brightness with movement of the magnet in any direction. (Two positions will be found; use position NEAREST BASE of tube).
4. Make final adjustment of magnet with Brightness Control set just below point where "blooming" (defocus) occurs.

PICTURE POSITIONING ADJUSTMENTS RA-109A

Note 1: Be sure that ion-trap magnet has been properly adjusted before attempting picture positioning.

1. Set 3 wingnuts (B) so that focus coil is spaced a minimum of ¼" from rear of deflection yoke at all points. When set properly, the focus coil should exhibit practically no tilt.
2. Tune to a TV station and make the necessary front panel adjustments for a good picture.
3. If picture requires positioning in a rotary direction, loosen thumbscrew (A) and rotate deflection yoke. When retightening, make sure yoke is full forward against cone of picture tube. This may be checked by applying forward pressure on rear of yoke cover while tightening (A).

4. Loosen 2 nuts (C) holding focus coil mounting ring to yoke bracket and move focus coil assembly to position picture as correctly as possible. Up-and-down movement of focus coil assembly results in horizontal positioning of picture, horizontal movement of focus coil assembly results in vertical positioning. Retighten nuts (C). (Immediately reset ion-trap magnet if change in brightness occurs.)
5. Using 3 wingnuts (B), accurately position picture by UNSCREWING necessary wingnut(s). Vertical tilt of coil moves picture horizontally. Horizontal tilt of coil moves picture vertically. (Immediately reset ion-trap magnet if change in brightness occurs).

Note 2: If picture cutoff (shadowing) occurs, the tilt of the focus coil (wingnuts B) may have to be readjusted, followed by readjustment of the positioning (nuts C). Do not attempt to eliminate cutoff (shadowing) or obtain screen coverage by adjustment of ion-trap magnet.

VERTICAL HOLD

Rotate hold control until picture falls out of sync. Adjust control to bring picture back into sync and note point where this occurs. Rotate hold control until picture goes out of sync in direction opposite to that just described. Adjust control and note point where picture falls into sync. Correct setting is approximately half-way between the two points where picture falls into sync. A final adjustment should be made for best interlace.

VERTICAL LINEARITY

If vertical non-linearity is observed in the upper half of the picture, adjustment of this control should correct the condition.
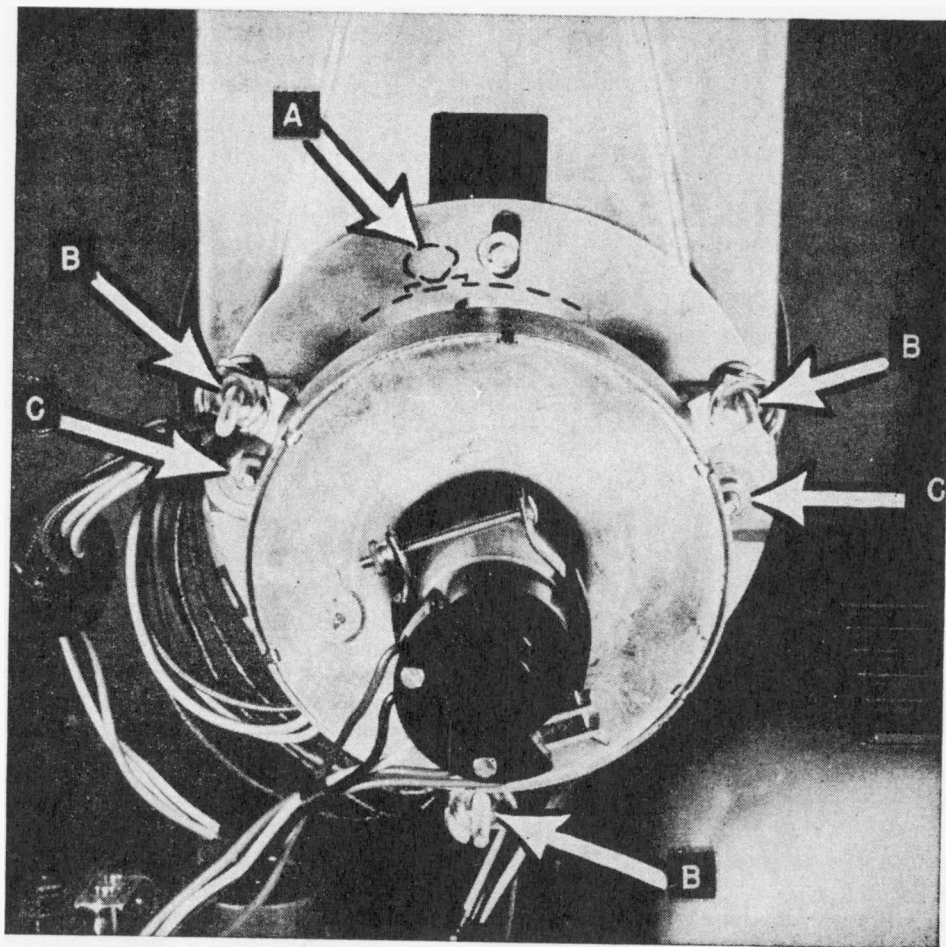
VERTICAL SIZE

This control affects the linearity of the bottom half of the picture as well as affecting the size. For best linearity and proper size, the linearity and size controls should be adjusted in conjunction with one another.

HORIZONTAL DRIVE

Adjust to the point where "packing" or foldover just disappears from the right edge of the raster.

HORIZONTAL LINEARITY

Adjust for optimum picture linearity. This control affects the center and the left half of the picture.

HORIZONTAL SIZE

Adjust for proper picture size. This adjustment does not affect linearity. Picture should be large enough so that on stations using maximum blanking, the picture completely covers screen. On stations using less blanking, the edges of the picture will not be visible.

HORIZONTAL FREQUENCY ADJUSTMENT

Rotate the horizontal frequency control until the picture falls out of sync. Adjust the control to bring the picture back into sync and note the point at which this occurs. Repeat the above but in direction opposite to that just described. The correct setting is half-way between the two points where the picture falls into sync.

The CRT SENSITIVITY CONTROL is located adjacent to the right corner of the power transformer.

This control is adjusted correctly as follows:

1. Remove antenna connection.

2. Adjust the brightness control until the voltage as measured between the control grid and cathode is —50 volts.

3. Adjust the CRT sensitivity control just to the point where the raster is no longer visible.

If it is not possible to obtain —50 volts under the above conditions then set it as close to —50 volts as possible.

Motorola Inc.   **SERVICE ADJUSTMENTS**
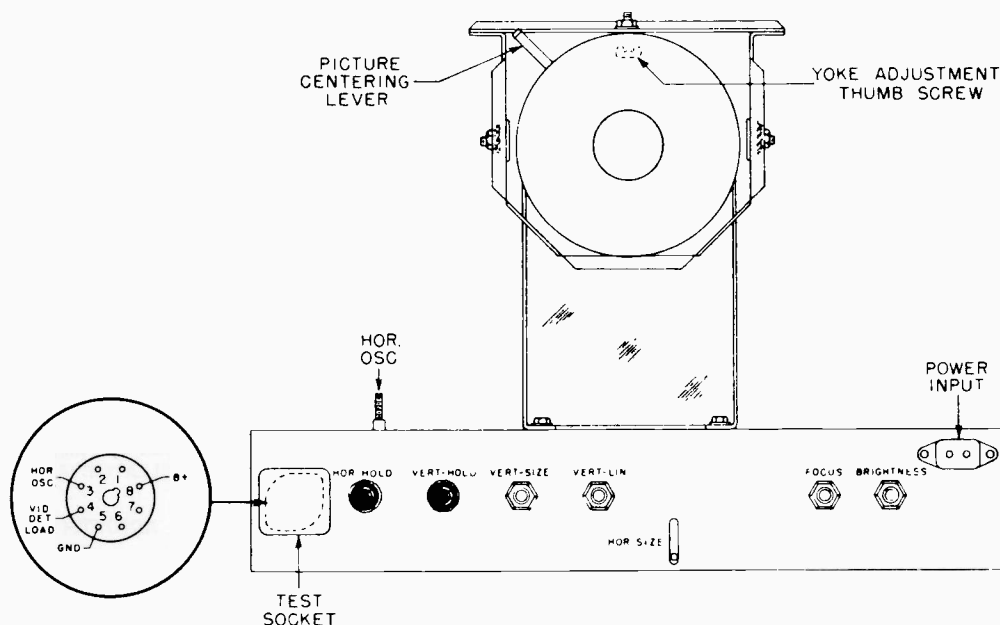
FIGURE 2.   SERVICE ADJUSTMENT CONTROLS

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 readjustment of the VERTICAL LINEARITY control and possibly of the VERTICAL 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.

VERTICAL HOLD ADJUSTMENT

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

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 pole pieces 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 it to obtain the brightest raster. If, in obtaining the brightest raster, the ion trap magnet has to be 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.

DEFLECTION YOKE ADJUSTMENT

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

CHASSIS NOS.
KCS117A & KCS117B

DEFLECTION YOKE ADJUSTMENT

If the lines of the raster are not horizontal or squared with the picture mask, rotate the deflection yoke until this condition is obtained. The yoke clamp must be loosened to allow the yoke to be rotated, see Figure 2. Make sure the yoke assembly is pushed forward against the kinescope bell.

CENTERING ADJUSTMENT

The electrostatic focus kinescope is provided with special centering magnets. These magnets are in the form of two discs mounted on the back of the deflection yoke. When the magnets are rotated on the tube so that the levers are together, maximum centering effect is produced. To shift the picture, rotate one of the magnets with respect to the other. To shift the picture in the desired direction rotate both magnets simultaneously in the same direction on the neck of the kinescope. By alternately rotating one magnet with respect to the other, then rotating both simultaneously around the neck of the tube, proper centering of the picture can be obtained. Refer to Figure 2.
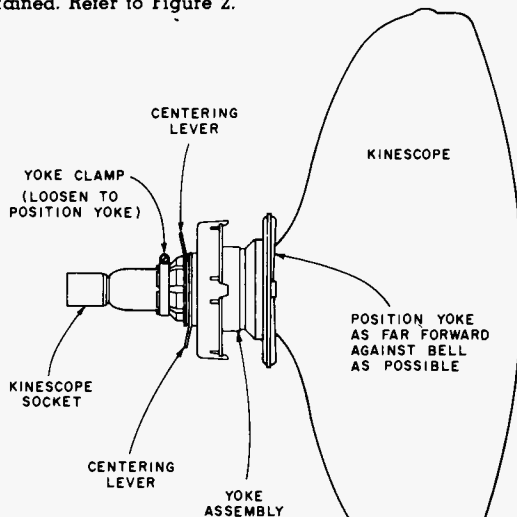
Figure 2—Yoke and Centering Magnet Adjustments

CHECK OF HORIZONTAL OSCILLATOR ADJUSTMENT

Turn the horizontal hold control to the extreme clockwise position. The picture should be out of sync, with a minimum of eight bars slanting downward to the left. Turn the control counter-clockwise slowly. The number of diagonal black bars will be gradually reduced and when only 1½ to 3 bars sloping downward to the left are obtained, the picture will pull into sync upon slight additional counter-clockwise rotation of the control. The picture should remain in sync for approximately one quarter of a full turn of additional counter-clockwise rotation of the control. Continue counter-clockwise rotation until the picture falls out of sync. Rotation beyond fall out position should produce a minimum of 2 bars before end of rotation or a minimum of 7 bars before interrupted oscillation "motorboat" occurs.

ADJUSTMENT OF HORIZONTAL OSCILLATOR

If in the above check the receiver failed to hold sync for one-quarter of a turn of counter-clockwise rotation of the control from the pull-in point, it will be necessary to make the following adjustments.

The width and drive adjustments should be properly set, as explained in the paragraph below, before adjusting the sine wave coil.

Connect a short jumper across the terminals of the sine wave coil L601 through the opening in the chassis. Also short the grid of the sync output tube, pin 2 of V501, to ground with a small screwdriver or jumper.

Adjust the horizontal hold to obtain a picture with the sides vertical (picture may drift slowly sideways). Remove the jumper on the sine wave coil L601 and adjust L601, see Figure 3, to again obtain a picture with the sides straight. When the sine wave coil is properly adjusted, alternate shorting and no short should not cause a change in frequency, only a slight sideways shift should occur.

Remove the short on the grid of the sync output. The horizontal hold should now perform as outlined above under "CHECK OF HORIZONTAL OSCILLATOR ADJUSTMENT."

WIDTH AND DRIVE ADJUSTMENTS

Set the horizontal control at the "pull-in" point. Set the width coil maximum counter-clockwise and adjust horizontal drive trimmer counter-clockwise until a bright vertical line appears in the middle of the picture then clockwise until the bright line just disappears. If no line appears set the drive trimmer at maximum counter-clockwise position.

At normal brightness adjust the width coil L102 to obtain ¾" overscan at each side with normal line voltage.

Readjust the drive trimmer C107 as was done previously.

HEIGHT AND VERTICAL LINEARITY ADJUSTMENTS

Adjust the height control (R510 on chassis rear) until the picture overscans approximately ⅝" at both top and bottom. Adjust vertical linearity (R516 on chassis rear) until the test pattern is symmetrical from top to bottom. Adjustment of either control will require a readjustment of the other. Adjust centering to align the picture with the mask.
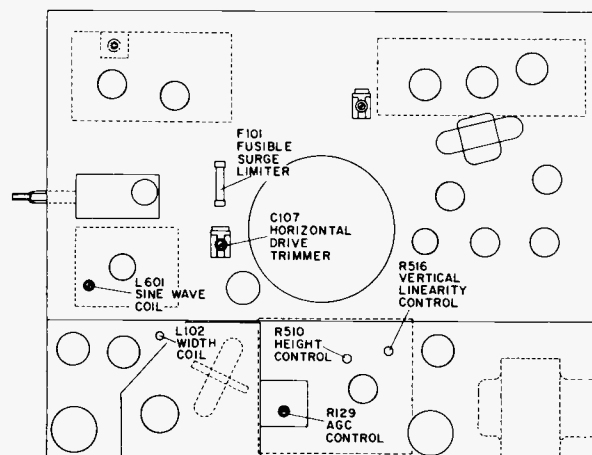
Figure 3—Rear Chassis Adjustments

LESSON 2

CIRCUIT FAULTS INDICATED BY A POOR PATTERN

The existence of certain faults in the circuits of a television set are suggested by symptons found in observing a pattern received. There are several different kinds of patterns, but the information presented will apply to all. In general, a pattern consists of several sets of converging alternately black and white lines, a centrally-located series of concentric circles of graduated shading, and possibly some additional lines and lettering. We shall discuss these elements of a pattern, consider their purpose, and try to see how they can suggest what may be wrong a TV set.
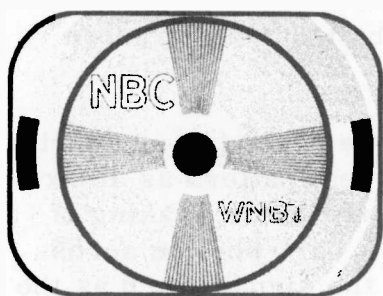
The converging lines constitute "resolution wedges" whose purpose is to indicate the amount of resolution (picture detail) that is being received. Those bars which are situated in up an down direction measure the resolution in horizontal direction, and those lying across measure the vertical resolution. The quality of resolution is a function of the receiver's high frequency response as we shall see.

At the transmitter the scanning of two lines, one black and one white, produces one cycle of the electrical signal (not one cycle per second). As you know, the scanning rate is constant and it is evident that the more closely spaced these lines are placed, the greater the number of cycles produced in a given lapse of time. So a spacing of lines represents a certain frequency of the video signal. The more lines or changes of tone in a given scene, the higher frequency required to reproduce this scene in electrical form.

Should the receiver be incapable of reproducing the high-frequency components in the transmitted image, the part of resolution wedges where the lines are closest together will not be clear. Here the alternate black and white lines will not be distinct, but rather they will merge into a single dark mass. Therefore, the point at which the lines merge into indistinction indicates the degree of high frequency response of the system. This merging effect should be near the center circles, but if continuous away from the center this effect will suggest that adjustments to improve high frequency response are in order. Some poorly designed receivers have a very narrow bandwidth under the best adjustment and nothing can be

done with such sets. Generally, however, proper alignment will improve high frequency response. Even without equipment, the I.F. adjustments may be touched up slightly while observing a pattern, to see if improvement results.

Next we shall consider the concentric circles in the center of the pattern. As in photographic work, an improper gamma (tone relationship) in reproduction will lead to a picture which is "washed out" or one which is "overly contrasty." If the proper gamma is present, the graduation in shading in these concentric circles will appear in equal steps. The tones from what represents white to black should be in what appears equal changes of color. In a properly operating receiver correct gamma can be secured with the correct setting of the contrast and brightness controls.

We have already considered how a pattern is used for basic adjustments of a television set. It is clear that if such adjustments cannot be made to correct a fault detected in the pattern, than some more serious trouble is present in the set. Such problems will be treated in a more advanced lesson.

Should the frequency response of the receiver be peaked at any portion of the response curve, this will be indicated in the test pattern as an excessive dark part of the resolution wedge. Watch out for the making of this fault if you try touching up I.F. adjustments. A dark portion across the screen may be the result of hum-modulation of the signal, such as the entrance of 60-cycle hum into the video portion of the receiver, but this fault will be distinguished by a dark band extending from left to right extremities of the raster.

Peaking in the video section will produce a darkened portion of the wedge alone and the frequency of this peak may be judged by the part of the wedge which is dark (overly contrasty). If at the high frequency part of the band-pass, the effect will be noted at the high frequency portion of the wedge (closer to center circles).

Interlace check can be made by observing the lines of the horizontal wedges or any diagonal lines present. These will indicate satisfactory interlace if they are smooth and not jagged.

Some patterns may have straight horizontal lines of varying length usually placed at the bottom of the pattern. These can be made to represent half cycles of square wave signals from about 19 KC. to 0.6 MC., and are used for checking low frequency phase shift by analyzing intensity, duration, and polarity of leading and trailing smears. This last test is mentioned here only to suggest to you that a pattern is also of use to TV design engineers and station operators.

LESSON 3

FINDING BAD TUBES BY OBSERVING PICTURE FAULTS

Many faults that develop in television sets are due only to bad tubes and such faults can be corrected by a simple replacement. Rather than actually testing tubes with a tube tester, which may not detect weak tubes, it is more logical to guess which tube is at fault by observing symptoms shown on the picture or raster, and hearing the sound. Naturally, in trying to tell what tube is at fault from picture symptoms you must be certain that these symptoms are not due to poor adjustment or outside interference of the types discussed in previous lessons.

To judge what fault exists from picture observation you should have an actual idea of how the signal progresses through a TV set and the action of different sections on the picture itself. We present block diagrams of separate I.F. type and inter-carrier type sets.

SEPERATE CHANNEL IF SYSTEM

```
                  ┌──────────┐           ┌──────────┐  ┌─────────┐  ┌──────────┐  ┌──────────┐
                  │  V-3     │           │ V-4 & V-5│  │  V-6    │  │  V-8     │  │  V-7     │
                  │  R-F     │           │ 1ST & 2ND│  │ SOUND   │  │1ST AUDIO&│  │ AUDIO    │        ◁ SPEAKER
                  │  OSC.    │           │ SOUND I-F│  │ DISC.   │  │BIAS CLAMP│  │ OUTPUT   │
                  └────┬─────┘           └────┬─────┘  └─────────┘  └──────────┘  └──────────┘
                       │                      │                                                  KINESCOPE
  ┌──────┐  ┌──────────┐  ┌──────────┐  ┌────────────┐  ┌──────────┐  ┌──────────┐
  │ ANT. │→ │  V-1     │→ │  V-2     │→ │ V-9,V-10&V-11│→│  V-12A   │→ │  V-13    │
  │      │  │  R-F     │  │CONVERTER │  │1ST,2ND&3RD  │  │ 2ND DET. │  │1ST & 2ND │
  │      │  │ AMPLIFIER│  │          │  │ PIX. I-F    │  │          │  │VIDEO AMP.│
  └──────┘  └──────────┘  └──────────┘  └────────────┘  └──────────┘  └──────────┘
                                        ┌──────────┐  ┌──────────┐  ┌──────────┐
                                        │ V-12B    │→ │ V-14     │→ │ V-16     │
                                        │ LIMITER  │  │SYNC.AMP.&│  │SYNC.HORIZ│
                                        │          │  │SEPARATOR │  │GUIDE OSC.│
                                        └──────────┘  └──────────┘  └──────────┘
                                        ┌──────────┐  ┌──────────┐  ┌──────────┐
                                        │ T-8      │→ │ V-17     │→ │ V-19     │
                                        │HORIZ.OUT.│  │ HORIZ.   │  │ DAMPER   │
                                        │&H.V.TRANS│  │ OUTPUT   │  │          │
                                        └──────────┘  └──────────┘  └──────────┘
          ┌──────────────┐  ┌──────────────┐  ┌──────────┐
          │C-81 & C-82   │→ │ V-15         │  │ V-18     │
          │R-92,R-94&R-95│  │VERT.OSC. VERT│  │H.V.RECT. │
          │ INTEGRATOR   │  │&DISCH. OUTPUT│  │          │
          └──────────────┘  └──────────────┘  └──────────┘
```

Another block diagram of separate I.F. type set.

As you can see in the block diagram applicable to sets using separate channel I.F. systems, the signal from the antenna is handled in the R.F. tuner section and selection of the wanted channel is made with the tuning control. It is clear, therefore, that if a fault detected exists on more than one channel, this section is probably not at fault. The R.F. section is probably at fault if only a single channel of several gives poor reception. The remaining sections handle the signals from all channels identically and should be suspected if the fault exists on more than one of the channels in your area.

In the separate channel I.F. sets we are discussing, separate I.F. signals are produced for sound and video, and the sound section handles only that portion of the signal that results in audio output. You can understand that if sound reception is acceptable, no fault exists in this section. On the other hand, if the picture is correct but sound is poor or missing entirely the fault must lie in one of the stages of the sound section. In such circumstances, tubes in the sound section may be tested and replaced and, in general, the repair needed will be in that section. This section is similar to FM type radios and you may have had some experience with such circuits in your radio work.

The I.F. used for video may be in the 25 MC. or 40 MC. range and is amplified by a number of stages designed and adjusted for wide band response. Between these various stages, and the video detector follow-

SOUND SECTION

| 1st SOUND IF | 2nd SOUND IF | SOUND DET | 1st AUDIO | AUDIO OUTPUT |

RF SECTION

| RF AMP | CONV. |

| OSC |

VIDEO SECTION

| 1st VIDEO IF | 2nd VIDEO IF | 3rd VIDEO IF | VIDEO DET | VIDEO AMP | VIDEO OUTPUT |

| SYNC SEP |

| DC REST. |

| LV POWER |

SWEEP SECTION

| V OSC | V. OUT |

| AFC | H. OSC | H. OUT | HV POWER |

INTERCARRIER IF SYSTEM
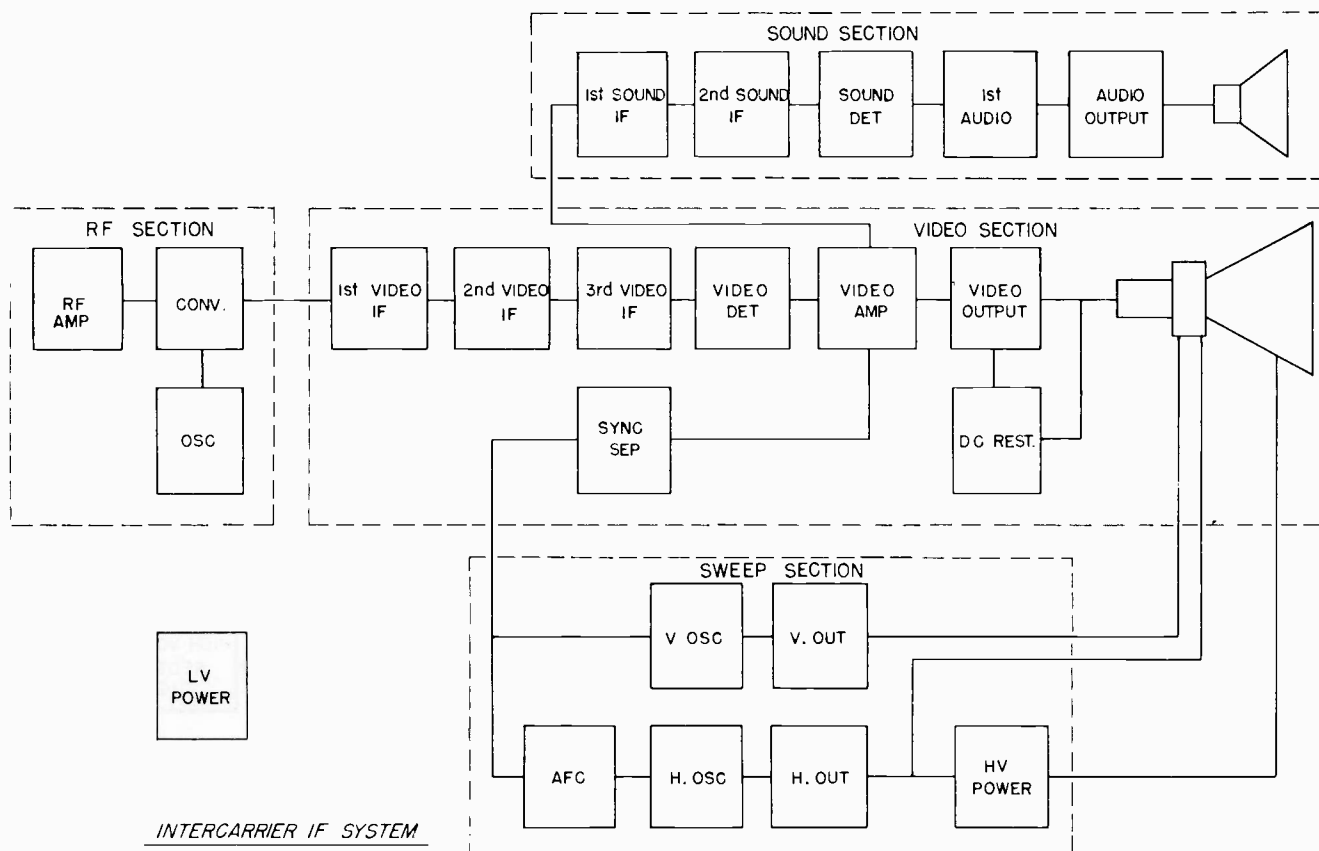
ing, there may be a number of traps to eliminate undesirable signals. The video detector is followed by a video amplifier and output stage that correspond in function to audio stages in radio sets but reproduce a much wider band of frequencies, up to 4 MC. in good sets.

From the video amplifier synchronizing (sync) signals are selected and separated to serve vertical sweep and horizontal sweep stages. Special circuits such as AFC and AGC as well as the high voltage power supply are related to the horizontal sync circuits. The low voltage power supply is used for filaments and low voltage B+ needs.

We will now review the passage of the signal through an intercarrier type set and then consider various faults observable on the screen and analyze them in terms of tubes causing these faults.

The primary difference between the two types of circuits we are considering and which are used in commercial television, rests on the design of the inter-carrier set to utilize the 4.5 MC separation between the video and audio carrier in any one television channel. With this method both video and audio are amplified through the initial video I.F. stages and separated at a later point. Therefore, in this type of set certain faults in sound or picture must be considered with the realization that besides the R.F. section other stages are handling both video and audio.
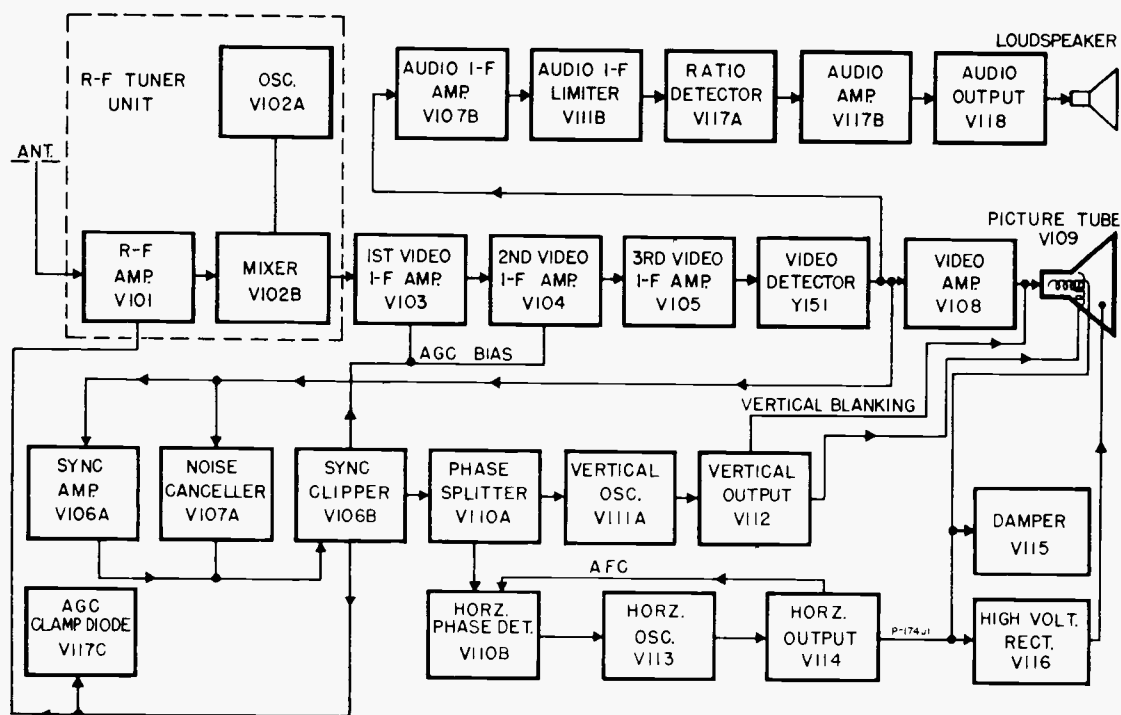
Block Diagram of a Recent Intercarrier Receiver

In a later lesson we are going to study the make-up of a television signal and the handling of this signal in the set to produce a satisfactory picture. At this time, you as a radio man can probably understand the basic function of all circuits except for the sweep section which does not correspond in any way to ordinary radio circuits. In the transmitted signal there are superimposed at specific intervals extra sync signals. These control the television set operation and cause the picture tube electron beam to move in the proper sequence to reconstruct the original picture. Besides the sweeping of the beam, its intensity is also controlled by the video signal and is completely blacked out during the intervals when the sync pulses retrace to start of a new line or return the sweep from bottom to top. This action is similar to that which takes place in an oscilloscope but is more complex in nature. It is not hard to see, for example, that if there were no vertical sweep moving the lines in step from top to bottom, all lines swept horizontally would be in one position and would result in a single bright horizontal line.

The fault we have just considered is quite common and is generally due to a defective vertical oscillator tube or vertical output tube. Of course, associated parts may also be the reason for this trouble but in this lesson we are considering only tubes.

The remedy is to replace one or both of these tubes and observe if the set operates properly. To find the position of such tubes a top

DU MONT

TUBE LOCATION RA-109 A

12AU7. IST. SOUND AMP. &
2ND. SOUND AMP.

6AL7-GT TUNING INDICATOR

6AB4 V.H.F. OSCILLATOR

6BC5 MIXER

6V6-GT/G 3RD. SOUND AMP.

6J6 R.F. AMP.

6AL5 SOUND DISCRIMINATOR

6AU6 3RD. SOUND I.F.
6AU6 2ND. SOUND I.F.
6AU6 IST. SOUND I.F.

6AU6 IST. VIDEO I.F.

6AU6 2ND. VIDEO I.F.

6AL5 VIDEO DETECTOR &
D.C. RESTORER

6BA6 IST. VIDEO AMP.

6AQ5 2ND. VIDEO AMP.

5U4G RECTIFIER

5U4G RECTIFIER

6SN7-GT SYNC. AMP. & VERT. SAW GENERATOR

6SN7-GT VERT. SWEEP AMP.

19AP4 C.R.T.

6AU6 3RD. VIDEO I.F.

6BC5 4TH. VIDEO I.F.

6BA6 AMP.

6AL5 A.G.C. & SYNC. DETECTOR

6AU6 SYNC. CLIPPER

6W4-GT DAMPER

6W4-GT DAMPER

6AL5 SYNC. DISCRIMINATOR

6AG5 REACTANCE TUBE

IX2 H.V. RECTIFIER

IX2 H.V. RECTIFIER

6BG6-GT HOR. SWEEP AMP.

6BG6-GT HOR. SWEEP AMP.

6AK6 HOR. OSCILLATOR

6SN7-GT. HOR. SAW MAKER
& A.G.C. CLAMP

ION TRAP MAGNET

view diagram is helpful. If this is not available, a schemetic diagram will tell you the types of tubes used and you then will be able to find them in the actual set. Helpful service material can be secured in the manuals issued by Supreme Publications and an index to all sets covered will be sent to you postpaid for 25¢. A number of top view drawings of popular sets are published here to suggest to you the gen-eral method for locating suspected stages and associated tubes. Quite often types 6J5, 6SN7, 12AU7, or 12SN7 are used as vertical oscillator tubes. As the vertical output tubes, types such as 6K6, 6S4, 6V6, 6W4, and 12AU7 are used.

From similar reasoning you can understand that a thin bright verti-cal line, in the center of the screen, present when the set is tuned to a station or even set to a channel not transmitting in your area, would be due to the failure of the horizontal sweep. There would be no sweep from left to right, and all elements would be in one place adding up to a vertical line. In the majority of sets, however, the high voltage power supply is associated with the horizontal sync circuits and a fail-ure in the horizontal sync stages may eliminate the high voltage com-pletely so that no picture or raster will be secured.
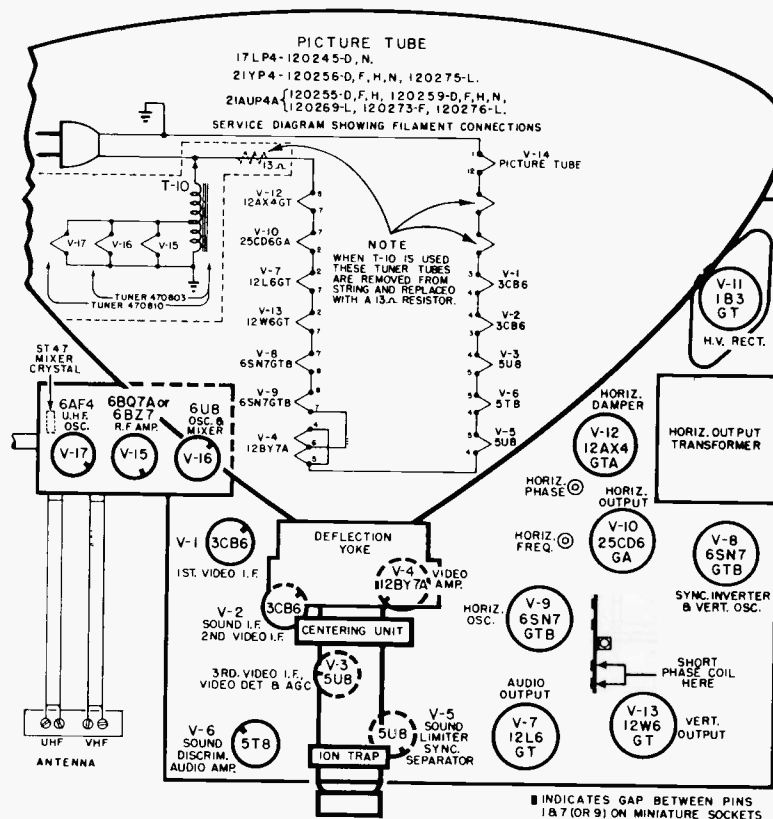
Tube location diagram of a recent Emerson receiver.

Many troubles observed as wavy appearance of the picture and raster in the vertical direction are due to hum being present in the sweep circuit and producing 60-cycle or 120-cycle modulation. Cathode to heater leakage in a tube is usually responsible and this fault should first be suspected in the horizontal oscillator and output tubes.

Again we want to remind you that many faults observed can be corrected by simple front panel or rear adjustments and these should be attempted first of all. There are situations when the regular horizontal sync adjustment will not stop the breaking up of the picture into a series of slant lines and areas. In such cases an adjustment of horizontal oscillator will be needed. This adjustment is not the same in all sets and several typical processes suggested for popular sets are printed on the adjacent page.

Dark shadows in one or more corners are due to poor adjustment of the ion trap or incorrect placement of the deflection yoke or focus

Horizontal Hold Adjustment in Typical Sets

Motorola

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).

3. Remove short 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.

Sentinel

HORIZONTAL HOLD CONTROL ADJUSTMENT

The setting of the **Horizontal Hold Control** is very important. Improper setting will result in fold over on the left hand side of the picture—this will show up either as a white > pointing in towards the center of the picture or a faint milky area extending between the left hand edge and center of the picture, the extent of the area covered depending upon the setting of the Horizontal Hold Control.

TO SET THE HORIZONTAL HOLD CONTROL PROPERLY:

1. Turn the **HORIZONTAL CENTERING CONTROL** until the left hand edge of the picture becomes visible.

2. Adjust the HORIZONTAL HOLD CONTROL to the point where the fold over just disappears. If the extreme top of the picture starts bending or jitter is noticed then adjust **HORIZONTAL HOLD CONTROL** for minimum fold over with acceptable stability. To find this setting it may be necessary to readjust the **HORIZONTAL LOCK CONTROL** located on top of the chassis and in front of the High Voltage compartment. See pages 4 and 5.

3. Center picture with **HORIZONTAL CENTERING CONTROL—DO NOT USE THE HORIZONTAL HOLD CONTROL TO CENTER PICTURE.**

Montgomery Ward

Horizontal Hold Control

The horizontal hold control is located on the rear flange of the chassis and should be adjusted in the following manner.

Set the picture control to its normal operating position. Turn the thumb screw clockwise until it reaches its stop. Turn two complete turns counter-clockwise. The thumb screw is a vernier adjustment and will then be in the center of its range.

Turn the iron core with a small screwdriver or adjusting tool until the picture is steady (no horizontal movement). Set the core to the middle of its range.

After the iron core has been properly adjusted the thumb screw should then be used as a vernier adjustment to control synchronization when necessary.

Garod-Majestic

HORIZONTAL A. F. C.

If difficulty is encountered in locking-in the picture horizontally, or if it locks-in at the end of rotation for the HORIZONTAL HOLD control, adjust the horizontal A. F. C. control as follows:

1. Turn CONTRAST down about half way.

2. Turn HORIZONTAL HOLD control to approximately center of rotation.

3. Adjust HORIZONTAL A. F. C. control so that picture locks-in evenly on either side of rotation of the HORIZONTAL HOLD control.

This material is applicable to many other sets of different makes.
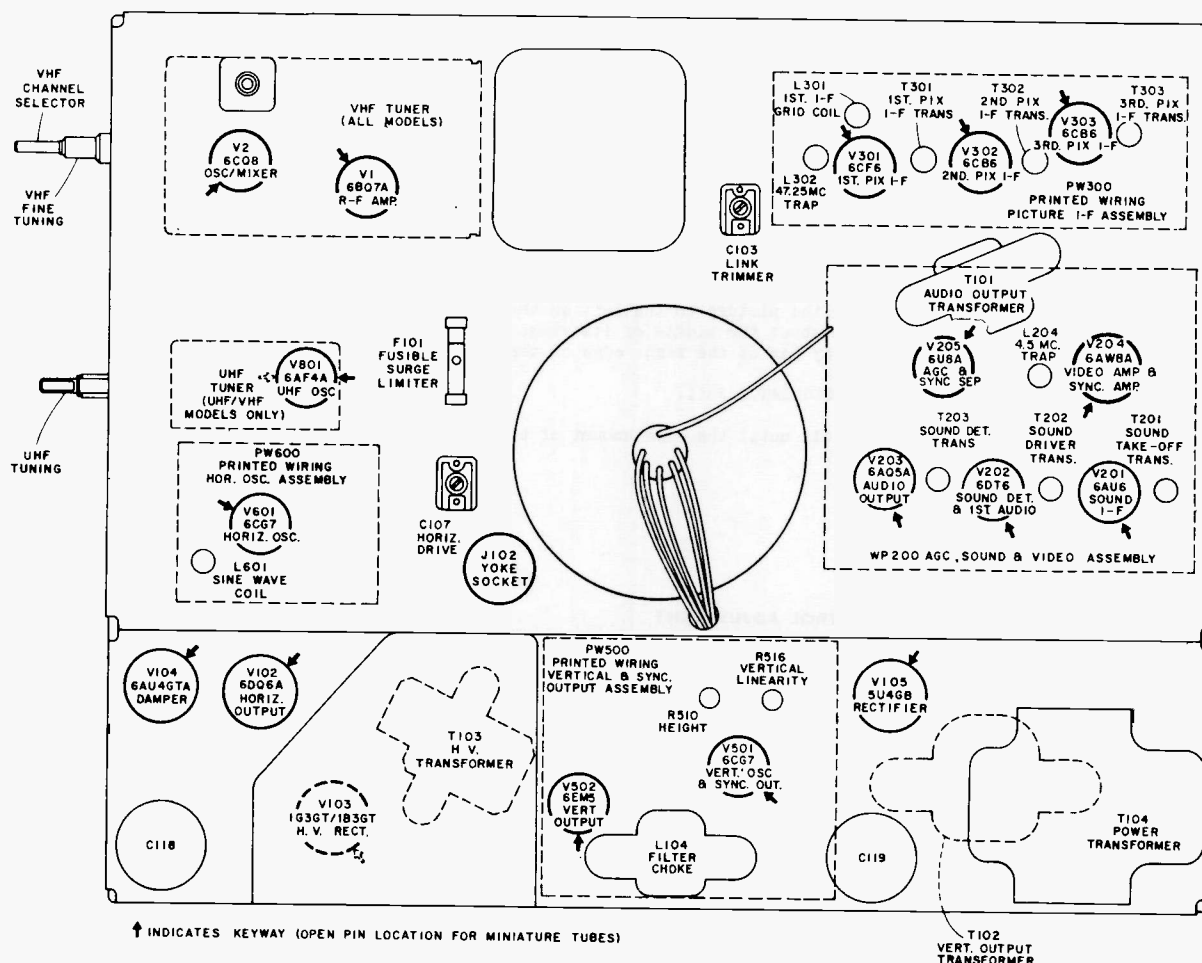
View of a RCA Victor set showing location and function of tubes.

assembly. The yoke and focus coil should be concentric with the neck of the picture tube and the deflection yoke should be close to the bell (flare) of the tube not to produce shadows.

In some sets that operate properly you may find that a single bright spot remains for a long time after the set is shut off. There are ways, of course, to change the circuit so that the high voltage filter condensers do not hold their charge after the set is shut off. This trouble is due to poor design in some of the lower priced sets. A stationery spot lasting over a period of time may injure the face of the picture tube by burning the flourescent material. You might suggest to the owners of such sets that by turning the brightness control to maximum an instant before the set is turned off may help. In some sets turning down brightness and contrast to minimum before shutting off may reduce this trouble.

In case a microphonic tube exists in a TV set, it may respond to audio output and distort the picture because of audio vibrations. This

fault will change in intensity with an adjustment of the audio volume control, and this is the test to use. It is more likely that the tubes causing this trouble are in the video section but others in the I.F. may be responsible. And sometimes tightening the screws holding the loudspeaker in place may help.

In case vertical movement cannot be stopped with the vertical hold control it is advisable to replace the vertical oscillator tube at first. Types such as 6C4, 6J5, 6SN7, and similar tubes in the 12-volt series are used in this application.

If the picture appears to be in reverse tones (known as a negative picture), and the contrast control is not advanced too far, anyone of a number of different tubes could be the cause. If the set uses AGC, the tube associated with this circuit should be suspected. At times the AGC adjustment is incorrectly set for conditions existing. This may be due to the owner moving from one part of the city to another or changing from an indoor to an outdoor aerial.

If this fault develops on a single channel, it may be that that particular channel has too strong a signal. Steps may be taken to wire in a resistor network and a switch to reduce the signal strength of that particular channel and not of others. Also the antenna may be adjusted to favor the other stations.

Negative picture may also be produced by defective video I.F. tube, video detector tube, or a video amplifier tube.

Some times the picture appears very dark with poor contrast between the light and dark areas. In this case the trouble may also be due to poor contrast adjustment or circuit fault, but it is worth while to replace the AGC tube if used in the set.

If the picture cannot be adjusted by means of the front controls and remains in a split position so that part of the right half of the picture is on the left side, an attempt should be made to adjust phase control if such an adjustment is provided. Replacement of AFC tube may also correct this fault.

In case the set you are servicing expands the center portion of the picture in a manner that is accomplished in some sets with a zooming feature, the trouble is usually due to reduction of high voltage being applied to the picture tube. This is often caused by a defective high voltage rectifier tube or damper tube. These tubes and their circuits are located inside of a metal container and the safety precautions,

called to your attention at the end of the lesson, should be followed in replacing these tubes. The high voltage rectifier usually has a grid cap connection and may be of one of the following types: 1B3, 1B2, 1X2, and 8016. For the damper tube, types 6W4, 25W4, 5V4G are used.

The contrary trouble to the one we just discussed is a picture dwarfed both horizontally and vertically. This being the opposite to the fault we just considered, it is due to the excessive high voltage or improper yoke placement. First make certain that the yoke is as close as possible to the bell (widening out part) of the picture tube.

Here again the fault may be due to the high voltage rectifier tube, damper tube, or the horizontal discharge tube.

In case there is present a vertical line or several lines at the left of the picture and this is followed by a bright area, and the same results can be secured when the set is tuned to a blank channel to receive a raster, the trouble is caused by oscillations set up in the horizontal output tube and picked up by the R.F. tuner. It is possible that this fault will be corrected by the simple replacement of the horizontal output tube.

Once again we want to call your attention that some of the faults illustrated in previous lessons and which are normally corrected by front or rear adjustments may also be due to a faulty tube or a defect in one of the circuits. For example, if adjustment of the horizontal drive control and the width control still do not produce sufficient width for the picture to fill the screen, the fault may be due to a defective low voltage rectifier. The line voltage should also be measured and if considerably under 115 volts should be assumed to be the cause of shrinking. A suitable transformer can be used to step up the line voltage to correct value. Low price auto-transformers are sold for this purpose.

Incandescent Lamp Interference. Printed through the courtesy of DuMont Laboratories.
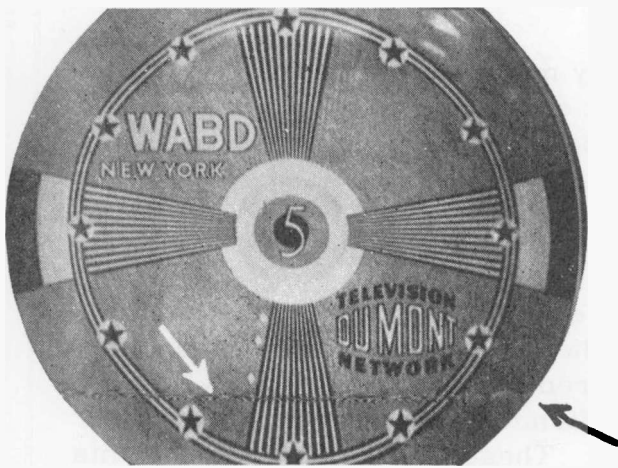
Test pattern showing interference caused by incandescent lamp.
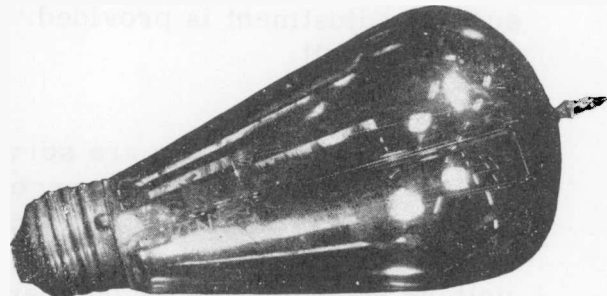
Old type B bulb, one of the types which produces the interference shown.

Width shrinkage may also be produced by horizontal output, horizontal discharge, or damper tubes. These tubes may also cause fold over on both sides. With so many faults due to bad tubes and majority of sets using identical types for similar applications, it is wise to carry in your tool kit one tube of each type mentioned in this lesson as sources of faults. This practice will permit you to complete the repair in one call instead of going to the shop for needed tubes.

In case the picture is absent completely, it is important to determine if at least the raster can be secured. If both picture and raster are missing, and sound is also absent, look for broken wire in power cord, blown fuse in set or in house circuit, interlock switch not being closed, combination sets not correctly set for TV operation, defective on-off switch, bad low voltage rectifier, or defective power transformer. In case the raster is secured but picture and sound are missing, the AGC amplifier tube (may be type 6AU6) is probably at fault.

In case picture and raster are missing, but sound is normal, the trouble may be due to poor ion trap adjustment or failure of the high voltage supply. Since the high voltage can be measured at the picture tube connection without removing the chassis from the cabinet, if you have a voltmeter with a high voltage probe than a test can be made to ascertain this fact.

In removing tubes for examination or replacement, it is advisable to have the set turned off. When working on tubes near the high voltage supply, for added safety disconnect the cord from the wall outlet. The high voltage section is usually enclosed in a perforated metal compartment and these precautions should be taken before working inside this container. Since the high voltage condensers keep their charge for a period of time after the set is shut off, these condensers should be discharged by means of a length of insulated wire used to short the condenser terminal to chassis ground. A long blade screw driver can be used for this purpose. Keep your hand on insulated part. Whenever possible use only one hand near the set. Certain types of picture tubes have their outside bell at high potential or may have an external metal cone at high voltage. Since these surfaces act as capacitors, they too must be discharged for safety reasons.

From your radio service experiences you probably have learned correct proceedure for working with high voltage and this should be applied without a single exception to your work in television. As an additional precaution, you should keep in mind that the picture tube is under extremely high pressure from the outside air because of its vacuum. When the picture tube itself must be handled or removed, heavy gloves and protective type goggles should be employed.

LESSON 4

ANTENNA PRINCIPLES AND PRACTICES

It is necessary to understand the behavior of the transmitted signal and its effect on various types of receiving antennas to solve many problems that come up in installing and servicing such antennas. This is why you should take time to follow the explanation of the behavior of the transmitted signal for this knowledge will pay real dividends when you are doing actual work.

The material on the transmitted signal and factors in selecting the right antenna are taken in part from a film and circular on the subject issued by American Phenolic Corporation, manufacturers of Amphenol products, and is printed with their permission.

A television transmitter radiates electro-magnetic waves in all directions. Depending on the design of the antenna, the waves form a pattern of lobes of power -- more power going out in some directions than others. Such antennas are designed to reduce lobes pointing upwards which would be lost in the atmosphere. In general, attempts are made in transmitting antenna design to direct the energy into the areas of TV set concentration.

Because the space wave travels in the atmosphere and is affected by buildings, trees, and other physical objects, we must consider these effects. Attenuation is the wave's loss of strength as it travels through the air and contacts physical items. As with radio stations, distance reduces the strength of the signal. This is more pronounced with the higher frequencies used in television transmission.

Refraction occurs when a wave enters a lighter or denser medium at an angle. This is a bending effect. It depends on the difference in density and the frequencies involved. Refraction can change the direction of waves (and reception quality) because of clouds, rain, or just temperature changes in the atmosphere.

The television stations that existed for some time and some of the newer ones are assigned channels 2 to 13, and the band of frequencies so used are called VHF (very high frequencies). Many of the newer TV stations are assigned new channels 14 to 83, using much higher frequencies that are called UHF (ultra high frequencies). These bands require different types of antennas as we will discuss later, but now it is important for you to realize that VHF, because of refraction, does

curve slightly beyond the horison and reception is possible beyond the line-of-sight.

UHF transmission, on the other hand, is almost completely line-of-sight, almost like a beam of light. There is practically no bending to reach points beyond the horizon. Therefore, in UHF antenna installations, the antenna must be mounted progressively higher as the distance from the transmitter becomes greater. In VHF antenna installations, however, because of the effect of refraction, it is not usually necessary to mount the antenna as high as is needed in UHF.

The effect of diffraction is similar to refraction except that it is caused by a solid object. When a wave passes the edge of solid object, it tends to split up, with part of it bending around the solid. Tall buildings produce this effect. You get more diffraction with a low frequency wave than you do with a high, so this action is important in VHF. Except for diffraction, so called shadow areas would receive little or no TV signals in VHF band. Shadow areas receive little benefit from diffraction in the case of UHF signals.

When a wave strikes any solid object which is at least one-half the wave length of the TV signal, reflection occurs. Because the UHF wave length is shorter than VHF, and there are many more smaller objects than big ones, there is more reflection with UHF than VHF. But in UHF or VHF you don't get just one wave, but an infinite number of waves, direct and reflected. Sometimes only reflected waves are accessible to a certain location. Reflection can also be caused by transmission line mismatch at the receiver.

DIRECT WAVES

TELEVISION TRANSMITTING
STATION

UNDESIRED
REFLECTED WAVE

DESIRED WAVE

TELEVISION RECEIVER
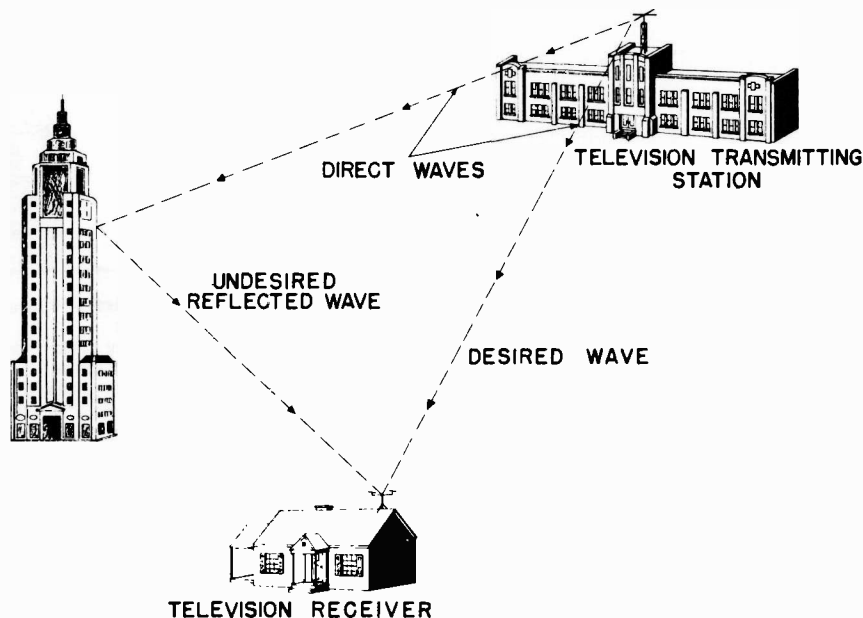
Using just two waves for example, one direct and one reflected, the reflected wave must travel a greater distance and will arrive at the antenna later than the direct signal. See the illustration on previous page. If both signals are received, a ghost image will result. How ghosts are formed is explained below. Two or more reflected waves may arrive at different times, causing a weak and fuzzy picture because they tend to cancel each other out. Signals arriving at the antenna at different times are said to be "out of phase."

When two television signals arrive at the antenna at the same time, as in the case of a direct wave refracted by the upper atmosphere and a ground reflected wave, they are then said to be "in phase." Phasing or placement of the antenna to receive two or more waves simultaneously is extremely important to clear, bright TV reception for when waves arrive in phase they reinforce each other.

We have stated that reflection can produce on the screen the main image plus one or more ghosts. Usually only one noticeable ghost is present. Such a double image is the result of simultaneous reception of a signal over two paths wherein a slightly greater time is required for the travel over one path than is required for travel over another.

In view of the tremendous velocity of the propagated wave, it may appear that the time of travel over one path would be, in comparison to the time taken over another, not very important unless

Belden transmission line cables
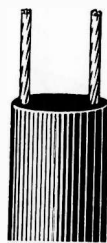
20 A.W.G.

7x28 **stranded** "Weldohm" copper coated steel wire
2 conductors parallel
Brown polyethylene plastic insulation
.072"x.400" Nom. Diam
Nom. Attenuation —
    1.1 db/100 ft at 100 mc
    1.7 db/100 ft at 200 mc
    2.2 db/100 ft at 300 mc
    2.7 db/100 ft at 400 mc
Nom. Impedance — 300 ohms
Velocity of propagation — 85%
Nom. Capacitance — 4.6 mmf/ft

7x28 **stranded** "Weldohm" copper coated steel wire
2 conductors parallel
Brown polyethylene plastic insulation
.185"x.520" Nom. Diam
Nom. Attenuation —
    1.1 db/100 ft at 100 mc
    1.73 db/100 ft at 200 mc
    2.28 db/100 ft at 300 mc
    2.74 db/100 ft at 400 mc
    3.18 db/100 ft at 500 mc
    3.7 db/100 ft at 700 mc
    4.5 db/100 ft at 900 mc
Nom. Impedance — 300 ohms
Velocity of propagation — 77%
Nom. Capacitance — 5.0 mmf/ft

7x28 **stranded** — 1 bare — 1 tinned copper conductor
Polyethylene plastic insulation
2 conductors cabled:
Polyethylene plastic jacket
Tinned copper braid **shield**
Black vinyl plastic jacket
.325" Nom. Diam
Nom. Attenuation —
    4.1 db/100 ft at 100 mc
    6.4 db/100 ft at 200 mc
    8.4 db/100 ft at 300 mc
    10.2 db/100 ft at 400 mc
Nom. Impedance — 100 ohms
Velocity of propagation — 62%
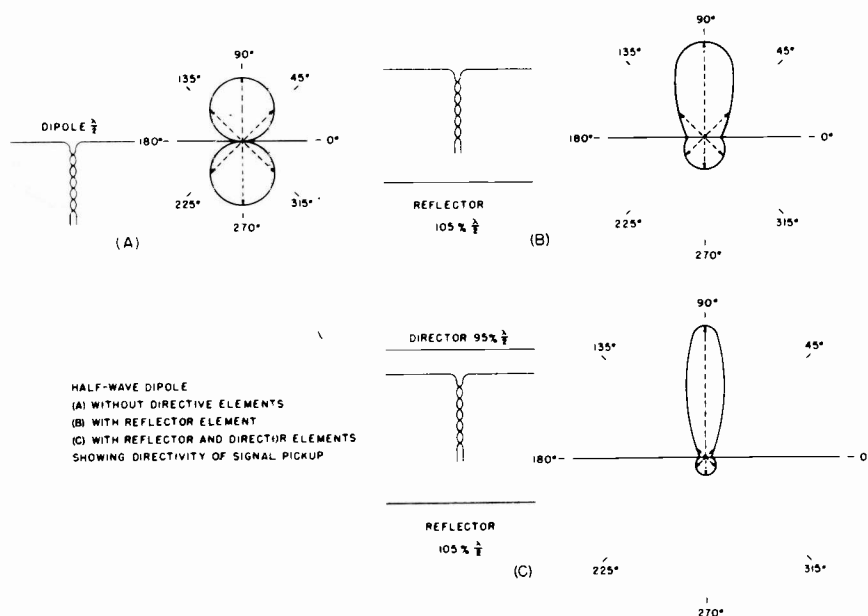Nom. Capacitance — 15.5 mmf/ft between conductors

large. But because the scanning spot of the picture tube also trav-
els at high speed, this is not true, and a path difference of 200 feet
can be seen as a definite ghost. Even a difference of 70 feet will
be noticed as a fuzzy picture. The solution to this problem is dis-
crimination against the unwanted signal and will be explained in
connection with the study of antenna types.

We have already noted the effects of interference in studying
picture faults. Electrical equipment, airplane and auto ignitions,
etc., can transmit wave energy, too. These waves sometimes
interfere with TV signals of lower frequencies so interference can
be a problem in VHF. A UHF signal, on the other hand, is so
much shorter than the wave length of the interference that it is
seldom a problem to good television picture reception.

All of these factors: interference, attenuation, refraction,
diffraction, and reflection can affect the quality of the picture on
the TV set. Your knowledge of these can mean either good recep-
tion or poor reception and each factor will have to be considered
in selecting and installing the antenna for each type of location.

It is helpful to understand some basic facts of a simple dipole
antenna and this we reprint below from "Farnsworth TV Handbook"
with the permission of Farnsworth Television & Radio Corp.

Figure (a) shows the field pattern of a half-wave dipole, sensi-
tivity of signal pick-up varying as the length of the radius vector
— the dashed lines shown extending from the center to any given
point on the radiation pattern.

HALF-WAVE DIPOLE
(A) WITHOUT DIRECTIVE ELEMENTS
(B) WITH REFLECTOR ELEMENT
(C) WITH REFLECTOR AND DIRECTOR ELEMENTS
SHOWING DIRECTIVITY OF SIGNAL PICKUP

Thus the greatest signal pickup is seen to be when the antenna
is broadside to the transmitter, zero when in line with the trans-
mitter. Also, note that the signal dipole is a bi-directional device,
receiving equally as well from either the forward or the backward
direction. The impedance of half-wave dipole at resonance is about
73 ohms. This value changes for other frequencies and for other
size (in terms of wavelength) antennas.

The second antenna type, figure (b), is the dipole with the ad-
dition of a second element which causes accentuated signal pickup
in one direction. Addition of the second element is here shown to
be a reflector, causing the accentuated pickup to be on the opposite
side. By slight modification of its length, it could be caused to be
a director in which case the directivity pattern would be reversed,
accentuation toward the side of the added element.

Part (c) shows a combination of reflector and director, the
effect of the two being additive to further increase the signal ener-
gy pickup of the antenna. Note that the pattern of directivity has
been made unidirectional; signal pickup is now from one direction
only, to the rejection of all others. The pattern also has become
quite elongated, indicating, as shown by the length of the dashed
lines, greater signal "sensitivity." The angle of pickup has been
narrowed, necessitating careful orientation of the antenna. Such
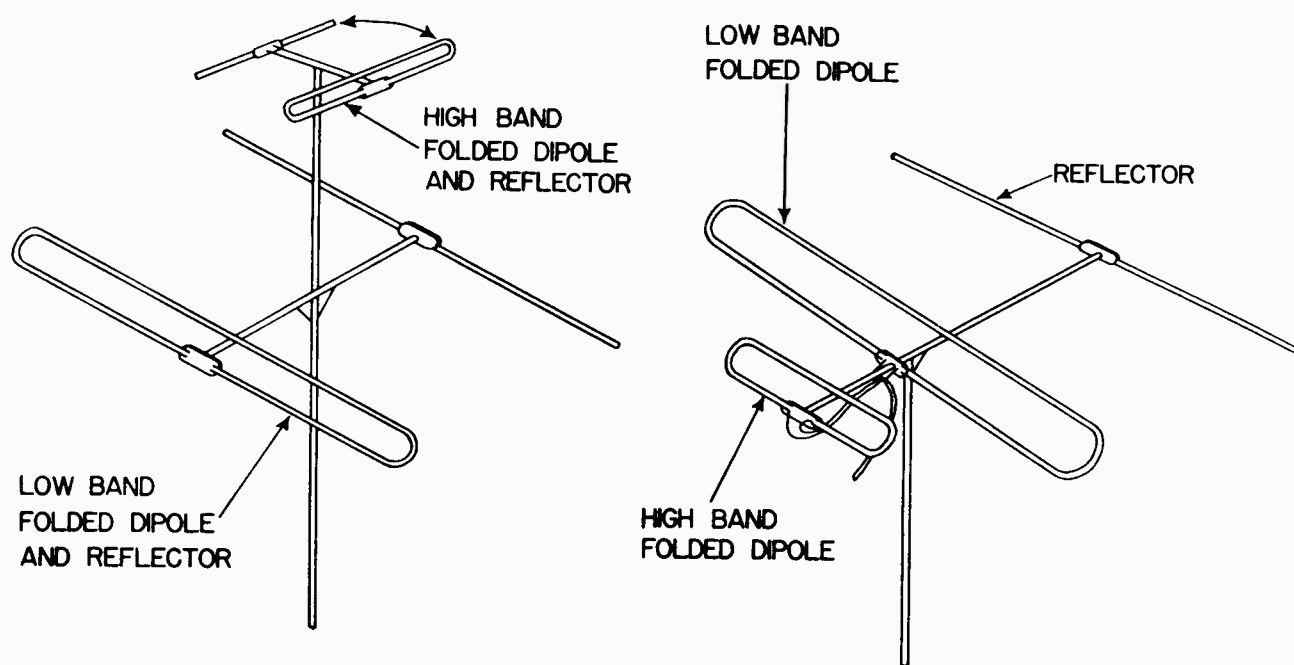
increase is usually considered as a power gain expressed in decibels, the decibel being a power (energy) ratio. It indicates that the signal energy delivered to the receiver has been increased just as though the radiated power from the transmitter had been increased.

A second modification of the dipole antenna which may be employed in the reception of television signals is the folded dipole, illustrated in the figure. It consists of a pair of closely-spaced (2 or 3 inches apart), parallel rods to which is attached the transmission line which feeds the receiver. Since the center of the shorting bar or rod always has zero potential, this point may be grounded to the metal mast by its supporting member. The directional characteristics of the folded dipole are essentially the same as those of the conventional dipole. Its impedance, however, is four times as great. Therefore, a transmission line having impedance of 300 ohms is used with the folded dipole antenna.

Let us now consider factors important in selecting the right antenna. Since you cannot control wave effects or installation location, it is necessary to use extreme care in picking an antenna. Gain is one consideration. This is determined by comparing the power developed by the antenna at each frequency with that of folded dipoles cut to the same frequencies. The folded dipole gain is considered to be 0 db and the gain of the antenna is recorded by the number of db's it develops against that of the tuned dipoles for each frequency.

DB gain figures put into graph form, give the gain curve of the antenna. Negative gain means it intercepts less signal voltage than the tuned dipole — positive gain is the number of db's it develops over the number developed by the tuned dipole. Whether it's VHF or UHF, you want fairly level gain across the channels in your area. In selecting an antenna, then, two requirements are high gain and the ability to cover the channels assigned to your area.

Just as the transmitting antenna has a radiation pattern, every receiving antenna has a response pattern. The lobes represent the areas in which the antenna is sensitive to signals at a particular frequency — so the pattern is different at every frequency. Response patterns are shown in graph form, which is a horizontal cross section of the pattern at one frequency. The antenna is aimed toward zero degrees. Distance from the center represents relative field strength in that direction.

From the relative field strength of the lobes shown in a response graph, front-to-back and front-to-side ratios can be determined. That is, the amount of energy picked up in the front or major lobes
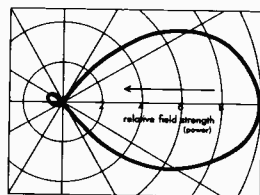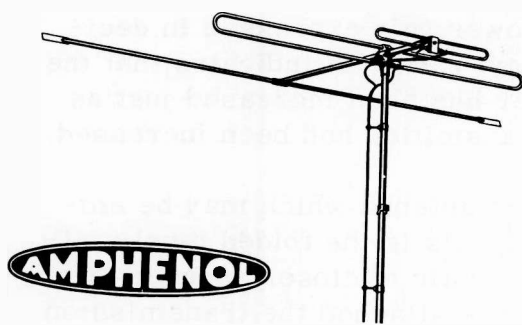
low band

high band

66 mc   **194 mc**
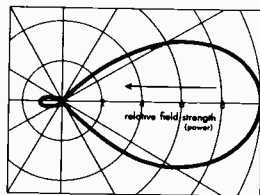
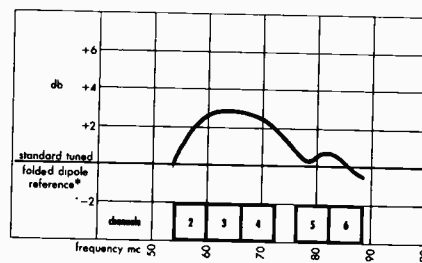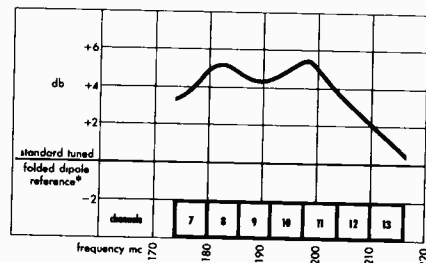*Measured in accordance with current RETMA standards.

compared to the energy picked up at the back or sides. Normally, you want one good major lobe, and minor small lobes, for good directivity. The antenna can be pointed toward the best TV signal with less chance of intercepting reflections or man-made interference.

Beam width is another important point to consider in response patterns. It is the width of the major lobe of the half-power point, or the widest part. With an extremely wide beam, the antenna is sensitive to television signals from many different directions even though there may be only one major lobe and the minor lobes are small. Although this might make for better picture reception in some areas, in others a narrower beam width might be desired.

On the other hand, even though an extremely narrow lobe might pick up the one best signal and reject all others under ideal conditions, weather changes may refract the wave enough so the narrow lobe won't intercept it. In UHF with less refraction, narrow beams are effective. Since the pattern of an antenna is different for each frequency, the antenna selected should have good response patterns — not too wide or too narrow, in the channels assigned to your area.

Besides its electrical characteristics — gain, broad-banding ability, response patterns at the frequencies of the channels in your area — the mechanical characteristics of the antenna under consideration should be noted. It should be able to withstand wind, ice loadings, rust and corrosion — should have sturdily reinforced elements and quality construction.

The basic antenna types commercially available are described and illustrated to help you in selecting the type needed for any one installation.
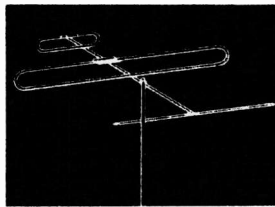
Single Folded Inline
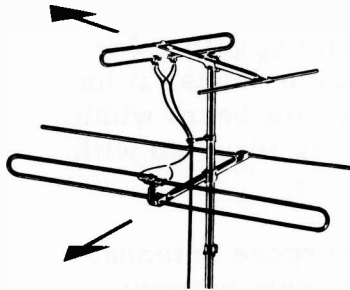
The Inline is still the outstanding array for VHF reception. Its gain curve shows good gain across all channels, with increased gain in the high band to allow for the greater attenuation at higher frequencies. The response pattern has an unusually good major lobe with a negligible back lobe. The patterns on all frequencies are exceptionally uniform and beam widths are narrow enough for good directivity, yet wide enough to pick up signals at different frequencies from the same general direction.

Stacked Folded Inline

The Inline is also available as a stacked array, or a single bay can be converted to a stacked array in the field. With a two-bay Inline, over-all gain is increased on average of 2 DB for greater signal strength in suburban, rural, and fringe areas. All of the desirable characteristics of the single-bay Inline are retained and the response pattern is very much the same except the beam width is a little narrower.

Piggy-back type is used for VHF and has separate dipoles and reflectors for high and low bands. This permits dipoles to be oriented separately for reception from two different directions.
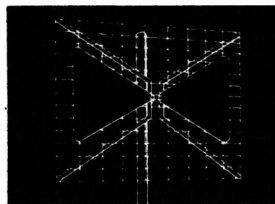
Single Bow Tie and Screen

The Bow Tie with a relector is a variation of the simple dipole, with triangular sheets of metal instead of rods. Its gain curve ranges from 6 to 8 DB over the entire UHF band for which it is used. This gain, plus its uni-directional response pattern, makes it ideal for installation in areas troubled with reflections as well as providing efficient operation in both major and weak signal areas. For added gain in fringe areas, two Bow Ties may be stacked.
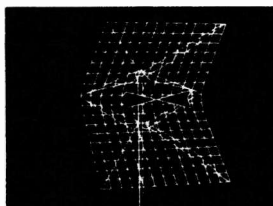
Single Corner Reflector

The Corner Reflector might be called a variation of the Bow Tie. A corner angle of 90° with a similar bend in the driven element is used. Its gain curve indicates another broadbanded antenna with very good gain ranging from 8 to nearly 13 DB.
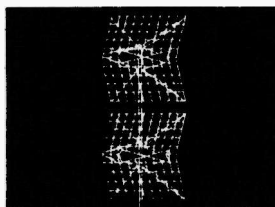
Stacked Corner Reflector
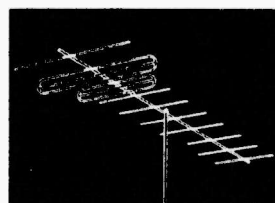
Single High or Low Band Yagi
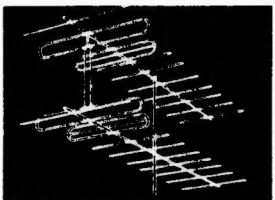
Stacked High or Low Band Yagi
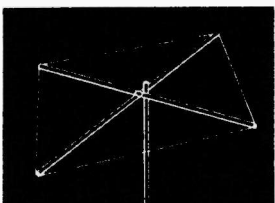
Rhombic
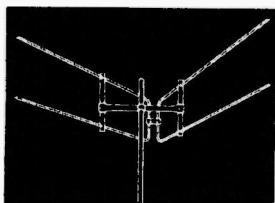
Dual Vee

It has but one major response lobe typical of most frequencies, with narrower beam width which means high directivity and excellent rejection of unwanted signals. The Corner Reflector receives all UHF channels, 14 to 83.

The Yogi, a familiar array for certain VHF applications, has been redesigned for similar UHF applications. The Amphenol Yogi is a six-element wide spaced array consisting of four directors with a driven element and a reflector. The Yogi is designed to be used for a particular frequency range. Bandwidths covered by a series of Yogi antennas vary from about four channels at the low end to about eight up around 900 megacycles. The Yogi has fine directional response and very small minor lobes.

The Rhombic, an antenna type used for VHF but better suited for UHF, is a broadbanded antenna with from over 6 to almost 14 DB gain, increasing with frequency. The higher frequencies are subject to greater attenuation but this is compensated for by the Rhombic's rising gain. Although the Rhombic has some minor lobes, it has a good major lobe with fairly narrow beam width. It is particularly effective in areas troubled with ground reflections.

The Stacked-V is a multi-purpose antenna, its application depending on the angle between the elements. At a 50° angle, it is a broadbanded UHF antenna with increasing gain from over 6 to nearly 11 DB. If the angle is increased to 70°, the array will receive both UHF and VHF with good UHF gain and fair VHF gain. For VHF reception only, the angle is increased to 90°. The result is improved gain, especially in the higher channels.

The antenna is connected to the receiver with a non-resonant transmission line. For most applications a 300-ohm parallel twin-lead line is used. There are several types in use including an open type which has lower losses. For noisy locations, a coaxial cable is used. A single center conductor type has an impedance of about 72-ohm or about 95-ohm. Twin conductor coaxial of 300-ohm impedance is also available. Attenuation of coaxial cables are higher than parallel lead lines.

Stand-off insulators are used to keep twin-lead lines away from objects which could change its characteristics. Coaxial cables, of course, contain their electrical field within the outer conductor and may be placed in contact with walls, roof, etc. along their path. Special problems of transmission lines used for UHF are treated on the next page in an article prepared by engineers of Admiral Corp.

In carrying out antenna installation work it is not always practical to use an antenna, transmission line, and set input of the same impedance. In all instances you should try to eliminate the need for matching networks and this can be done in majority of cases since the input of most sets is 300 ohms and suitable antennas as well as transmission lines are available in this impedance.

Correct impedance match between any two devices is important. A mismatch will produce reflections causing picture distortion and also an actual loss of signal power. Resistors may be arranged in a network so that two unequal impedances can be used together and each will "see" the correct impedance value. This can be used, for example, in connecting a 300-ohm lead to a 75-ohm antenna. While the impedance match will be there, there will be some signal strength loss.

Sections of transmission line for a given frequency will act as impedance matching devices. This method for matching unequal impedance components is practical primarily in locations where there is only one station of importance or if a separate antenna is employed for the high or low bands with the object of receiving but a single station.

Line stubs (shorted short lengths of transmission line) can be used for impedance matching or for shorting out interferring signal of a near-by frequency. You need not go into this subject very far, for in almost every requirement it is possible to secure all needed components such as the antenna and lead-in to match the input impedance of a television receiver you may be installing.

We have already considered the selection of suitable antenna and transmission line for different types of installations. It is also important to select proper accessories for correctly mounting the antenna and making a neat installation of the lead-in. The antenna itself is mounted on a chimney, sanitary ventilating pipe, brick wall, or on the roof itself. Various items of hardware for this purpose are sold by radio parts jobbers. You should visit your nearby jobber and ask

UHF TRANSMISSION LINES

Transmission line losses in UHF are much greater than in VHF due to the fact that losses increase with frequency. A chart showing relative losses of commonly used transmission line on VHF and UHF is shown below.

Type of Line	Loss in DB per 100 Feet			
	100 MC		700 MC	
	Dry	Wet	Dry	Wet
300 ohm Flat	1.2	7.3	3.6	26.5
300 ohm Tubular	1.2	2.5	3.6	8.2
RG-59/U Coax (72 ohm)	3.7	3.7	11.7	11.7
RG-11/U Coax (72 ohm)	1.9	1.9	6.2	6.2

It should be noted that attenuation losses on ordinary 300 ohm flat line increase tremendously when wet. The effect of this loss is far more severe on UHF as shown on the chart.

On new UHF installations, 300 ohm flat line should be avoided if possible, particularly when long lengths are required.

A minimum distance of six inch separation from all surrounding objects should be adhered to in order to prevent signal absorption loss. In cases where this is impossible, coaxial cable may be used, preferably RG 11/U. The total attenuation loss may be actually less than the 300 ohm flat or tubular line under this condition. It should be noted, however, in normal installations, coaxial lines should not be used on long runs due to the large loss per foot.

The loss figures given for both types of 300 ohm line assume that proper installation techniques have been used.

When installing 300 ohm tubular line, the end connected to the antenna must be sealed against moisture either by using tape or fusing the insulation together with a soldering iron as shown in figure 12.

Make a drainage loop in the line just before it enters the house and punch a hole at the bottom of the loop to release moisture condensation. See figure 13.

Open wire (ladder type) line has the lowest attenuation loss per foot of all lines used. The main disadvantage is the difficulty in handling the line due to its physical construction and the fact that its characteristic impedance is 450 ohms.

It is very important that the transmission line not be coiled or have any "kinks" anywhere between the antenna and the tuner itself. Always cut the transmission line to just reach the receiver and do not allow any extra length of line. When checking the lead-in (transmission line) the short line inside the receiver should also be checked and any kinks, folds, or turns should be removed.

STANDING WAVES

Attenuation of the incoming signal may be the result of standing waves on the transmission line. To check for standing waves, hold the lead-in at various points along the line, starting from the receiver antenna terminals up to a point about three feet out along the line. If picture contrast changes at any point, standing waves are present. To correct this condition, wrap the transmission line with a strip of tinfoil and vary its position along the line until a point of maximum picture contrast is obtained. However, it must be remembered that this method is frequency selective and, therefore, may attenuate other frequencies. A compromise adjustment can be made if more than one channel is to be received.

SEALING 300 OHM TUBULAR LEAD-IN
Preferred Method   Alternate Method

Be sure to leave at least 2" of bare wire for necessary connections.
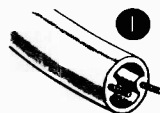
Be sure to leave at least 2" of bare wire for necessary connections.

Cut insulation allowing approx. 3/8" flaps to remain on each side.

Use rubber or Scotch Brand electrical tape.
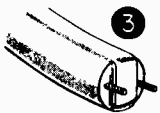
Fold flaps in as shown and apply heat to seal seams. Heat will melt insulation and cause it to fuse together. Use either a match or soldering iron as shown.

Continue wrapping rubber or Scotch Brand electrical tape around top end and wire until sealed.
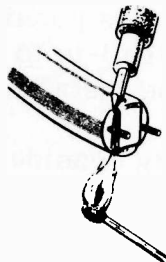
Figure 12. Sealing End Of Tubular Transmission Line.
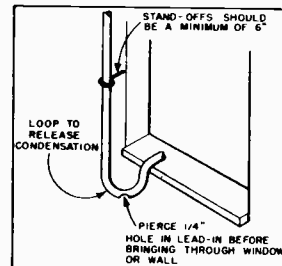
Figure 13. Tubular Transmission Line At Point Of Entry.

him to show you these items first hand. You will then be in a good
position to judge what will be needed for each installation as the jobs
come up. For each type of installation different items may be needed.
Chimney mounting straps are available and simplify this type of place-
ment. To mount the mast against a brick wall, holes will have to be
drilled with a star drill and special anchors used. In all cases not less
than three guy wires are attached to the upper part of the antenna mast
and to points some distance from the antenna, preferably 120° apart.

Before the actual location of the antenna is decided upon, it is
advisable to connect temporarily this antenna to the set after it is
placed on the mast but not mounted in position. By using a long lead-
in wire and carrying the mast in your hands you will be able to try
various locations and angles, while someone else observes the results
on the TV set and reports to you. This probing for best location can
be quickly performed in this manner and the best location found. If a
good location cannot be found where an actual installation is feasible,
increasing the size of the mast an additional five or six feet by means
of an extension may change the results entirely.

The lead-in itself should be as short as possible. In case two-wire
parallel line is used it should be kept off objects by means of insulators.
Coaxial lines need not be kept off walls or roofs but should be securely
tied in position. Sharp bends should be avoided in all types of lead-in
lines and a number of small angle bends is better than one right angle.

There are many practical tricks that help eliminate problems of
poor reception that cannot be solved by a different installation of the
antenna system. You may find that wrapping six to ten inches of tin
foil on a parallel line may greatly offset certain faults. Sometimes
this trick may improve the reception on a weak station with some loss
of signal strength on a strong one. This tin foil should be moved up
and down the line not too far from the TV set while results are ob-
served. Another trick is to hang three feet of ordinary two-wire
transmission line on the terminals of the set where the lead-in is
also connected. By using a razor blade dug into to make contact with
both wires of the line, you will be able to short the stub line at any
point along its length. By trying several points, you may find one
that will give improved reception. In particular, this shorted stub
is useful for eliminating the signal from an interferring station.

In using a low and high band dipoles in localities where stations
operate in both of these band groups, the low band antenna (longer one)
will act as a 3/2 wavelength antenna for the high band stations. Since
this mode of operation produces large lobes at 45°, the combination
of these two antennas may give poor selectivity of direction. This
problem may be solved by using separate lead-ins and incorporating

a switch at the receiver to select the antenna wanted. Another solution is to connect the lead-in to high band antenna (small one) and couple this to the low band antenna with a lead exactly 80% of a 1/4 wavelength of the high band station in the locality. This lead will couple the low band antenna but will trap out its pick up of the high band station.

Direction of Television Station

Twin-Lead Transmission Line to Television Receiver

Item No.	Description
1	Reflector Element
2	Crossarm
3	Reflector Element with Plug
4	Large Folded Dipole Element
5	Tubular Insulator
6	Large Folded Dipole Element with Plug
7	Short Transmission Line
8	Small Folded Dipole Element
9	Mast
10	Twin-lead Transmission Line
11	Swivel Type Mounting Bracket
12	Guy Clamp
13	Stand-off Insulators
14	1/4" Allen Wrench
15	1/4-20 x 1/4" Allen Set Screw
16	8-32 x 3/4" Round Head Machine Screw
17	1/4-20 x 1 1/4" Hex Head Machine Screw
18	1/4" Internal Tooth Lock Washer
19	#8 Internal Tooth Lock Washer
20	8-32 Hex Nut
21	Cap
22	8-32 x 1" Round Head Machine Screw
23	1/4-20 x 5/8" Round Head Machine Screw
24	1/4-20 Hex Nut
25	#6 x 5/8" Self-tapping Screw.
26	#6 x 3/4" Round Head Wood Screw
27	8-32 x 7/8" Round Head Machine Screw

Since many homes today have two television sets, some of your installations will call for using one antenna system for multiple sets. Coupling units are sold by your jobber which simplify this work and produce correct match between sets and antenna. For multiple hotel and apartment building installations, special booster-amplifier units are used to bring the signal strength to a point to serve many sets. Usually such installations have a separate antenna (cut exactly to size) and separate booster-amplifier for each channel in use in the area. You are safe in undertaking this work since the equipment needed is available and is supplied with complete instructions.

LESSON 5

FACTS ABOUT THE TV SIGNAL TO HELP YOU IN SERVICE WORK

An understanding of how a typical television signal is formed and transmitted is very helpful in servicing TV circuits and carrying out adjustments. For the most part, this lesson is made up from material taken from a training course, "Television Receiver -- Fundamentals of Theory and Servicing," prepared and used by Montgomery Ward.

The complete television signal actually consists of two distinct signals. The video signal is an amplitude modulated carrier. Its amplitude modulation contains all of the variations necessary to recreate the picture density tone interpolated into electrical impulses that will produce the proper shades on the receiver picture tube, and also variations that enable the receiver circuits to be synchronized with the transmitter, and variations that eliminate unwanted electron beam retrace lines in the received picture. The sound signal is a FM signal. The frequency variations in this signal, when properly handled in the receiver, will reproduce the sound which accompanies the television picture.

Certain channels are assigned to television transmission, each channel occupying 6 MC. Channels 2 to 6, are in the 54 to 80 MC band; 7 to 13, in the 174 to 216 MC band; and UHF channels 14 to 83, in the 470 to 890 MC band. The standards assigned by the Federal Communications Commission to the make up of any one channel will now be described, and these standards are applicable to all TV stations operating in the United States.

1 - The video and sound carriers shall be 4.5 MC apart with the sound carrier being the higher of the two.

2 - The video carrier shall be of the vestigal side band amplitude modulated variety with a portion of the lower side band suppressed. The video carrier frequency shall be 1.25 MC from the lower limit of the channel.

3 - The sound carrier shall be of the frequency modulated variety with a frequency deviation of not more than 25 kc.

These essentials are graphically shown in the figure. So that all stations would transmit picture signals of the same type the FCC standards specified that a 525 line interlaced scanning system, producing 30 frames (or 60 fields) per second be transmitted. Synchronizing pul-

PICTURE LINE AMPLIFIER STANDARD OUTPUT

SYNCHRONIZING SIGNAL AMPLITUDE α SHALL BE HELD CONSTANT WITHIN ± 4% DURING ANY TRANSMISSION. α MAY HAVE ANY VALUE BETWEEN 0.375 AND 0.625 VOLTS. THE RATIO $\frac{-8}{\alpha}$ SHALL BE 0.25. DRAWINGS NOT TO SCALE.

BLACK NEGATIVE DIRECTION

TIME

BOTTOM OF PICTURE

TOP OF PICTURE

PICTURE

SYNC.

HOR. BLANKING PULSE

VERTICLE BLANKING PULSE 0.05V +0.03V −0 SEE NOTES 3&5

VERT. SYNC. PULSE INTERVAL

EQUALIZING PULSE INTERVAL

HORIZONTAL SYNC. PULSES

(A) 3H (B)3.025H +H −0 (C) 3H (D) 3H

0.5H

H

T₁ T₁+V

B

B

①

②

③ DETAIL BETWEEN A-A IN 2

REAR SLOPE OF VERT. BLANKING SEE NOTE 3
REFERENCE WHITE LEVEL
REFERENCE BLK. LEVEL
BLANKING LEVEL
HOR. SYNC. PULSE
FRONT PORCH
BACK PORCH
H
.05H
B

④ DETAIL BETWEEN B-B IN 2

(L) 0.04H
(M) 0.5H
(R) 0.07H ±0.01H
0.1H 0.1H
H
BLANKING LEVEL
EQUALIZING PULSE SEE NOTE 6
VERTICAL SYNC. PULSE
ALL ABOVE SLOPE INTERVALS 0.003H MAX.

⑤ DETAIL BETWEEN C-C IN 3

(U) 0.18 MAX.
(U) 0.14 H MIN. SEE NOTE 4
(Y) 0.14 H MIN.
(X) 0.025H MIN.
0.1H 0.1H
BLANKING LEVEL
(U) 0.003 H MAX.
(W) 0.08H +0 −0.01H
(S) 0.003H MAX.

NOTE:

1. H-TIME FROM START OF ONE LINE TO START OF NEXT LINE.
2. V-TIME FROM START OF ONE FIELD TO START OF NEXT FIELD.
3. LEADING AND TRAILING EDGES OF VERTICAL BLANKING SHOULD BE COMPLETE IN LESS THAN 0.1H.
4. LEADING AND TRAILING SLOPES OF HORIZONTAL BLANKING MUST BE STEEP ENOUGH TO PRESERVE MIN. & MAX. VALUES OF (X+Y) AND (Z) UNDER ALL CONDITIONS OF PICTURE CONTENT.
5. ALL TOLERANCES AND LIMITS SHOWN IN THIS DRAWING APPLY FOR LONG TIME VARIATIONS ONLY AND NOT FOR SUCCESSIVE CYCLES.
6. EQUALIZING PULSE AREA SHALL BE BETWEEN 0.45 AND 0.5 OF THE AREA OF A HORIZONTAL SYNC. PULSE.
7. ALL SLOPE INTERVALS TO BE MEASURED BETWEEN 0.1 AND 0.9 AMPLITUDE REFERENCE LINES.
8. THE OVERSHOOT ON BLANKING SIGNAL MUST NOT EXCEED 0.02α AT THE BEGINNING OF THE FRONT PORCH AND MUST NOT EXCEED 0.05α AT THE END OF THE BACK PORCH. THE OVERSHOOT ON SYNCHRONIZING SIGNALS MUST NOT EXCEED 0.05α.

Summary of FCC Standards applicable to television signals.

ses and blanking pulses of a standard type were also specified in the
FCC ruling. These standards are summarized in graphical form in
the illustration below. These facts will become clear after an explana-
tion in the following paragraphs on how the television signal is formed.
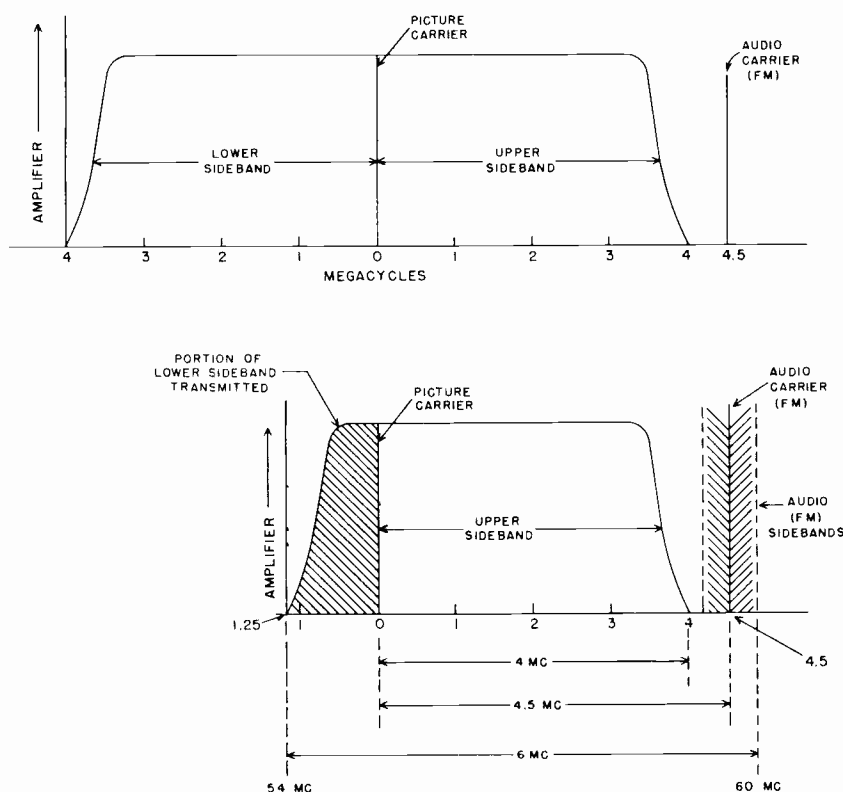
The video signal originates in the camera tube of the television
camera at the transmitting station. In the television camera the image
of the televised scene is focused on the face of the camera tube by an
optical lens system. The camera face is light sensitive and holds a
charge in proportion to the amount of light falling on any one area. As
the electron beam in this tube passes over any area, this charge is dis-
sipated and appears at the output of the camera tube across the load
resistor. Thus if the electron beam in the camera tube is passed over
the face of the tube in an orderly fashion the output of the tube will con-
sist of a series of electrical impulses proportional to the shading in
the televised scene, a white area creating a pulse of minimum intensity
and a black area a pulse of maximum intensity.

A camera tube, such as that shown in the illustration, consists
basically of an evacuated envelope containing the light sensitive screen,
or mosaic, previously mentioned, and an electron beam source similar
to that in the common cathode ray oscilliscope tube. An external sys-
tem of coils provide a means of deflecting an electron beam.

SCENE

LENS

ELECTRON GUN

ICONOSCOPE

DEFLECTING YOKE

COLLECTOR RING (2ND ANODE)

SIGNAL PLATE (METAL)

MICA SHEET

SCREEN

VIDEO OUTPUT

LOAD RESISTOR

FIELD I

START OF FIELD I RETRACE

START OF FIELD 2 TRACE

262 1/2 LINES

END OF FIELD I

A

FIELD 2

START OF FIELD I RETRACE

START OF FIELD 2 TRACE

END OF FIELD 2

B

START OF FIELD I

START OF FIELD 2

525 LINES

END OF FIELD I

END OF FIELD 2

C

HORIZONTAL PULSE

TRACE

RETRACE

15,750 SEC

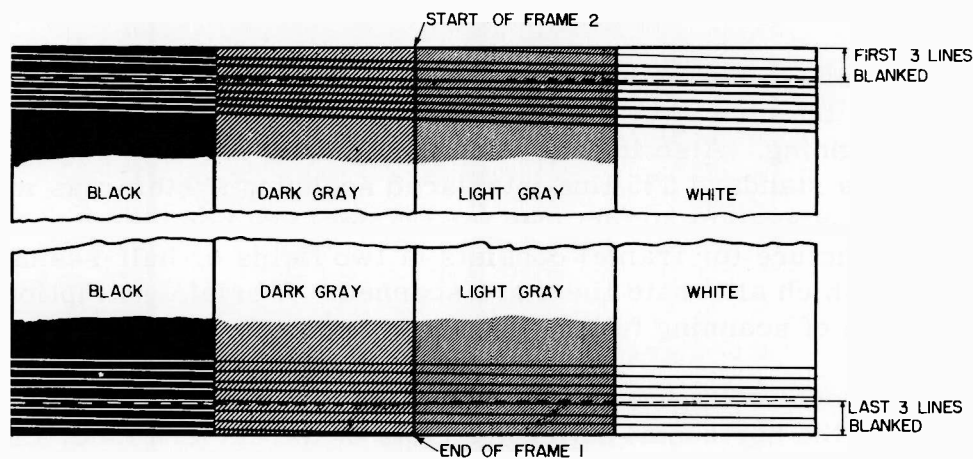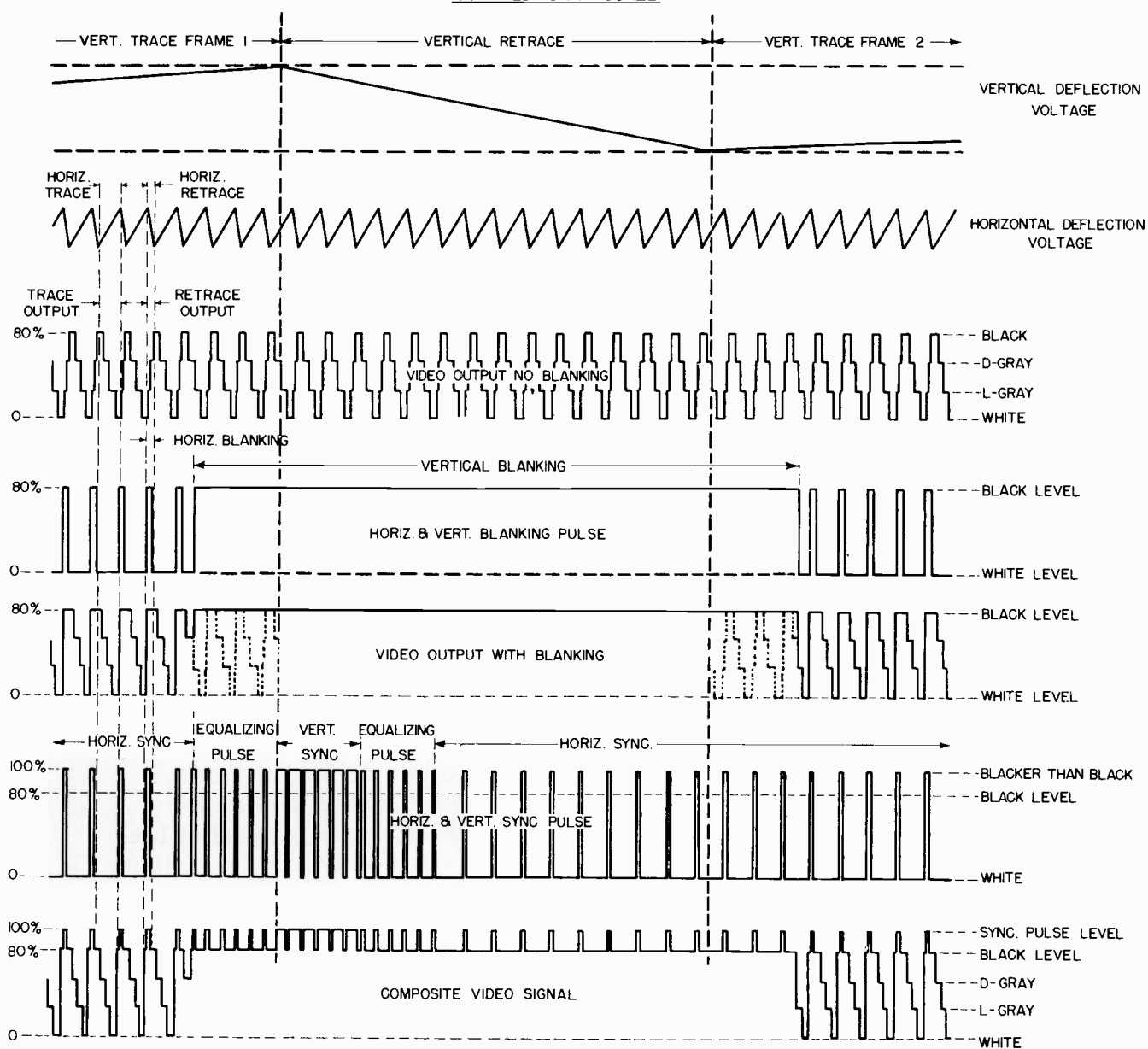VERTICAL PULSE

TRACE

RETRACE

60 SEC

D

We already talked about an orderly fashion of moving the electron beam across the face of the camera tube (and the televised image)., This is called scanning. Also in preceding paragraphs the FCC regulations governing the standard 525 line interlaced scanning system was mentioned. In this system 30 pictures (or frames) are completed each second. Each picture (or frame) consists of two fields or half-scanned pictures in which alternate lines are scanned. A brief description of the operation of scanning follows.

If a sawtooth voltage having a frequency of 15,750 cycles per second is applied to the horizontal deflection coils of the camera tube, the electron beam in the tube will be deflected from left to right and back across the face of the tube 15,750 times each second. If at the same time another sawtooth voltage having a frequency of 60 cycles per second is applied to the vertical deflection coils of the camera tube the beam will be deflected from top to bottom and back over the face of the tube 60 times each second. The voltage pulse applied to each of the deflection coils is shown in part D of the figure. When these deflection voltages are synchronized, the electron beam will make 262-1/2 horizontal scans during one pulse of the vertical deflection voltage. This results by dividing 15,750 by 60. This would produce one scanning field and is illustrated in figure A. During the next vertical pulse the beam would make another 262-1/2 horizontal scans, these scans falling between (or interlacing) the previous ones. This is illustrated in figure B. Thus when these two fields are viewed as one (they occur in 1/60th of a second so the eye cannot notice them apart), a complete picture or frame of 525 (262-1/2 X 2) lines is developed each 30th of a second. Reversing the order of the above statement, it can be said that one complete picture (or frame) consisting of 525 horizontal scans occurs each 30th of a second, each frame consists of two fields of a 60th of a second duration and are made up of 262-1/2 alternate, or interlacing, horizontal scanning lines. A complete scanning frame is shown in figure C.

Using such a scanning system provides at the output of the camera tube, a series of voltages pulses representing the variations in shading of the televised scene as it appears along each horizontal scanning line. To make this information useful to the receiver and to enable its circuits to be synchronized with the transmitter certain other pulses must be added to the video signal. In the figure on the next page is shown the video signal as it would appear near the end of the first frame and at the beginning of the second. This signal is shown as it would appear without blanking or synchronizing pulses and represents the signal derived from a scene consisting of a step graduation from black to white through two shades of gray.

In the figure it can be seen that video signals are generated during the horizontal and vertical retrace periods of the beam in the camera.

START OF FRAME 2

FIRST 3 LINES
BLANKED

BLACK   DARK GRAY   LIGHT GRAY   WHITE

BLACK   DARK GRAY   LIGHT GRAY   WHITE

LAST 3 LINES
BLANKED

END OF FRAME I

SCANNED GRAY SCALE

— VERT. TRACE FRAME I —   — VERTICAL RETRACE —   VERT. TRACE FRAME 2 —

VERTICAL DEFLECTION
VOLTAGE

HORIZ.
TRACE   HORIZ.
RETRACE

HORIZONTAL DEFLECTION
VOLTAGE

TRACE
OUTPUT   RETRACE
OUTPUT

80%

0

VIDEO OUTPUT NO BLANKING

BLACK
D-GRAY
L-GRAY
WHITE

HORIZ. BLANKING

VERTICAL BLANKING

80%

0

HORIZ. & VERT. BLANKING PULSE

BLACK LEVEL

WHITE LEVEL

80%

0

VIDEO OUTPUT WITH BLANKING

BLACK LEVEL

WHITE LEVEL

HORIZ. SYNC   EQUALIZING
PULSE   VERT.
SYNC   EQUALIZING
PULSE   HORIZ. SYNC.

100%
80%

0

HORIZ. & VERT. SYNC. PULSE

BLACKER THAN BLACK
BLACK LEVEL

WHITE

100%
80%

0

COMPOSITE VIDEO SIGNAL

SYNC. PULSE LEVEL
BLACK LEVEL
D-GRAY
L-GRAY
WHITE

FORMATION OF VIDEO SIGNAL

Signals during this period are of no particular use as the retrace time is so short that the signals would make no visible impression on the receiving picture tube. Therefore, the signals during retrace periods are blanked out by a voltage pulse applied to the camera tube grid. These pulses and their resultant video signal out of the camera tube are also shown in the figure.

So that the deflection circuits in the receiver may be synchronized with those in the transmitter other voltage pulses are added to the video signal. Since these sync pulses may be conveniently added to the signal during the blanking interval it has become common practice to refer to the blank-pulse as the "pedestal" on which the sync signal is erected. The sync signals which are added to video signal are illustrated in next to the last graph. Note that the pulses during the vertical blanking time, while of greater duration, are spaced at the same time intervals as the horizontal pulses. The manner in which these sync pulses are utilized will be taken up in the lesson dealing with receiver sync and deflection circuits.

The composite video signal shown in the graph at bottom, containing the picture information, blanking and sync pulses, is the signal that is used to amplitude modulate the television transmitter picture carrier. This modulation is accomplished in such a manner as to have the sync signals represent maximum carrier strength and white area in the television scene represent minimum carrier strength. This is called negative carrier modulation.

Up to this point, only the video signal before it modulates the transmitter carrier, has been discussed. During modulation, using the AM system, side band frequencies equal to the highest frequency in the modulating signal are produced above and below the transmitter carrier frequency. Exactly the same action takes place in AM radio transmission. In the video signal frequencies as high as 4 MC (4 million cycles) may be present. If such a video signal modulates the carrier, side band frequencies 4 MC above and below the carrier frequency are produced. Therefore, a band width of about 8 MC would be required to transmit the video signals. As the band width allotted to each station is only 6 MC all frequencies above 1.25 MC in the lower side band are attenuated at the transmitter. This does not affect the quality of the received signal, but does affect the strength of the detected signal. This deficiency is compensated for in the receiver by additional amplification.

The sound signal, transmitted by the television station, is of the frequency modulated type. There is no essential difference in this signal from the signals used in conventional FM broadcasting services. Therefore, no detailed discussion of its characteristics will be undertaken. Refer to companion volume, "Radio Servicing Course," for a large lesson on FM theory and repair practices.

TELEVISION INTERFERENCE AIDS

TVI Causes, Effects and Solutions...

1. Diathermy, industrial heaters, etc.
Solution: High pass filter. AC line filter. If these measures are ineffective contact owner of interfering equipment and recommend manufacturer be advised.

2. Radiation from local oscillator of nearby TV and FM broadcast receivers.
Solution: Re-alignment of offending receiver.

3. Strong signals from nearby radio stations, including FM broadcast, amateur, police, taxi, government, airways and military services.
Solution: Install high pass filter, line filter, or in extreme cases install an absorbtion filter tuned to the interfering signal. If these measures ineffective locate and contact owner of equipment.

4. Cross modulation external to the receiver, but possibly including external rectification sources such as corroded antenna and transmission line connections.
Solution: Check lead-in or antenna for broken or corroded connections. Additional possibilities are poor connections in house wiring, plumbing, stovepipes, etc.

5. Multiple images.
Solution 1: Reorient or relocate antenna and/or lead-in.
Solution 2: May be caused by standing waves due to an impedance mis-match between antenna, transmission line and receiver impedance. This condition can be detected by wrapping a piece of metalized paper around lead-in, watching for variations in reflections and signal strength while sliding metalized paper along lead-in.

6. Direct I.F. pickup.
Solution 1: Shield section responsible. (Shielding must be complete).
Solution 2: Realign I.F. (See section C for more detailed information).
Solution 3: Check lead dress, particularly of long leads.

7. Image interference (This situation exists when a strong signal occurs at the oscillator frequency plus or minus the I.F.)
Solution: Use appropriate stub or tunable trap. (Refer to section B). High pass filter is ineffective in this specific application.

8. Signal operating in normal receiver pass band.
Solution: Find offending source and if unable to obtain cooperation, report to FCC.

9. Misadjustment of I. F. traps, I. F. tuned circuits, or misadjustment of TV receiver controls (traps may be faulty).
Solution: Correct misalignment or replace, or repair, defective component.

10. Faulty neutralization, particularly in triode or triode connected pentode cascode type tuners, may cause cross-hatch pattern on picture tube.
*Solution:* Locate defective component and replace.

11. Audio rectification characterized by audio from other than TV stations, such as police broadcast, taxi, utility, amateur stations, etc.
Solution: Since this rectification normally occurs at the grid of the first audio amplifier it can be eliminated by insertion of an RC filter placed as close as possible to the grid of the first audio tube (100 k resistor in series with the audio grid lead and 500 mmfd condenser direct from grid to cathode). It may be necessary to increase the value of the inserted by-pass condenser to as much as 1000 mmf and in the case where the manufacturer has used an extremely high value grid resistor in the order of 10 or more megohms, it may also be necessary to decrease this value. It is not usual for the audio signal to be degraded by changing the value of the grid resistor, for example, from 10 to 5 megohms).

12. Ignition (Pulse) type interference sources including electric motors and other power equipment, household appliances, thermostatic devices and florescent lighting and fixtures.
*Solution:* Line filters, change location of antenna, more directive antenna, use of coaxial in place of flat line. If these measures do not correct the condition locate the source and contact owner for his cooperation in eliminating the interference at the source.

A

HIGH PASS FILTER FOR 300 OHM TELEVISION RECEIVER INPUT
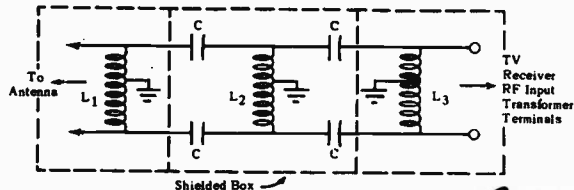
C = 15 mmfd Ceramic
L₁, L₃ = 1.2 mh (21 Turns No. 24 Enamel Wire Close Wound on ¼" Diameter Polystyrene Rod)
L₂ = 0.6 mh (15 Turns No. 24 Enamel Wire Close Wound on ¼" Diameter Polystyrene Rod)
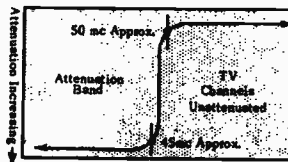
Commercial filters are available in the following ranges both fixed and tunable.

0-30 Mc   0-50 Mc   20-30 Mc   40-50 Mc   88-174 Mc

Caution!

No. 1 Be certain to supply a good electrical ground with an absolute minimum of lead, preferably to set ground. Where receiver has AC/DC chassis, ground through 0.001 mfd, 600 Volt mica condenser.

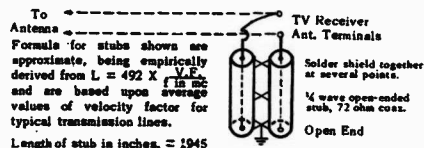**2.** Place filter as close as possible to r.f. input transformer.

B

STUB WITH 300 OHM TWIN LEAD IN
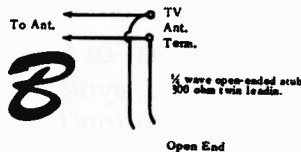
Length of stub in inches = $\frac{2450}{f \text{ in mc}}$

EXAMPLE
For an interfering signal at 75.5 mc : $\frac{2450}{75.5} = 32.5$ approx.

¼ WAVE OPEN-ENDED STUB WITH 2 PARALLEL LENGTHS OF 72 OHM COAX FOR USE WITH 300 OHM INPUT

Formula for stubs shown are approximate, being empirically derived from $L = 492 \times \frac{V.F.}{f \text{ in mc}}$ and are based upon average values of velocity factor for typical transmission lines.

Length of stub in inches = $\frac{1945}{f \text{ in Mc}}$

This type of stub has several advantages over 300 ohm tape:

1. It can be moved or rolled up with negligible change in characteristics.
2. It is completely shielded, and it will not re-radiate, nor itself pick up signals.

* Refer to Caution No. 1 on High Pass Filter (Above)

Table of lengths of 1/4 wave open, 300 ohm line covering the FM band:

Frequency in Mcs	L in inches
88	27.8"
95	25.8"
108	22.7"

C

When a television receiver is in a strong field of r.f. close to the intermediate frequency of the receiver, direct pickup in one or more of the i.f. stages is likely. For example, a signal on 21.9 Mc would probably be picked up in the i.f. of a television receiver using a 21.9 audio i.f. channel. If a high pass filter is ineffective in eliminating the interference the i.f. should be re-aligned to a frequency different from the interfering signal by a few hundred Kc (As an example, in this case, to 22.2 Mc).

D

R.F. OSCILLATOR SETTINGS, NOMINAL FOR 20 to 30 Mc AND NOMINAL FOR 40 to 50 Mc.

Channel	Channel Frequency	Pix Carrier	Sound Carrier	Rcvr. rf Oscillator (21.9 mc I. F.) Low	Rcvr. rf Oscillator (21.9 mc I. F.) High	Rcvr. rf Oscillator (41.25 mc)
2	54-60	55.25	59.75	37.85	81.65	101
3	60-66	61.25	65.75	43.85	87.65	107
4	66-72	67.25	71.75	49.85	93.65	113
5	76-82	77.25	81.75	59.85	103.65	123
6	82-88	83.25	87.75	61.85	109.65	129
7	174-180	175.25	179.75	157.85	201.65	221
8	180-186	181.25	185.75	163.85	207.65	227
9	186-192	187.25	191.75	169.85	213.65	233
10	192-198	193.25	197.75	175.85	219.65	239
11	198-204	199.25	203.75	181.85	225.65	245
12	204-210	205.25	209.75	187.85	231.65	251
13	210-216	211.25	215.75	193.85	237.65	257

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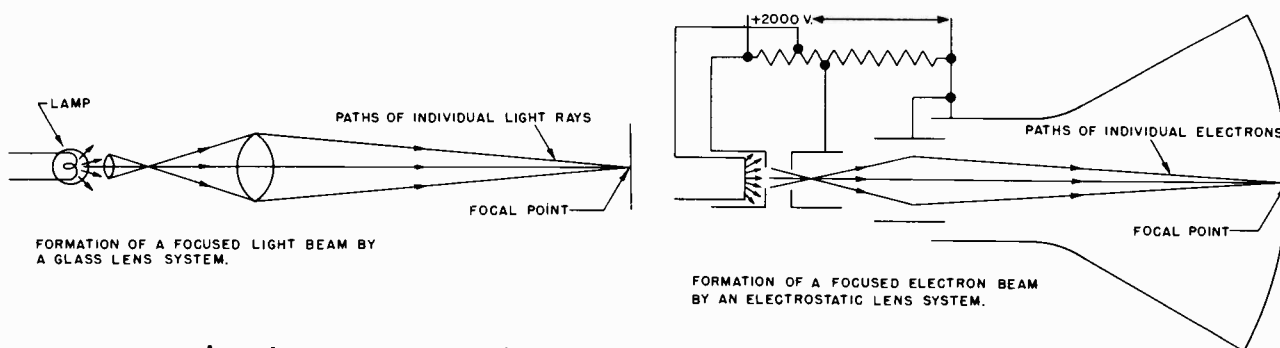
LESSON 6

ALL ABOUT CATHODE RAY TUBES

The source of electrons in any cathode ray tube is an oxide-coated cathode identical to that used in the familiar receiver-type tubes. The cathode is heated to incandescense by a conventional heater operating from a filament transformer.

Focusing may be accomplished by either of two methods; electrostatic or electromagnetic, both of which accomplish the end result, i.e., a narrow concentrated stream of electrons.

We are all familiar with the action of a glass lens upon visible light. The lens may be used to collect a divergent bundle of light rays, converging them to a point, known as focusing the light. An electron lens may be employed to control the many electrons leaving the cathode in precisely the same manner that an optical lens controls the light leaving a lamp. Focusing is accomplished by varying the potentials on the elements of the electron lens as shown in figure and is due to the electrostatic fields established between successive elements.

FORMATION OF A FOCUSED LIGHT BEAM BY A GLASS LENS SYSTEM.

FORMATION OF A FOCUSED ELECTRON BEAM BY AN ELECTROSTATIC LENS SYSTEM.

Another method of focusing, more commonly used in the television receiver than is the above electrostatic method, is electromagnetic focusing. Here, instead of an electrostatic field, a magnetic field is applied to the electron stream. Such a field is derived from a coil which slips over the tube gun (neck) external to the tube, through which is passed a direct current of variable magnitude to effect best focal conditions.

In either method of focusing, electrostatic or electromagnetic the amount of focus potential (or current) is varied while observing the fluorescent screen for sharpness of image detail.

The beam now having been focused to a spot of small diameter at the fluorescent screen, it remains to deflect the beam for scanning in an orderly sequence. Here, again, may be employed either an electrostatic or an electromagnetic method. The latter method is used to a much larger extent in television, but we will first consider electrostatic scanning since it is easier to explain. Creation of an electrostatic field between any set of plates will cause the electron stream, which passes between them, to be deflected from its normal path in one direction or the other, depending upon the polarity of potential applied. There is a linear relationship between magnitudes of deflection and applied potential. Therefore, by the application of potential to both vertical and horizontal deflection plates, the electron spot may be caused to move to any desired point on the fluorescent screen. For example, to cause the spot to move upward, the top vertical plate must become positive with respect to the bottom vertical plate.
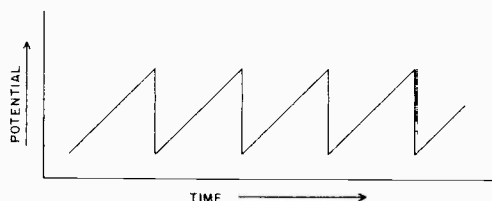
For downward spot displacement, the polarity is reversed. A similar application to the horizontal plates above will cause either right-hand or left-hand spot movement and a spot at the upper right-hand corner of the screen would indicate equal displacements in both the vertical and the horizontal directions.

Therefore, for scanning, a linear rise of potential is applied to the horizontal plates at a high repetition rate (15,575 KC in present standards) while a slow repetition-rate is applied to the vertical plates (60 cycles). These scanning potentials are illustrated in figure.

A linear rise of potential causes the beam to be deflected linearly across the screen. After it has traversed the screen, it suddenly returns to the side from whence it started, only to again take up its slower motion in the scanning direction (left to right).

As above mentioned, a high repetition rate of scanning is applied to the horizontal plates, a much slower rate to the vertical. Hence, analyzing the spot motion, we find that during the time that it has traveled across the screen, left to right, it has traveled downward by but a very small amount. At the start of the second horizontal cycle, therefore, the slow downward motion has caused the spot to be moved

downward in amount equal to the spot size. The second horizontal cycle then carries the spot parallel to and immediately adjacent to the travel of the first cycle. A third cycle finds the downward motion again equal to the spot size and a third scansion is completed. So is scanning effected, several complete scansions being completed in each second of time.

The same general outline may be applied to electromagnetic scanning. In this case, the deflection plates are omitted and a set of deflection coils are placed over the tube neck. There are four coils -- two vertical coils (one above and one below the neck of the tube) and two horizontal coils. Instead of a sawtooth of potential, as used with the deflection plates, a sawtooth wave form of current is used which produces a sawtooth of magnetic flux. It will later be shown that a sawtooth of voltage applied to the deflection coils does not produce a sawtooth of current and that special pulses of voltage must be produced. The complete set of coils, horizontal and vertical, which is placed over the tube for magnetic deflection is known as a Deflection Yoke.
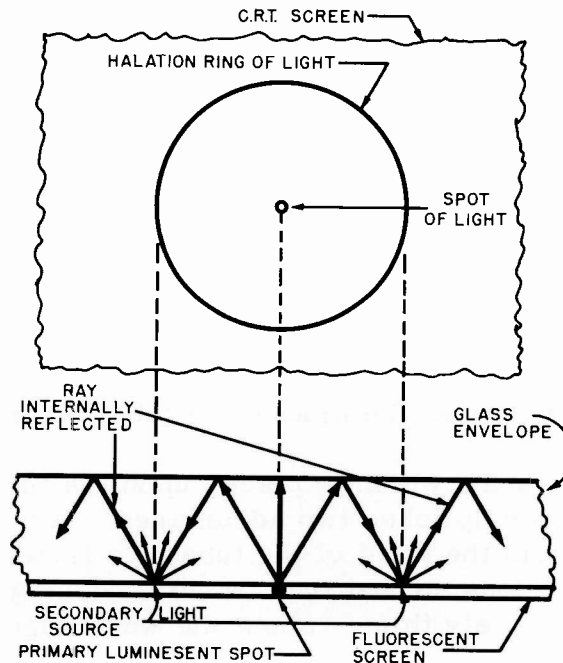
Several physical and electrical properties of the picture tube will now be discussed.

Halation is a term which signifies one undesirable property of the cathode-ray tube. The face of the tube must have appreciable thickness in order to withstand the atmospheric pressure. A pin-point source of light appearing at the inside surface of the face will radiate light in all directions, being not restricted to the desired direction

(straight out from the tube). Such a source is the phosphor being bombarded by a beam of electrons. As illustrated in figure, internal reflections of the light within the glass wall, from surface to surface, give rise to one or more rings of light which surround the original (desired point). This effect is known as halation.

A second property of the tube is the formation, after some hours of operation, of a darkened area near the center of the screen known as an ion spot.

An ion spot is the result of the bombardment of the phosphor by charged particles known as ions. This bombardment results in the deterioration of the phosphor which then produces less light, upon being struck by the electron stream, than does that portion of the surface which has not been so bombarded. The ions travel down the tube in a rather wide-angle stream, impinging upon the screen near its center.

There are several factors leading to the elimination of this difficulty, one of which is the use of a completely electrostatic tube which is not troubled with this difficulty. In television practice, two methods used are (1) the use of a bent-gun tube and (2) a metallic coating on the inside surface of the phosphor.

The bent-gun tube is one whose electron-emitting element is not in line with the axis of the tube — its electron stream is directed toward the side of the tube neck. Since the ion stream is not much effected by a magnetic field, a magnet is placed over the neck of the tube which bends the electron stream, directing it axially down the tube in the normal path, allowing the ion stream to continue in its original course. It strikes the side of the tube, where it does no damage.

The metallic coating which is placed upon the inside surface of the phosphor coating accomplishes two advantages. It increases the light which is emitted from the front of the tube by a factor of about two and and it disperses the ions so that they cause no damage to the phosphor. This coating is extremely thin — about the wavelength of light.

A cathode-ray tube, being subjected to tremendous pressure from the outside, is subject to implosion. Implosion is just the reverse of explosion, the force being from the outside. While an implosion probably is less dangerous than is an explosion, yet, there is a great shattering and scattering of glass in such an event. In fact, the glass may fly to all parts of the room. Nothing further need be said of the potential danger to the person who stands nearby. Therefore, all diligence should be observed in working with such a tube, carefully removing the tube from the chassis if extensive work is to be done in

which the tube is not concerned, protecting the tube from jars or blows which may cause an implosion, and protecting the eyes and hands with goggles and gloves.

A television picture tube is probably the most expensive component used in the set. Transvision, Inc. of New Rochelle, N. Y. are manufacturers of devices intended to permit correction and further use of picture tubes that normally would be discarded. We give the explanation of these methods prepared by David Gnessin of this firm.

The most common causes of tube failure are the ones which can most easily be corrected. These failures are: (1) Low cathode emission resulting in poor brightness. (2) Electrical leakage such as cathode-grid leakage resulting in poor brightness control, internal arcing, etc.

Faults of point (2) cannot be corrected and tubes with such faults must be discarded. But there are two methods of correcting low emission. Both means are of value to the serviceman and can be used to advantage. Reactivation duplicates a process used in almost all picture tube factories. It consists of raising the cathode temperature considerably above normal temperature while at the same time drawing a heavy grid current. This grid current is many times the normal emitting current of the cathode.

It is important that this current be limited to a value which is not heavy enough to lift the cathode coating from the cathode. In the factory, this process is called "ageing." All picture tube factories use this or some similar practice. The theory of operation is now explained.

Low emission is due to the disappearance of the pure barium from the cathode surface. All materials emit electrons, but certain materials are better emitters. Pure barium is one of the best of all. In order to get sufficient emission, pure barium must always be present on the cathode surface. In the manufacturing process, the function of the ageing process is to cause the deposition of pure barium on the cathode surface.

During the life of the tube, barium is continuously being replaced on the cathode surface as the old surface is evaporated or poisoned by the barium combining with the gas in the tube. If this surface is not replaced as quickly as it is used up, then the tube becomes dimmer and dimmer until it can no longer be used.

Reactivation tends to reverse this process so that the rate of formation of a pure barium surface is increased. Once emission increases because of this, the rate of ionization of residual gases in the tube in-

creases. Since ionized gases are picked up by the getter in the tube more easily than gases which are not ionized, the poisoning of the barium surface is reduced. Thus, a reactivated tube has good prospects of staying good for a long time.

Tube brightening devices are another means of increasing emission are connected in the filament circuit of tubes. Increasing the cathode temperature usually increases the emission because emission increases with an increase in cathode temperature in a bad tube (In a good tube, emission does not increase because it is stabilized by the space charge effect).
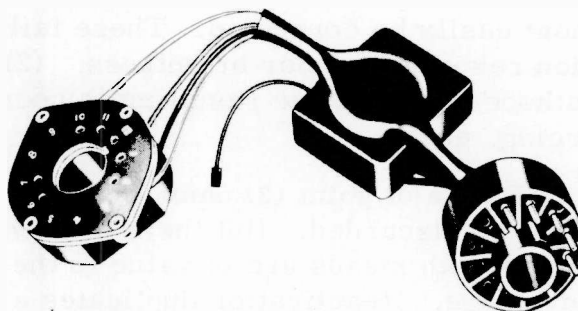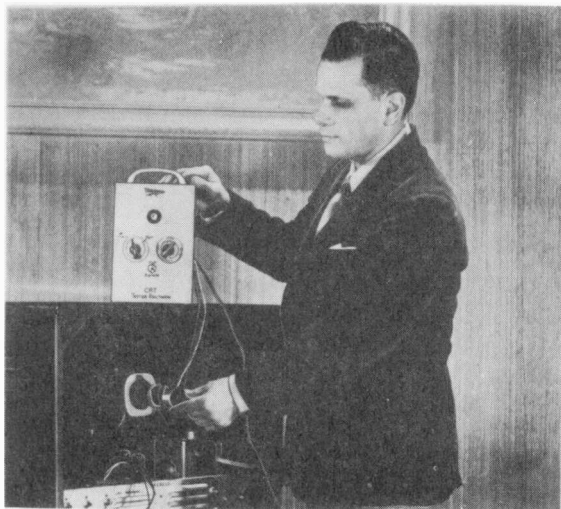
At left is illustrated a commercial reactivator being used on a service job. Above is shown a revitalizer used for brightening worn out picture tubes.

Filament devices must be permanently plugged into the set. In cases where such devices are used, it is best practice to utilize as low a filament voltage as possible because increasing the filament voltage can cause serious side effects.

The increased temperature causes a marked increase in electrical leakage in the tube. This is not noted when the set is turned on but usually becomes serious after the tube has reached maximum heat (1/2 to 1 hour later). This leakage effect acts as a high resistance short between the tube elements, resulting in poor brightness control, internal arcing, and a number of other defects.

In general, it may be stated that reactivating devices and tube brightening devices are valuable tools for the serviceman. Neither work in all cases although both give a high percentage of good results. Reactivating devices have a higher initial cost but much lower cost per tube if used on a number of tubes because the device is not permanently left in the circuit.

Tests indicate that a tube which cannot be reactivated cannot be satisfactorily improved by a brightening device, but many tubes which do not improve with a brightener, can be successfully reactivated.

LESSON 7

HOW TO TELL WHAT IS AT FAULT

In this lesson we will consider additional methods used for finding faults in television sets. You already know, from the earlier lessons, how visual faults observed in the picture can guide you to possible repair by means of a simple adjustment or change of a defective tube. At times, similar faults are due to an actual defect in some component or adjustment inside the chassis.
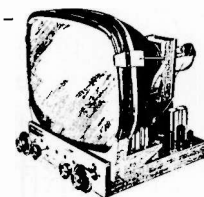
This study will permit you to increase your ability to service TV sets. As an aid we will refer to a schematic of a Bendix set of 1952 which, of course, is similar to many other sets of this period. It is an inter-carrier type set and this circuit should be compared to the arrangement shown in the block diagram of Lesson 3.
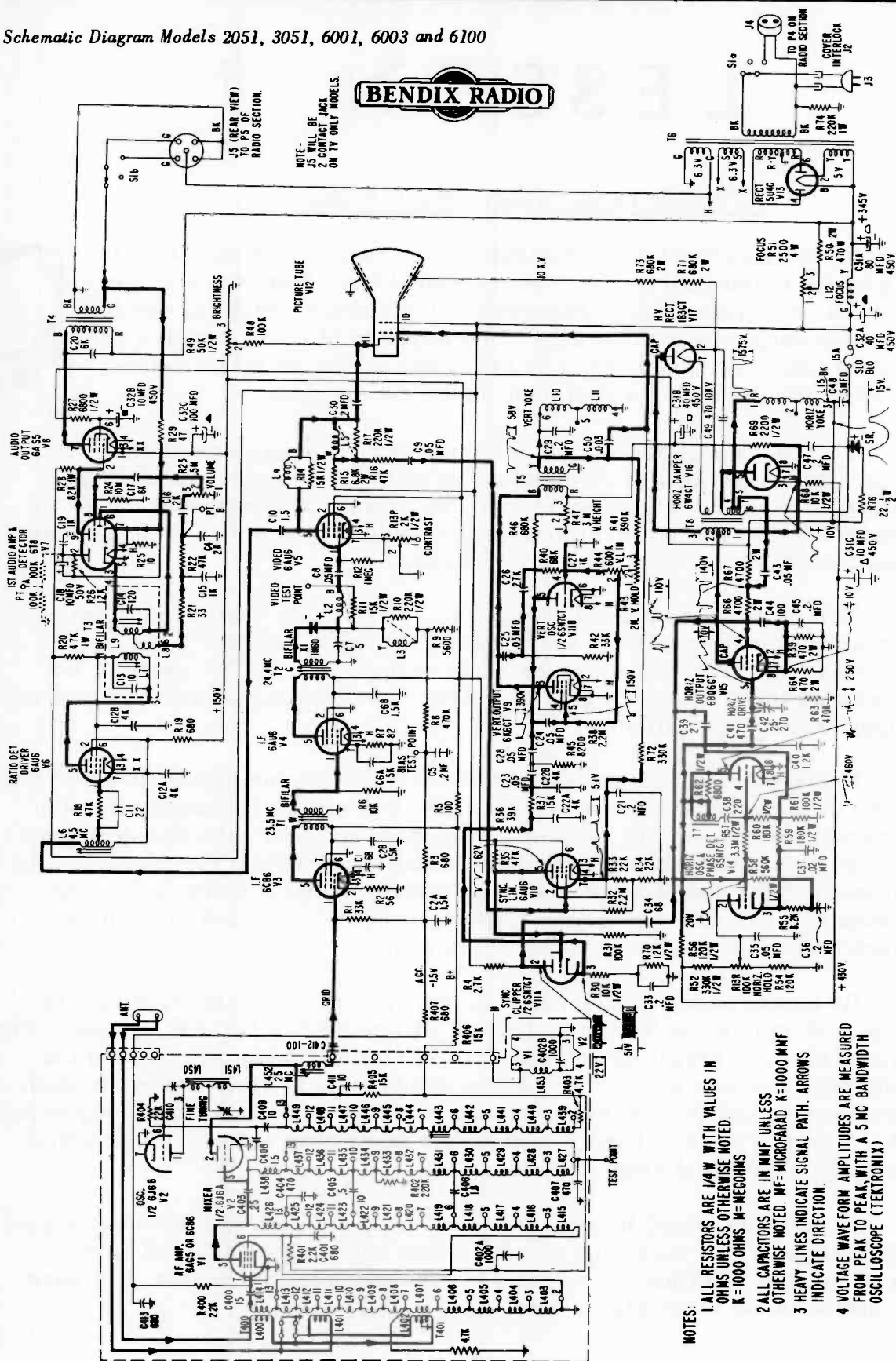
This is a combination TV-radio set. The radio section consists of a complete radio receiver and connects through J4 and J5 jacks to the TV chassis. The speaker of the radio is used with the TV section, but otherwise these units are distinct. Other combinations combine the power supply and audio section.

From your experience with radio circuits you can understand that the tuner or front end of the set corresponds to a similar arrangement of a superhet circuit. In the case of a television receiver, the tuning is performed by actually changing the inductance or switching in different coils for each of the desired stations. Fine tuning is usually carried out by means of a variable condenser. The frequencies used are, of course, much higher than those encountered in radio.

By means of superheterodyne action, an intermediate frequency is produced and this is further amplified with the aid of two I.F. stages. The gain in the I.F. stages is smaller than in similar radio circuits and the band pass is much wider. The audio intelligence is also carried through these stages and is selected by means of a tuned circuit L6 properly adjusted. A trap is used to keep 4.5 MC audio modulated signal from reaching the picture tube and sync circuits.

As we have stated before, the part of the set handling the audio signal only is essentially a section of a FM radio and can be serviced in the usual manner. Naturally, any faults developing in this section will have an effect on the audio signal only.

Schematic Diagram Models 2051, 3051, 6001, 6003 and 6100

BENDIX RADIO

NOTES:
1. ALL RESISTORS ARE 1/4 W WITH VALUES IN OHMS UNLESS OTHERWISE NOTED. K=1000 OHMS M=MEGOHMS

2. ALL CAPACITORS ARE IN MMF UNLESS OTHERWISE NOTED. MF=MICROFARAD K=1000 MMF

3. HEAVY LINES INDICATE SIGNAL PATH. ARROWS INDICATE DIRECTION.

4. VOLTAGE WAVEFORM AMPLITUDES ARE MEASURED FROM PEAK TO PEAK, WITH A 5 MC BANDWIDTH OSCILLOSCOPE (TEKTRONIX)

Faults in the I.F. stages can produce various observable picture defects such as poor definition, lack of brightness, or even complete lack of picture. As you can readily understand, faults developing in this section will be equally noticeable on all channels received by the set. Since the sync signals are also handled by these stages, it is probable that picture faults mentioned may be accompanied with tearing or poor synchronization.

In television servicing, it is always a good policy to suspect tubes as being at fault when a defect is present. It will be worth your while to re-place, for test purposes, tubes in the I.F. and video stages if these stages are suspected. Good practice demands that if such action does not correct the fault the original tubes should be placed back since different tubes may require a re-alignment of the circuits. These stages may also be tested by the usual voltmeter and ohmmeter methods. These tests will help you locate such faults as shorted condensers, defective resistors, and open coils. The actual testing process is similar to the method carried out in radio work and is probably familiar to you.

The sync circuits are a source of trouble and are somewhat more diffi-cult to service. Here again tubes should be suspected and further the picture faults analyzed in the earlier lessons will suggest which tubes should be re-placed first. However, there are many other components used in these circuits which, because of a defect, could produce exactly the same symp-toms on the picture tube. Experience has shown that these circuits are best serviced by observing waveforms on an oscilloscope to determine what produces the incorrect response. From this type of observation the section and parts producing the faults can be isolated.

Material on how to use an oscilloscope in securing waveforms of dif-ferent types will be given in a complete lesson dealing with waveform patterns. At this stage, it is interesting to note that circuit diagrams are issued with such waveforms placed in respective points of measure-ment. Other service material has waveforms published separately.

As you understand, the sync circuits control the formation of the pic-ture and when at fault will effect the picture by causing it to move or to be broken up. The horizontal sync circuits also produce high voltage for the picture tube and the faults here may influence the brightness of the video signal.

For example, bottom fold over may be caused by a defective coupling condenser C24 between vertical oscillator and vertical output tube. In the next lesson you will understand why this is so, but even now you know that verticaul faults (up and down fold over is a vertical change) are produced in vertical sync circuits. Tests used in radio practice would successfully locate this faulty condenser.

The low voltage power supply, of course, supplies all filament power to all stages. These supplies are of various types including full wave A.C. arrangements, half wave transformerless types, and various voltage doubling arrangements. These circuits are familiar to you from your radio work with the possible exception of voltage doubling circuits. Two typical circuits of this type are illustrated and explained to aid you in understanding similar arrangements used in television sets. These circuits are printed through the courtesy of Sarkes Tarzian, Inc.

HALF WAVE VOLTAGE DOUBLER
FIGURE 2 A

SYMMETRICAL VOLTAGE DOUBLER
FIGURE 2 B
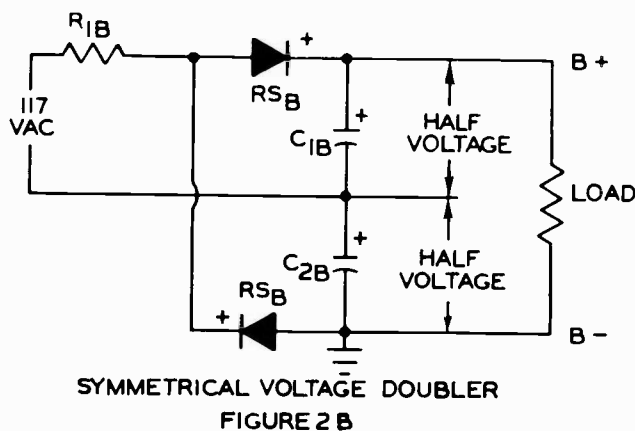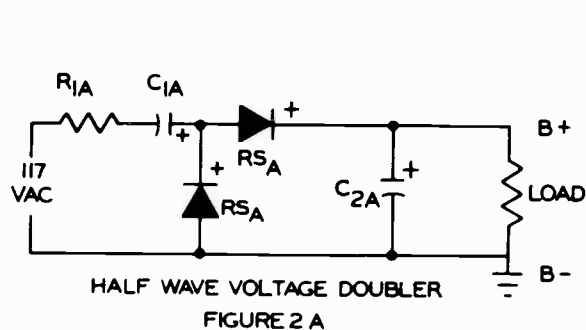
VOLTAGE DOUBLER

The voltage doubler is the most frequently used transformerless voltage multiplier circuit. The no load D. C. output voltage of a voltage doubler circuit is 2.82 times the RMS value of the input voltage.

The design engineer can choose between two types of voltage doubler circuits. The half wave voltage doubler is shown in figure 2A; the full wave or symmetrical voltage doubler in figure 2B. The half wave circuit has the advantage that one side of the A. C. supply is common with the negative D. C. output, thereby minimizing hum difficulties and secondly, it is not necessary to use identical capacitors in the doubler circuit. In the full wave or symmetrical voltage doubler circuit the negative D. C. terminal can not be made common to one side of the A. C. supply and this increases the possibilities of hum in high gain amplifiers. The advantages of the full wave or symmetrical voltage doubler are: lower ripple component; better voltage regulation and ripple frequency double that of the A. C. supply. It is important that the capacities of C_{1B} and C_{2B} are kept as nearly equal as possible to keep the load divided equally between the two rectifiers.

The functions of R_{1A} and R_{1B} are to limit the initial surge current while the capacitor is being charged and to act as a fuse in the event a short circuit is caused across the load.

Maximum voltage regulation and minimum ripple are acquired by use of large values of capacity.

In the next lesson a complete explanation of every circuit will be given. The generalities included in this lesson should permit you to begin actual television repair even in cases where the chassis must be removed from the cabinet and circuits tested to locate any existing faults.

L E S S O N   8

EXPLANATION OF TELEVISION CIRCUITS

Nearly all sections of a television receiver have parallels in a conventional superhet radio and, therefore, will not be entirely new to you. Sweep and deflection circuits, of course, are not used in radio sets, and higher frequencies used in TV impose the need for mechanical differences. Circuits used in any television receiver can be arranged into five sections as outlined below. This basic grouping should be kept in mind as various circuits are explained. With only slight revisions the material in this lesson is taken from "Television Receiver — Fundamentals of Theory and Servicing" issued by Montgomery Ward.

1. RF SECTION — This section, often referred to as the front end or tuner, consists of an RF amplifier, a mixer or converter, and a local oscillator circuit. Its function is to select, amplify, and convert to IF both the video and sound signals.

2. SOUND SECTION — This section consists of one or more stages of IF amplification, an FM detector, and an audio amplifier. This portion of the television receiver functions just as does the FM section of a conventional broadcast receiver.

3. VIDEO SECTION — This section performs several functions. It usually consists of two or more stages of IF amplification, a detector circuit, a video amplifier to supply the picture tube with the video signal. Along with the video amplifier is the DC restorer circuit that enables the video signal to have the effect of a pulsating DC voltage on the picture tube grid.

4. SWEEP SECTION — The function of this section is to generate and amplify the sawtooth voltage pulses necessary to sweep the beam in the picture tube. A portion of the sweep section are those circuits which separate the sync pulses from the composite video signal and apply these sync pulses to the proper sawtooth oscillator circuit. These sync pulses then time the oscillators.

5. POWER SECTION — This section of the receiver provides the necessary AC and DC voltages to various circuits. In most receivers, the very high voltages required by the picture tube are a by-product of the horizontal sweep circuit that are rectified by a separate tube.

It is very important to recognize and understand the functions of these basic sections and their relationship to receiver servicing.

The RF section of a television receiver consists of a RF amplifier, a mixer or converter stage, and a local oscillator. The components of this section are often mounted on a separate subchassis and may be referred to as the Tuner or Front End. These circuits perform the same functions as comparable circuits in a conventional broadcast receiver. However, due to factors peculiar to television reception, these circuits differ somewhat, both electrically and mechanically, from those in a conventional broadcast receiver. In this lesson we will consider VHF tuners intended for reception of channels 2 to 13. Tuners for UHF involve extra circuitry for double conversion and will be discussed in a later lesson.
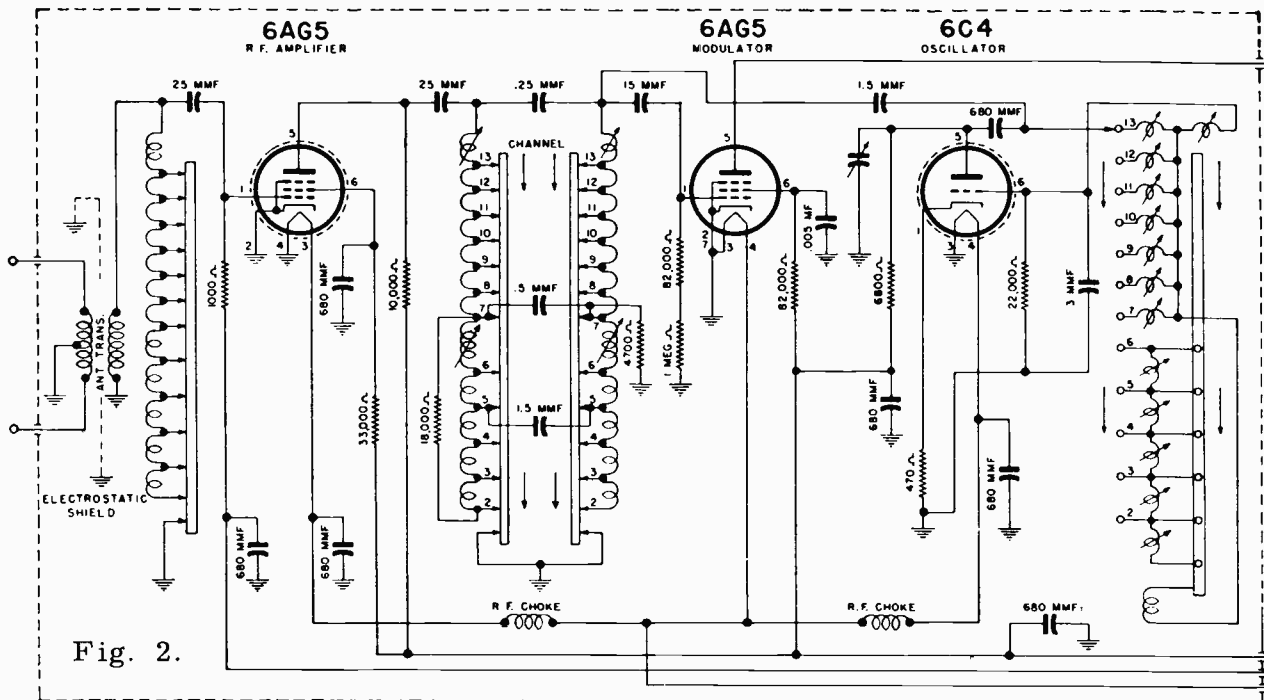
The RF tuning systems in use are inductively tuned although some manufacturers vary capacity across the coil while others vary the inductance of the coil to accomplish individual channel tuning. In some units a combination of inductive and capacitive tuning is used. Mechanically, tuners may be classified as follows:

1. Continuous tuning systems where either inductive or capacitive reactance is varied to tune in each channel. This system may employ a mechanical detent mechanism to select the proper inductance value for each channel.

2. Step tuning systems where inductances are tapped and proper inductance is selected by a rotary or pushbutton switch for each channel.

3. Turret coil switching systems in which individual tuned coils are selected for each channel.

From your own experience you probably know that the tube complement is considerably different than in conventional AM receivers. Not only are the usual octal tubes replaced by miniature type tubes, but in the RF stage the tube is often a triode rather than a pentode.

The construction of the miniature tube provides low inter-electrode capacity and short base connections which are definitely superior for television work. The use of triodes, rather than pentodes, is due to the circuit characteristics encountered in television. To obtain wide-band response, low "Q" circuits are a necessity and tubes must work into low plate loads. In such cases the use of the triode also improves the signal to noise ratio in the RF circuits. Triodes also are adaptable to grounded-grid circuits often used in television.

A circuit representative of a continuous tuning type front end used in some of Belmont built receivers is shown in Figure 1. The input to the 6AG5 consists of an impedance matching coil to match the 300-ohm line to the tube input. The RF amplifier output is capacitively coupled to the 6J6 converter input. The 6AG5 output and the 6J6 input are in-

Figure 1.

ductively tuned by iron cores to the proper RF channel. The 6J6 oscillator is also inductively tuned to a frequency 22.25 mc higher than the sound carrier, to provide the proper intermediate frequency. Oscillator signal injection is accomplished by capacitive coupling to the grid of the converter section of the 6J6.

Mechanically the tuner consists of a sub-chassis on which are mounted the necessary component parts. Tuning is accomplished by moving the iron cores in and out of the coils by a cam and lever arrangement connected to the tuning dial through a planetary drive. Six coils are tuned, one set of 3 being used for low band reception and the other 3 for high band reception. Proper coils, and input circuit, are selected by a switching arrangement operated by the tuning shaft. Each individual coil is tuned to the correct band by a trimmer capacitor.

A tuner representative of the step tuning type is used in some Sentinel receivers. The schematic diagram of this tuner is shown in Figure 2, on page 66. In this tuner the antenna impedance is matched to the tuner by a transformer coupling. The input and output circuits of the 6AG5 RF amplifier, and the input circuit of the 6AG5 converter, are tuned to the proper frequency by a shorting type rotary switch that selects the proper amount of inductance for each channel. The coils in the 6C4 oscillator circuit are individual coils for each channel.

The turret type tuner units such as those made by Standard Coil consist of a conventional RF and converter-oscillator circuit. The schematic of such a tuner is shown in Figure 3 below. Electrically these tuners are very similar to previously described types. The mechanical layout varies considerably from other tuners. In the turret tuner coils for each channel are mounted on individual panels that are inserted in a turret. Connections for each coil are brought out to contact points. Because of this construction lead lengths may be kept at a minimum resulting in increased utility.

Fig. 2.

As you have learned from earlier lessons, two methods of IF amplification of the sound and picture signals are used. In either system, just as in any superhetrodyne circuit, there is available at the converter tube output a frequency that is the difference between the incoming signal and local oscillator frequencies. This difference frequency retains all of the characteristics of the incoming signal except the carrier frequency itself.
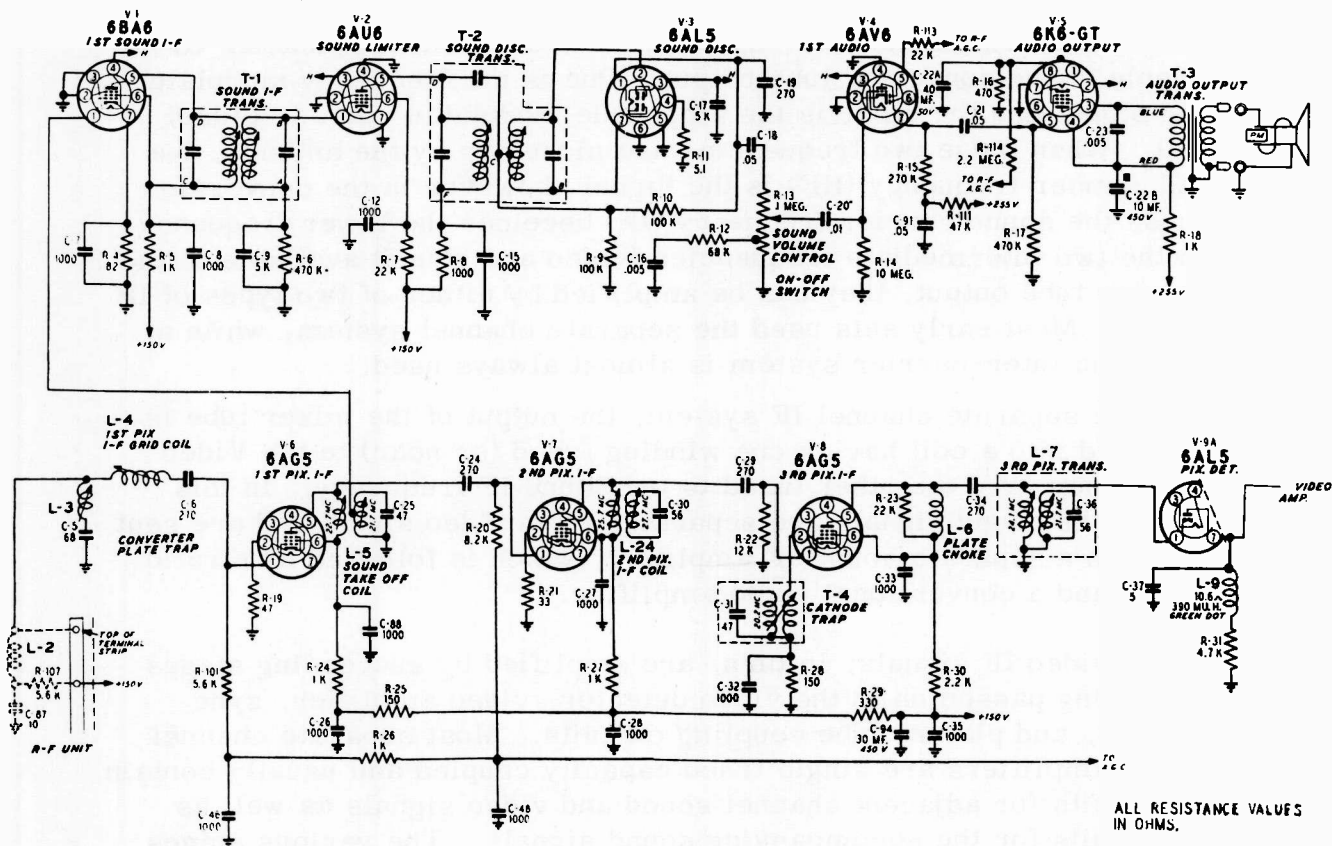
Figure 3.
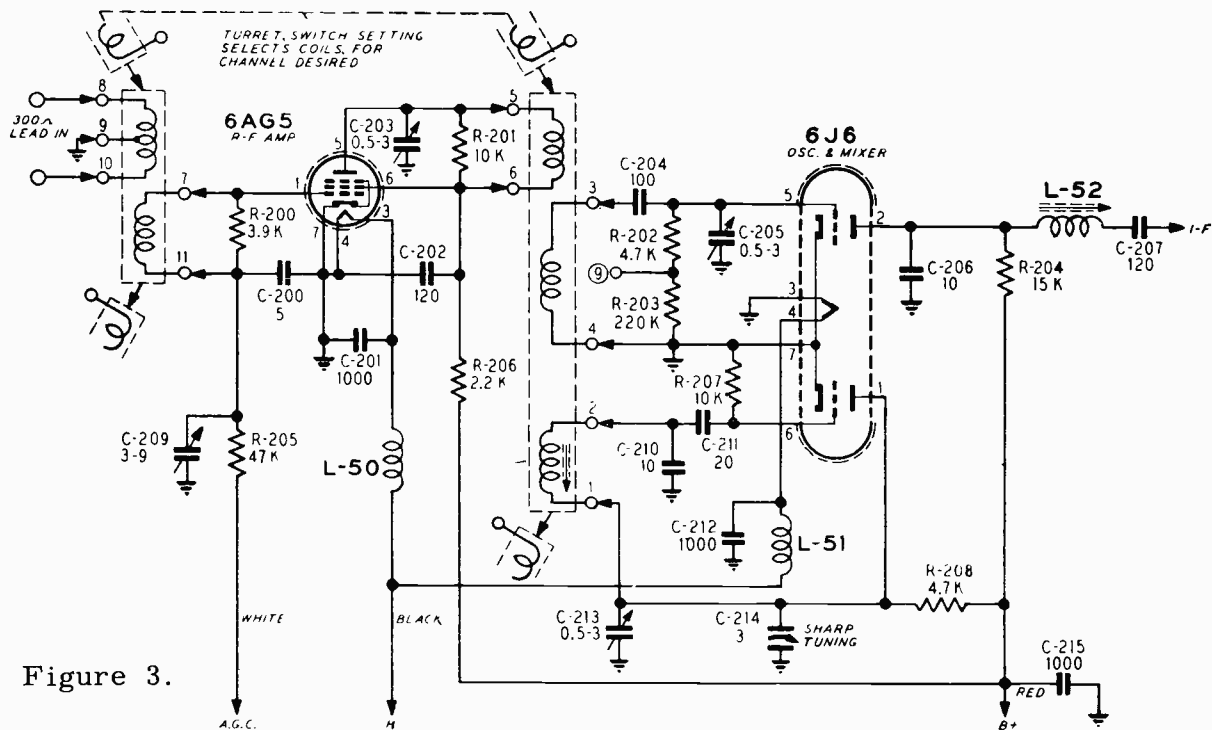
In the television receiver there are two different frequencies (IF) available at the converter tube output. One is the frequency modulated sound signal and the other is the amplitude modulated video (picture) signal. When these two frequencies are picked up by the antenna, the sound carrier frequency (RF) is the higher; however in the conversion process the sound carrier frequency (IF) becomes the lower frequency. With the two intermediate frequencies (video and sound) available at the converter tube output, they can be amplified by either of two types of IF systems. Most early sets used the separate channel system, while at present the inter-carrier system is almost always used.

In the separate channel IF system, the output of the mixer tube is usually fed into a coil having one winding tuned (or near) to the Video IF frequency, and the other tuned to the Sound IF frequency. In this manner, the sound signals are separated from video signal and are sent on through a separate sound IF amplifier, which is followed by a ratio detector and a conventional audio amplifier.

The video IF signals, in turn, are amplified by succeeding stages before being passed on to the video detector, video amplifier, sync separator, and picture tube coupling circuits. Most separate channel video IF amplifiers are single tuned capacity coupled and usually contain trap circuits for adjacent channel sound and video signals as well as trap circuits for the accompanying sound signals. The various stages of the video IF amplifier are stagger tuned to provide a wide band-pass circuit. The sequence of alignment usually consists of peaking the trap circuits and then adjusting the tuning coils for the proper bandwidth.

In Figure 4 is shown a separate channel IF system used in early sets. In this circuit, the output of the converter is fed into a one stage combined video and sound amplifier. The output of this stage (L-5) is tuned to 22.7 mc and couples to the second video IF amplifier tube through C-24. The trap winding of L-5 is tuned to 21.7 mc (sound IF) and traps the sound signals out. From the tap of this winding the sound IF signal is applied to the first sound IF tube (V-1). From V-1 the sound signals are fed into V-2 the sound signal limiter stage and then into a conventional FM discriminator (V-3). A 6AV6 (V-4) is the first audio amplifier and a 6K6 acts as a power amplifier feeding to the loudspeaker. In the plate circuit of V-7 one winding of L-24 is tuned to 25.7 mc and the adjacent channel sound trap circuit is tuned to 27.7 mc. The signal is then coupled to the third video amplifier (V-8) through C-29. In the cathode circuit of this tube is an adjacent channel video trap circuit tuned to 20.2 mc. The input circuit of the video detector circuit is tuned to 24.1 mc by one winding of L-7. The other winding is tuned to 21.7 mc to provide additional sound signal attenuation. Gain of the video IF amplifier is controlled by the voltage developed by the video detector which is applied to the AGC amplifier tube. The output of the AGC amplifier varies bias voltage on the first and second video IF tubes.
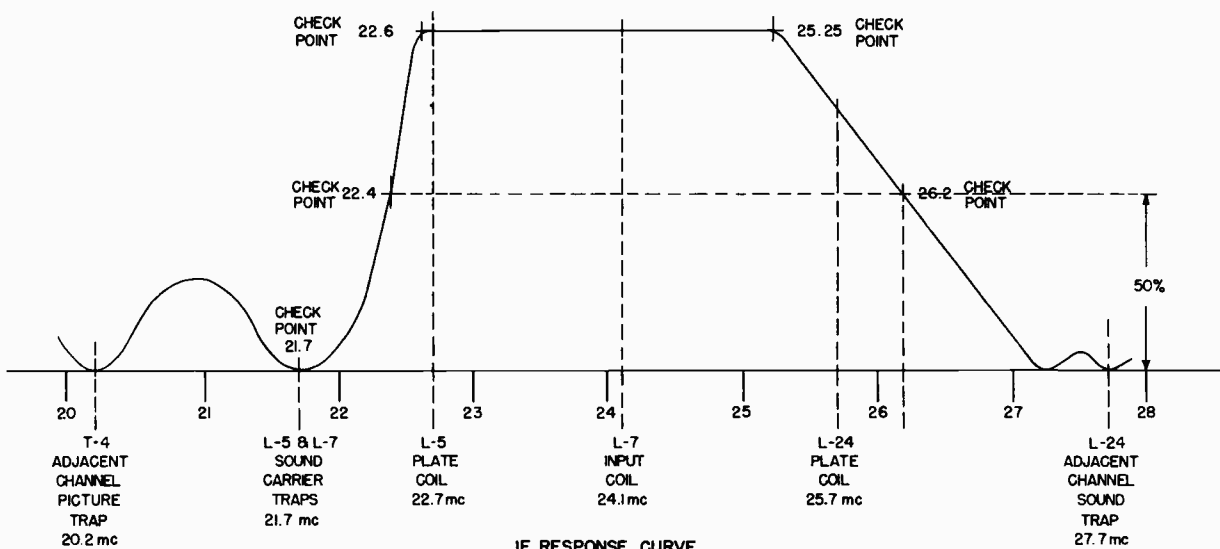
SEPERATE CHANNEL IF
FIGURE 4

ALL RESISTANCE VALUES IN OHMS.

ALL CAPACITANCE VALUES LESS THAN 1.0 IN MF. AND ABOVE 1.0 IN MMF., UNLESS OTHERWISE NOTED.

To see how the trap and coupling circuits are tuned, refer to figure 5. Here the solid line on the graph represents the ideal response curve of an IF amplifier with the picture IF carrier at 26.2 mc and the sound IF carrier
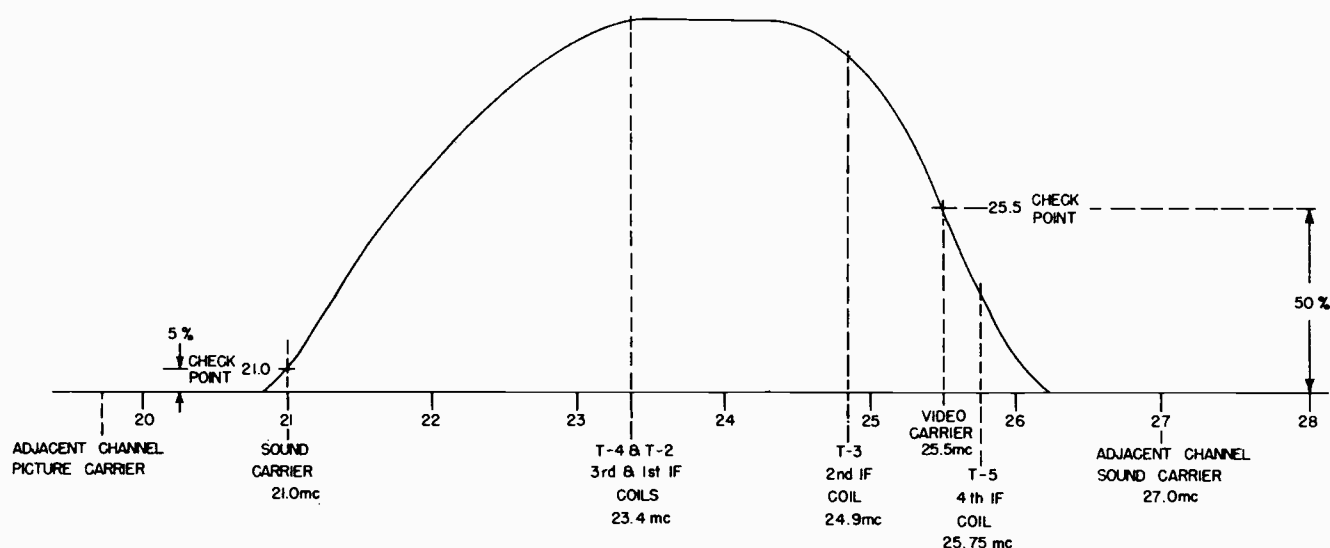

IF RESPONSE CURVE
FIGURE 5

at 21.7. The dotted vertical lines indicate the frequencies at which the coupling coils and trap circuits are aligned. Note that two trap circuits are used to remove the video sound signals and that one trap is used for removal of adjacent channel sound and another for the removal of adjacent channel video signals.

In separate channel IF systems trap circuits are adjusted to attenuate accompanying sound, adjacent sound and adjacent picture signals to a minimum. The coupling circuits are usually stagger tuned to provide as flat a response curve as possible for the desired video signals. In the set considered previously the coupling circuits are adjusted to 22.7, 24.1, and 25.7 mc to provide a flat response curve. The video carrier frequency of 26.2 mc appears half way (50%) down from maximum response and the sound carrier frequency of 21.7 mc is at minimum (0%) level. The trap circuits are adjusted to 20.2, 21.7 and 27.7 mc to attenuate adjacent channel video, accompanying sound and adjacent channel sound signals.
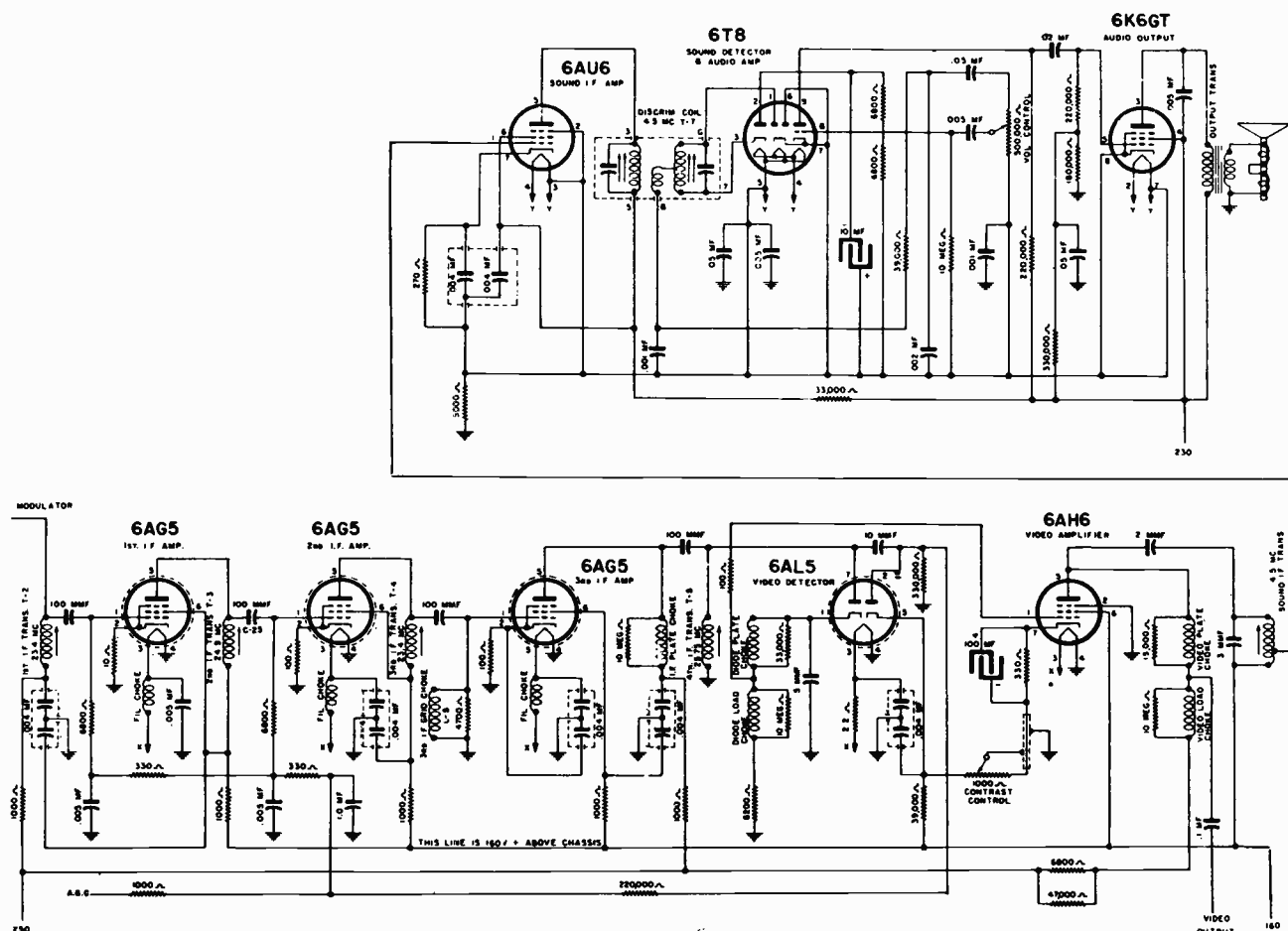
INTERCARRIER CIRCUIT
FIGURE 6

IF RESPONSE CURVE
FIGURE 7

In the inter-carrier IF system, both the Sound and Video IF signals pass through one amplifier circuit. Therefore, the bandwidth of such an amplifier must be somewhat wider than that used in the separate channel system. The response to the Sound IF signal is relatively low so that when the Video and Sound IF signals reach the detector circuit, the Video signal is about ten times as strong as the Sound signal. When these two signals combine in the detector output circuit they hetrodyne with each other producing a difference frequency of 4.5 mc. Since the Sound signal is the weaker of the two, the 4.5 mc signal will take on the character- istics of the Sound (FM) signal. This difference frequency of 4.5 mc then becomes the Sound IF "operating" frequency. When it is trapped out of the video detector (or amplifier) circuit and amplified by a 4.5 mc IF stage it may be converted to an audio signal by a conventional FM detector circuit. (This may be a limiter-discriminator or a ratio de- tector circuit). The detected audio signal is then amplified and fed to the speaker. See Figures 6 and 7.

In the IF circuits just considered, the gain of the IF amplifier (and the RF stage of the tuner) is controlled by a bias voltage developed by the detected video signal (AGC, automatic gain control). However, in many sets the gain of IF amplifier is governed by the value of a negative voltage applied to the amplifier (and RF) stages through a manually oper- ated CONTRAST control. The picture contrast is dependent upon the strength of the video signal, therefore, if the gain of the IF amplifier is varied picture contrast may be controlled.

The video detector at the television receiver performs the same essential functions as the diode second detector in a conventional radio receiver. However, due to television receiver circuit requirements and the nature of the television signal certain significant circuit changes are necessary.
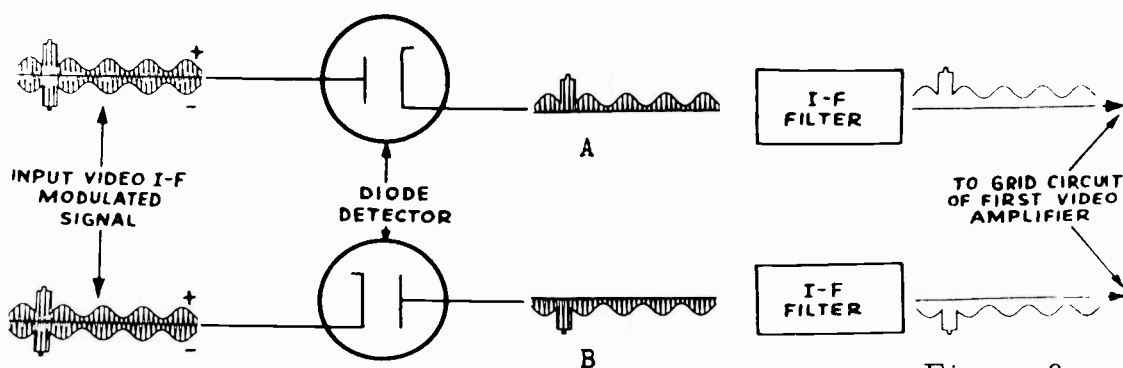
Figure 8.

First of all the polarity of the detected signal must be correct to reduce the picture tube grid bias to reproduce increased white tones. The polarity of the detector tube output must be negative going (in respect to chassis) if an even number of video amplifier stages are used, positive going if an odd number (usually one) of stages are used. This rule applies when the output of the video amplifier is applied to the picture tube grid. In some cases, to simplify video amplifier design, the output of the amplifier is applied to the picture tube cathode. In such cases the polarity of the above rule is reversed. Figure 8 will help you understand this explanation.

Another significant difference between the operation of the diode detector in a conventional radio and the video detector in a television receiver is in the frequencies present in the circuit. In radio circuits a comparatively high value of load resistor (.5 to 2 megohms) may be used. This results in a high output voltage and is permissible as the frequencies handled (between 60 and 5000 cycles) are not attenuated by the circuit reactance and tube capacitance. However, in a television receiver detector circuit the frequencies range from 30 cycles to more than 4 megacycles. If a high value of load resistance is used under these conditions, the equivalent reactance of the circuit and tube capacitance becomes lower than the load resistance resulting in severe attenuation of the higher frequencies through the low reactance of the circuit and tube capacitance. Therefore, in television receivers the video detector load resistance usually is in the order of a few thousand (3000 to 5000) ohms.

Even with this low value of load resistance, there is some attenuation of the higher frequencies. To compensate for this, series and shunt peaking coils are incorporated in the output circuit. In Figure 9 is shown a typical video detector circuit using these peaking coils. By proper design of these coils the desired frequency response may be secured. Also in this figure is shown the characteristic of the video output with and without peaking coil compensation. These peaking coils are also used in the video amplifier stages to maintain this desired wide band frequency characteristic.
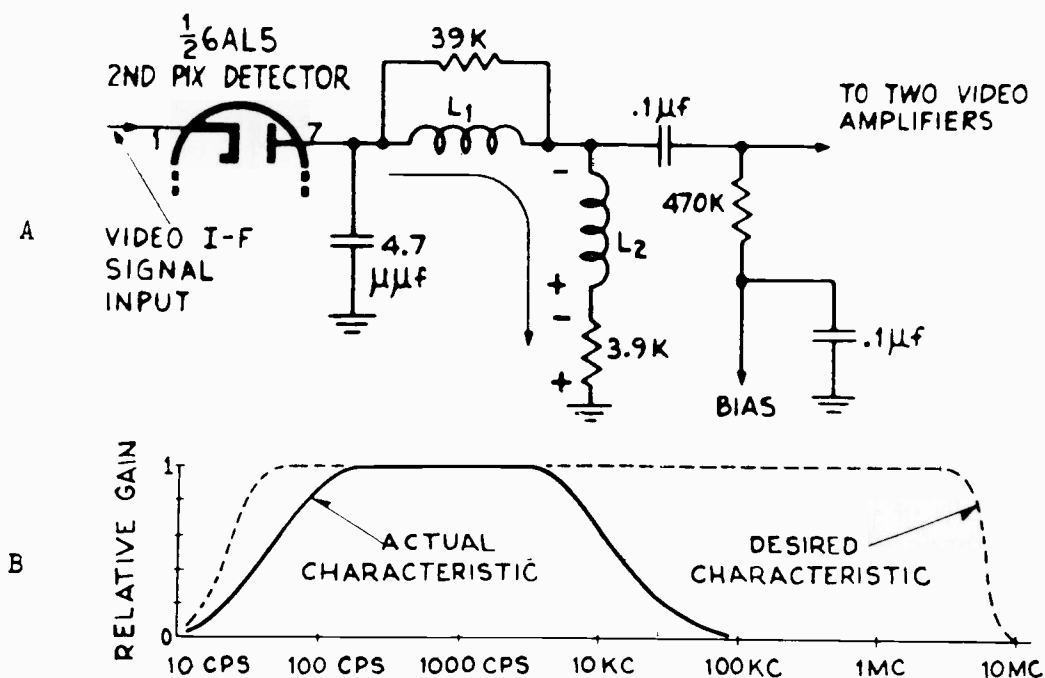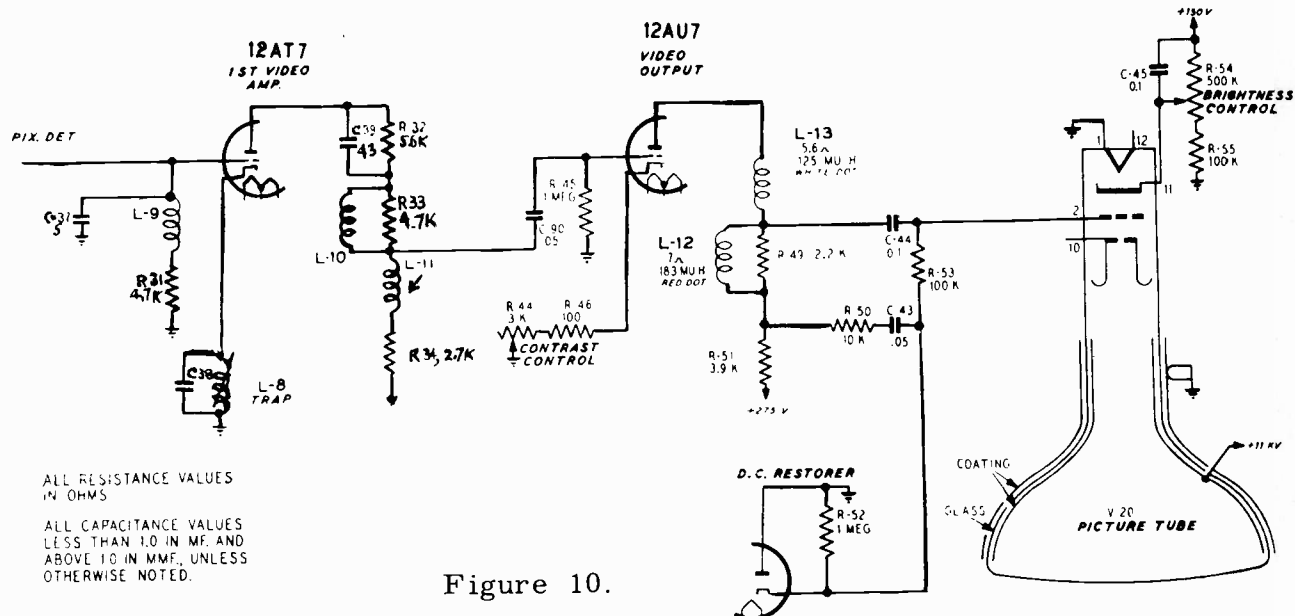
Figure 9.

The small fixed cartridge type Germanium crystal diode is used to some extent to replace vacuum tube diodes in present day television receivers. Several features that make such application practical are: lower internal capacitance, smaller size, lower dynamic resistance, ease of installation and elimination of heater power requirements. The lower capacitance and lower dynamic resistance result in higher rectification efficiency over a given bandwidth.

The output of the video detector seldom exceedes a few volts and since the grid of the picture tube requires about 40 volts to cover the range from white to black, it is necessary to amplify the video signal by one or more stages of amplification.

The basic circuit of the video amplifier is that of the common resistance-capacitance coupled amplifier used in radio circuits. However, since the video signal contains frequencies ranging from about 30 cps to over four million cycles (4 mc), the video amplifier must have essentially uniform gain over this very large range. Due to the coupling circuits between stages and the interelectrode capacity in the tubes, both low and high frequencies are attenuated in the conventional resistance-capacitance amplifier. To overcome this condition and to provide uniform gain over the wide band of frequencies shown by the dotted line in Figure 9, low frequencies are increased by a "bass-boost" circuit similar to that used in audio amplifier. Poor low frequency response to signals generated by scanning large objects, will be evidenced by improper contrast between these large objects and small objects of the same shade.

Figure 10.

High frequency compensation, required to reproduce fine detail in the picture is usually accomplished by using series and shunt peaking coils in the plate circuits of the video amplifier stages.

In Figure 10 is shown a typical two stage video amplifier used in some of the earlier sets. Here L-9, C-37, and R-31 receive the detected signal from the plate of the video detector. L-9 is the shunt peaking coil in the detector circuit. L-8 and C-36 in the cathode of 1/2 of a 12AT7 video amplifier, provide a trap circuit for any 4.5 mc signals that might enter the video amplifier. Note that this tube is self-biased by the voltage developed across R-31 the 4.7K grid resistor. This method of grid bias provides the necessary "bass-boost" or low frequency compensation. In the plate circuit C-39, R-32, L-10, and R-33 are the series peaking circuit with L-11 being the shunt peaking.

Again in the video output stage, consisting of 1/2 of a 12AU7, grid bias is developed across R-45 with the gain of the stage controlled by an unbiased cathode resistor (R-44 and R-46) acting as a contrast control. In the plate circuit, L-13 is the series peaking coil and L-12 is the shunt peaking control. The video signal is applied to the grid of the picture tube through C-44.

In video amplifiers other factors (other than frequency response) affect quality of the picture. One of these is phase distortion. This is particularly true in video amplifiers as they must reproduce many square waves developed by an abrupt change from white to black or black to white. If the black or white area is large the edge of the area will be followed by a trailing edge of the same or opposite shade depending upon the compensation of the amplifier to the frequency involved. Fortunately
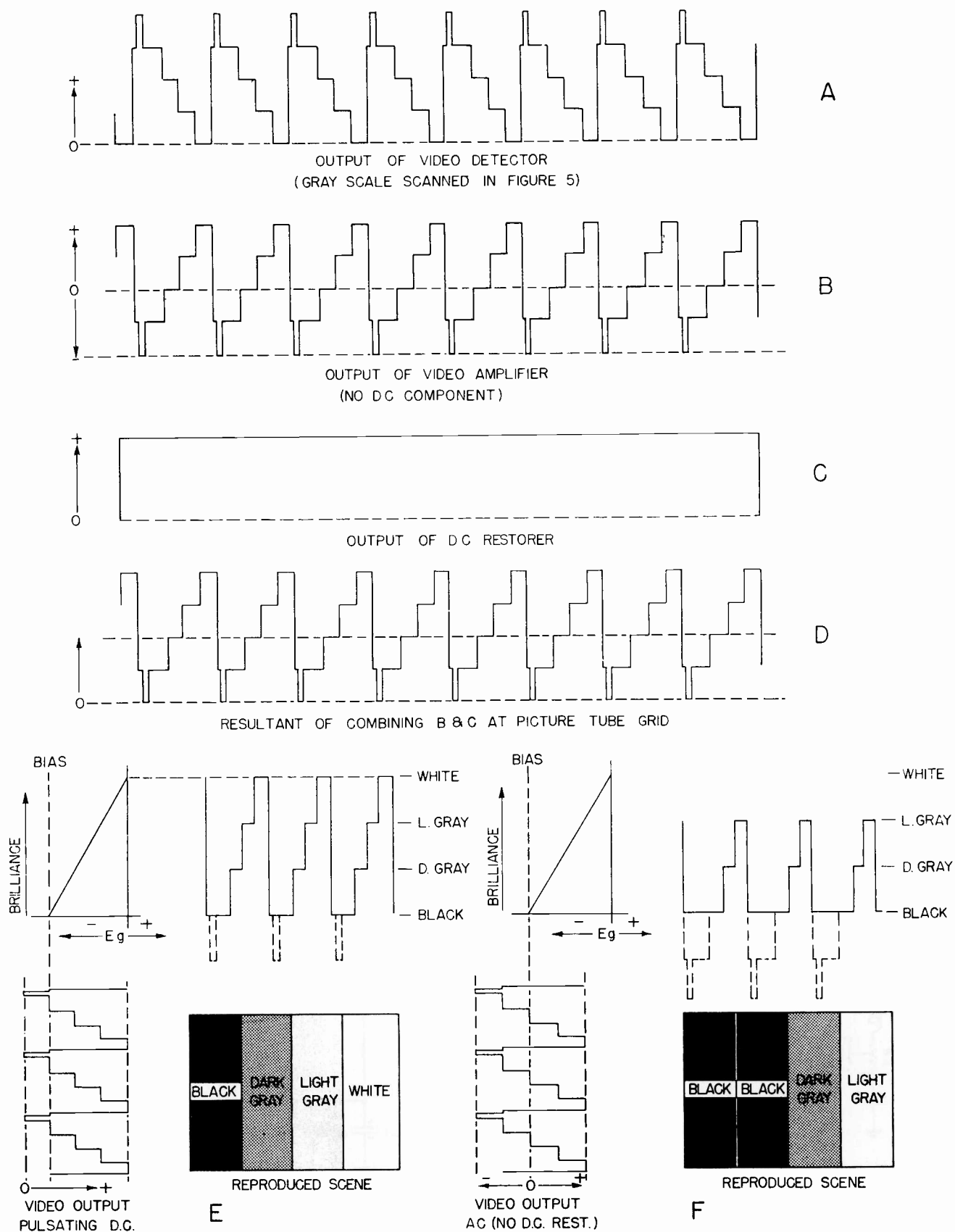
an amplifier compensated for good frequency response also is compensated against phase distortion. Another factor affecting picture quality is the proper damping of the peaking coils. If they are not shunted by damping resistors (See L-10 and L-12 in Figure 10), the picture may become smeared or a "ghost" of opposite shading may develop.

In many receivers a 4.5 mc trap circuit is incorporated in the video amplifier. In sets employing the separate channel IF system this trap is usually placed in the input of the first video amplifier to remove any 4.5 mc difference frequency signals that might interfere with proper picture rendition. In sets using inter-carrier IF, a 4.5 mc trap is usually placed in the first video amplifier output circuit and is used to trap the 4.5 mc difference frequency signal (sound signal) to remove any trace of the 4.5 mc signal that might interfere with good picture reproduction. This trap should not be confused with the 4.5 mc sound take-off coil used to divert the 4.5 mc sound signals to the sound IF amplifier.

While actually a part of the picture tube circuit, the Brightness Control functions to apply a fixed negative bias to the picture tube grid. This is required as the electron beam must be cut off at the correct point to establish the black level of the picture. With this bias voltage value established, the variations in the positive going video signal, applied to the picture tube grid, will modulate the beam in accordance with the intensity of the light in the televised scene.

In the discussion of the transmitted video signal it was shown that the signal impressed on the transmitted carrier was of a pulsating DC nature. The carrier then was amplitude modulated with maximum strength representing the peaks of the sync pulses and minimum strength representing white areas in the televised picture. When this signal is demodulated by the video detector in the receiver, the signal again becomes a pulsating DC voltage. This is the type of signal which must be impressed on the picture tube grid to modulate the electron beam and vary its intensity to reproduce white, black, and the various shades of gray, on the face of the picture tube.

However, when a pulsating DC voltage is applied to the input of a resistance-capacitance coupled amplifier, the output becomes an AC voltage with a zero axis equal to the average value of the DC component. Such an AC voltage, applied to the picture tube input, will not render correct picture detail. The reasons for this are shown in Figure 11 on the adjacent page. At A is shown a positive going signal as it is applied to the video amplifier input. This voltage passed through the video amplifier and at the output it appears as shown at B. If this voltage is applied to the picture tube grid the resulting picture would be like that shown at E. Since the picture tube is biased to cut-off, any additional negative voltage (from sync pulse and black or dark gray portions of

A

OUTPUT OF VIDEO DETECTOR
(GRAY SCALE SCANNED IN FIGURE 5)

B

OUTPUT OF VIDEO AMPLIFIER
(NO D.C. COMPONENT)

C

OUTPUT OF D.C. RESTORER

D

RESULTANT OF COMBINING B & C AT PICTURE TUBE GRID

BIAS

WHITE
L. GRAY
D. GRAY
BLACK

BRILLIANCE

Eg

BIAS

WHITE
L. GRAY
D. GRAY
BLACK

BRILLIANCE

Eg

VIDEO OUTPUT
PULSATING D.C.

E

| BLACK | DARK GRAY | LIGHT GRAY | WHITE |

REPRODUCED SCENE

VIDEO OUTPUT
AC (NO D.C. REST.)

F

| BLACK | BLACK | DARK GRAY | LIGHT GRAY |

REPRODUCED SCENE

FIGURE 11

the signal) would not affect the beam current. Only the positive portion of the signal (light gray and white) would cause an increase in the electron beam current. Since this signal has insufficient strength, light gray would be rendered as dark gray and white as light gray. The black and dark gray portions of signal are rendered as black as they are negative going pulses.

This condition may be corrected by restoring the video signal to its original pulsating DC state by introducing a correct reference level. This is accomplished in a number of ways. However, in general it may be stated that the negative going portion of the video signal, at the output of the video amplifier, is rectified and this voltage is applied to the picture tube grid in opposition to the negative going portion of the signal. This, in effect restores the video signal to its original pulsating DC state. This action is illustrated at C and D of the figure. At F is shown the result of applying the restored DC video output signal to the picture tube.

Probably the simplest system of DC restoration in the video amplifier is to employ a direct coupled amplifier between the video detector and picture tube. Such a circuit is shown in Figure 12A. While this circuit has the advantage of not requiring a restorer circuit the fact that all cathode and grid returns are at a high negative potential below ground places a high voltage between cathode and filament.
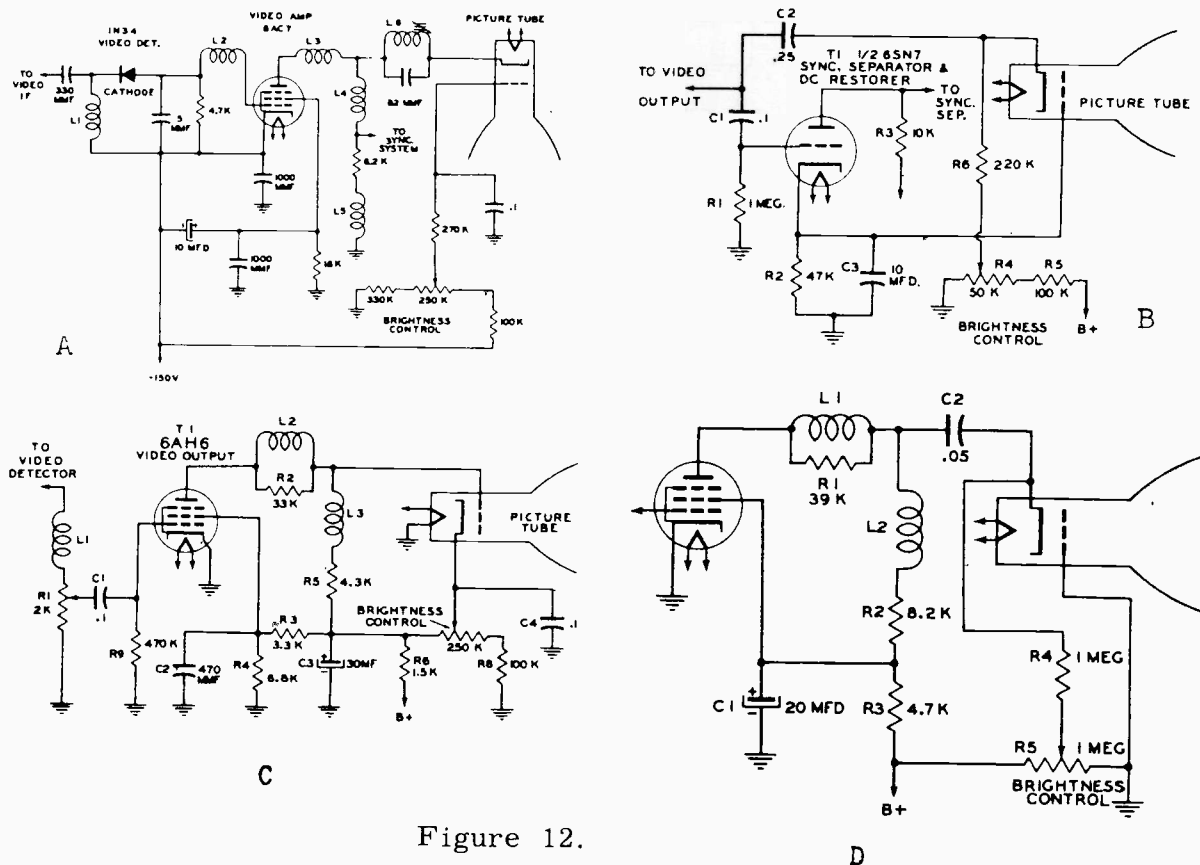
Figure 12.

One of the most common DC restorer circuits employs a separate diode for this purpose. Such a circuit is shown as part of the video amplifier illustrated in Figure 10. Here the cathode of the DC restorer receives the video amplifier output through R-50 and C-43. During positive swings of the video output the restorer cathode is positive in respect to its plate and will not conduct. However, during negative swings of the video output the cathode is negative and the diode conducts developing a voltage across R-52. This voltage then charges C-43. Since C-43 is coupled to the picture tube grid through R-53 the rectified voltage is applied to the picture tube at the same time as the video signal from the amplifier. This action restores the signal to its desired DC nature.

Another commonly used DC restorer circuit is shown in Figure 12B. Here a triode is used as a combined DC restorer and sync separator. The video signal is applied to the cathode of the picture tube through C-2 and to the grid of the DC restorer-sync separator through C-1. In this circuit, the tube should conduct only when a voltage equal to or greater than the black level is applied to the grid. (This action allows only the sync pulses to appear in the plate circuit). Therefore, the tube is biased to a voltage equal to the black level of the signal. Since this voltage, appearing across R-2 and C-3, is equal to the DC component of the video signal it may be used for DC restoration by applying it to the picture tube grid.

Inspection of circuit diagrams of some recent sets does not reveal any apparent DC restoration circuit. In one version restoration is accomplished in the grid circuit of the last video amplifier and in another circuit it is accomplished in the picture tube input circuit. A circuit incorporating grid circuit rectification, or DC restoration, is shown in Figure 12C. Here the last video amplifier is directly coupled to the picture tube grid. The picture tube grid is kept negative in respect to the cathode by applying a higher positive voltage to it through the brightness control.

The grid and cathode of the last video amplifier tube act as a diode and provide the necessary bias. This bias will be equal to the value of the positive going portion (sync pulse portion) of the input signal, therefore only the negative going portion of the signal will change the plate current flow. Due to direct coupling to the picture tube the plate voltage changes will affect the picture tube grid circuit as a DC voltage and effectively restore the DC component to the output.

A circuit using the picture tube input circuit for DC restoration is shown in Figure 12D. This system often called "AC stabilized brightness control" operates in the following manner. Self bias (in the absence of a signal) is established across R-4 and R-5. When the video signal is applied, a DC voltage is developed across R-4, to provide the necessary restoration.

Contrast in a television picture is the ratio of the light intensity in the brightest highlight to that of the deepest shadow. Since this ratio is governed by the value of the voltage swing applied to the picture tube grid it can be seen that the contrast in the picture may be controlled by varying the output of the last video amplifier stage. This output can be varied at any point in the television receiver, either in the RF, IF, or Video amplifier stages. Usually a combination of controls at several points is employed to prevent overloading and distortion of the signal as it is amplified.

Contrast control in the Video Amplifier stages, generally used with Automatic Frequency Control in the RF and IF stages, may consist of a potentiometer used at the Video Amplifier input in a manner similar to the conventional radio volume control, or it may be an unbypassed (to introduce degeneration) variable resistor in the cathode circuit of one of the Video Amplifier stages. Another gain control system employed by some set manufacturers consists of a potentiometer across a source of negative voltage, to supply the various Video Amplifier stages with an adjustable grid bias voltage. In such circuits isolating networks are used in each grid return lead to prevent unwanted interstage coupling.
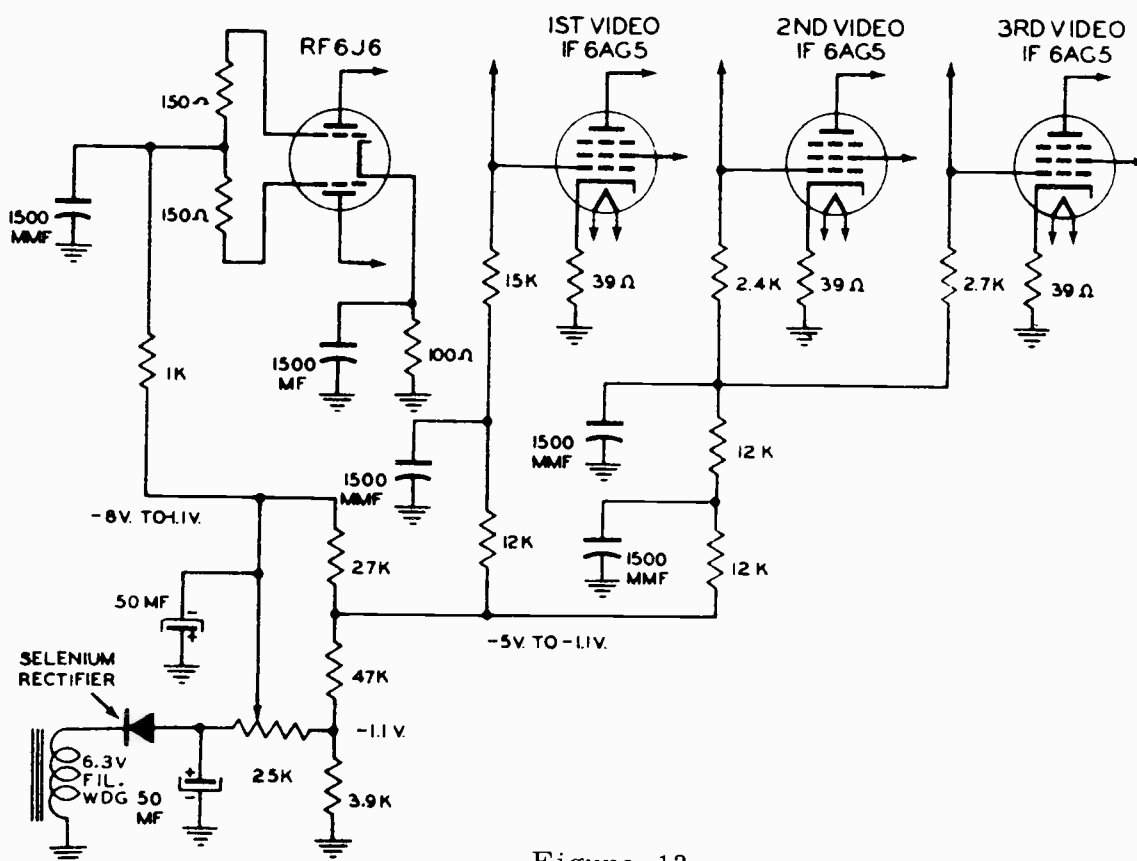
Figure 13.

When contrast is controlled by varying the gain of the RF and IF circuits, by means of varying the grid bias, several problems arise. The most important of these is to vary the RF bias in such a manner as to assure maximum output from the RF unit and at the same time not overload any of the IF stages. This is generally accomplished by applying a negative voltage to the RF and IF tube grids, through a variable control and voltage divider network. Such an elaborate system is required as most RF tubes are of the remote cut-off type and the IF tubes are of the sharp cut-off variety. Such a circuit is shown in Figure 13. In this circuit the bias on the RF tube may be varied from -1.1 volts to -8 volts, while the bias on the IF tubes may be varied from -1.1 to -5 volts.

An improvement on the elaborate network bias system just described employs a diode as the controlling element in the circuit. The purpose of the diode is to allow the RF circuit to operate at full gain over a large portion of the Contrast Control range. This aids in maintaining a high signal-to-noise ratio. The gain of the RF circuit is reduced only when it is necessary to prevent overloading of the first IF stage. Such a circuit is shown in Figure 14.
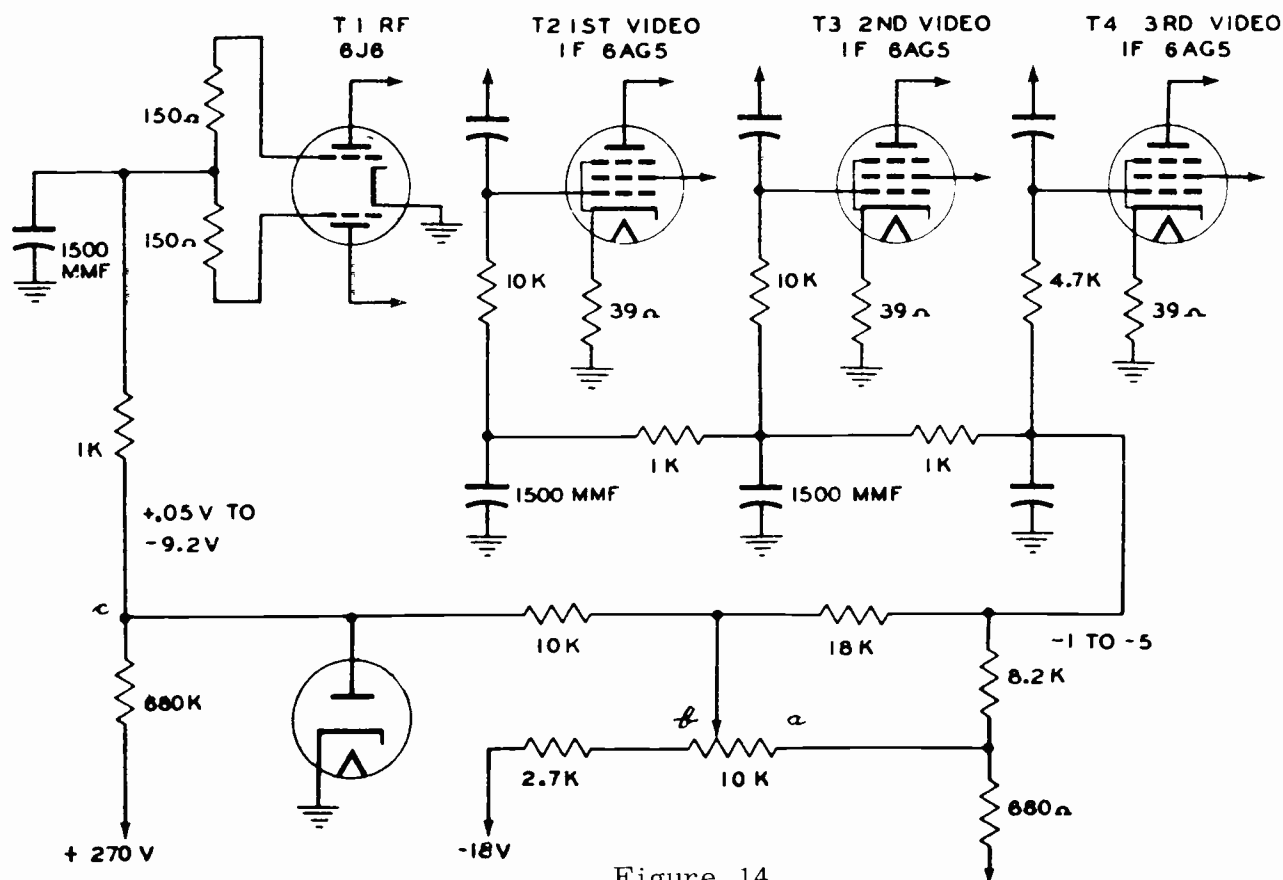
Figure 14.

When the Contrast Control is in the maximum gain position (a) the bias on the IF amplifier is about −1 volt. The RF bias, taken from tap (c) on the divider network connected to B+, would be several volts positive except for the heavy conduction of the diode (since the diode plate is positive). This heavy conduction (low resistance) of the diode holds the RF bias at approximately zero. As the contrast control is moved away from its maximum gain position, the IF bias increases rapidly and takes over control of the picture contrast. As the contrast control is moved away from maximum gain position (toward a more negative position) the diode conduction decreases and at about 75% rotation the RF bias voltage increases rapidly taking over most of the gain control. This system allows the RF section to run nearly "wide-open" on weak signals and to run at low gain on strong signals to prevent overloading.
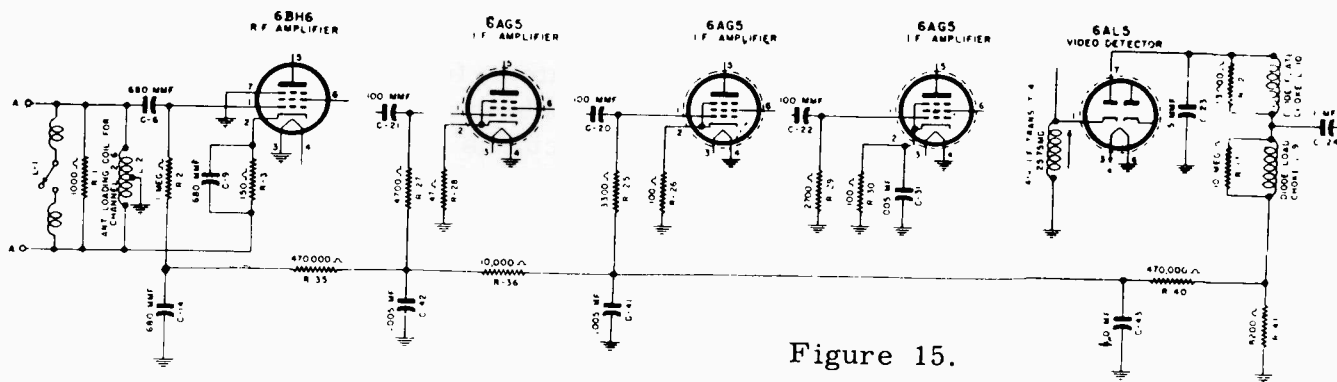
Figure 15.

In a television receiver the automatic gain control (AGC) circuits function much in the same manner as the automatic volume control (AVC) circuits in a radio receiver. In a television receiver, the AGC circuit functions to hold the overall gain (or contrast) constant as the receiver is tuned from channel to channel and signals of varying intensities are received. In Figure 15 is shown a circuit in which a portion of the detected video signal, developed across R-41, is applied through an isolating network to the grids of the RF, 1st and 2nd IF tubes to provide AGC action. Since C-43 is a 1 mfd. condenser, the time constant is comparatively long and the voltage developed across R-41 will represent the average strength of the received signal. As the sync pulses are all of the same strength, with only the picture information varying, the applied AGC voltage will remain relatively constant. One draw-back of such a circuit is that when scenes are rapidly changed from light to dark (or vice-versa) the AGC voltage cannot change rapidly enough to provide proper control. This is especially true of those sets that do not employ automatic frequency control in the sweep circuits. To improve on the AGC action a "gated" system was developed.

In the gated AGC system only the sync pulses (which are of constant amplitude) are used to develop the AGC voltage. Such a circuit is shown in Figure 16. Here the 6AU6 AGC amplifier is so arranged that its
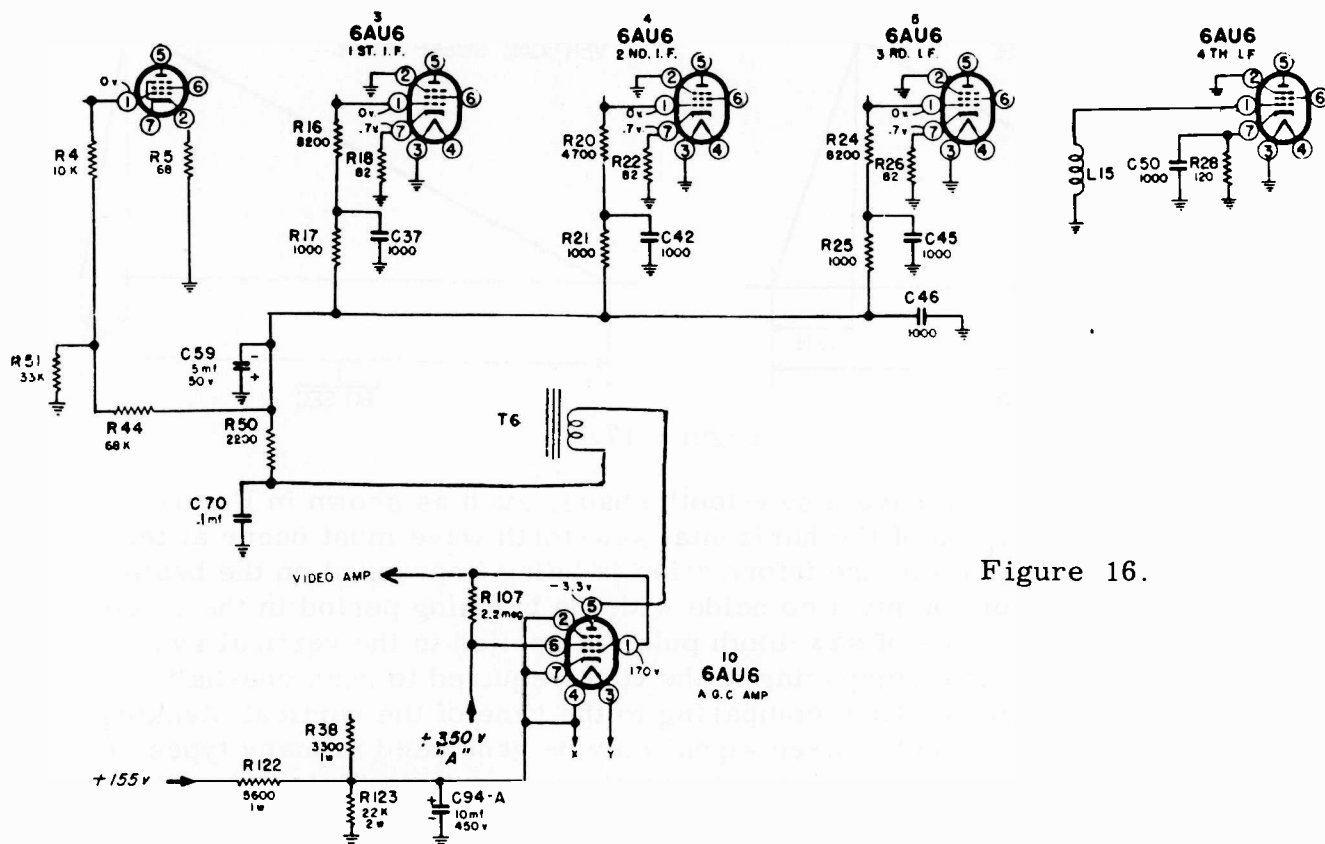
Figure 16.

plate receives a positive voltage pulse only during kick-back period of the horizontal sweep. This voltage is derived from a winding on the horizontal output transformer. Therefore, the tube can conduct only during the kick-back time, and a voltage is developed across R-50, R-44, and R-51. At the same instant the grid of the tube is supplied with a sync pulse signal from the video amplifier circuit. This sync pulse increases the plate current flow, and the voltage developed across R-50, R-44, and R-51. If the pulse from the video amplifier is great (strong received signal), the voltage developed across the resistors will be great and grid bias will be high. If the pulse from the video amplifier is low (weak received signal), the voltage developed across the resistors will be low and the grid bias reduced. Thus this system will vary the AGC voltage in proportion to the strength of the received sync portion of the signal and will function independently of the strength of the picture information portion of the video signal.

Up to this point, the various circuits required to bring the electron beam under control of the video signal picture information have been considered. To complete the picture section of the receiver, a voltage pulse to sweep the beam across the face of the picture tube to recreate an image of the original televised scene must be provided. First let us consider the type of sweep voltage pulse required, what circuits are needed to produce such a pulse, and how this pulse can be synchronized with the incoming signal.

HORIZONTAL SWEEP PULSE

.15 H

$$\frac{1}{15,750} SEC$$

VERTICAL SWEEP PULSE

.07 V

$$\frac{1}{60 SEC}$$
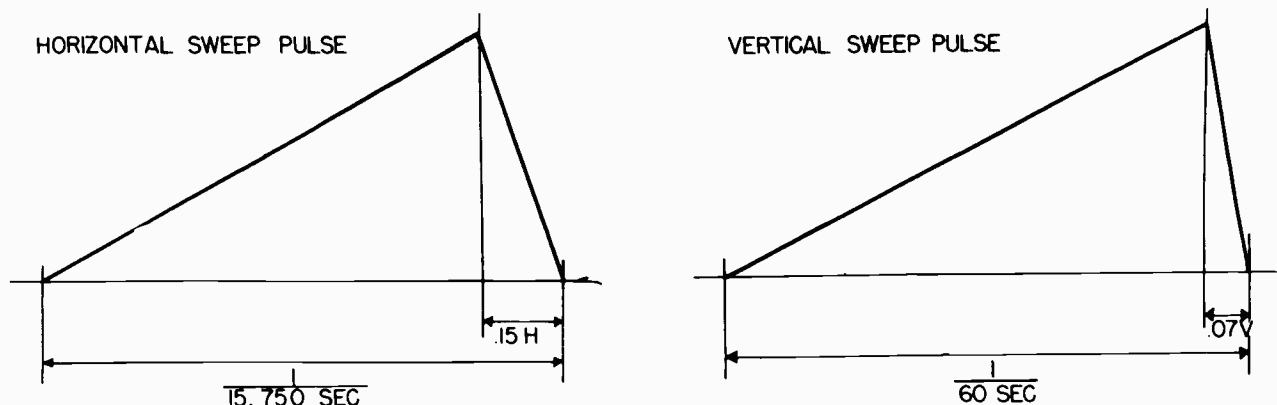
Figure 17.

This pulse should have a saw-tooth shape, such as shown in Figure
17. The trace portion of the horizontal saw-tooth wave must occur at the
same instant that the picture information is being impressed on the beam,
and the retrace portion must coincide with the blanking period in the video
signal. The same type of saw-tooth pulse is applied to the vertical sweep
signal, the trace time comparing to the time required to scan one-half
frame, and the retrace time comparing to the time of the vertical blanking
period. Such a saw-tooth sweep signal may be generated in many types of
oscillator circuits. However, two types of saw-tooth oscillator circuits
are in common use. One of these is a resistance-capacitance multivibrator
circuit in which the output and input circuits of two tubes feed into each
other. Such a circuit is shown in Figure 18. In this circuit, the output
of V1 is fed to V2 through condenser C1, and the output of V2 is fed to V1
through the interconnected cathodes. When this circuit is used in tele-
vision receivers, the grid of V2 is connected to ground through resistor
so the synchronizing signals may be fed to the first tube.
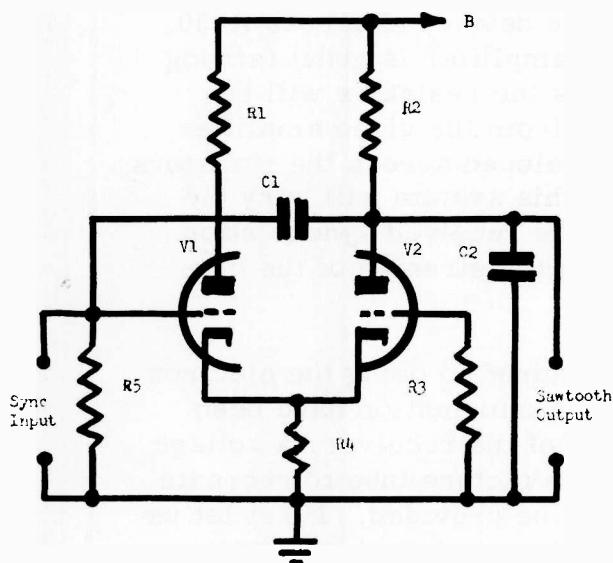
R/C Multivibrator
Figure 18.
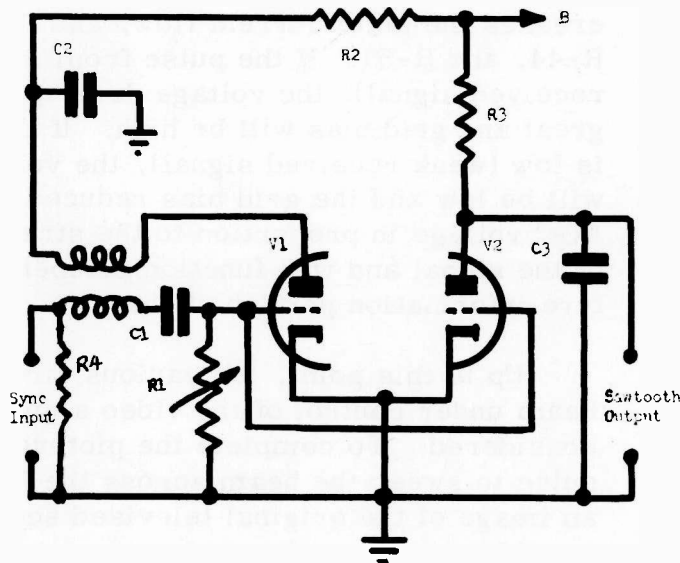
Blocking Oscillator
Figure 19.

Resistor R3 is made variable so the frequency of the circuit may be controlled. Such a control is called the Hold Control. Since such circuits do not have sufficient power to be coupled directly to the deflection circuits, so an amplifier stage is employed to increase the strength of the signal. A variable control, called the Width (or Height) Control, is usually used between the oscillator and amplifier stages to control the gain of the amplifier.

The other type of saw-tooth wave generator in common use is the Blocking Oscillator. The basic circuit of such an oscillator is shown in Figure 19. The oscillator portion of this circuit is very similar to the old familiar tickler-feedback circuit, except that the grid resistor and capacitor are rather large. This change provides an output that has a saw-tooth shape but with too long a retrace time for television use. Therefore, a second tube, acting as an electronic switch, is employed. The frequency of the circuit is controlled by the resistance of R1, and the sync signals are inserted across R4. This circuit, as with the multivibrator, requires the use of an amplifier for sufficient gain. The amplitude of the circuit may be controlled by varying the plate voltage on the second half of the tube — the electronic switch.

The most important problem in magnetic deflection systems is the need of altering the shape of the saw-tooth voltage, from the oscillator circuit, so that the current passing through the deflection coil will have the required saw-tooth shape. We know that the deflection coil has both inductance and resistance. When a saw-tooth current passes through an inductance, a rectangular voltage is produced. When saw-tooth current passes through a resistance, a saw-tooth voltage is produced. When both inductance and resistance are present, a trapezoidal voltage wave is produced.
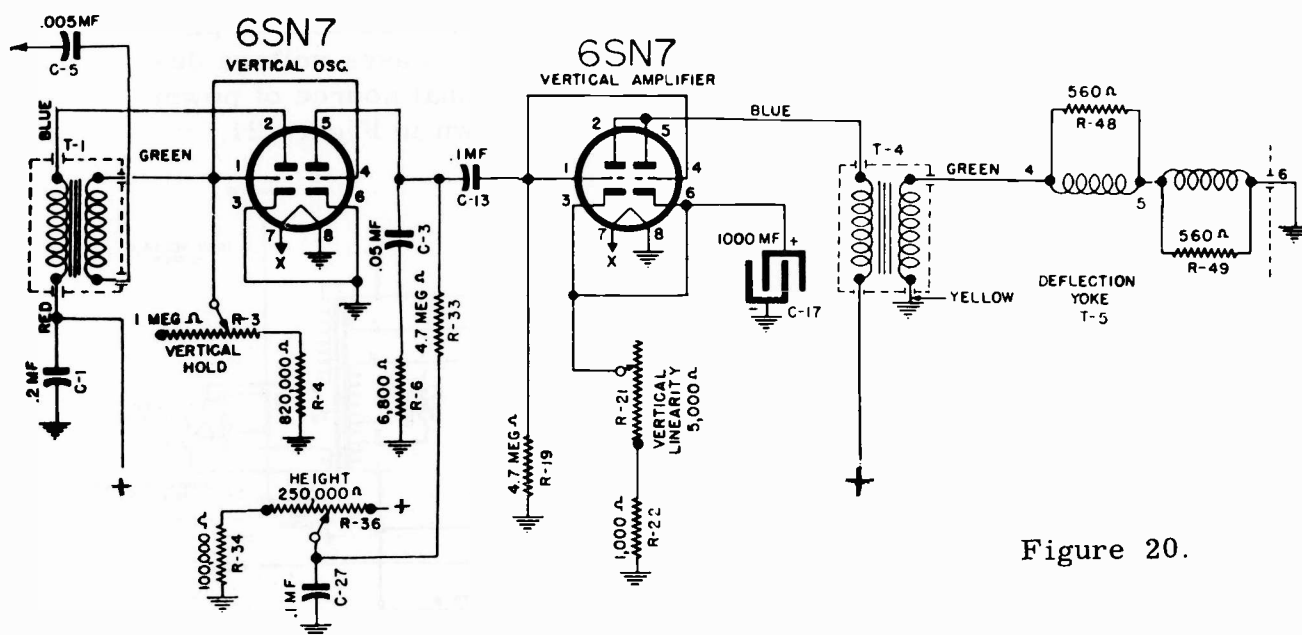
Figure 20.

By the same token the reverse is true. If we desire to produce a saw-tooth current in the deflection coil, a trapezoidal voltage wave is required. Therefore, we must alter the shape of the saw-tooth wave from the oscillator before applying it to the deflection coils. This alteration is easily accomplished in the output of the oscillator. In Figure 20 is shown a vertical deflection circuit that may be considered as typical of a magnetic deflection system.

A blocking oscillator is used to generate the vertical deflection voltage. The sync signals are fed into the primary of T-1 through C-5. The frequency being determined by resistor R-3 (Hold Control), and the amplitude of the oscillator is controlled by R-36 (Size Control). The output of the oscillator is normally a rectangular wave. However, before being passed on to the amplifier stage the rectangular wave is impressed on R-6 and C-3, that are in series and connected across the input of the amplifier. Here the rectangular wave appears across R-6, but a saw-tooth wave appears across C-3. The resultant wave, that is impressed on the amplifier, has the required trapezoidal pattern. With this pattern impressed on the grid, the output of the amplifier stage will have the required saw-tooth form.

In actual operation, the shape of the wave that is impressed on the amplifier grid is not a true trapezoid. To correct this condition, and to secure a saw-tooth current output, a Linearity Control (R-21) is included in the cathode circuit of the amplifier stage. This resistance induces distortion into the circuit to counteract the errors in the input wave form, to produce a true saw-tooth current output. In this circuit the output of the amplifier is transformer coupled to the deflection coil.

In most receivers, the horizontal output circuit is also used to provide the high voltage for the picture tube, and in some cases voltage developed in the "bootstrap" circuit provides an additional source of power for the horizontal output tube. Such a circuit is shown in Figure 21.
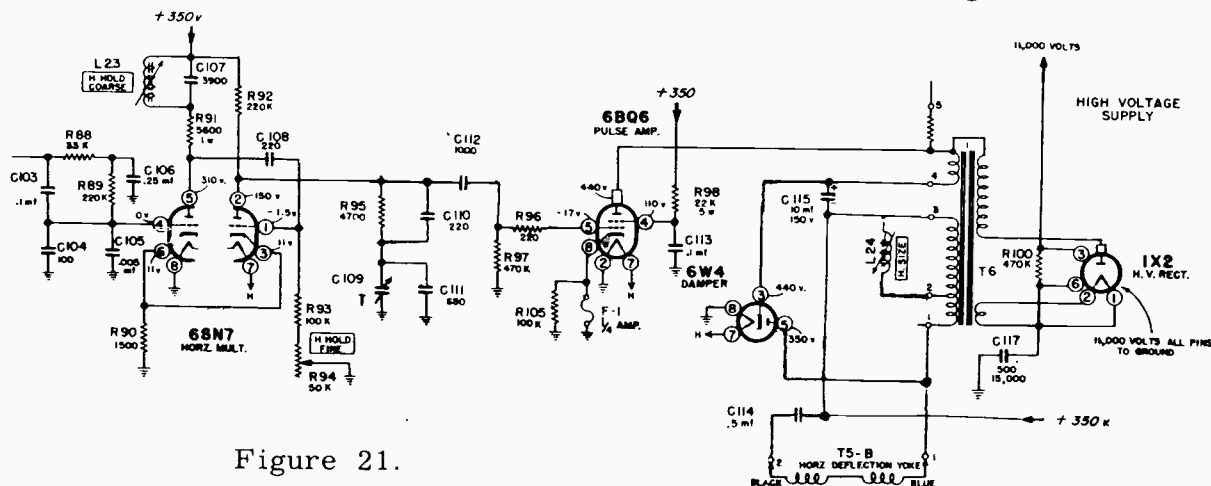

Figure 21.

In this circuit a 6SN7 tube operates as a multivibrator to provide the sweep voltage. In addition to the Hold Control (R-93), a shunt tuned circuit (L-23 and C-107) in the plate circuit of the input half of the multivibrator tuned to approximately 15.75 kc is used to stabilize the oscillator action at the correct frequency. This stabilized circuit is often referred to as a "fly-wheel" circuit due to the action of the L/C combination. In the output circuit trimmer condenser (Horizontal Drive) C-109 controls the shape of the sawtooth wave leaving the multivibrator. Because of its effect on the output wave shape this Drive Control will alter the horizontal linearity of the picture as well as control the value of the sawtooth wave supplied to the amplifier circuit.

In the amplifier circuit several actions take place simultaneously and are inter-related when their effect on the picture is considered. However, when the saw-tooth voltage from the multivibrator is applied to the 6BQ6 amplifier tube, it is amplified and coupled to the deflection coils through windings numbered 4 and 5 (primary) and 1 and 3 (secondary) of the output transformer.

To control the amplitude of the sweep voltage applied to the deflection coils, coil L-24 (Horizontal Size) is connected across the output transformer secondary terminals 2 and 3. This variable inductance provides an adjustable load on the output to control picture width. Some receivers employ an adjustable inductance to control the horizontal linearity of the picture. If such a coil is used it is generally inserted in series with terminal 4 of the output transformer and B+.

As previously mentioned several actions take place simultaneously in the output circuit. One of these actions produces the voltage pulse required to develop the high voltage. This pulse is developed in the following manner. At the end of the trace period the magnetic field in the deflection coil is at its maximum. At this point the amplifier tube ceases to conduct since the applied voltage pulse falls to zero. With the removal of a driving force on the deflection coils, the magnetic field collapses and a surge of voltage is "kicked back" into the output transformer. This kick-back voltage induces a voltage into the winding connected to the 1X2 and allows it to conduct. This 15.75 kc voltage is then rectified and filtered by C-117 and applied to the picture tube anode.

The kick-back voltage from the deflection coils, if allowed to continue, would set up an oscillating voltage in the deflection circuit that would distort the linearity of the received picture. To secure a rapid drop in the kick-back voltage, the output of the deflection circuit is tuned to approximately 70 kc since this frequency coincides with the period of the retrace time of 0.7 microseconds. To stop the oscillation of the kick-back voltage a Damper Tube circuit is included in the horizontal circuit. This tube, a 6W4 in the circuit being considered, conducts during the kick-back period, and charges C-115, thus developing a vol-

tage that will oppose continued oscillations. In this particular set the voltage developed across C-115 is used to provide additional plate voltage to the 6BQ6 amplifier tube since it is in series with the B+ line supplying this plate circuit.

From the foregoing it can be seen that the operation of the horizontal amplifier, high voltage, and damper circuits are all interdependent. Failure of any component in any one circuit can affect the operation of the other two. Thus, if the damper tube should become weak, the voltage to the amplifier tube would be reduced, this in turn would reduce picture width and high voltage in addition to the possibility of affecting picture linearity.

In the explanation of the formation of the video signal it was indicated the synchronizing signals (sync pulses) were added to the transmitted signal so that the received picture could be kept in step, or locked-in with the transmitter. How these pulses are separated from the video signal and utilized will be covered in the following paragraphs.

If an oscillating circuit is operating at or near a frequency equal to the rate of occurrence of a pulsating voltage, the oscillator will lock in with this pulsating voltage if the voltage (of suitable potential) is applied to the oscillator grid. It is this feature of the multivibrator or blocking oscillator circuit that makes it possible to utilize the sync signals in the composite video signal.
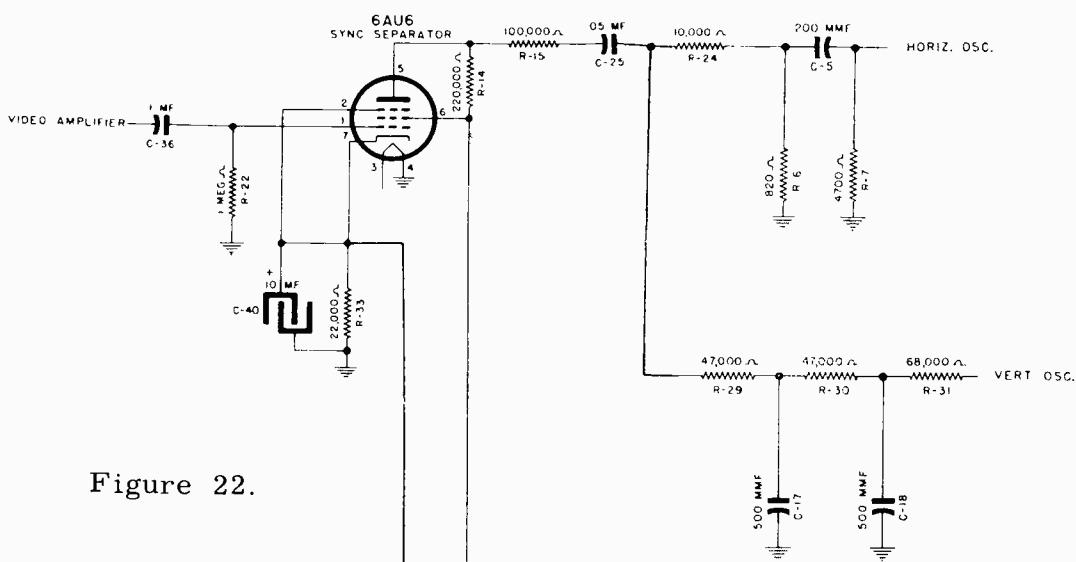
Figure 22.

The sync signals are usually separated from the video signal by a circuit similar to that shown in Figure 22. Here a pentode is biased to cut-off with a voltage equal to the strength of the black level of the video signal. When the composite video signal is applied to the tube only the sync portion of the signal will cause the tube to conduct and develop a

voltage pulse in the plate circuit. These pulses will have the same occurrence rate as the horizontal and vertical sync pulses. When these pulses are applied through suitable band-pass networks, horizontal through a high pass and vertical through a low pass, they can be used to trigger the proper oscillator circuit. In Figure 22, R-24, R-6, R-7 and C-5 make up the high pass filter for the horizontal pulses while R-29, R-30, R-31, C-17 and C-18 make up the low pass filter for the vertical pulses.

In many cases the sync separator circuit is followed by a sync limiter circuit in which a tube is operated near saturation. Thus, any noise pulses, that may have entered the video signal, are reduced to the same level as the sync pulses. This reduces their effect upon the oscillator circuits. The horizontal amplifier circuits are more subject to noise pulse break-up due to the frequency of most interference, therefore in many receivers an improved means of horizontal frequency control is resorted to.

Horizontal sweep oscillators dependent upon stabilization by sync signals alone are quite susceptible to noise and interference, and often lose sync on weak signals. Several types of automatic frequency control circuits have been developed to hold the horizontal oscillator in sync with the horizontal scanning generator at the transmitter. Many sets employ circuits that compare the phase relationship of the horizontal output with the incoming sync signals. If there is a phase difference the circuit utilizes this phase displacement to generate a voltage which is applied to the horizontal oscillator in a manner which will bring its frequency back in phase with the sync signals.

There are several different types of AFC circuits in use. One type, called the phase detector, will be described. A simplified circuit is shown in Figure 23. In this circuit the output of the phase detector supplies either negative or positive bias to the grid of a cathode coupled multivibrator to control the multivibrator frequency.

Positive sync pulses, from the sync separator circuit are applied to the plate of D1 through condenser C-48. During the pulse time the diode conducts and develops a voltage across R-104, R-51, R-59, and R-65. Because of the direction of current flow, point A on R-59 will be negative in respect to ground. At the same time, negative sync pulses from the sync separator circuit are applied to the cathode of D2 through condenser C-59. This causes D2 to conduct during the pulse interval developing a voltage across R-105, R-54, R-59, and R-65. Due to the direction of current flow, point A on R-59 will in this case be positive in respect to ground. Since the potential of both the positive and the negative sync pulses is equal, the net result will be a zero potential at point A, from this action.
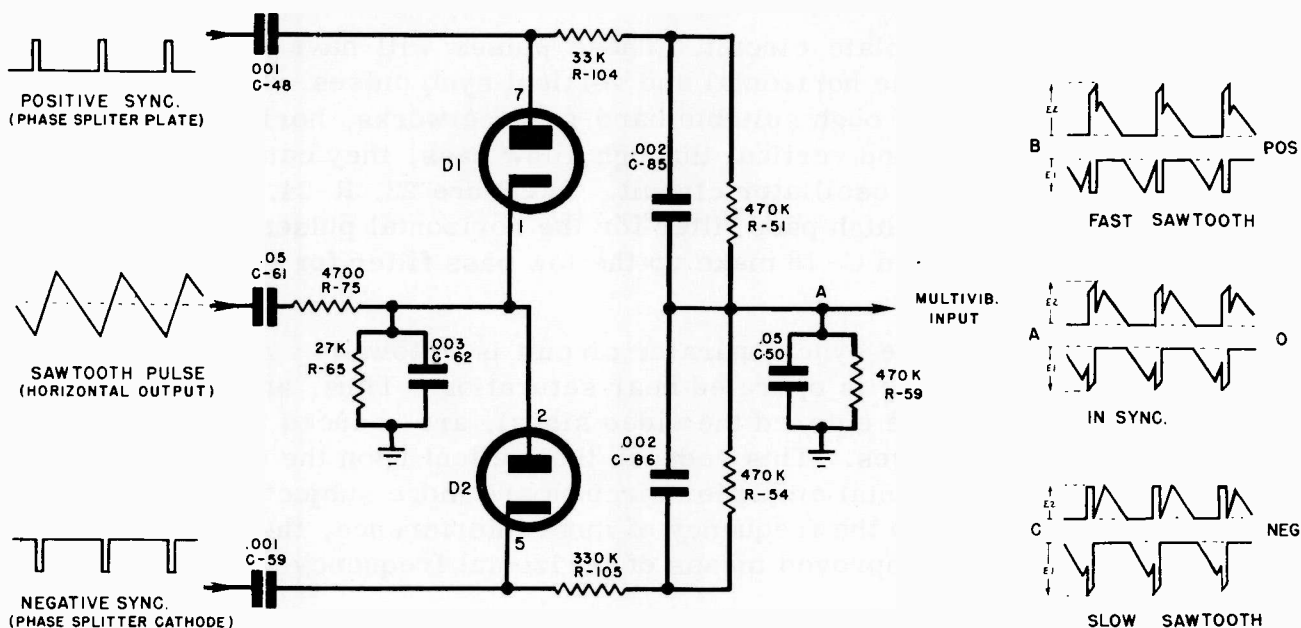
POSITIVE SYNC.
(PHASE SPLITER PLATE)

001
C-48

33 K
R-104

7

D1

.002
C-85

470K
R-51

.05
C-61

4700
R-75

SAWTOOTH PULSE
(HORIZONTAL OUTPUT)

27K
R-65

.003
C-62

2

D2

5

.002
C-86

470K
R-54

330 K
R-105

NEGATIVE SYNC.
(PHASE SPLITTER CATHODE)

001
C-59

A

MULTIVIB.
INPUT

.05
C-50

470K
R-59

B   POS

FAST SAWTOOTH

A   O

IN SYNC.

C   NEG

SLOW   SAWTOOTH

Figure 23.

In addition to the positive and negative sync signals, a sawtooth voltage, developed by integrating a pulse from the horizontal output circuit, is applied to the cathode of D1 and the plate of D2. During the negative excursions of the sawtooth voltage, D1 conducts and develops a negative potential across R-59. During the positive excursions of the sawtooth, D2 conducts and because of its circuit position develops a positive voltage across R-59. Although the two diodes do not conduct simultaneously, the time constant of R-59 and C-50 is long enough so that when considering only the effect of the sawtooth voltage, the net result is a zero voltage across R-59.

If the output of the horizontal amplifier is of the same frequency as the sync signals, the rectified sync pulses will occur during the time the sawtooth voltage output is at zero. Under these conditions, the voltage developed by D1 (E1 of side illustration A) will be equal to the voltage developed by D2 (E2 of illustration A). However, if the oscillator frequency is fast, the sync pulse will "move up the slope," (as shown in side illustration B) causing E2 to become greater than E1. This positive voltage, when applied to the grid of a cathode coupled multivibrator will lower its frequency and bring it into sync.

Under the opposite condition, where the oscillator frequency is slow (as shown in side illustration C of Figure 23), E1 becomes larger than E2 value, resulting in a negative potential at A of the circuit. This voltage, when applied to the grid of the oscillator, increases its frequency and brings it into synchronization.

LESSON 9

AN ANALYSIS OF A STAGGER TUNED I.F. RECEIVER

As you service television receivers, you will be getting first hand knowledge of practical TV circuits explained in the previous lesson. To aid you further in future service work, we will review the operation of several popular television sets of different periods. This will serve as a review and additional practical information to help you on actual jobs.

In this lesson circuit material on an early General Electric set will be presented. This is a stagger tuned type TV set using I.F. in the 25 MC range. This material is reproduced through the courtesy of General Electric Company. Similar circuits, of course, are used in sets of different makes of the same period.
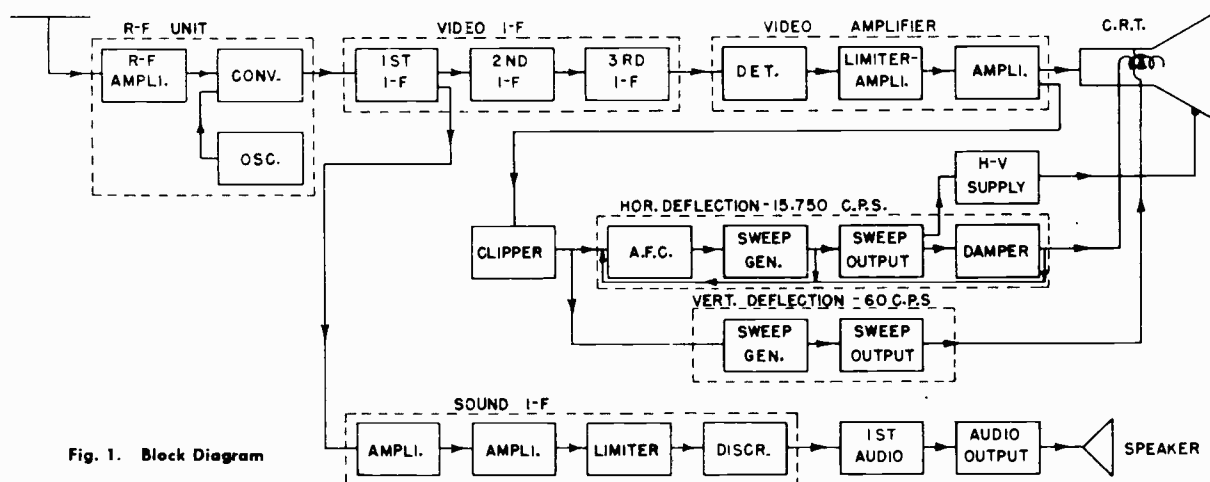
Fig. 1. Block Diagram

The receiver circuits are divided into the following sections:

1. R-F amplifier, converter and oscillator.
2. Video and audio i-f amplifier.
3. Video detector and amplifier.
4. Sync separation.
5. Horizontal sweep generator and AFC sync.
6. Horizontal sweep output.
7. Vertical sweep generator and output.
8. High voltage power supply.
9. Low voltage power supply.

A brief description of the operation of each section is described in the following paragraphs. This is supplemented by simplified circuit diagrams of each portion of the circuit under discussion. Reference is also made to the complete schematic diagram as shown in Figure 21.

1. R-F AMPLIFIER, CONVERTER AND OSCILLATOR (SEE FIGURE 2)—The r-f amplifier makes use of a Type 6AU6 pentode tube connected as a triode grounded grid amplifier. The antenna is connected into the cathode circuit of the tube through a transformer, T1, so as to provide a substantially constant input impedance of 300 ohms to the antenna and lead-in at all frequencies. The transformer, T1, is balanced to ground in the primary winding providing cancellation of noise pick-up on the antenna lead-in. An electrostatic shield is incorporated between the primary and secondary windings to prevent noise being transferred from primary to secondary by capacity effect. R1 is the normal bias resistor for V1. A choke (L_K in Figure 2) is placed in series with this cathode resistor to prevent the input impedance from being lowered by the shunting effect of the cathode bias resistor and by-pass capacitor, R1 and C2. It also neutralizes the total cathode capacity, thus preventing it from affecting the input impedance. The choke value is changed when switching from the lower five to the upper seven channels. L1 is a series compensating choke which prevents a loss in gain on the high frequency channels.

The r-f amplifier is coupled to the converter tube by a wide-band transformer consisting of windings L_p and L_s. The windings are self-tuned by the distributed and tube capacities to provide optimum gain. Variable trimmers C5 and C6 are shunted across the primary and secondary windings, respectively, of the r-f
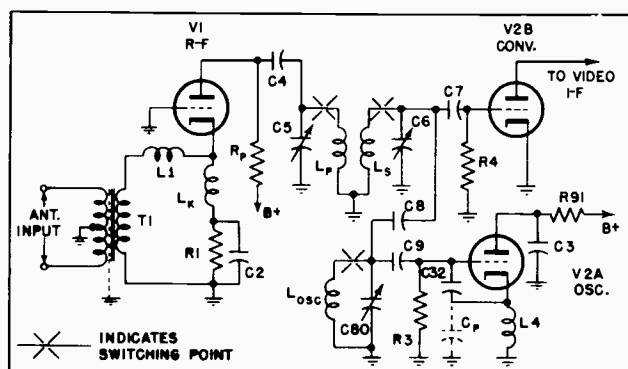
Fig. 2. R-F Amplifier, Converter and Oscillator

transformer to permit compensation for misalignment resulting from differences of tube capacities when a tube change is necessary. On Channel No. 2, the transformer is triple tuned to provide better image frequency attenuation of the 88–108 mc FM band. Three of the transformers, T8, T9, and T10, are used to cover the upper six channels. Each transformer is made sufficiently broadband to accept two television channels.

The triode converter is one section of a Type 12AT7 dual triode, V2B. Bias for this tube is developed by the oscillator voltage appearing in the grid of V2B, causing grid rectification charging the grid resistor-capacitor combination, R4 and C7.

The oscillator makes use of the remaining half of the Type 12AT7 tube, V2A, and is capacity coupled to the converter tube through the capacitor, C8. The oscillator is a modified Colpitts oscillator, oscillation being produced by the grid-to-cathode capacitor, C32, and the plate-to-cathode interelectrode capacity, C_p, of the oscillator tube. The choke, L4, provides a d-c ground to the cathode of the oscillator tube and maintains the cathode off-ground at the r-f frequencies. The oscillator operates on the high frequency side of the r-f signal on all channels. Three oscillator coils, L11, L12 and L13, are used to cover the upper six channels, the frequency range of the oscillator circuit at each coil switching being sufficient to tune two channels.

To prevent hum modulation by the local oscillator when operating on the high frequency channels, the filament supply to V2A is rectified by the selenium rectifier SR1 and filtered by C102.

The r-f amplifier, converter and oscillator section is constructed as a complete unit sub-assembly which can be readily demounted from the main chassis.
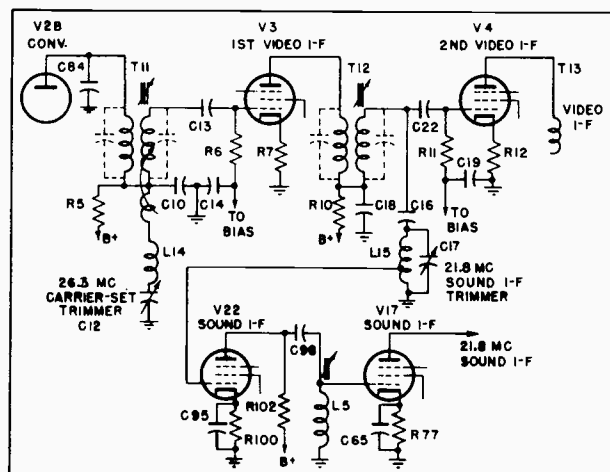
Fig. 3. Video and Audio I-F Amplifier

2. VIDEO AND AUDIO I-F AMPLIFIERS (SEE FIGURE 3)

—The video i-f amplifier makes use of a three-stage bandpass amplifier using three Type 6AU6 tubes. The transformers, T11, T12, T13, and T14, are overcoupled and then loaded with resistance in the secondary circuits to give an adequate bandpass frequency characteristic. A single movable powdered iron core is used in transformers, T11, T12 and T13, for tuning. This adjusts the secondary side. The transformer T14 uses two tuning slugs to tune both primary and secondary. A tertiary winding is incorporated on T11 which connects to a series resonant trap circuit to permit adjustment of the slope of the high frequency end of the bandpass. It is adjusted so that 26.3 mc falls at the 50 per cent point on the curve to compensate for the sesqui-sideband transmission of the video carrier frequencies.

A series-tuned trap circuit consisting of C16, and the parallel combination of L15 and C17, is connected across the secondary of T12 and tuned for maximum attenuation of 21.8 mc in the video amplifier. This affords the necessary attenuation of the accompanying sound i-f from being passed through the video i-f and in addition is used to take-off the sound i-f for the audio i-f channel. The audio i-f is taken off at a tap on the inductance, L15, and then applied directly to the grid of the audio i-f amplifier tube V22. Additional i-f gain and selectivity is provided by two stages of single tuned impedance coupled amplification. Since the television audio is frequency modulated, the transformer T19 functions with the diode section of V19 as the discriminator.

Bias voltage derived from the grid return circuit of the horizontal blocking oscillator, is applied to the grid circuits of the video i-f amplifier tubes, V3, V4 and V5. A potentiometer (Contrast) control, permits this voltage to be changed on V3 and V4 so as to vary the gain of the video i-f amplifier.
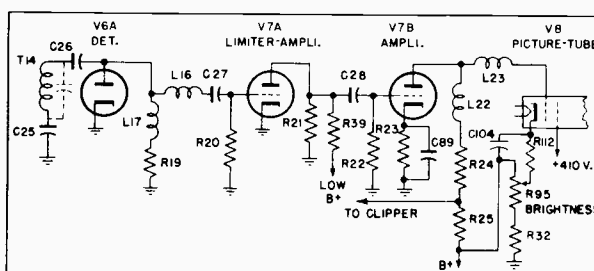

Fig. 4. Video Detector and Amplifier

3. VIDEO DETECTOR AND AMPLIFIER (SEE FIGURE 4)

—The video i-f amplifier output is applied to one section of a 6AL5 dual diode, V6A, which is connected as a shunt diode so as to develop a negative-going signal across the diode load resistance, R19. The signal is then amplified by two triode amplifier stages using a Type 12AU7 dual triode tube, V7. L16 and L23 are series compensating coils, while L22 and L17 are shunt compensating coils. These are used to obtain good high frequency response and provide sharp cut-off at frequencies above the usable pass band. L16 also helps prevent harmonics of the i-f frequency from being passed through the video amplifier.

In addition to amplification, the first video amplifier tube, V7A, operates as a noise limiter. The B+ voltage applied to the plate circuit is low and the video signal from the detector is negative-going. Any large excursions of voltage above sync level such as introduced by transient noise, will drive the grid to plate current cut-off. Thus, the interference will be limited close to the level of the super-sync signal. This improves the signal to transient noise interference ratio without affecting the video signal.

With the use of capacity coupling in the video amplifier, the d-c component of the video signal must be restored to maintain proper background illumination. This is accomplished in the grid circuit of V7B. The video signal at this grid is positive-going so that with the resultant grid current flow, the capacitor C28 charges up to the peak value of the sync pulse. Since this charge will vary with the amplitude of the pulse, the resulting bias change will provide the required restoration of the d-c. This restoration in the grid circuit of V7B, necessitates direct coupling of the

picture tube, V8, grid to the plate circuit of V7B. By connecting the cathode of V8 to a variable B+ source, the proper bias may be maintained on the picture tube and the brilliance may be changed.
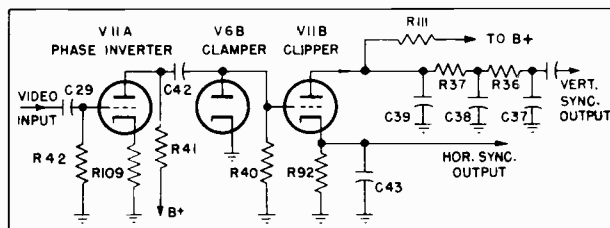

Fig. 5. Sync Separator Circuit

4. SYNC SEPARATION (SEE FIGURE 5)—Amplification and separation of the sync pulse from the composite video signal is accomplished by tube sections, V11A, V6B, and V11B.

Triode section, V11A, is used to amplify and invert the phase of the composite video signal applied to its grid circuit and also to further limit the transient noise. This produces a video signal in the plate of V11A wherein the sync pulses are the most positive portion of the voltage waveform. This positive-going signal is applied across the diode section, V6B, which rectifies the positive portion and charges the capacitor C42 negatively in proportion to the amplitude of the sync pulses. This diode thus establishes a bias for tube V11B and also clamps the sync so that each recurring pulse originates at the zero voltage axis.

The clamped composite video waveshape applied to the grid of tube section V11B, which is biased by the diode V6B, causes the negative portion of this waveshape to be cut off in the cathode and plate circuits of V11B, leaving only the sync pulses. The horizontal synchronizing pulses are developed across R92 in the cathode of V11B and are positive-going. The vertical pulses are developed at the plate of V11B and are negative-going.

An integrating network consisting of C39, R37, C38, R36, and C37, is used to separate the horizontal sync from the vertical sync pulses before passage of the sync signal to the vertical sweep generator.
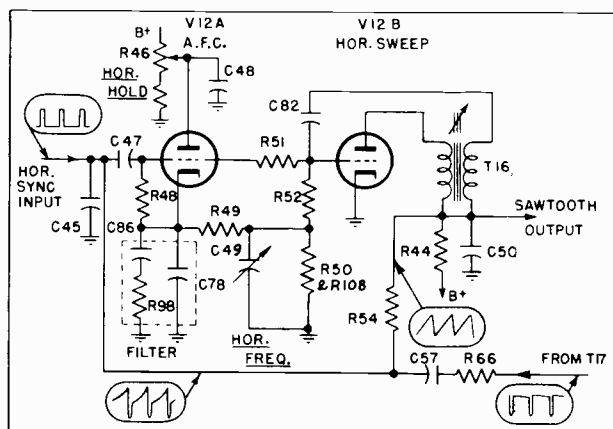
Fig. 6. Horizontal Sweep and A.F.C. Sync

5. HORIZONTAL SWEEP GENERATOR AND AFC SYNC (SEE FIGURE 6)—The horizontal sawtooth generator makes use of one section of a Type 6SN7GT tube, V12B, connected in a blocking oscillator circuit. Instead of its frequency being controlled directly by the horizontal sync pulses, it is controlled by a d-c voltage on its grid, which is the resultant of the phase difference between the incoming sync signal and a voltage wave derived from the output of the sweep generator. The resultant d-c voltage produced by the tube V12A is called an automatic frequency control (AFC) voltage.

The tube V12A obtains its operating bias through its connection to the grid circuit of the blocking oscillator tube, V12B, through resistor, R51. The blocking oscillator produces a large negative bias in its grid circuit during its normal operating cycle. When the horizontal sync pulses or the combined output voltage (shown at lower left of Figure 6) are impressed separately on the grid of tube V12A, they do not have sufficient positive amplitude to cause appreciable plate current flow in tube V12A. However, if they are combined and phased properly as shown in Figure 7A, 7B, or 7C, their composite amplitude is sufficient to cause plate current to flow during that portion of the cycle where the waveshape is above the dash line axis in Figure 7. During the time that conduction takes place, the capacitors C86 and C78 become charged positive in respect to ground, the magnitude of the charge and the resultant voltage thereon, being dependent upon the duration of the flow of plate current in tube V12A.

Since the resistor R50 is in the bleeder circuit across the filter and also forms a part of the grid return circuit for the sweep generator tube V12B, any change in voltage across R50 will thus result in a change of frequency in the sweep generator. Thus if the contributing voltage of R50 makes the grid of V12B less negative, the frequency will be raised; likewise, if the contributing voltages make the grid of V12B more negative, the frequency will be lowered. Thus, it will be seen that the longer the conduction period of tube V12A, the higher will be the frequency of the blocking oscillator and its sawtooth output.

Referring to Figure 7, the (B) curve shows a sync pulse phased so that about 50 per cent of the pulse width is riding on top the integrated sawtooth, while the remainder of the pulse after point (x) falls down into the trough, making the conducting portion have a width which is an average between curves represented by (A) and (C). If each successive sync pulse falls in the same phase relation as shown in curve (B), the Horizontal Hold control which controls the amount of current flow through V12A is set so that this phase relation does not change. This would cause the sweep generator V12B to be running at the same frequency as that of the transmitted signal. Under this condition, if the sweep generator tends to run slower than the incoming sync signal, the conduction period will be made longer through tube V12A because the pulse will move forward in relation to the integrated sawtooth wave with a result as shown in Figure 7 (A). It will be noted that the conduction pulse is of greater duration (wider) than in curve (B). Therefore, tube V12A will conduct for a greater period of time, thus raising the positive potential across R50. This greater conduction period causes the sweep generator to speed up until it attains the condition in (B). Likewise, if the sweep generator is operating at too high a frequency, the pulse will advance along the integrated sawtooth wave until a large portion of it falls down into the trough of the waveshape, as shown in Figure 7 (C), with the resultant shortening (narrowing) of the conducting pulse. This causes the frequency of the sweep generator to be reduced until the condition in Figure 7 (B) is again restored.

The Horizontal Frequency Control, C49, is a capacitor that forms a part of the discharge circuit in the grid of the blocking oscillator, V12B. By varying its value, the free running speed of this oscillator can be adjusted to supplement and act as a course control for the Horizontal Hold control on the front panel.
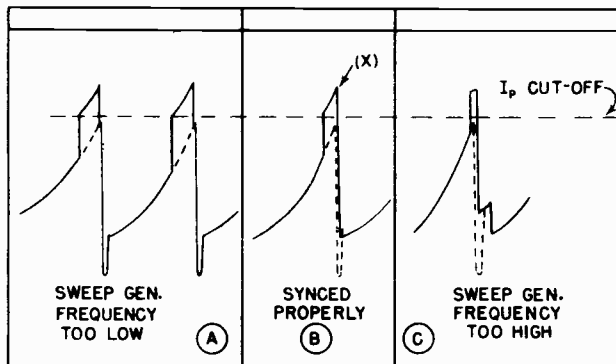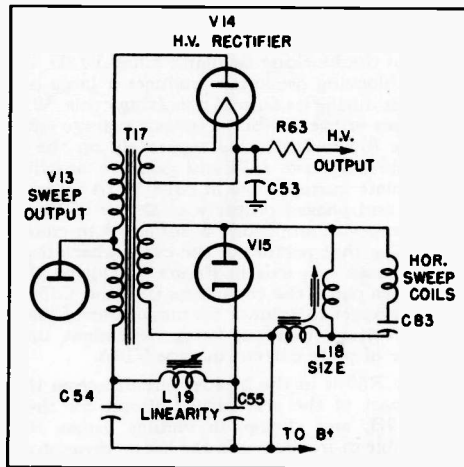

Fig. 7. A.F.C. Waveshapes

Fig. 8. Horizontal Sweep Output

Fig. 9. Vertical Sweep and Output

The free running speed of the blocking oscillator is also adjusted by the inductance variation of the blocking oscillator coil, T16.

6. HORIZONTAL SWEEP OUTPUT (SEE FIGURE 8)—The horizontal sawtooth voltage generated by the blocking oscillator, V12B, is shaped and then amplified by a Type 6BG6G tube, V13. The output of this tube is coupled to the horizontal deflection coils, D2, through an impedance matching transformer, T17. The damping tube diode, V15, is used principally to remove a transient oscillation created by the rapid retrace of the current in the high inductance of T17 and still retain the positive overshoot in the primary winding for use in the high voltage supply. It also is used to provide a linear trace and to recover some of the energy from the inductive kick-back and use it to help supply the B+ requirements of the output tube. During conduction of V15, capacitors C54 and C55 are charged up and since they are in series with the B+ voltage to tube V13, they contribute a sizeable portion of the plate voltage. The variable inductance, L19, and C54 constitute a phase shift network which alters the phase of the ripple voltage developed across C55. This means of changing the ripple voltage which also supplies part of the B+ to the output tube provides a method of controlling the linearity.

A horizontal drive control, C81, forms a capacity voltage divider in conjunction with capacitor C51 so as to control the amount of sawtooth voltage supplied to the grid of V13. This permits adjustment of the grid sawtooth voltage to compensate for variations in output tubes.

The Horizontal Width Control, L18, forms a series-parallel circuit in respect to the output to the yoke. The inductance is variable in both coils of this control; the inductance of the series choke is maximum when the parallel choke is minimum and vice-versa. The parallel circuit shunts the current around the deflection coil, depending upon its inductance, and the series coil attenuates the current by changing the impedance of the series circuit. This type of control provides a uniform impedance to the output transformer over a wide range of adjustment.

7. VERTICAL SWEEP GENERATOR AND OUTPUT (SEE FIGURE 9)— The vertical sawtooth voltage is generated by a Type 6SN7GT tube, V9, connected as a multivibrator. This voltage is coupled directly to a Type 6V6G vertical sweep output amplifier tube,
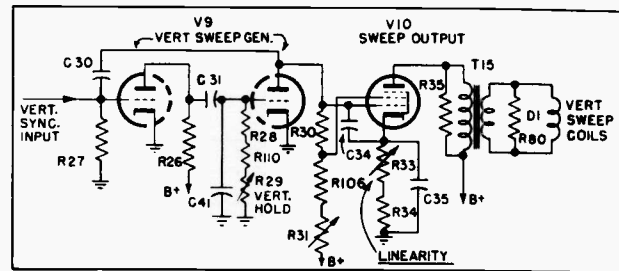
V10, and then to the vertical sweep yoke, D1, through the impedance matching transformer, T15. Vertical speed is controlled by changing the time constant of the multivibrator grid circuit by the potentiometer, R29. Sweep size or height of picture is changed by the potentiometer, R31, which changes the B+ voltage applied to the charging network (R30, C34) of tube V9 simultaneously with the screen voltage on tube V10. Vertical linearity is controlled by feeding back correcting voltage developed in the cathode circuit of V10 through C34 into the grid circuit of the output tube, V10. The cathode voltage of V10 which is fed back through C34 has an opposite curvature corresponding to the non-linear portion of the generated sawtooth output of V9 so that by combining these voltages in the grid of V10 correction may be affected. The amount of the correction voltage is controlled by the Vertical Linearity potentiometer, R33, in the cathode of V10.

8. HIGH VOLTAGE SUPPLY (SEE FIGURE 8)—The high voltage for the second anode of the picture tube is derived by making use of the inductive "kick" voltage produced during retrace in the horizontal output transformer, T17. This kick voltage has a magnitude of several thousand volts and is positive-going, appearing between the plate of V13 and ground. Since this voltage in itself is not sufficient to produce the required anode potential, an additional winding connected electrically and magnetically with the primary is added to provide further step-up of this voltage. The top of this autotransformer is connected to the plate of a rectifier tube, V14. This tube is a Type 1B3GT/8016 which derives its filament voltage from the horizontal sweep transformer T17 by a single turn around the core. Since the frequency supplied the rectifier tube is high (15,750 cps), a 500 mmf. filter capacitor is more than adequate to give a smooth d-c output. Due to the small capacity of the filter, this supply is relatively safe to handle.

9. LOW VOLTAGE POWER SUPPLY—Two rectifier tubes, V16 and V21 (type 5U4G and 5Y3GT respectively), are used to supply the required plate current for the receiver. Each tube is used in a separate and complete rectifier circuit to supply two values of output B+ voltage, 290 volts and 360 volts. The Focus coil which is a combination permanent and electro magnet is connected in series with a portion of the output current path for the lower voltage supply, the current through it being controlled by the Focus Control potentiometer, R72.
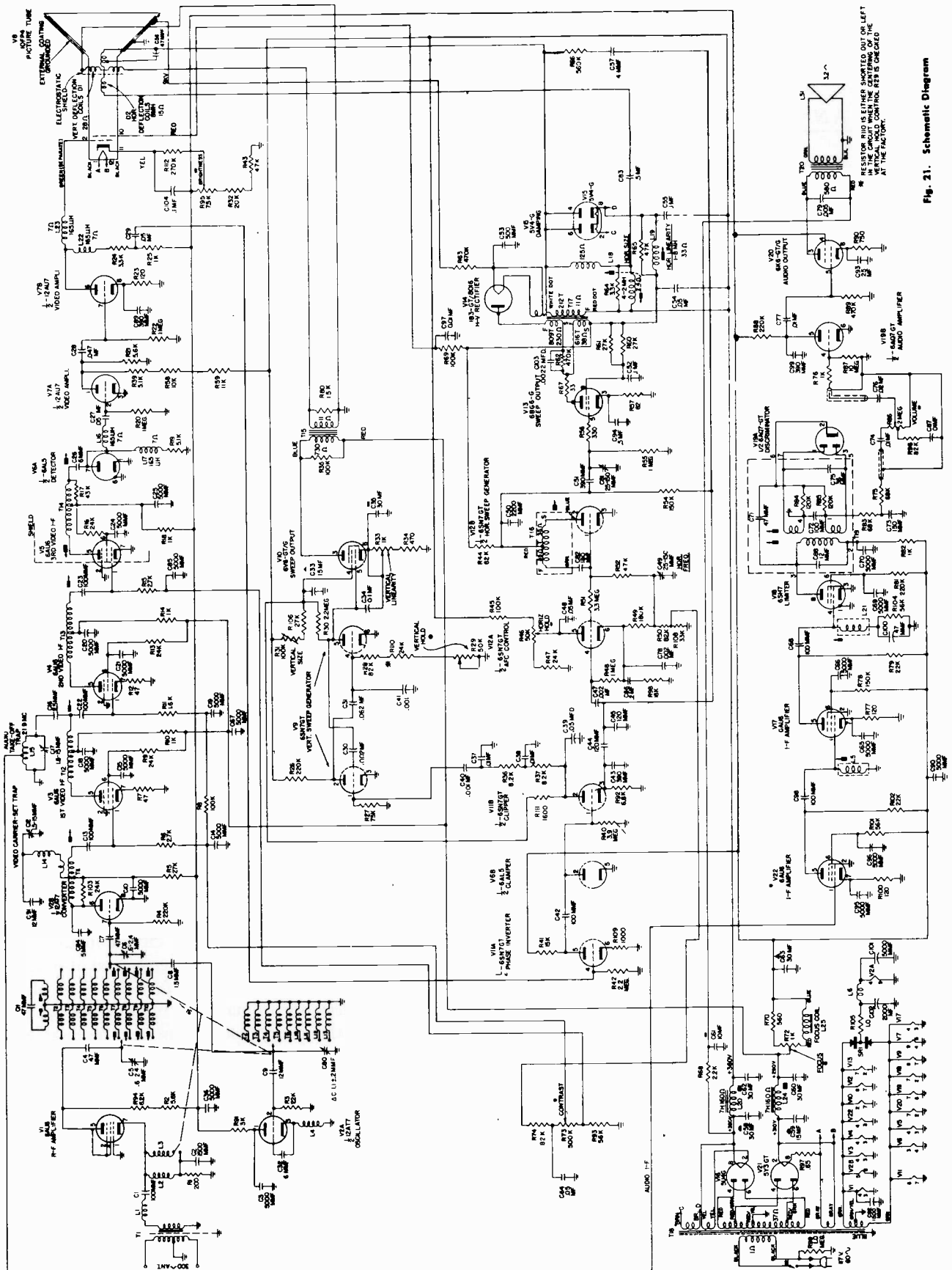
Fig. 21. Schematic Diagram

LESSON 10

ANALYSIS OF THREE INTER-CARRIER TYPE RECEIVERS

In this lesson you will find interesting, practical explanation of three popular television sets which represent basic inter-carrier types. These types selected will give you needed experience with so called 25 MC and 40 MC I.F. The Air King chassis described will introduce you to a stagger tuned inter-carrier arrangement.

The material on Tele King chassis making up the first part of this lesson is reprinted with the kind permission of the Tele King Corporation.

CIRCUIT ANALYSIS

The Tele King television receiver chassis TVJ has all its components, except the speaker, contained on a single chassis. The receiver utilizes a unique method of eliminating the common B-minus wiring bus found in most television receivers and also all the irregularities and wiring problems that are associated with such a system. The complete top of the chassis is a separate plate and is insulated from the rest of the chassis. This plate is used as B-minus and all the necessary connections are made to it. The B-minus plate is separated from chassis ground by the parallel combination of a 220,000 ohm resistor and a 0.05 microfarad capacitor.

The receiver is of the intercarrier type and employs a new type of f-m detector in the sound section. This detector circuit uses the 6BN6 gated-beam tube. A block diagram signal flow chart appears in Fig. 1. For ease in understanding the operation of the system, the block diagram is functionally divided into six main sections. These are the r-f tuner, the video section, sound section, deflection circuits, picture tube, and power supply system. The schematic diagram of the complete receiver appears as Fig. 18. The following is a circuit description of the TVJ chassis.

The R-F Tuner

Only one type of tuner is used on chassis TVJ series. It is Model TT-7 and it is Tele King's own design and manufacture. It is a twelve channel switch-type tuner that contains two tubes and has good stability, high gain, and exceptionally low noise factor. Either a 6CB6, 6AG5, or 6BC5 tube is employed as an r-f

amplifier (either type tube is directly interchangeable) and a 6J6 (twin triode) is used as an oscillator-mixer. A fine tuning control is incorporated in the tuner.

A schematic diagram of the tuner is shown in Fig. 2 and also appears on the main schematic.

The input of the tuner can be matched to either a 300-ohm or 72-ohm transmission line through this transformer. The method for such connections is indicated in Fig. 3. For the 300-ohm connection, all that has to be done is to connect both ends of the twin lead to input transformer connections as shown in part (A) of Fig. 3. For the 72-ohm coaxial line (or the 75 ohm twin lead line) the connections are made between the center tap of the transformer primary and either end. The ground or shield end of the line is connected to the center tap of the transformer through a parallel combination of a one megohm resistor and a 0.005 microfarad capacitor as shown in (B) of Fig. 3.

Also at the input to the r-f amplifier is a tuned r-f circuit. The use of a tuned input circuit further adds greatly to the selectivity of the receiver and also to the gain. This arrangement plus the fact the set is of the intercarrier design, eliminates the need for special trap circuits. For the proper pass band and further selectivity, a tuned r-f stage is also employed between the output of the r-f amplifier and the input to the mixer system. The mixer utilizes one triode section of a 6J6 tube. This interstage circuit is double-tuned and has an overcoupled response. The overall r-f pass band of all channels is maintained above 75% relative response between picture and sound carriers.

Fig. 1. Signal-flow block diagram.

Fig. 1. Signal-flow block diagram.

The Video Section
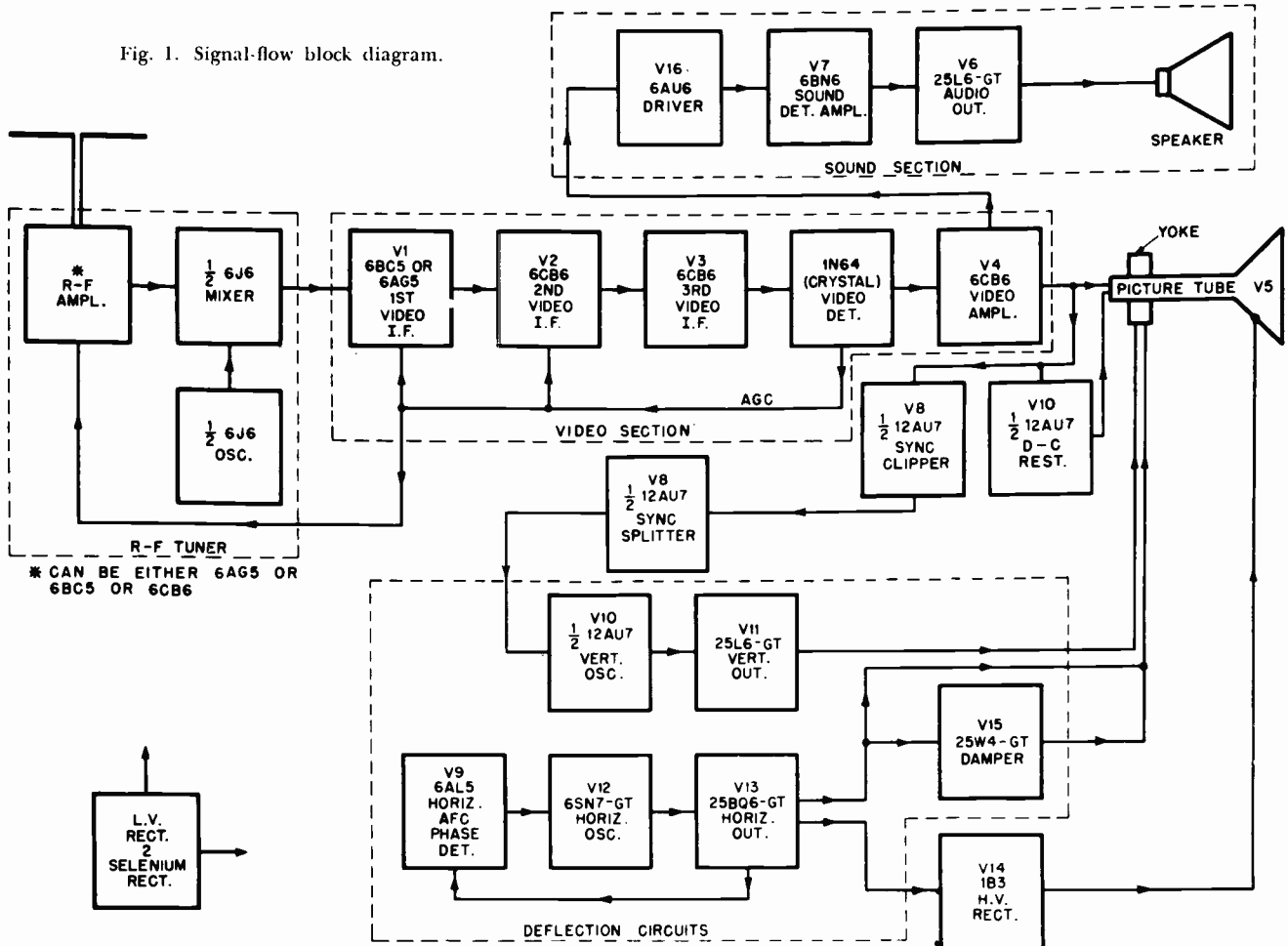
The oscillator circuit employing the other half of the 6J6 tube functions as a modified Colpitts Oscillator. The r-f and oscillator inputs to the mixer, heterodyne together, with the resultant beat note being the i.f. of the system. This i.f. is selected by broad-band transformer *TLP-1* in the output of the mixer tube. The transformer passes both the video and sound i-f signals to the first video i-f amplifier stage through pin 5 on the small terminal strip shown in Fig. 2.

The Video Section

The signal output from the tuner is fed directly to the video section of the receiver. This section of the receiver consists of three main functional categories, namely the video i-f amplification and selection system, the video detector, and the video amplifier. Each video category will be considered in the order of signal travel as it leaves the mixer stage of the r-f tuner.

The Video I-F System. The video i-f system consists of three amplifiers, *V1*, a 6BC5 or 6AG5 tube functioning as the first video i-f amplifier, and *V2*, and *V3*,

6BC6 tubes functioning as the second and third video i-f amplifiers respectively. Between the input to the first video i-f amplifier and the output of the last video i-f amplifier are four i-f transformers which are staggered-tuned to produce the necessary bandwidth. As seen on the schematic diagram, these video i-f transformers are designated as *TLP1*, *L1*, *L2*, and *L3*. The staggered-tuned arrangement is such that the first and third video i-f transformers, *TLP1* and *L3* respectively, are resonant at 22.4 Mc and the second and fourth video i-f transformers, *L1* and *L3* respectively, are resonant at 24.6 Mc.

Although this section of the receiver is referred to as the video i-f system, both the sound i-f and video i-f signal outputs from the 6J6 mixer tube are passed through this complete i-f amplifier system. Thus it is seen that this section actually functions as a *combined* sound and video i-f system. There is no separation whatsoever between the sound and video i-f signals as they pass through these i-f amplifiers and both are fed directly into the video detector.
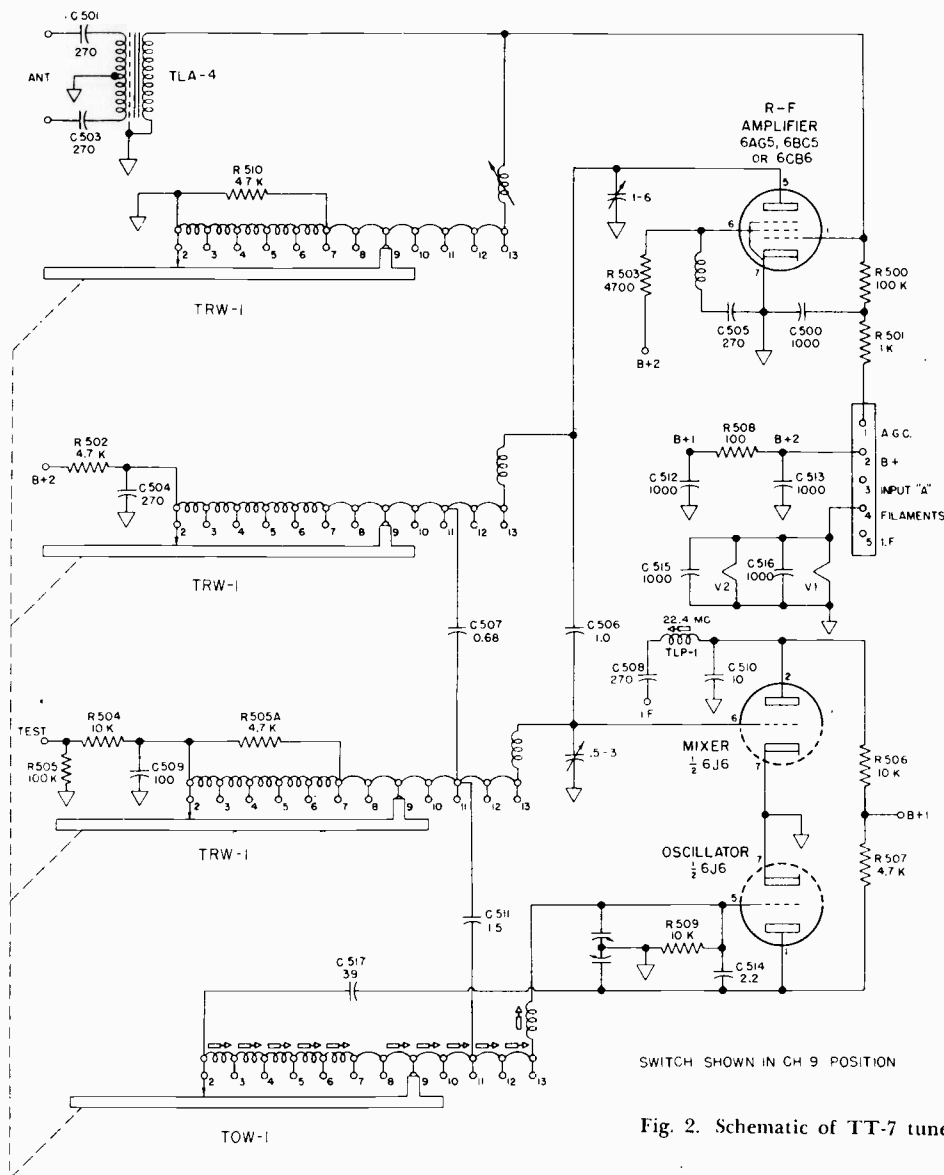
Fig. 2. Schematic of TT-7 tuner.

The response of each i-f transformer is such that when they are all combined the correct over-all video i-f response results. (Response shaping is discussed in the alignment section.) The shape of this over-all i-f response is such that the amplitude of the sound i-f carrier is a small percentage of the video i-f carrier when they are simultaneously fed to the video detector. This amplitude relationship between these two signals is the basis for correct operation of the intercarrier system.

Because of the intercarrier system, sound or video traps are not necessary, therefore no traps are employed and hence there are no trap adjustments in this receiver.

The Video Detector. As mentioned previously, the sound and video i-f signal output from the combined i-f amplifier system is fed to the video detector. A germanium crystal diode, type 1N64, is employed as the video detector. The use of such a unit instead of a regular vacuum tube obviates the need for a tube socket and filament voltages.

In appearance the crystal detector resembles a small resistor or ceramic capacitor. Since a tube socket is not necessary, the germanium crystal, which has two leads similar to the resistor or capacitor, is completely wired underneath the chassis. When any servicing work is to be done on the video detector circuit, or any other nearby circuit, care should be exercised not to mistake the crystal diode for any other component.

300-OHM INPUT CONNECTION
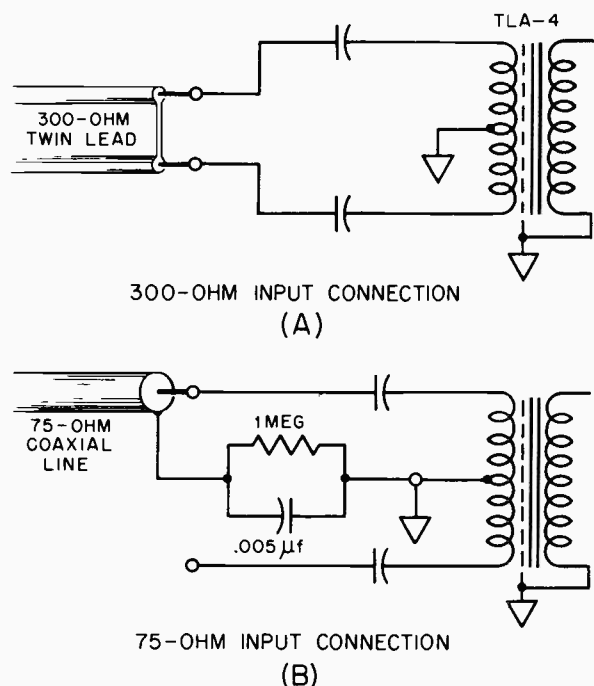
(A)

75-OHM INPUT CONNECTION

(B)

Fig. 3. Connections of 75-ohm or 300-ohm transmission lines to input transformer TLA-4.

The sound i-f signal appears to the video detector as just a high frequency sideband of the video i-f signal. This is so because the sound i-f signal is at the high frequency end of the over-all video i-f response. Consequently video detection occurs in the normal manner with picture signal frequencies up to 4 Mc appearing in the output. The sound and video i-f carriers are considered as beating or mixing together inside the video detector. The carriers of these two signals are always separated by 4.5 Mc so that, after the beating process, their difference frequency of 4.5 Mc also appears in the output of the video detector. (Even as r-f input signals to the r-f tuner, this separation exists since this is an FCC requirement for all commercial television broadcast stations.)

Because of the high amplitude ratio of video to sound i-f carrier input to the detector, the 4.5 Mc output beat note contains all of the f-m characteristics of the f-m sound signal picked up by receiver and very little a-m effects. This 4.5-Mc f-m signal is now considered as the new sound i-f of the receiver. If the amplitude of the sound i-f carrier input to the detector is increased beyond what is desired, distorted sound output may result. The degree of distortion depends on how badly a serviceman may align the receiver. Always follow the alignment curves.

The output from this crystal detector, which consists of the video signal plus the 4.5-Mc f-m signal, is coupled to the grid of the video amplifier through a high-frequency compensating network primarily consisting of peaking coils L4 and L5. These peaking coils are so designed that their response is good past 4.5 Mc so as to allow for proper passage of the 4.5-Mc f-m signal.

Automatic Gain Control (AGC). To insure uniform gain on all channels and for all signals, an automatic gain control (agc) system is incorporated in this receiver. At the output of the video detector, some of the video signal is taken off at the junction of R118 and L5 and is fed through a double resistance-capacitance filter arrangement consisting of R119-C114 and R112-C109. This filter network functions similarly to those in avc systems in radio receivers in that it filters out the r-f components of the signal and substantially a d-c voltage exists. This is the agc voltage and is negative in character. This agc signal is fed to the control grids of the r-f amplifier and to the first and second video i-f amplifiers. On strong signal inputs to the receiver the agc voltage becomes more negative and on weak signal it becomes less negative. In this manner the amplification of the above mentioned amplifiers is controlled by automatic adjustment of their bias voltages. Thus the over-all gain of the receiver is automatically controlled on both high and low signal inputs to the receiver.

The Video Amplifier and Contrast. A 6CB6 tube, V4, is used as the video amplifier. This tube receives both the video signal and 4.5-Mc f-m sound i-f signal from the video detector and amplifies both of them. In this manner, the 4.5-Mc signal receives additional amplification which it really needs because its output from the video detector is usually weak. Thus it is seen that V4 also serves a dual purpose similar to the video i-f amplifiers.

In the plate circuit of the video amplifier is the primary of a double parallel-tuned 4.5-Mc transformer, L6, referred to as the sound trap on the main schematic. This transformer selects the 4.5-Mc sound i-f signal which is then fed to the sound section of the receiver via the secondary of L6. At the same time, due to its high impedance qualities, the primary of L6 prevents any 4.5-Mc signal from being fed to the picture tube.

This transformer is *sharply* tuned so that it accepts only the narrowband 4.5-Mc f-m signal. The video signal which consists of frequencies below 4.0 Mc, therefore passes through the primary of L6 and is fed to the cathode of the picture tube. Inductances L7 and L8 serve as series and shunt high frequency compensating coils respectively. These coils are not peaked beyond 4.0 Mc which insures further rejection of any 4.5-Mc f-m signal from finding its way to the cathode of the picture tube.

In the cathode circuit of the video amplifier is a 2,000-ohm potentiometer, *PD10*, which serves as the contrast control of the receiver. This control regulates the bias and hence the gain of the video amplifier and in this manner controls the level of the video signal input to the cathode of the picture tube. Turning the contrast control clockwise decreases the bias on the video amplifier, increases its gain, and hence makes the reproduced picture darker. The reverse is true if the control is turned counterclockwise.

The Sound Section

The sound section consists of three parts, namely an i-f amplifier-driver stage, an amplifier-detector stage, and the audio system. One tube is employed in each part of the sound section.

The Amplifier-Driver Stage. The 4.5-Mc f-m signal output from the secondary of *L6* is fed to the control grid of *V16*, a 6AU6 tube functioning as the sound i-f amplifier-driver stage. The circuit is of the conventional type. It is intended primarily to provide amplification to the 4.5-Mc f-m signal so that it will be of sufficient strength to drive the f-m detector system. It must be remembered that the input f-m i-f sound carrier to the video detector was very weak and that the only gain in strength to this 4.5-Mc signal was through the video amplifier. Thus this extra stage of 4.5-Mc amplification insures proper sound circuit operation. The output from this stage is coupled to the f-m detector stage through a 0.002 μf capacitor *C127* and a single-tuned circuit *L20*. This tuned circuit gives better 4.5-Mc i-f selectivity and also helps increase gain.

The Amplifier-Detector Stage. The 4.5-Mc signal from the high side of tuned circuit *L20* is fed to the control grid circuit, pin 2, of *V7*, a 6BN6 tube which functions as an amplifier-detector system. The 6BN6 tube has a special construction. It is a gated beam tube which acts as a limiter, discriminator, and audio amplifier. It has excellent a-m rejection characteristics and does not react to pulse noise because of the absence of time constants. Besides detection of f-m signals a-m rejection is, of course, the primary purpose of an f-m detector.

Although schematically the tube appears as a pentode, its construction is more intricate. From the schematic, as shown in Fig. 4, we see that three grids, a cathode, and a plate have provision for external connections besides the heater elements of the tube. A very important section of the tube, which is not shown schematically and which does not have any external connection is the *focus electrode*. This special electrode is constructed around the cathode and focuses the beam of electrons as they leave the cathode.

The first grid, pin 2, functions as the *limiter* grid and receives the 4.5-Mc f-m i-f input signal from the secondary of the sound i-f transformer *L20*. Pin 5 shown schematically as a screen grid is actually not a grid at all but an accelerator anode. This anode is connected to B plus through *R120*, a 7,500 ohm, 1 watt resistor. The anode is of a metallic construction
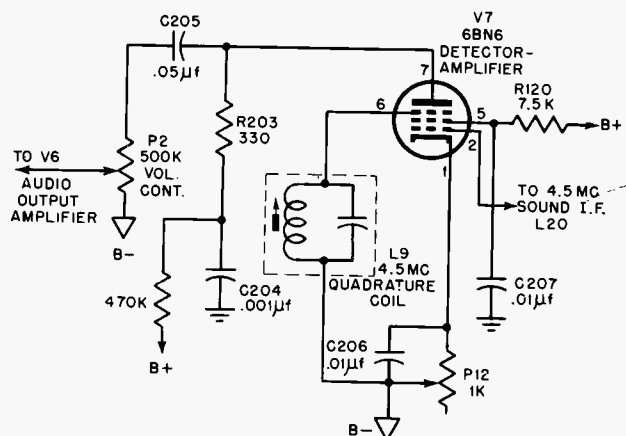

Fig. 4. The 6BN6 f-m detector-amplifier circuit.

similar to the electron gun of a cathode-ray tube. The accelerator encloses the first grid. The bottom part of the accelerator is slotted near the focus electrode and together with the focus electrode forms an electron gun which helps project an electron stream upon the limiter grid. Due to the construction of the accelerator and focus electrode, the cathode is unaffected by the potential on the limiter grid and, consequently, the cathode current is independent of the control-grid voltage. This effect helps the tube perform the function of a *limiter*.

The third grid of the tube is not a suppressor grid as its schematic would seem to indicate but also functions as a control grid and is referred to as the *quadrature grid*. Connected to this grid is a high Q tuned circuit, *L9*, called the quadrature coil. It is resonant to 4.5 Mc, the frequency of the sound i.f. The coil is made variable to insure proper tuning of the circuit. Because of the nature of the tube construction and this high Q tuned circuit, a signal voltage exists at this grid which lags the signal input to the limiter grid by 90°, hence the name quadrature grid. This phase relation exists, of course, when the quadrature circuit is tuned to resonance, which is the same resonant frequency as that of the incoming f-m signal to the limiter grid. Consequently, we see that operation of the tube is generally controlled by the limiter and quadrature grids.

These two grids exert a step function control over the plate current. They can be considered as two gates opening and closing periodically with the quadrature gate lagging behind the limiter gate. A couple of volts negative on the limiter grid will cut off the tube and a couple of volts positive will bring it into full conduction again. The electron beam naturally can only reach the plate of the tube when both gates are essentially open. Therefore, we can consider the flow of plate current as starting just at the time the second gate opens (i.e., the grid nearer the plate) and ending when the first gate closes.

When an f-m signal input exists at the limiter grid, the frequency variation of the signal on either side of its center frequency causes a phase shift between the two control grids such that the degree of signal-voltage lag on the quadrature varies by an equal amount on either side of 90°. This phase-shift variation, in turn, causes shorter or longer bursts of electrons from the cathode through to the plate. By this process, the audio intelligence of the f-m input signal can be extracted across the integrator network consisting of a 0.001 µf capacitor $C204$ and the 330-ohm load resistor $R203$ in the plate circuit as shown in Fig. 4. In this manner, discriminator action is achieved.

Due to the construction of the tube, a-m effects may slip through because the audio signal output exists in the plate circuit of the 6BN6 tube itself. This a-m interference can be eliminated, however, by careful adjustment of the limiter-grid bias. This bias is determined by the 1,000-ohm cathode resistor which in this case is potentiometer $P12$. Adjustment of this potentiometer will control the bias on the tube. Consequently by critical adjustment it can be used to produce the best a-m rejection results.

The Audio System. The audio output signal from the 6BN6 circuit which appears across the integrator network in the plate circuit is coupled through a 0.05 µf capacitor, $C203$, to the volume control of the system. This control is a 500,000-ohm potentiometer and is designed as $PD10$. The variable arm of this potentiometer is connected directly to the control grid of $V6$, a 25L6GT-G tube functioning as the audio-output amplifier. This latter tube is in a conventional type of circuit. It has its audio-output signal fed to the audio-output transformer which in turn feeds the loudspeaker of the system.

The Sync Clipper

Part of the output signal from the video amplifier stage is fed to the grid, pin 2, of one triode section of $V8$ a 12AU7 tube through $R129$, $C123$, and $R218$.

(In some receivers this may be a 12AT7 tube.) This stage serves as a sync clipper. Because the signal output of the video amplifier is fed to the cathode of the picture tube the nature of this output signal is such that the sync pulses fed to pin 2 of $V8$ (as well as the cathode of the picture tube) are in a positive going direction. These positive sync pulses are readily seen in the proper waveform pictures at the grid of this stage as indicated in Fig. 8. The circuit constants of the sync clipper are so chosen that only the blanking and picture information part of the video signal are beyond (negatively greater) the cutoff bias on this tube. In this manner, the tube will only conduct during the time of the sync pulses, and, hence, only the sync pulses will be passed. An R-C circuit with a fast time constant, consisting of $R218$ and $C216$, permits the sync pulses to go through the sync clipper but blocks off the slower noise pulses.

When the positive sync pulses are applied the conduction path is from the cathode to the plate through resistor $R211$, to B plus, thru B minus, and then back to the cathode.

The D-C Restorer

Another portion of the signal output from the video amplifier is taken from the junction point between $R129$ and $C123$ and is coupled through $C125$, a 47µµf capacitor, to the grid, pin 2, of $V10$, one triode section of a 12AU7 tube functioning as a d-c restorer. The signal input is still in the positive going direction (see Fig. 8), the same as with the sync clipper, since it has not passed through any special circuits that would change its polarity.

The operation of this circuit is so designed that the tube will conduct only during the positive sync pulses because of the negative bias on the tube. The conduction path is from the cathode to the plate, to B plus, through B minus, and back to the cathode through the 1-megohm resistor $R220$. A positive d-c voltage that is an average of the sync-pulses amplitude is developed across the resistor $R220$ and is applied to the grid of the picture tube through resistor $R219$ for restoration purposes.

The Sync Splitter

The amplified sync-pulse output from the plate of the sync clipper is fed through a 0.01 µf capacitor $C213$ to the grid, pin 7, of the other triode section of 12AU7 tube, $V8$, employed as a sync splitter. This is indicated in the circuit of Fig. 5. Because of the phase inversion qualities of a vacuum tube the sync-pulses
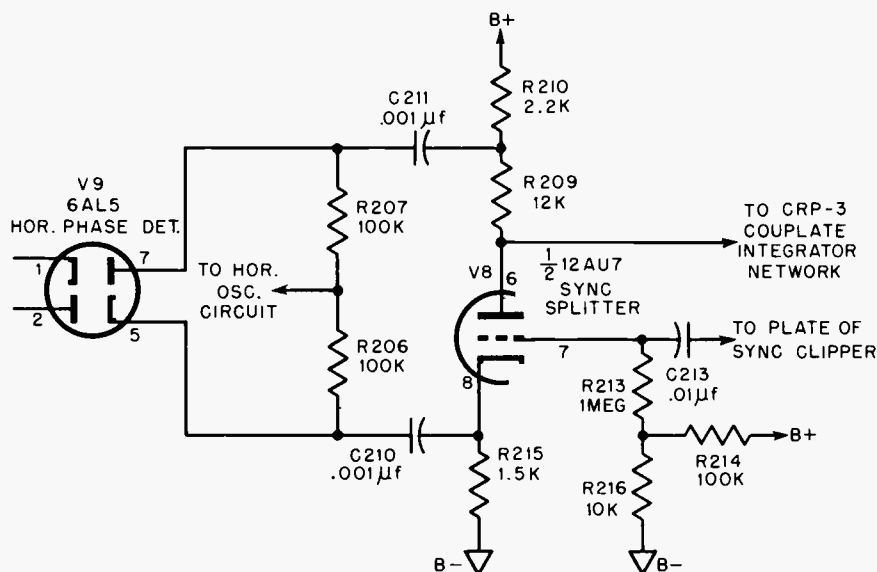
Fig. 5. The sync-splitter circuit.

input to the sync splitter are negative in character (see Fig. 8). Normally this would cut off the sync splitter, however, the grid of this tube is also connected to B plus through a resistance voltage divider network consisting of *R214* and *R216*. The value of this positive voltage is such that it overcomes most of the negative sync-plus voltage and a fair degree of balance is maintained. Thus the amplitude of the sync pulses determines the flow of current in the sync splitter.

With negative sync-pulse input to the grid, positive pulses exist in the plate circuit and negative pulses in the cathode circuit. Horizontal sync pulses of equal amplitude but of opposite phase are taken from the sync splitter and applied to the horizontal phase detector, *V9*. From the junction of *R209* and *R210* in the plate circuit of the sync splitter horizontal sync pulses of a positive polarity are applied through a 0.001 μf capacitor *C211* to the plate, pin 7, of one diode section of the horizontal phase detector. This is seen in Fig. 5. From the cathode of the sync splitter, horizontal sync pulses of a negative polarity, but of the same amplitude as that applied to the plate of *V9*, are fed through a 0.001 μf capacitor *C210*, to pin 5 of the horizontal phase detector. These horizontal-sync pulses are applied to *V9* for comparison with the sawtooth voltage derived from the horizontal sweep circuit.

Another path of signal pulse output is taken from the plate circuit of the sync splitter. Directly from the plate of this tube, the positive pulse signal is fed through a couplate integrator network *CRP-3* to the vertical-oscillator circuit.

The Vertical-Deflection Circuit

The vertical-deflection circuit is divided into two main parts, namely the vertical-oscillator system and the output system. The circuit analysis of these two sections will be considered together and the different vertical sweep controls will be discussed as a separate item.

Vertical Oscillator. The integrator network through which part of the combined sync-pulse signal passes, basically consists of three resistance-capacitance cascaded circuits, composed of six circuit elements in all. These six components are manufactured as a single unit, in the form of a printed circuit. Consequently if any trouble is suspected in this integrator network, the complete unit will have to be replaced.

The function of this integrator is to separate the vertical-sync pulses from the horizontal-sync pulses and apply the former to the grid circuit, pin 7 of tube *V10*, the other triode section of the 12AU7 tube. The sync pulses insure exact synchronization in the vertical direction between the transmitted picture signal and the reproduced picture. Together with *V11*, a 25L6GT tube wired as a triode (the screen grid, pin 4, is externally connected to the plate) this triode section of the 12AU7 tube functions as a low-frequency multivibrator whose frequency of oscillations is 60 cps.

The operation of the oscillator circuit is as follows: The signal output from the plate pin 6, of *V10*, is coupled to the grid pin 5, of *V11*, through a 0.05 μf capacitor *C305*. Tube *V11* amplifies this signal and a small portion of this amplified voltage is differentiated by components *C304*, *R302*, *C303*, and *R303* and fed

back to the grid, pin 7, of *V10*. This differentiating action is necessary to shape the voltage waveform so that it is in the proper phase and magnitude to be applied back to the grid of *V10* for oscillator action.

The 25L6GT tube besides functioning as part of the vertical oscillator also functions as the vertical-output tube. The signal output from the plate of *V11* is transformer-coupled through *T3* to the vertical deflection coil of the yoke.

At the high side of the vertical-output transformer secondary is connected a 0.01 μf capacitor *C309*, the other end of which is connected directly to the grid of the picture tube. A high negative pulse exists at this point during the retrace time of the vertical sweep waveform and about 100 volts of this negative pulse is fed to the grid of the picture tube through *C309*. This high negative pulse drives the grid of the picture tube beyond cutoff thereby causing blanking during its duration of application. Since this pulse exists during the vertical retrace it means that all horizontal lines that appear during this time are also blanked out. By this method the brightness controls can be used more freely without worry of the horizontal retrace lines appearing during the vertical retrace time.

Vertical Controls. A number of different potentiometers exist in the vertical-deflection circuit. In the grid circuit, pin 7, of *V10* is a 1-megohm potentiometer, *P17* which functions as the *vertical hold control*. This control regulates the time constant of the circuit that controls the frequency of oscillation. It is used to adjust the frequency to exactly 60 cycles. The 2.5-megohm potentiometer, *P5* in the plate circuit, pin 6, of *V10* acts as a variable plate load. Therefore, it controls the amplitude of the signal output from this stage and is referred to as the *vertical size control*. The 5,000-ohm potentiometer, *P2*, in the cathode circuit of *V11* regulates the bias on this tube thereby controlling the range of the dynamic transfer characteristic over which the input signal operates. The control of *P2* is such that the nonlinear characteristic of the deflection signal is corrected by the exact opposite nonlinear characteristic of the amplifier, resulting in linearity correction. Consequently, this potentiometer is known as the *vertical linearity control*.

The Horizontal-Deflection Circuits

The primary purpose of the horizontal-deflection system is to produce a sweep signal of the correct frequency, linearity, and amplitude to allow for proper horizontal deflection of the electron beam in the picture tube. The horizontal-deflection circuit of this receiver consists of a horizontal oscillator, output tube,

damper, and phase detector. Each stage functions in such a manner so as to apply the correct waveform to the horizontal-deflection coils.

The Horizontal Oscillator. To obtain the necessary horizontal-sweep-voltage waveform that is to produce a sawtooth of current flowing through the horizontal deflection coils, duo triode tube, *V12*, type 6SN7GT, is employed as the horizontal oscillator. This circuit actually performs two oscillatory operations, namely it functions simultaneously as a combined sine wave oscillator and cathode-coupled multivibrator. The series of waveforms about this tube can be seen in Fig. 8. The output from the plate, pin 5, of this oscillator, which is of the proper sawtooth voltage waveform, is coupled through a series capacitance-resistance network consisting of *C315* and *R315* to the grid of *V13*, the horizontal-output amplifier.

The Horizontal-Output Tube. Horizontal-sweep-output amplifier, *V13*, utilizes a 25BQ6GT tube. The output from the plate (cap) of this tube, which is a very high voltage, is fed to tap number 2 on the horizontal-output transformer *T4*. This tube does not conduct continuously but only during certain periods. The transformer and damper tube work in conjunction with the horizontal-output tube to produce the proper voltage and shape of the horizontal-deflection signal. A high kick-back type voltage is fed back to the plate of *V13* from the cathode of the damper tube through primary of transformer *T4*.

The Damper. The horizontal-deflection coils are connected across taps 5 and 6 of the *T4* secondary winding. A 25W4GT tube, *V15*, serves as the horizontal damper with the plate connected to tap 4 on the secondary of the horizontal-output transformer. The purpose of this tube is to damp out the natural period of oscillations of the output transformer and associated circuit which are set into oscillations due to the high horizontal-output pulse. Conduction of the damper and horizontal-output tube does not occur at the same time but occurs at somewhat different intervals. During most of the time the damper is conducting, the horizontal-output tube is not conducting and the damper supplies the deflection current to the yoke. When the damper is not conducting, the horizontal-output amplifier is conducting and supplies the remainder of the horizontal-deflection current to the yoke to complete the cycle of operation to insure a *continuous* flow of current to the yoke. There is a small degree of overlapping where both tubes are conducting but the combination of both voltages is such that by a proper control the horizontal-deflection voltage waveform is linear.

The Horizontal-Phase Detector. Coupled to the secondary of the horizontal-output transformer is another coil which has one end connected to B minus and the other end connected through an 18,000 ohm resistor, *R208*, to the cathode and plate (pins 1 and 2 which are tied together) of *V9*, a 6AL5 tube functioning as the horizontal-phase detector. Thus some of the horizontal-sweep voltage is fed to the *V8*. Pins 1 and 2 of this tube are the cathode and plate of the respective diode elements of the tube — and not of the same diode.

As mentioned previously, the horizontal-sync pulses from the *V8* sync splitter are applied to the other plate and cathode sections of the horizontal-phase detector. These sync pulses are compared in phase with that of the horizontal-deflection signal inside the 6AL5 tube. If their phases are different, an automatic frequency control (afc) voltage is developed across *R206* and *R207* and applied to the grid, pin 1, of the horizontal oscillator *V12* via the parallel combination of *R308* and *C311*. These two components in conjunction with *R307* form an afc filter network. This afc voltage insures that the horizontal-sweep oscillator *V12* be in synchronization with that at the transmitter.

Horizontal Controls. There are five variable controls in the horizontal-deflection circuits. Each control is important to the proper operation of the receiver and the adjustment of one may affect the circuit such that another may have to be readjusted. The controls, their locations, and their functions are as follows:

In the grid circuit, pin 4, of the horizontal oscillator, there is a 50,000-ohm potentiometer *P18* which functions as the *horizontal hold control.* Variation of this resistance changes the time constant of the circuit which, in turn, changes the frequency of operation. Proper adjustment of this control sets the frequency of operation at about 15,750 cps. The variable inductance *L16*, called the *afc coil* also controls the frequency of the horizontal oscillator. The afc coil is a preset control while the horizontal hold control is an adjustment on the front panel for rapid readjustment of the oscillator frequency. The variable capacitor *C316* (25 to 280 $\mu\mu$f) primarily affects the horizontal-pulse height and also the linearity somewhat and is referred to as the horizontal-drive control.

A variable inductance *L17* is connected across pins 5 and 8 of the horizontal output transformer secondary. This latter connection is across only part of the secondary that feeds the horizontal-deflection coils. Variation of the slug of *L17* changes its inductance and hence the current flowing through the deflection coils. It therefore controls the amplitude of the sawtooth current and hence the size of the picture in the

horizontal direction. It is termed the *width control.* The last horizontal control, the *horizontal linearity,* appears in the filter network that exists in the cathode output circuit of the damper tube *V15*. This control is a slug adjustment for coil *L18*. Variation of this slug and hence, the inductance of *L18* regulates the phase of the recovered voltage applied to the plate of *V13*. This regulation affects the final shape of the horizontal-deflection curve (with regard to linearity) as it controls the overlapping period of conduction between the damper and horizontal-output amplifier.

Power Supply—High Voltage

In the horizontal output circuit also appears the high voltage power supply system utilizing a 1B3 tube, *V14*, as the rectifier. From the high side of the primary of the horizontal output transformer, tap 3, the horizontal sweep signal which is of a very high positive pulse, is fed to the plate cap of *V14*. The 1.25-volt filament supply needed for this tube is obtained from a special secondary winding on the horizontal output transformer. This high voltage rectifier is used solely for supplying a high d-c voltage of approximately 13 to 14 kilovolts to the second anode of the picture tube. Since the operation of this high voltage supply actually depends upon the proper operation of the damper and horizontal-output amplifier, failure in these latter circuits can easily effect the high voltage system.

Extreme care must always be exercised in taking any measurements or doing any troubleshooting or servicing in this section of the receiver as well as that of the horizontal-output and damper systems because of the high voltages that exist there.

Power Supply—Low Voltage

The low-voltage power supply provides the B plus voltage for the remainder of the television receiver that the damper tube and high-voltage rectifier do not supply. Two groups of 300-ma selenium rectifiers, *SR-300*'s, are used in a voltage-doubler circuit to provide the necessary voltage. A capacitor input filter is used in the output of this doubler circuit.

Current flow in the selenium rectifiers is from alloy cathode to aluminum plate. If sparking appears across the rectifier plates when the set is first turned on, it should remain on, unless the sparking is excessive. A reforming action takes place when the set is turned on, sometimes causing such sparks, but the selenium rectifiers rapidly adjust themselves to normal function again. Selenium rectifiers should be replaced when the rated voltage output drops about 20 volts or more.

TELE KING CORPORATION

SCHEMATIC
TVJ

WAVEFORMS

The voltages that are found under each waveform are all peak-to-peak values. The frequency identification of either 60 cps or 15 kc, which is also included with each waveform, indicates the fundamental frequency of the waveform. At the pins of some tubes both the vertical-sync pulses (60 cps) and horizontal-sync pulses (15 Kc) exist, therefore two waveforms are shown for each of these pins. The tubes at which this occurs are *V4*, *V8*, and *V9*.

For correct waveform measurements the picture received must be steady. To best obtain this, measurements were made while a test pattern was being received and all on the same channel. The contrast and brightness controls were set for a normal picture for all the measurements except for that at pin 1 of *V8* for 60 cps. In this latter instance, the contrast was set high in order for a good waveform to appear on the oscilloscope. The drive control was set for proper horizontal size and linearity.

The exact shape of the waveforms depend upon the frequency response of the vertical amplifiers in the oscilloscope that is used. It should be remembered that where the complete video signal is concerned, frequencies up to 4 Mc are encountered. The pulses, however, are the important waveforms for observation, whether being part of the video signal or alone. For most practical purposes, if the frequency response of your oscilloscope is 300 kc or higher, it should suffice for such measurements, although some difference may exist in the appearance of the video signal part of some waveforms.

| V4 | PIN I | GRID | V4 | PIN I | GRID | V4 | PIN 5 | PLATE | V4 | PIN 5 | PLATE |
| 5V | | 60 CPS | 5V | | 15 KC | 50V | | 60 CPS | 50V | | 15 KC |

| V8 | PIN I | PLATE | V8 | PIN I | PLATE | V8 | PIN 2 | GRID | V8 | PIN 2 | GRID |
| 22V | | 60 CPS | 22V | | 15 KC | 30V | | 60 CPS | 30V | | 15 KC |

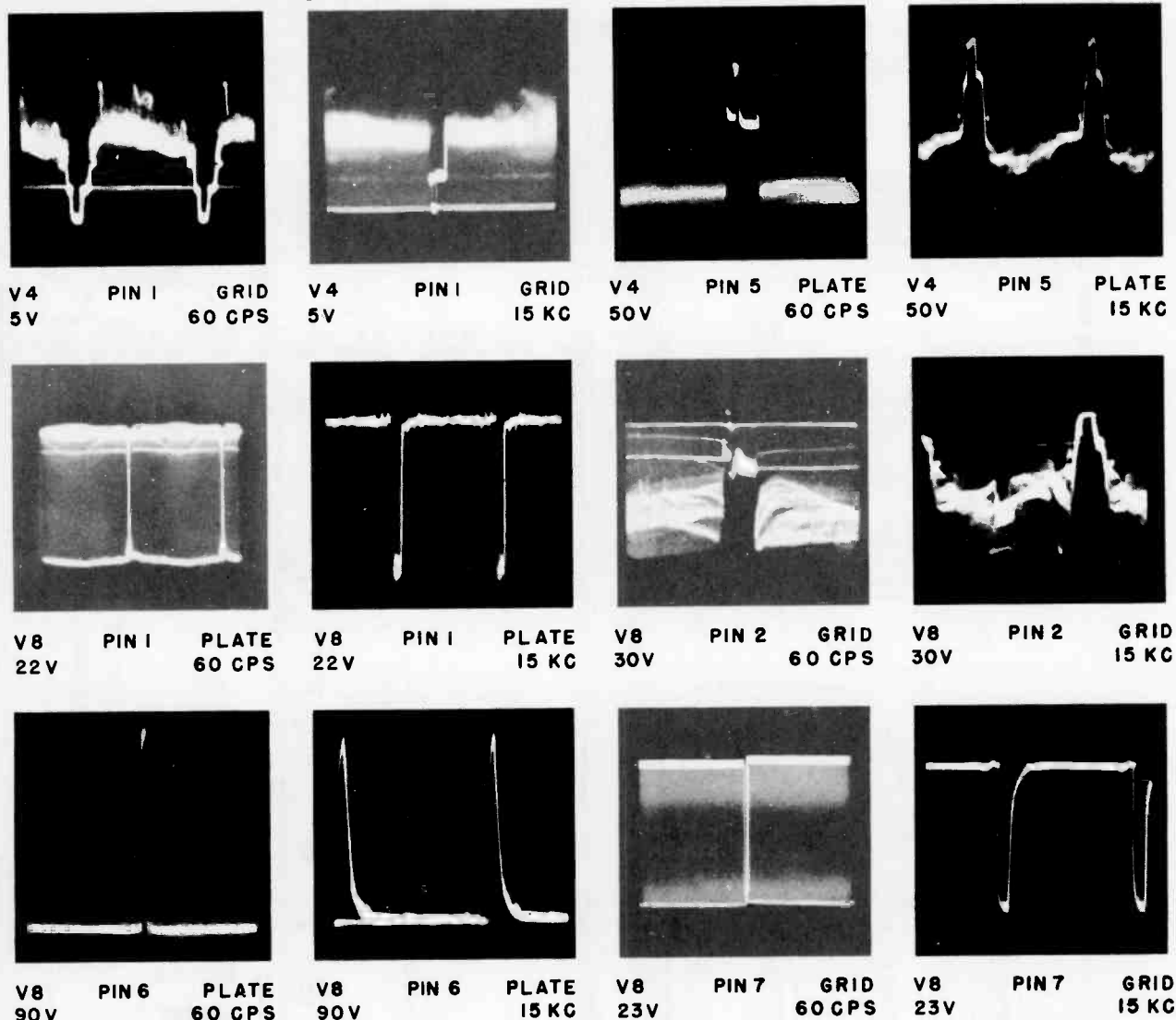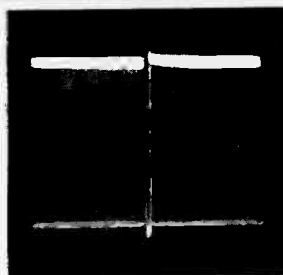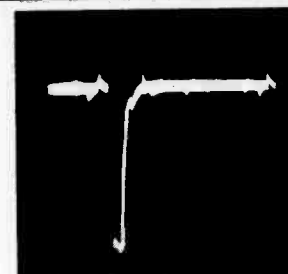| V8 | PIN 6 | PLATE | V8 | PIN 6 | PLATE | V8 | PIN 7 | GRID | V8 | PIN 7 | GRID |
| 90V | | 60 CPS | 90V | | 15 KC | 23V | | 60 CPS | 23V | | 15 KC |

Fig. 8. Video, sync, and sweep waveforms chart indicating the tube pin number where each waveform exists and the peak-to-peak voltages.
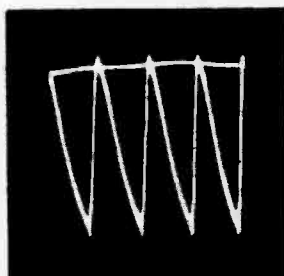
Fig. 8. Continued.
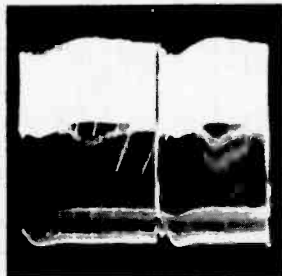

V8   PIN 8   CATHODE
12V   60 CPS
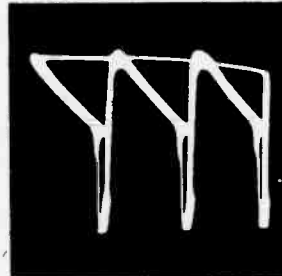

V8   PIN 8   CATHODE
12V   15 KC
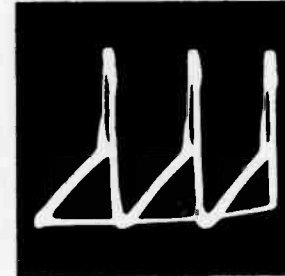

V9   PINS 1,2
12V   15 KC
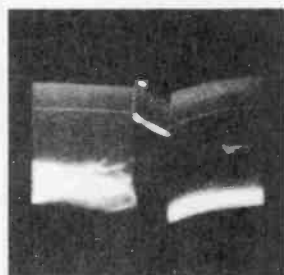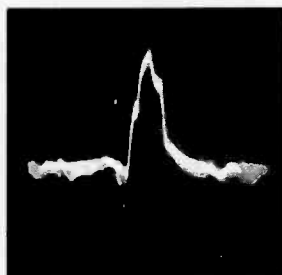

V9   PIN 5   CATHODE
16V   60 CPS

V9   PIN 5   CATHODE
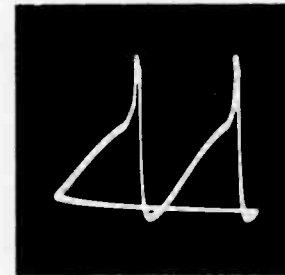16V   15 KC

V9   PIN 7   PLATE
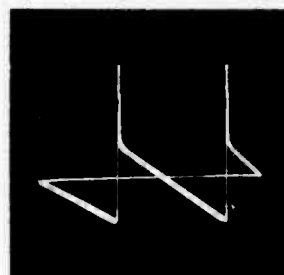10V   15 KC

V10   PIN 2   GRID
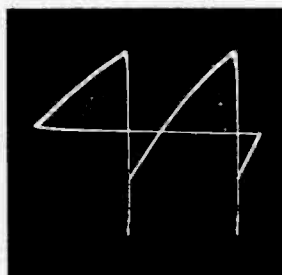42V   60 CPS

V10   PIN 2   GRID
42 V   15 KC

V10   PIN 6   PLATE
100V   60 CPS
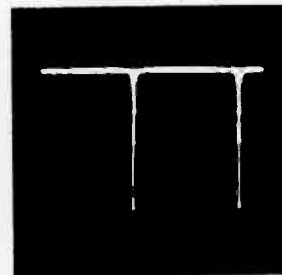

V10   PIN 7   GRID
50 V   60 CPS
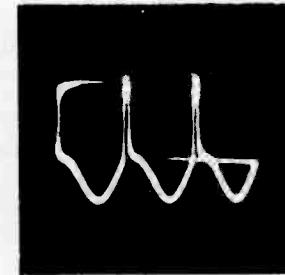

V11   PIN 3   PLATE
750V   60 CPS

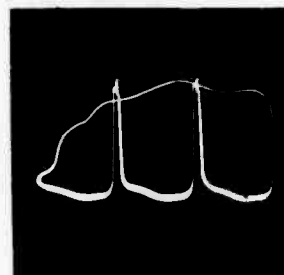V11   PIN 5   GRID
130V   60 CPS

V5   PIN 2   GRID
100V   60 CPS
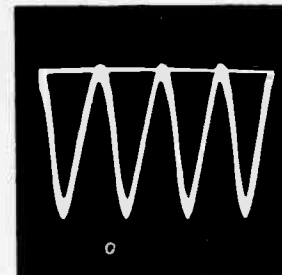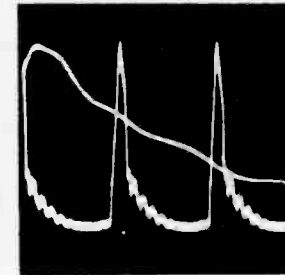

V12   PINS 2,4
30V   15 KC

V12   PINS 3,6   CATHODE
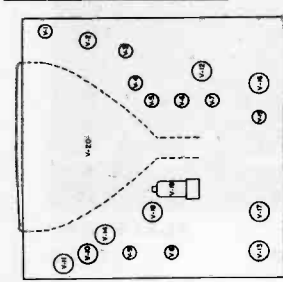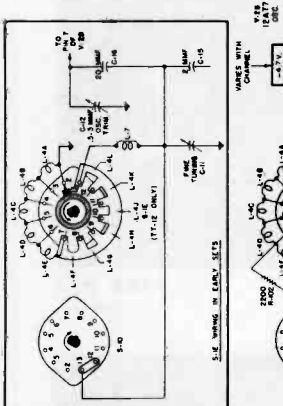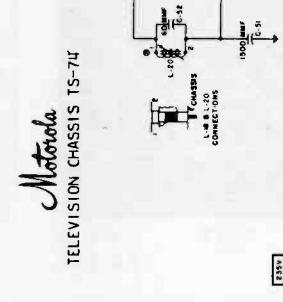12V   15 KC

V12, V13   PIN 5
130V,140V   15 KC

V13   PIN 4   SCREEN
8V   15 KC

V13   PLATE CAP
4200 V   15 KC

Motorola
Television Chassis TS-74

The material on popular Motorola sets of the 1950 period is presented on the next eight pages with a circuit diagram of a specific chassis of this type printed on the page at the left. A great many other Motorola models as well as sets of other makes use similar circuits. This is excellent material to supplement your study with practical analysis. This material, of course, is reprinted through the courtesy of Motorola, Inc.

Please follow the explanation in all details, referring to illustrations as suggested, and also comparing each simplified schematic with its corresponding section in the main schematic printed on the page at left.

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 HV rectifier, which is energized by the horizontal sweep current.

One low voltage secondary of T-8, 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 i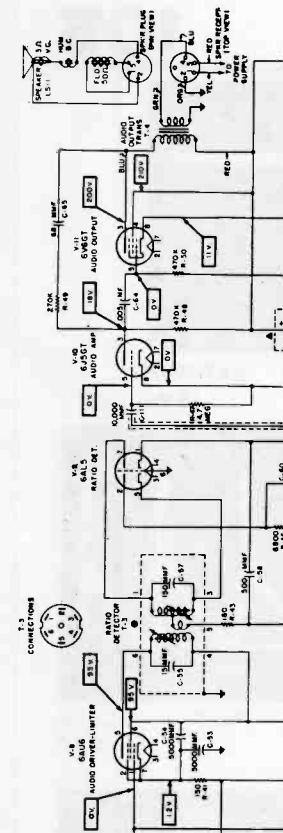ts cathode, and its cathode is tied to the filament to prevent breakdown in the tube, it is necessary to provide a separate, low capacity, well-insulated transformer (T-7) to heat this filament. The vertical output tube V-14 (25L6GT) requires a 25 volt filament supply and, hence, is provided with a separate 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.

The B plus plate supply uses a voltage doubler. R-104 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-104 negative, E-2 will conduct and charge C-106 (300 mmf) 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-106. This results in a charge of about 260 volts on C-63C (200 mf). The speaker field 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.
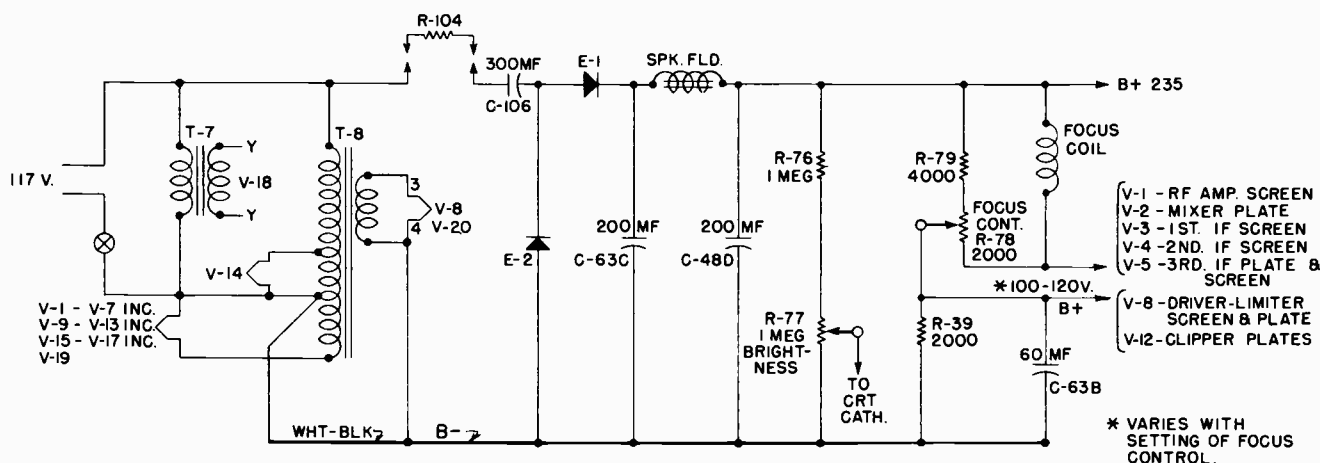

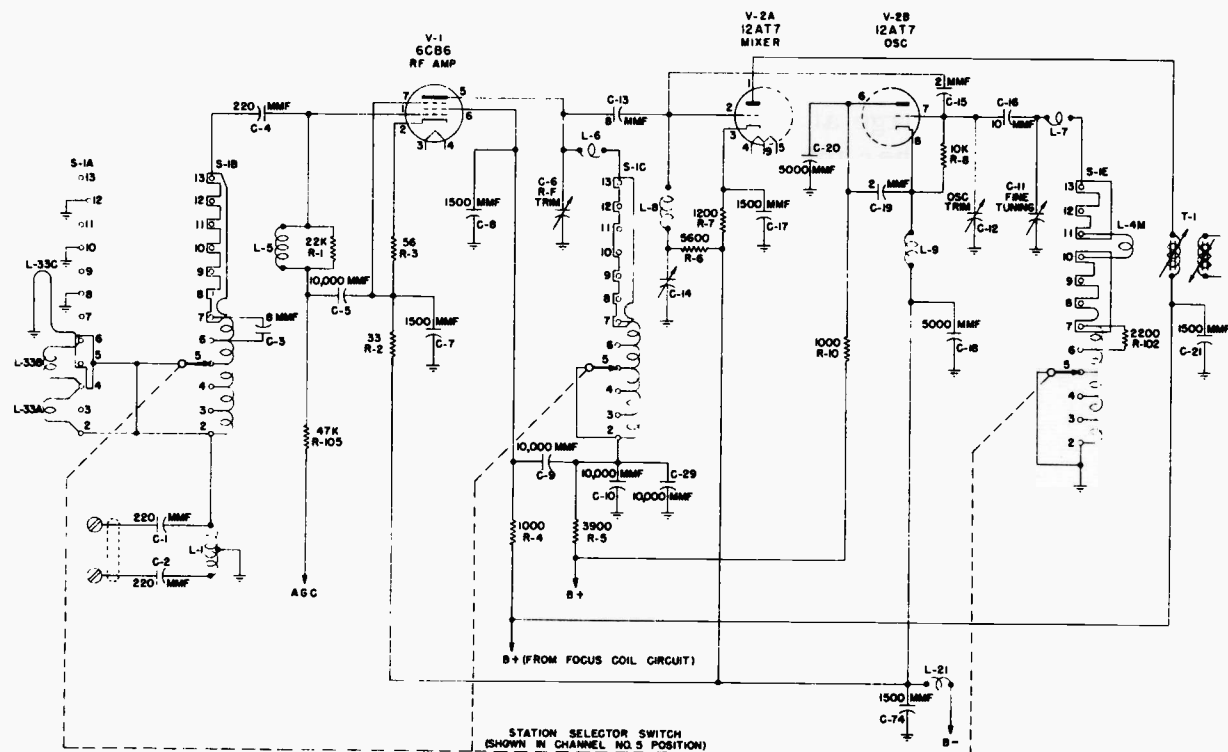FIGURE 12. SIMPLIFIED SCHEMATIC OF HEATER AND LOW VOLTAGE POWER SUPPLY

FIGURE 13. SIMPLIFIED SCHEMATIC OF RF TUNER

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 8, 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 stamped metal plate in series with the coil for the high channels (7-13). The purpose of the antenna coil, coupling leads, and the 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 2 to channel 13, shorts out the unused portion of the secondary winding or stamped metal plate. The bandwidth of channels 7 thru 13 is about 8 mc. The stamped metal plate is carefully designed so that with this bandwidth no adjustment is needed on the high channels. The individual coil sections on the low channels, however, may be tuned by spreading or compressing them as outlined in the alignment procedure.

RF Amplifier

The grid of the RF amplifier V-1 (6CB6) is returned to the AGC bus thru L-5 and a bypass capacity (C-5). The plate load of this tube consists of another tapped coil for the low channels and a stamped metal plate for the high channels mounted, in this case, on switch wafer S-1C. Here again, the switch progressively shorts out the unused sec-

tions of the inductance in tuning from channel 2 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 mmf) couples the RF amplifier output to the mixer grid. Oscillator injection is accomplished by C-15 (2 mmf). 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-12 are provided to set the center frequency on the high channels while the low channels are aligned by spreading 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.

THE IF AMPLIFIER

The IF amplifier uses two 6AU6 tubes and one 6AG5 tube. Figure 14 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 (6AU6), is coupled to the grid
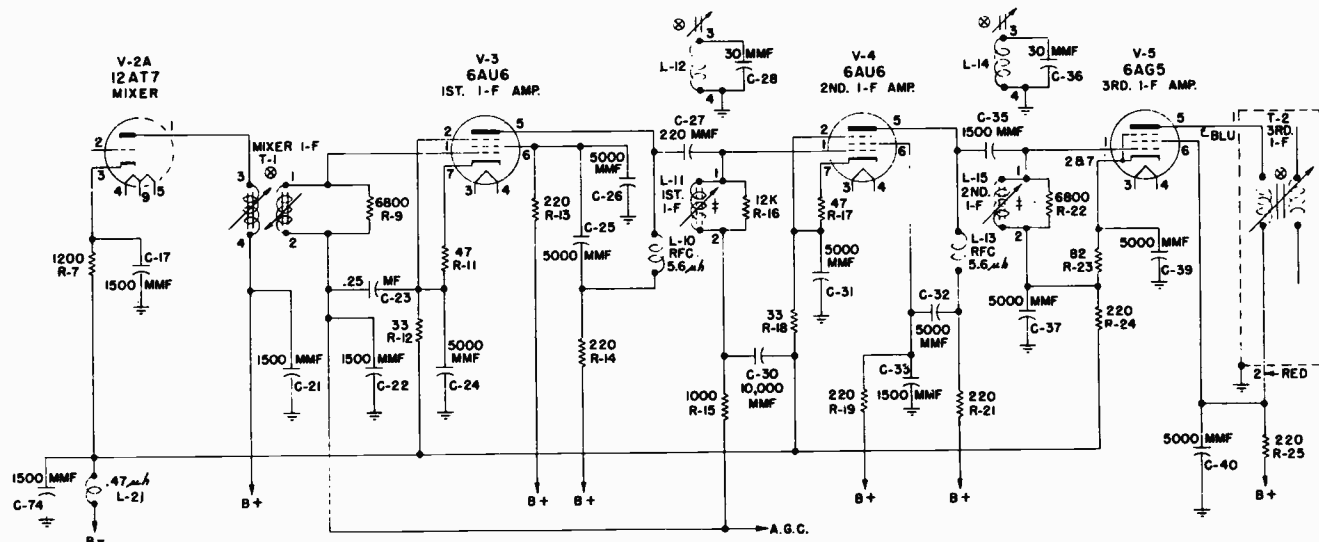
FIGURE 14. SIMPLIFIED SCHEMATIC OF IF AMPLIFIER

coil, L-11, of the 2nd IF tube V-4 (6AU6) thru C-27 (220 mmf). 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. 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-36, they from absorption type trap circuits which steepen the high and low skirts of the IF response for better picture quality and to 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 (6AL5) 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-16, L-32 and C-42, form a low pass filter to keep IF frequencies off the grid of the video amplifier.

Since this chassis 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 the high side of the detector load R-26 (5600) will be a function of carrier level. This voltage is fed to the AGC bus thru R-28 (1.5 meg) and controls the gain of the RF and 1st and 2nd IF amplifiers.

THE VIDEO AMPLIFIER

The video amplifier V-7 (6AH6) 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-limiter tube V-8 (6AU6) by C-49 (2.2 mmf) and L-20, the sound take-off coil. The 4.5 mc trap, L-18 and C-50, 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 amplifier, a noise limiting action is achieved because noise pulses of amplitude greater than the sync level will drive the tube to cut off and, therefore, will not be present in the plate circuit. Since a single video amplifier tube is used, the signal at its plate will be positive and, as might be expected, is used to modulate the cathode of the picture tube rather than the grid, because the blanking pulses must cut the picture tube off and the polarity of the video information must be such that dark picture elements result in making the grid more negative with respect to the cathode.

L-17 and L-19 are peaking coils to extend the high frequency response of the amplifier. The contrast control, R-31A, is placed in the cathode circuit of the video amplifier and controls the bias and, therefore, the gain of this tube. The network of resistors and condensers across taps on the contrast control decreases degeneration at the higher fre-
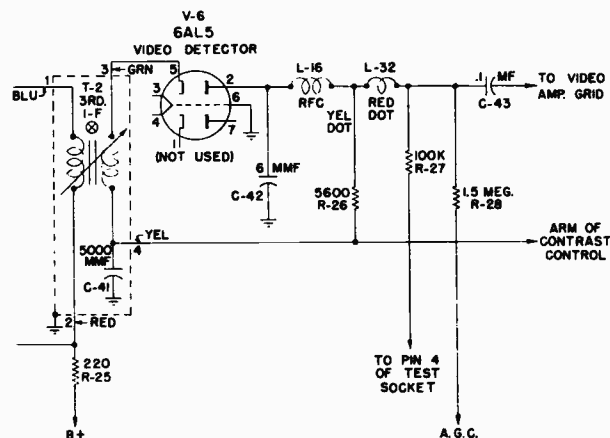

FIGURE 15.
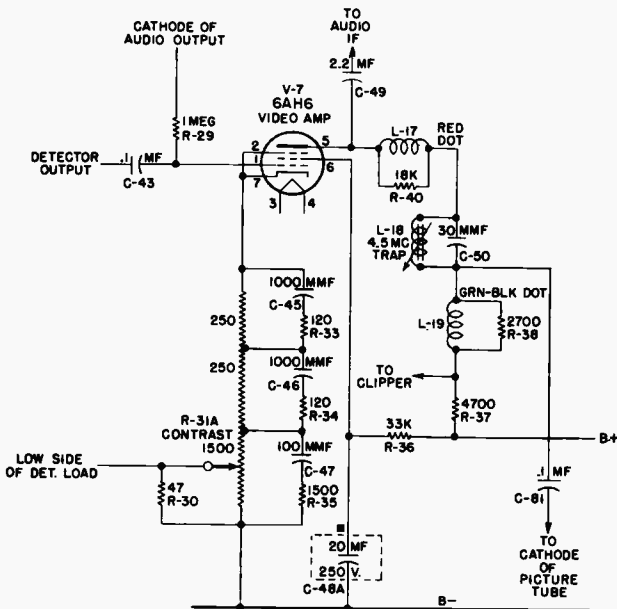SIMPLIFIED SCHEMATIC OF VIDEO DETECTOR

FIGURE 16.
SIMPLIFIED SCHEMATIC OF VIDEO AMPLIFIER

quencies and, therefore, helps to extend the high frequency response. The composite video signal is fed to the picture tube cathode thru coupling condenser C-81 (.1).

THE AGC

The negative DC voltage developed across the detector load resistor, R-26 (5600), is the AGC voltage. It will be noted that the low side of this resistor is connected to the

arm of the contrast control potentiometer, R-31A. R-30 (47) is shunted across the arm of the contrast control and B-. In weak signal areas, this arrangement results in a delay in the AGC action. For a weak signal, minimum bias is desired on the video amplifier, therefore, the arm of the contrast control will be closest to the cathode end of the potentiometer. Because R-30 is then shunted across the entire contrast control, most of the plate current will flow thru it and develop a positive voltage of approximately one volt at the arm with respect to B-. Since the low side of the detector load is tied to this positive voltage, no AGC voltage will develop until the signal is strong enough to overcome this positive voltage and, therefore, no AGC bias is applied to the controlled tubes under weak signal conditions. In a strong signal area, however, where the arm of the contrast control approaches the B- end of the control, R-30 is shorted out and full AGC voltage is developed.

THE AUDIO SYSTEM

The audio system employs a driver-limiter, V-8 (6AU6); a ratio detector V-9 (6AL5); a first audio amplifier, V-10 (6J5), and an audio output tube, V-11 (6V6). Figure 17 is a schematic of the audio system. The driver-limiter is operated at low plate and screen voltages to act as a partial limiter to minimize any amplitude modulation. A conventional ratio detector and audio amplifier are used.

THE CLIPPER

The clipper uses a 6SN7GT tube. The clipper schematic is shown in Figure 18. The composite video signal with positive going sync is applied thru R-56 (10K) and C-66 (.005) to the grid of the first clipper from the plate circuit of the video amplifier. Under no signal conditions, the tube is unbiased. The positive signal, however, will cause the tube to draw grid current and the voltage drop across R-55 (1 meg), negative at the grid, will charge C-66 to such a value that only the most positive part of the signal, which is the sync pulse,
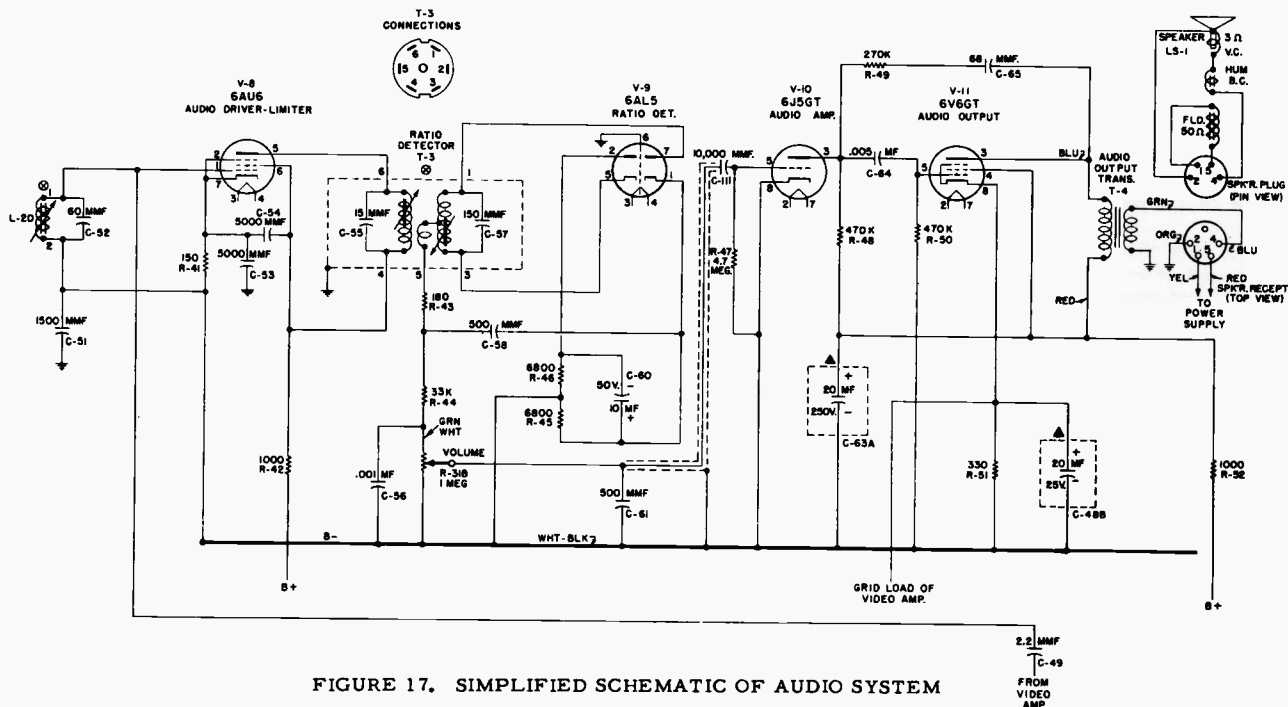

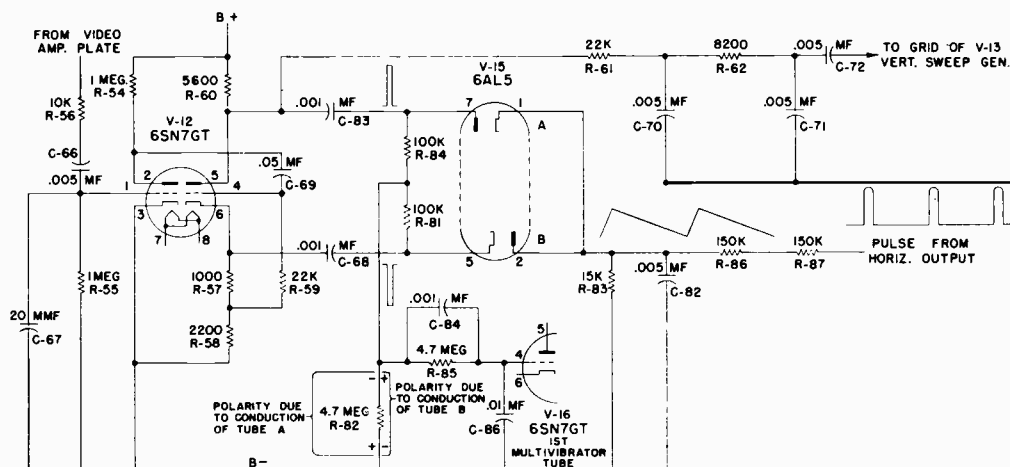FIGURE 17. SIMPLIFIED SCHEMATIC OF AUDIO SYSTEM

FIGURE 18. SIMPLIFIED SCHEMATIC OF CLIPPERS & PHASE DETECTOR

will cause plate current to flow. Therefore, the video information and the blanking pulses are clipped off and only the sync pulses, now negative in polarity, appear in the plate circuit. The second clipper is so biased that the peaks of the sync pulses will drive the tube to cut off, which results in squared pulses of positive polarity in the plate circuit of this tube. A slight increase in sync pulse amplitude is obtained by a small positive voltage applied to the grid of the 2nd clipper by R-106 (390K).

THE VERTICAL SCANNING SYSTEM

Figure 19 is a schematic of the Vertical Scanning System.

The integrating network, shown in Figure 18, composed of R-61, C-70, R-62, and C-71, changes the vertical group of sync pulses into a single pulse of suitable amplitude to trigger the vertical oscillator. The vertical oscillator is an asymmetrical multivibrator using two tubes V-13 (6J5) and V-14 (25L6). V-14 also serves as the output tube.

A multivibrator can be considered as a resistance coupled amplifier in which the output of the second tube is coupled back to the input of the first tube. V-13 is the automatic switch which charges and discharges the sawtooth forming condenser C-75 (.05), connected in its plate circuit. The circuit components of the multivibrator are chosen so that V-13's conductance period is about 7% of the entire cycle,

to insure that retrace time of the scan will have the proper relationship with the trace time. This circuit is modified from the conventional resistance coupled multivibrator in that the plate of the output stage, which is also the second multivibrator tube, has a fairly large value of inductance, introduced by the output transformer stepping up the yoke inductance. When the tube is cut off, a positive pulse of several hundred volts is developed across this inductance. A portion of this pulse, obtained by means of the feedback network R-73, R-74, R-75 and C-78, C-79 and C-80, is used to cause the discharge tube V-13 to go into heavy conduction.

For the purposes of explaining the circuit action, assume that a time has been reached in the cycle when the trace period is almost completed. During this trace period V-13 is cut off and V-14 is conducting. C-73 has been discharging thru the grid resistors of V-13, R-63 (680K) and R-64 (the vertical hold control) and resistors R-75 and R-74. This discharge circuit makes the grid end of R-63 negative and biases the tube beyond cut-off. When the energy stored in the condenser has decreased sufficiently, the grid of V-13 reaches the threshold of conductance and the tube begins to draw current. Condenser C-76, which has been charged to nearly the B plus voltage, now starts to discharge thru V-13 and R-69 (3.3 meg) and this discharge current makes the grid end of R-69 negative tending to cut off V-14, and initiates the retrace. With the sudden change of plate current in V-14 developed across the plate inductance, a positive pulse is applied to the grid of V-13 through the feedback network,
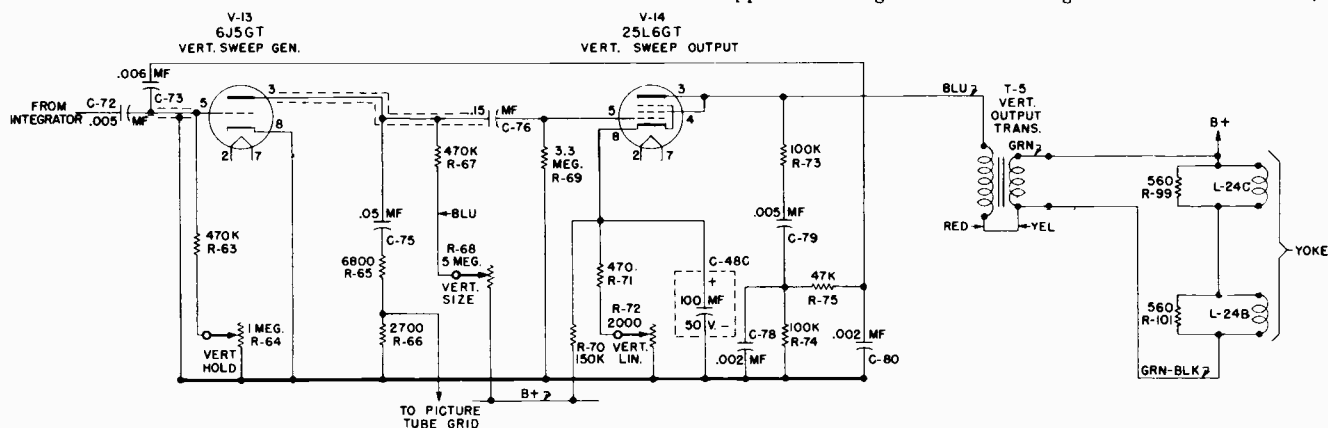
FIGURE 19. SIMPLIFIED SCHEMATIC OF VERTICAL SCANNING SYSTEM

driving this tube into heavy conduction. C-75 will then discharge thru V-13. The voltage developed at the plate of V-13 will be the combination sawtooth and pulse voltage shown in Figure 22(1). The pulse is formed by the peaking resistors R-65 and R-66. When V-13 goes into conduction, the voltage at the plate of V-13 drops suddenly to a value determined by the relationship of the plate resistance of V-13 to the total resistance in the discharge circuit of C-75, which consists of R-65, R-66 and the plate resistance of V-13. After this initial instant, the charge on C-75 decreases, causing the voltage decrease at the plate shown between points "c" and "d" of Figure 22(1). When the positive pulse on the grid of V-13 has decreased to the value where the negative charge on C-73 becomes operative and cuts off V-13, the voltage on the plate of V-13 and, correspondingly, on the grid of V-14, rises quickly to point "a" on the curve, the start of the trace.

The negative pulse shown between point "b" and "a" of Figure 22(1) acting on the grid of V-14, tends to cut the tube off and raises its plate resistance to the larger value required to dissipate the energy in the plate circuit inductance during the short retrace period.

Since the plate circuit of the vertical output stage V-14 has inductance, and as the time constant of an inductive circuit decreases with an increase of resistance, just the opposite of an RC circuit, the increase in plate resistance of the tube is used to obtain the short time constant circuit required for proper retrace time.

By returning the grid of the picture tube to the junction of the two peaking resistors, R-65 and R-66, a negative pulse of suitable amplitude to cut the picture tube off during retrace is obtained, resulting in elimination of retrace lines on the screen.

The feedback network to the grid of V-13 also serves to filter out horizontal pulses which are present in the plate of V-14 due to coupling in the yoke and which are coupled to the plate thru the output transformer. The windings of the vertical output transformer are connected series opposing, which reduces the step-down ratio and, hence, the inductance in the plate of V-14 in order to shorten the retrace time.

The controls found in this circuit are:

1. The Vertical Hold Control R-64 (1 meg). This control varies the resistance in the discharge circuit of C-73 (.006) and, hence, provides a means of varying the frequency of the multivibrator. In practice, this control is adjusted so that the incoming positive sync pulses, which are of constant amplitude, will fire the tube in exact synchronization with the transmitting station's vertical scan.

2. The Vertical Size Control R-68 (5 meg). This control varies the charging current into C-75 (.05) and, hence, the amplitude of the voltage developed across it. Variation of this voltage varies the drive on the grid of V-14 and controls vertical size.

3. Vertical Linearity R-72 (2000). This control, by bleeder action thru resistor R-70 (150K) and the output tube's plate current, sets the bias and determines the tube's operating point on its plate current curve. Since this curve is not linear, some distortion can be introduced to counteract any non-linearity in the sawtooth grid voltage.

Since all of these controls are also in the multivibrator circuit and have an effect also on its frequency, there will be some interaction between them. Usually readjustment of size or linearity will require readjustment of the hold control.

HORIZONTAL SCANNING SYSTEM

The horizontal scanning system comprises a phase detector V-15 (6AL5), a cathode coupled multivibrator V-16 (6SN7), the output tube V-17 (6BQ6) and a damping diode V-18 (6W4). Figure 20 is a simplified schematic of this system.

The Horizontal Oscillator

In order to see how the phase detector automatically corrects for multivibrator frequency change, it will be necessary to understand how the correction voltage affects the multivibrator. It will be noted that this circuit differs from the vertical multivibrator in that only one coupling condenser is used but that the two tubes have a common cathode resistor. This arrangement is known as a cathode coupled multivibrator.

The operation is as follows. Assume that the trace period is almost completed. At this time, tube "A" is conducting, tube "B" is cut off. C-87 is discharging thru tube "A", R-92 (150K) and R-91 (the hold control). The discharge current of C-87 is still high enough to keep the grid of tube "B" negative and cut off. Bias is being applied to both tubes by current flow thru R-89 (1000) the common cathode resistor. When the energy stored in C-87 is reduced to the point where its discharge current no longer holds the grid of tube "B" below conductance, tube "B" starts to pass current and this current causes a greater voltage drop across R-89, the common cathode resistor, which increases the bias on tube "A" reducing its plate current. The resulting increase in voltage at the plate of tube "A" begins to charge C-87 and this charging current applies positive voltage to the grid of tube "B". The resulting heavier conduction of tube "B" develops a pulse of voltage across R-89 which cuts tube "A" off and results in a positive pulse at the plate of tube "A" which throws tube "B" into heavy conduction. This allows C-88, the saw-forming condenser to discharge thru tube "B" and R-93. When C-87 becomes charged, the charging current thru R-92 and R-91 decreases and the positive voltage on the grid, which has far exceeded the bias developed across R-89, is reduced. This results in reducing the plate current thru tube "B" and, therefore, the bias applied to tube "A" by the voltage drop across R-89. Tube "A" starts to conduct and condenser C-87 starts to discharge, cutting tube "B" off. C-88 begins to charge, starting the next trace.

L-23 and C-85 in the plate circuit of tube "A", form a resonant circuit which is tuned to the horizontal frequency (15,750 cps). The 15,750 cycle sine wave generated by this circuit, if properly phased, will insure that the positive pulse at the plate of tube "A", which throws tube "B" into conduction, will be more frequency stable.

C-88 and R-93, the peaking resistor, will produce the same combination pulse and sawtooth voltage shown in Figure 22(1). This action was explained in the vertical circuit.

The Phase Detector

The foregoing explanation is based on the assumption that tube "A's" grid is returned to a fixed potential point. 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 then 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-8. would discharge for less time before "B" started to conduct, thereby increasing the frequency.
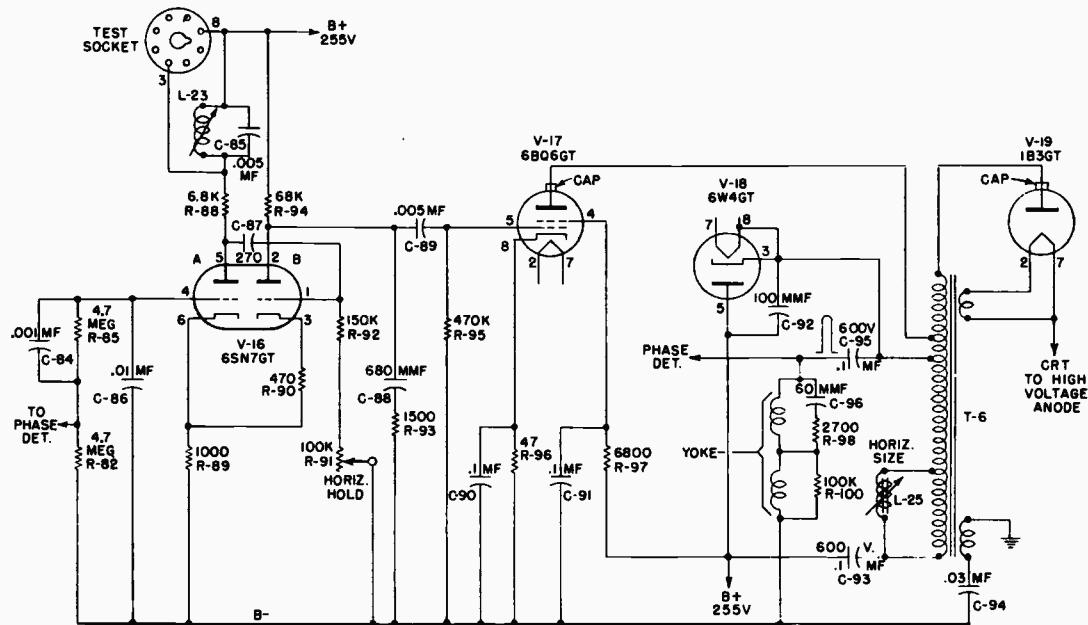
FIGURE 20. SIMPLIFIED SCHEMATIC OF HORIZONTAL SCANNING & HV SYSTEM

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 derived from the horizontal output system is made. A positive sync pulse from the plate of the 2nd clipper V-12 (6SN7) is fed thru C-83 (.001) to the plate of diode "A" of V-15. A negative sync pulse from the cathode of V-12 is applied thru C-68 (.001) to the cathode of diode "B" of V-15. A sawtooth, derived from the integration of a pulse in the horizontal output circuit, at the yoke, by the integrating network, composed of R-86 (150K), R-87 (150K), and C-82 (.005) is applied to the cathode of diode "A" and the plate of diode "B", which are tied together and returned to B- thru R-83 (15K). The load for diodes "A" and "B" consists of resistors R-84 (100K) and R-81 (100K) 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.

If 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 retrace time. See Figure 21(1). The 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, which means that in the "on frequency" condition shown in Figure 21(1), 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 18, no control voltage is applied to the grid of V-16.

If the oscillator tends to increase in frequency, with respect to the sync pulses, the phase relationship shown in Figure 21(2) 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 positive saw is also 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 saw 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 bucking the pulse voltage at 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 decrease in frequency, with respect to the sync pulses, the phase relationship shown in Figure 21(3) exists at the diodes. At the same instant that the negative pulse is applied to the cathode of diode "B", the negative saw is applied to its plate so that only the shaded portion of the pulse causes conduction. Diode "A", however, conducts on the full amplitude of the positive pulse applied to its plate aided by the negative saw applied to its cathode at the same time. Since current flow thru diode "B" makes the grid end of R-82 positive, with respect to B-, the decreased current thru diode "B" results in applying a more negative voltage to the grid of V-16 which, as we have seen, results in increasing the oscillator frequency. C-84, R-85 and C-86 provide two time constant filters which are necessary to obtain "fly-wheel" action of this AFC sync circuit.

The Horizontal Output System

The combination sawtooth and pulse waveform developed across C-88 (680) and R-93 (1500) by the multivibrator circuit, is fed to the grid of the horizontal output tube V-17 (6BQ6). Figure 20 is a simplified schematic of the horizontal output system. It will be noted that in this system an auto-transformer is used. In the horizontal scan, it is necessary that retrace be completed in about 7 microseconds. In order to accomplish reversal of current in the inductance of the output transformer and the yoke in this short a 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 such a circuit into oscillation will retrace be accomplished in the time allowed. The cir-
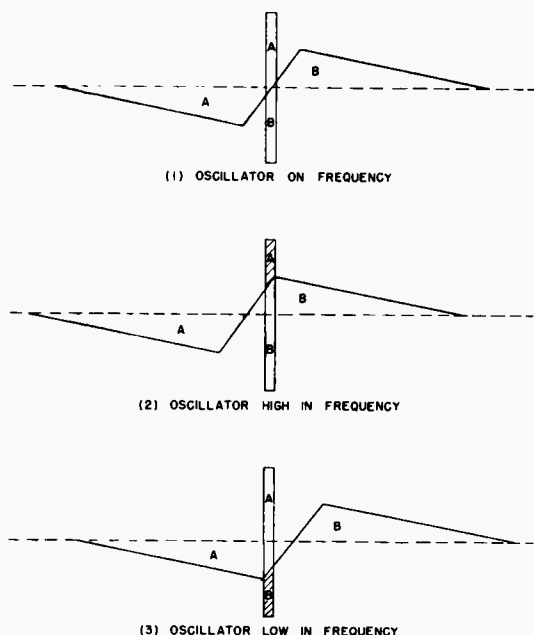
(1) OSCILLATOR ON FREQUENCY

(2) OSCILLATOR HIGH IN FREQUENCY

(3) OSCILLATOR LOW IN FREQUENCY

FIGURE 21. WAVEFORMS AT PHASE DETECTOR

(1) OUTPUT TUBE GRID VOLTAGE WAVEFORM

(2) OUTPUT TRANSFORMER CURRENT WAVEFORM (WITHOUT DAMPING DIODE)

(3) (C)EFFECT OF DAMPING DIODE (e) CURRENT WAVEFORM IN OUTPUT TRANSFORMER DUE TO CONDUCTANCE OF OUTPUT TUBE

(4) COMPOSITE CURRENT WAVEFORM IN OUTPUT TRANSFORMER

FIGURE 22. WAVEFORMS IN HORIZONTAL SCANNING

cuit 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(1), 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 voltage waveform, the output tube is suddenly cut off because its grid has been made highly negative, (point "c" on the grid voltage 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 voltage pulse which makes the cathode of the damping diode (V-18) positive, with respect to its plate; therefore, it cannot conduct. C-92 (100 mmf) 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 current would flow in the output transformer as shown in Figure 22(2). 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 at "c" Figure 22(3). At the time "d" in Figure 22(3) the voltage at the grid of the output tube has become less than cut off [point "a" in Figure 22(1)] and the tube again demands current. The rising current in the tube results in superimposing the waveform "e" of Figure 22(3) on the current flow already in the output transformer due to the decaying current which resulted from the damped oscillation. Combination of these two currents results in the linear trace current indicated at "f" in Figure 22(4), which is a composite waveform of the entire action. During the peak conduction of the damping diode, C-93 (.1) charges 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.
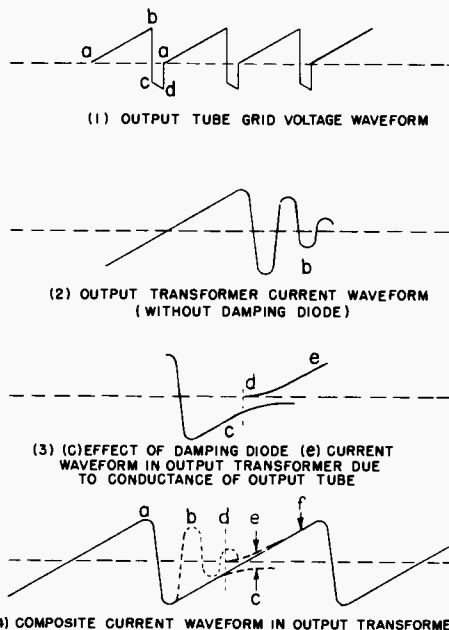
When the grid voltage waveform of the output tube again reaches point "b" of Figure 22(1), the tube is cut off and another cycle starts.

In order to properly match the yoke inductance to the required output inductance for the tube, the yoke is connected to a tap on the winding which effectively makes an auto-transformer of this section. The positive pulse of voltage at this tap is coupled to the yoke thru C-95 (.1) 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, one terminal of which is connected to chassis while the other terminal is connected to B- thru C-94 (.03), 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 degrees 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 (1B3) and the resulting DC is applied to the second anode of the picture tube. The filament voltage for the 1B3 rectifier is obtained from an additional winding on the output transformer.

Controls

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

L-25, paralleling a small portion of the output choke controls, to a small degree, the inductance of the choke and acts as a size control.

This lesson will be completed with a detailed circuit description of Du Mont sets which use 45.75 MC intermediate frequency and have other interesting differences from the sets we just reviewed. This material is reprinted through the courtesy of Allen B. Du Mont Laboratories.

GENERAL.—A block diagram of the RA-160 and RA-162 Telesets is shown in figure 1. The r-f tuner is of the twelve-channel switch-turret type and employs the new 6BK7 low-noise dual triode in a cascode r-f amplifier circuit. A 6J6 dual triode is used in the mixer and oscillator circuits. The outstanding feature of the r-f tuner is its extremely low noise figure. To minimize the possibilities of interference, particularly from signals in the vicinity of the i-f passband, a high pass filter is provided between the antenna and the input circuit of the tuner.

The output of the tuner is fed to a four-stage inter-carrier i-f amplifier. The i-f stages are of the over-coupled type as used in past Du Mont models. A video intermediate frequency of 45.75 mc is employed to minimize interference and improve image rejection, particularly in the u-h-f band.

The video detector is followed by a single high-gain video-amplifier stage. D-C coupling is used between the video detector and video amplifier, as well as between the video amplifier and the cathode of the picture tube.

The RA-160 and RA-162 Telesets use the new Du Mont Selfocus Teletrons*. These new Teletrons* maintain sharp overall focus at all brightness levels without the use of an external focusing potential. Thus focusing controls and adjustments are not required in these Telesets.

The sync signal take-off is at the output of the video amplifier. Separate horizontal and vertical sync circuits are employed. Three horizontal and two vertical clipper stages are provided.

The familiar pulse-width circuit is used to provide automatic frequency control of the horizontal sweep. The high voltage supply is of the flyback type. A voltage doubler is used to provide a CRT anode voltage of 16 kv.

The vertical sweep circuits consist of a blocking oscillator and triode sweep amplifier.

Gated automatic gain control is used. The a-g-c voltage is applied to the first and second video i-f stages. A switch is provided on the front panel to enable the Teleset owner to apply a-g-c voltage to the tuner when receiving very strong signals.
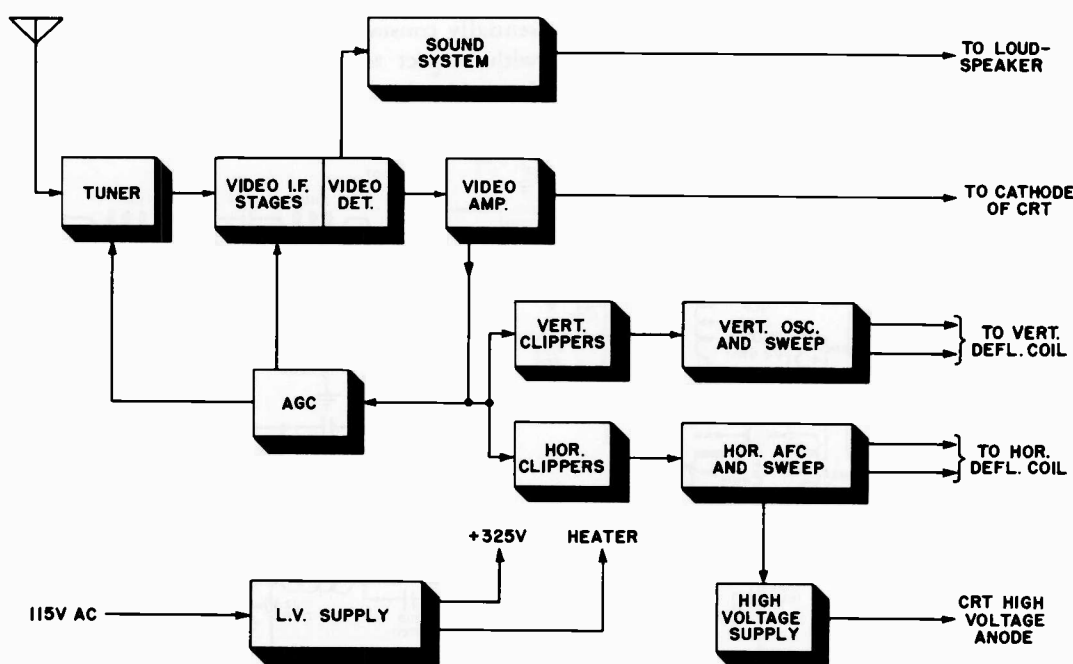
*Trade Mark

Figure 1. Block diagram of RA-160-162 receiver.

In the video-detector stage the 45.75 mc video i-f signal beats with the 41.25 mc sound i-f signal to produce a 4.5 mc sound i-f signal. Two 4.5 mc amplifier stages are employed to increase the amplitude of this 4.5 mc sound i-f signal to a level suitable for application to the ratio detector.

Dual-chassis construction is used in the RA-160 and RA-162 Telesets. The r-f tuner and the i-f, a-g-c, and sync stages are mounted on one chassis, referred to as the Signal Chassis; while the sweep, high-voltage and low-voltage supply circuits are mounted on a second chassis referred to as the Sweep Chassis. A single interchassis cable is provided to interconnect the circuits on the two chassis.

THE R-F TUNER.—Advanced circuit design and the latest tube types are employed in the RA-160 and RA-162 r-f tuner to produce a high-gain unit having a lower noise figure than it has been possible to obtain in the past. The tuner is of the 12 channel turret type and has been designed so that it may be conveniently converted for the reception of UHF stations.

The tuner circuits consist of a two-stage cascode-type r-f amplifier and a dual-triode mixer-oscillator as shown in figure 2. The 6BK7 dual triode, used in the r-f amplifier, is a new tube designed specifically for use in low noise r-f amplifiers. This tube and the cascode circuit in which it is used are responsible for the low noise figure of the tuner. The term "noise figure" may be new to many technicians and for their benefit a brief description follows.

All circuit elements generate noise which when visible on the face of the CRT appears as snow. This noise is due to the random movement of electrons and is referred to as thermal-agitation noise. Additional noise is generated in electron tubes due to variations in cathode emission, leakage current and minute grid currents. In multigrid tubes, noise is also generated by random division of current among the electrodes. Since triodes do not generate this last type of noise they are superior to multigrid tubes in this respect.

Although all of the stages in a receiver generate noise, the noise in the first stage is the most important. When the signal reaches the stages following the input stage it has been amplified enough to override the noise. This is only true if the signal is amplified sufficiently in the input stage.

From the above, it is apparent that to obtain a low-noise tuner the r-f amplifier and its input circuit must generate as little noise as possible and at the same time must amplify the signal enough to overcome the noise in the mixer stage.

To meet these conditions the RA-160, RA-162 tuner employs a low-noise dual triode in a modified cascode circuit. The cascode circuit actually consists of two amplifier stages, each of which uses one of the triode sections of the 6BK7 r-f amplifier tube, V101.

Input Circuit

The antenna is inductively coupled to the grid circuit of the first triode section, V101A, by means of coil L105. The input impedance of V101A is purposely made considerably higher than the transmission line impedance to obtain a voltage gain in the input circuit. Since the noise produced in V101A is essentially constant, this gain increases the signal level with respect to tube noise and establishes a more favorable signal-to-noise ratio. Two i-f traps, L103-
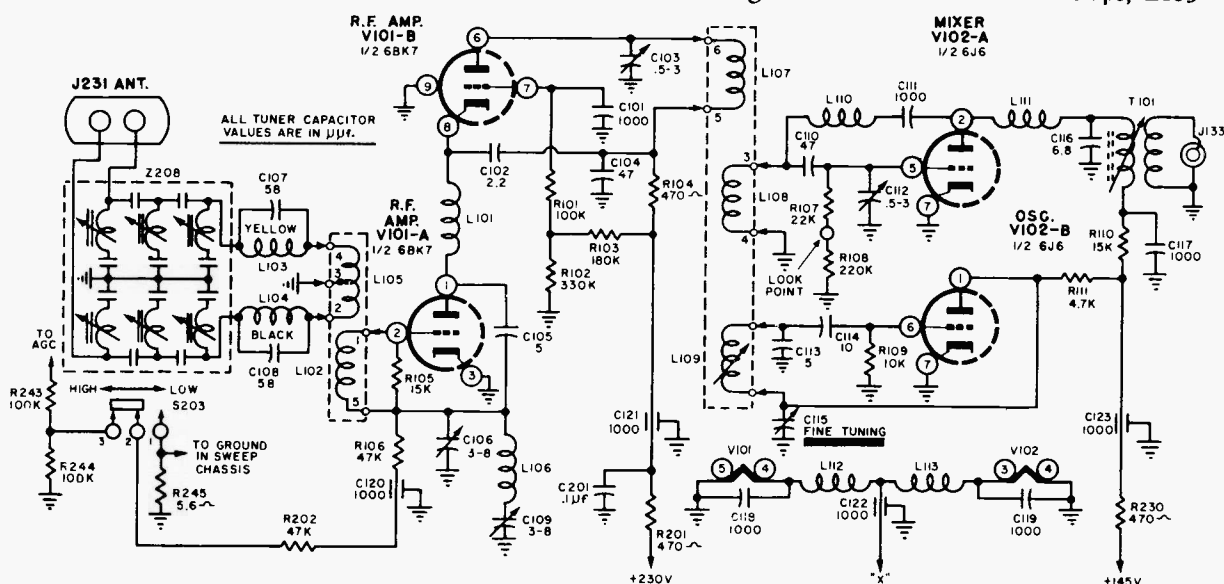

Figure 2. Schematic diagram of r-f tuner and associated circuits.

C107 and L104-C108, are connected between the antenna and the input coil to prevent signals which fall within the i-f passband from passing through the tuner and entering the i-f stages. An additional i-f trap consisting of L106 and C109 (series resonant) is connected between the lower end of grid coil L102 and ground. Its function is identical to that of the parallel-resonant traps in the antenna circuit.

Z208 is a high-pass filter which attenuates all signals whose frequencies are below approximately 48 mc. The filter further attenuates signals which fall within the i-f passband and in addition prevents strong signals, at frequencies below 48 mc, from overloading the tuner and generating interfering signals.

The balanced input circuit is designed to give a correct match between the input impedance of V101A and a 300 ohm transmission line. To obtain the bandwidth required to pass a TV signal, it is necessary to load the input tuned circuit. On the high channels the "transit time" of V101A provides the required loading.

R-F Amplifier

Transit time is the period required for electrons to pass from the cathode to the plate of a tube. At low frequencies this time is very short compared to a cycle at the operating frequency and it can be assumed that electrons reach the plate instantaneously. At the frequencies at which a television tuner operates, the transit time becomes an appreciable part of a cycle and its effects become important in circuit design. At these frequencies the velocity of the electrons passing through the grid structure varies, due to the comparatively long transit time, and an in-phase current is produced in the grid circuit. This current opposes the applied signal and effectively loads the input circuit.

The loading is greater than required and since it reduces the signal developed by the input circuit, provisions have been made to minimize it. This is accomplished by the addition of neutralizing capacitor C105.
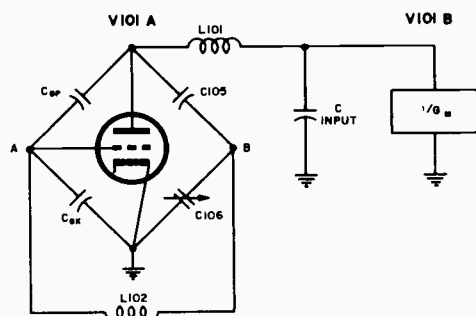
The operation of this portion of the circuit is illus-

Figure 3. Equivalent circuit of V101A showing method used to neutralize stage.

trated in figure 3. Signal voltage is fed back from the plate to the grid through the interelectrode and stray capacitance of the circuit. These capacitances may be represented as two of the legs (Cgp and Cgk) of a bridge, as shown in the figure. Since the plate voltage is 180° out of phase with the grid voltage, this feedback reduces the signal voltage at the grid.

To eliminate this reduction in grid signal voltage, another voltage, 180° out of phase with the undesired feedback, is applied to the grid. This neutralizing voltage is obtained from the junction of C105 and C106 which form the opposite legs of the bridge. The value of C105 is chosen so that when C106 is adjusted for optimum input-circuit response the voltage at B is approximately equal to the voltage at A. The voltages at A and B are in phase. To neutralize the circuit, the voltage at B must be applied to the grid 180° out-of-phase with the undesired feedback. This phase reversal is obtained by applying the neutralizing voltage to the lower end of the grid coil. The coil reverses the phase of the neutralizing voltage so that it cancels the undesired feedback voltage at the grid. C106 is adjusted for optimum response on channel 12.

On the low channels, the transit time loading is negligible and the bandwidth of the input circuit is determined by the input impedance of V101A, and resistor R105 which is shunted across the grid coil.

V101B functions as a grounded-grid voltage amplifier. Although the grid is not connected to ground, C101 effectively grounds it at the signal frequency. The signal at the plate of V101A is applied to the cathode of V101B through choke L101. L101 prevents the interelectrode and stray capacitance of V101B from loading V101A, producing an increase in the signal at the input of V101B. L101 is in series with the stray and interelectrode capacity of V101B as shown in figure 3. Its value is chosen so that it is series resonant with the input capacity (C input) of V101B at the center of the high-channel range. In a series resonant circuit a comparatively high voltage is developed across the capacitance. Since the input of V101B is effectively connected across this capacitance, the addition of L101 provides an increase in gain on the high channels.

R102 and R103 form a voltage divider from which a fixed grid bias is obtained. This bias is applied to the grid of V101B through R101. Fixed bias is used in preference to contact potential bias because fixed bias minimizes the effects of variations in tube characteristics and improves the a-g-c action on very strong signals. When the input signal to the tuner increases and S203 is in the high position, the a-g-c circuits increase the bias on V101A reducing the current through the tube causing its plate to become more positive. The cathode of V101B is directly coupled to

the plate of V101A therefore the cathode becomes more positive. Since the grid voltage of V101B is constant, as a result of the use of fixed bias, the rise in cathode voltage increases the bias on V101B and reduces its gain.

C104 is a partial bypass for the r-f amplifier output circuit. A portion of the signal appearing across C104 is coupled back to the cathode of V101B through C102. Since this voltage is out of phase with the signal at the cathode, it introduces a small amount of degeneration in the stage to improve its stability. C103 is provided to adjust the response of L107.

Mixer

The output of V101B is inductively coupled to the input of the mixer, V102A. The mixer stage employs one of the triode sections of a type 6J6. The mixer stage is neutralized by means of a voltage applied to the grid circuit through L110 and C111. L110 reverses the phase of the neutralizing voltage so that it cancels the feedback due to the stray and interelectrode capacitance of the stage. The inductance of L110 is chosen so that it resonates with the tube grid-

plate capacitance at the center of the i-f band, providing the greatest gain at these frequencies.

C110 is a d-c blocking capacitor. C116 in series with L111 form a low-pass filter to prevent signals above the intermediate frequencies from entering the i-f stages. Bias for the mixer is provided by resistors R107 and R108. The junction of the resistors is brought out to the top of the chassis to provide a "look point" for use in checking the overall response of the r-f and mixer tuned circuits.

The mixer output is coupled to a short length of 75-ohm line through T101. The 75-ohm line carries the signal to the input of the first video i-f stage on the signal chassis.

The oscillator stage of the tuner employs a Colpitts circuit which uses the other triode section of V102. Oscillator tuning is accomplished by means of a brass slug in each oscillator coil, and the fine-tuning capacitor, C115.

A-g-c voltage is applied to the first r-f amplifier tube (V101A) when the High-Low Signal switch (S203) is in the High position, to prevent the tuner from overloading on very strong signals. When the switch is placed in the Low-Signal position, the grid
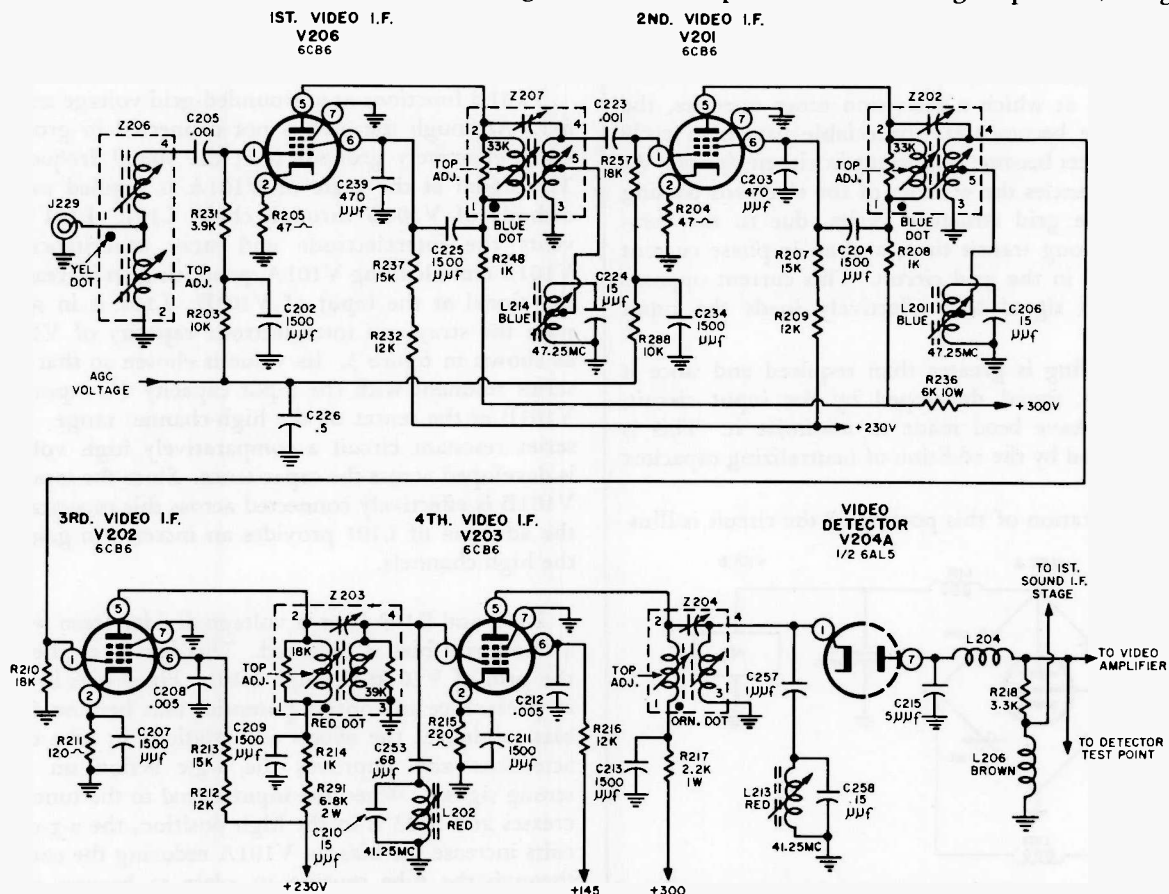

Figure 4. Schematic diagram of video i-f stages and the video detector.

circuit is connected to one end of R245, as shown in figure 2. The other end of R245 is grounded as shown in the figure. The end of R245 which is connected to S203 is also connected to ground on the SWEEP CHASSIS through the interchassis cable. This is the only ground connection between the chassis, consequently the B+ supply current of the signal chassis passes through R245 developing a negative voltage. This voltage biases V101A when a-g-c voltage is not being applied to the tuner.

VIDEO I-F STAGES.—As shown in figure 4, the RA-160 and RA-162 use an intercarrier i-f system consisting of four video i-f stages. Careful design of the i-f section has resulted in performance and picture quality superior to that which has previously been obtained with dual-channel i-f systems.

The signal appearing at the secondary of the mixer plate transformer is applied to the grid circuit of the first video i-f stage through a length of 75-ohm coax.

A 45.75-mc intermediate frequency is employed. This frequency was chosen for the following reasons:

1. The image rejection is greatly improved, particularly in the new UHF channels.

2. Local-oscillator interference is eliminated because the local-oscillator frequencies fall outside the TV channels.

3. External interference problems which have been encountered at lower intermediate frequencies (Ex., Diathermy at 27.12 mc) are minimized or eliminated.

All of the video i-f stages employ 6CB6 sharp cut-off pentodes. The 6CB6 is a new high-gain pentode designed specifically for use in high-frequency amplifier circuits.

In an intercarrier television receiver, a single i-f channel is employed to raise the amplitudes of the sound and video i-f signals to a level suitable for application to the second detector. At the output of the video detector the sound signal appears as part of a 4.5-mc beat, produced by the beating of the video and sound signals.

Some means must be provided to prevent the accompanying sound signal from entering the picture-tube circuits. This is accomplished by two traps located in the intercarrier i-f stages, and a third trap located in the video-amplifier stage.

The i-f traps consist of L202 and C210, in the grid circuit of the fourth video i-f stage (V203); and L213 and C258, at the input of the video detector, as shown in figure 4. These traps attenuate the sound signal so that only a small portion of it is present at the output of the video detector. The remaining detected sound signal is prevented from reaching the
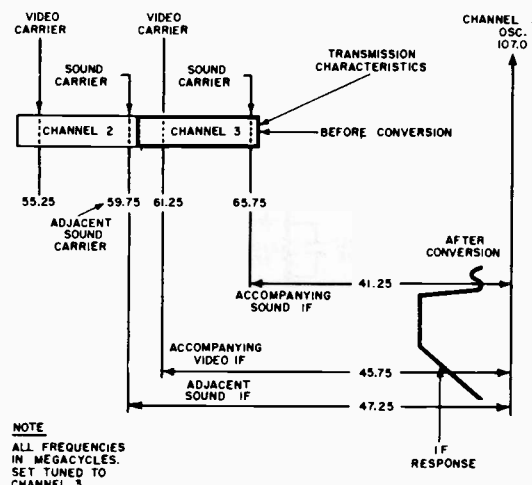

Figure 5. Video and sound carrier relationship of two adjacent channels. (Channels 2 and 3)

CRT by a 4.5-mc parallel-resonant trap, located between the video amplifier and the cathode of the CRT.

To prevent the lower adjacent-channel sound carrier (shown in figure 5) from causing interference, two adjacent-channel sound traps are included in the video i-f circuits. One trap, consisting of L214 and C224, is located in the grid circuit of the second video i-f stage; while the other trap, consisting of L201 and C206, is located in the grid circuit of the third video i-f stage (V202).

These traps are connected to low-impedance taps on the grid coils to minimize their loading effect on the grid circuits, and to reduce radiation of the adjacent-channel sound signal by the leads connecting the traps to the coils.

A-g-c voltage is applied to the grids of the first and second i-f stages (V206 and V201). To minimize changes in the input impedance of these tubes, with variations in a-g-c voltage (Miller effect), a small amount of degeneration is introduced in these stages. This is accomplished through the use of unbypassed cathode resistors R204 and R205. If degeneration were not employed the input impedance of V206 and V201 would vary with changes in signal strength and the alignment of Z206 and Z207 would be affected.

A few of the components in the video i-f stages have critical values. When they are replaced, exact replacement parts should always be used. Included among the critical components are the first and second video i-f amplifier screen-bypass capacitors, C203 and C239. Since these components also serve as neutralizing capacitors to prevent regeneration, their values are critical.

In the first, second, and third video i-f stages two resistors (15K and 12K) are connected in series to provide the screen dropping resistance. These resistors (R207, R209, R212, R213, R232, and R237)
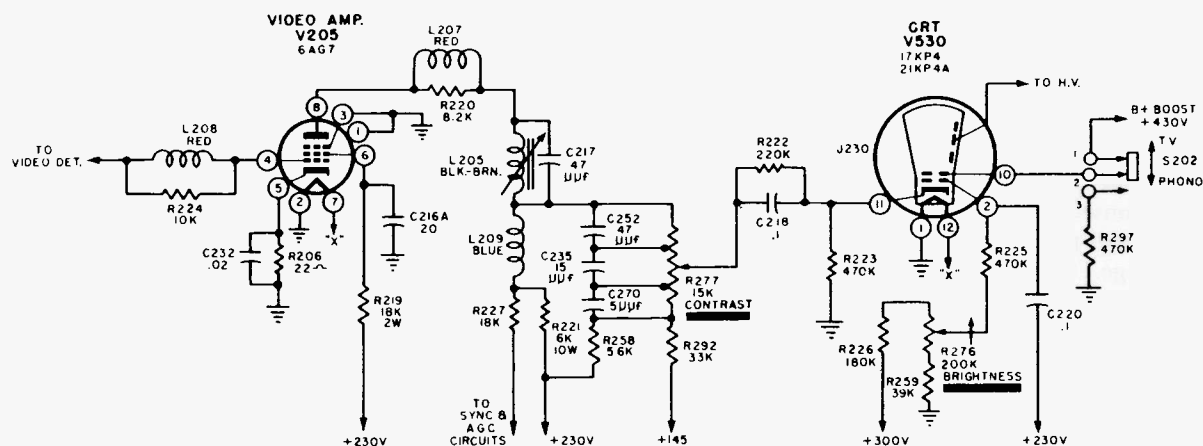
Figure 6. Schematic diagram of video amplifier and picture tube.

should not be replaced with a single resistor. This is also true of the plate decoupling resistors (R214 and R291) of the third video i-f amplifier.

VIDEO DETECTOR.—The signal appearing at the secondary of the fourth video i-f transformer (Z204) is applied to the cathode of the video detector, V204A, as shown in figure 4. Since the detector conducts on the negative portion of the r-f signal, the signal appearing at the output of the detector (across R218 and L206) is negative in polarity.

To prevent the sound and video i-f signals from entering succeeding stages an i-f filter, consisting of C215 and L204, is connected in the output circuit of the detector.

As an aid in checking the performance of the receiver a video detector test point is provided which is accessible from the top of the signal chassis. This test point is connected to the junction of R218 and L204 at the output of the video detector. A VTVM or an oscillograph may be used to measure the signal voltage at this test point.

When the receiver is operating normally the d-c voltage at this test point is approximately —.5 volts. The peak-to-peak signal voltage observed on an oscillograph and measured with a suitable voltage calibrator is approximately 3 volts.

VIDEO AMPLIFIER AND CRT.—The negative signal appearing across the video-detector load (R218 and L206 in figure 4) is directly coupled to the grid of the video amplifier through the parallel network consisting of peaking coil L208, and its damping resistor, R224, as shown in figure 6. A 6AG7 power pentode is used in the video-amplifier stage.

The d-c voltage developed across the video-detector load (R218 and L206) provides bias for the video amplifier. Additional bias is developed across the cathode resistor, R206. R206 is bypassed by C232 to prevent degeneration. R221 forms the basic plate load of the video amplifier.

Since the video (picture) frequencies to be amplified range from 30 cycles to 4mc., some means must

be provided to insure uniform response between these frequencies.

To insure good high-frequency response both shunt (L209) and series (L207) peaking coils are used in the video-amplifier plate circuit as shown in figure 6. To prevent L207 from ringing at its resonant frequency it is shunted by R220.

Since direct coupling is used between the video detector and the video amplifier, and between the video amplifier and the CRT, good low-frequency response is easily obtained. In addition the need for d-c restoration is eliminated.

The CONTRAST (R277) control is located in the plate circuit of the video amplifier. To maintain proper high-frequency response at all settings of the control, the resistance element is tapped and compensating capacitors C252, C235, and C270 are connected between the taps. Some additional high-frequency compensation is provided in the coupling circuit by R222 and C218.

Some of the 4.5-mc sound i-f signal enters the video amplifier. To prevent this signal from reaching the cathode of the picture tube a parallel-resonant trap, consisting of L205 in parallel with C217, is located in the video-amplifier plate circuit, as shown in figure 6.

The polarity of the signal appearing at the plate of the video amplifier is positive. Consequently, the video signal is applied to the cathode of the picture tube. A portion of the video-amplifier plate voltage is also applied to the cathode of the CRT. This voltage provides the bias for the tube. The conduction of the video amplifier varies with the transmitted video signal. As a result the video amplifier plate voltage also varies with the video signal.

Since direct current coupling is used between the video amplifier and the CRT this action would normally cause large variations in the CRT cathode voltage. To minimize this condition one terminal of R277 is connected to the 145 volt power supply source through R292, and to the 230 volt source

through R258. R292 and R258 form a tapped bleeder network across the two voltage sources. The bleeder current passing through these resistors establishes a voltage drop across R292 which aids in minimizing variations in the CRT cathode voltage. To prevent the voltage from exceeding the heater-cathode rating of the CRT, R222 is connected in the coupling circuit.

A positive voltage, obtained from a voltage-divider network (R226, R276, and R259), is applied to the grid of the CRT. The difference between this voltage and the cathode voltage constitutes the CRT bias. R276 is the BRIGHTNESS control. It functions by varying the positive voltage appearing at the grid. To prevent the CRT control grid from drawing excessive current R225 is inserted between the grid and the center arm of the control.

As shown in figure 6 the accelerating anode voltage is obtained from the boosted B+ source (flyback transformer circuit). Note that when the selector switch S202 is in the "Phono" position the voltage is removed from the accelerating grid which is then connected to ground through R297. This reduces the CRT beam current sufficiently to blank out the CRT screen.

HORIZONTAL AND VERTICAL SYNC CIRCUITS.

The purpose of the sync circuits is to separate the sync signals from the composite-video signal, to remove noise interference, and to amplify the sync signals to a level suitable for synchronizing the oscillator circuits.
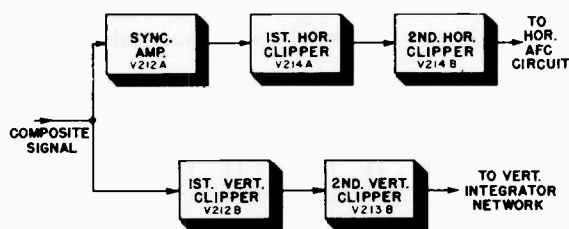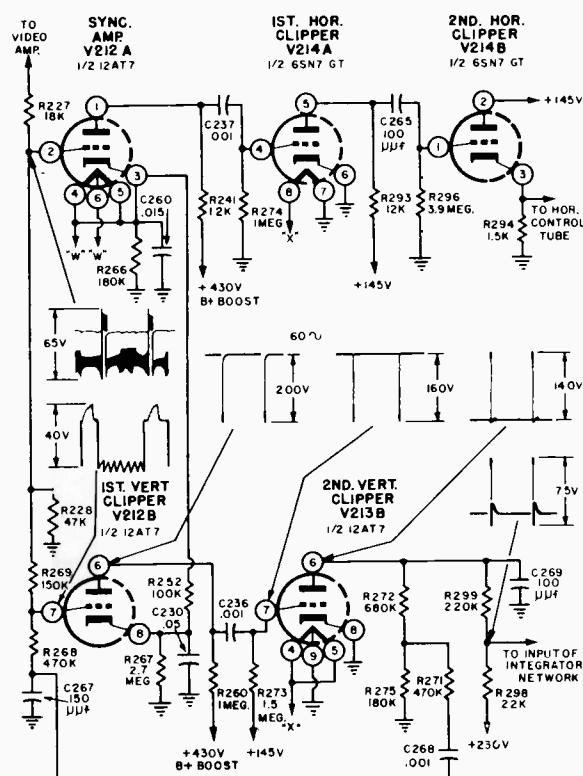

Figure 7. Block diagram of sync circuits.

As shown in the block diagram of figure 7 the RA-160 sync circuits differ from those used in former Telesets in that the vertical- and horizontal-sync signals pass through separate sync-separator stages. In former Telesets both vertical- and horizontal-sync signals passed through a common sync-separator system.

To fulfill the requirements mentioned above, the sync circuits of the RA-160 chassis consist of three horizontal-clipper stages and two vertical-clipper stages, as shown in figure 8.

The polarity of the composite signal appearing at the plate of the video amplifier (V205) is positive. This signal is applied to both the sync amplifier
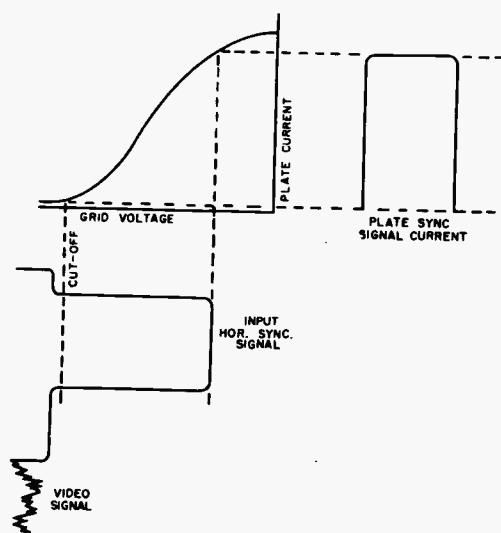

Figure 8. Schematic diagram of sync circuits.

(V212A) and first vertical-clipper (V212B) stages, through resistor R227.

The signal then appears across R228 which is the common grid-return resistor for both the sync amplifier and first vertical-clipper stages. Since direct-current coupling is used between the video amplifier and the first clipper stages (V212A and B), a portion of the video-amplifier plate voltage appears across R228. This voltage serves as the grid voltage for both the sync amplifier and first vertical-clipper stages.

Horizontal Sync Clippers

The heart of the horizontal and vertical sync-clipper system is the sync amplifier stage (V212A) as shown in figure 8. This stage performs the following functions:

1. It separates the horizontal sync signal from the composite signal.

2. It allows only the horizontal-sync signal to appear in its plate circuit for application to the first horizontal-clipper stage.

3. It incorporates an extremely efficient noise immunity system which prevents extraneous signals from affecting the oscillator circuits.

4. It provides cathode bias for the first vertical clipper stage.

Figure 9. Graph of grid-voltage plate-current waveforms of V212A.

As previously mentioned the polarity of the composite signal applied to the horizontal-sync amplifier and first vertical-clipper stages is positive.

Separation of the sync signal from the video signal in the horizontal-sync amplifier stage (V212A) is accomplished by biasing the tube near cut-off. The required bias is obtained from the cathode resistor, R266, bypassed by C260. Since the positive voltage which is present at the junction of R228 and R227 is applied to the grid of the tube, the effective bias on the stage is equal to the difference between the cathode and grid voltages. The cathode voltage is the larger of the two and therefore the tube is negatively biased.

The value of the bias voltage has been chosen so that the tube does not conduct on the video signal as shown in figure 9. Since the sync pulses are of a higher amplitude than the video signal they drive the tube above cut-off and consequently the sync signal appears in the output of the stage.

In addition to its action in eliminating video information from the sync signal the sync amplifier removes most of the vertical-sync signal. This is accomplished by the action of the cathode-biasing network (R266 and C260). The operation of this network is illustrated in figure 10.

The horizontal-sync pulses are of short duration and are widely separated in comparison to the vertical-sync signal as shown in figure 10A. The value of the cathode-bypass capacitor, C260, has been chosen so that most of the charge which is produced by each horizontal-sync pulse is dissipated before the following pulse occurs. Consequently the cathode bias on the stage is substantially equal to that produced by the static current through the tube. As a result all but a small portion of the horizontal-sync signal appears at the plate of the horizontal-sync amplifier (V212A) as shown in figure 10C. The equalizing pulses which are of even shorter duration than the horizontal pulses also appear in the output.

As shown in figure 10A the vertical-sync signals are of much longer duration and are not as widely separated as are the horizontal pulses. Therefore the charge on C260 produced by each vertical-sync pulse is considerably greater than that produced by each horizontal pulse. Since the vertical-sync pulses occur relatively close together, C260 does not have time to discharge in the interval between successive pulses.
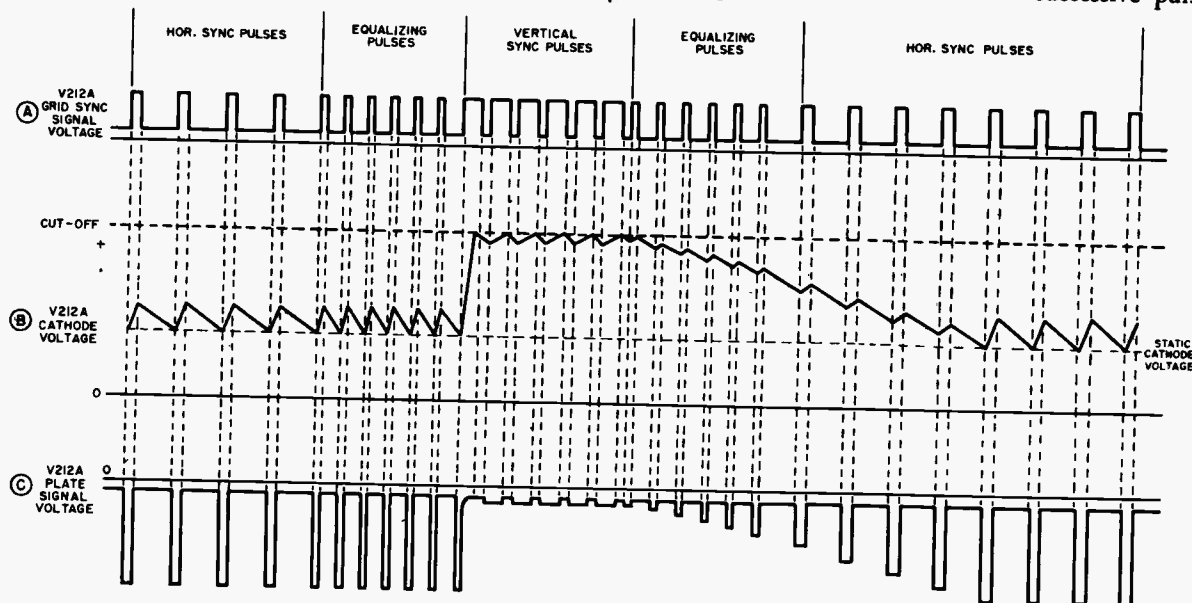

Figure 10. Operation of sync and a-g-c amplifier stages. A— Sync signal portion of composite video signal applied to grid of V212A. B— Waveform appearing at cathode of V212A. C— Sync signals appearing at plate of V212A.

As a result the vertical-sync signal develops a large cumulative charge across C260, as shown in figure 10B. This charge is added to the static cathode bias on the stage. Consequently, after the first vertical pulse, the bias on the tube is great enough to prevent further conduction, and the remainder of the serrated vertical signal does not pass through the stage.

When the vertical-sync signal is complete C260 begins to discharge, permitting the horizontal-sync signal to pass through the stage.

The cathode voltage of V212A is approximately 85 volts. The filament to cathode voltage rating of the 12AT7 is 90 volts. To prevent a filament to cathode break-down, one half of the filament is connected to the cathode, as shown in figure 8.

Since the video- and vertical-sync signals are eliminated in the horizontal-sync amplifier only the horizontal-sync signal is applied to the grid of the first horizontal clipper (V214A).

The purpose of the first horizontal clipper (V214A) is to remove extraneous signals which may have been superimposed upon the sync pulse as shown in figure 11. This is accomplished by clipping the top portion of the sync pulse as shown in the figure.
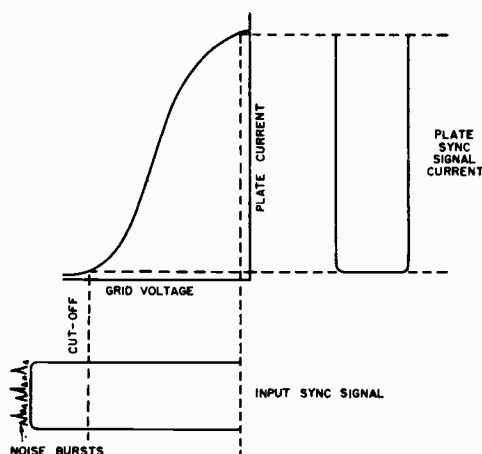

Figure 11. Graph of grid-voltage plate-current waveforms of V214A.

The polarity of the horizontal-sync pulse appearing at the grid of the second horizontal clipper (V214B) is positive. The purpose of this stage is to remove extraneous signals which may have been superimposed on the horizontal-blanking pedestal, as shown in figure 12. This is accomplished by biasing the tube beyond cut-off. The effective bias of V214B consists of the signal bias developed across the grid resistor, R296, and the cathode voltage produced across R294. The grid bias is sufficiently large so that the tube does not conduct on small extraneous signals that are superimposed on the pedestal level, as shown in figure 12.
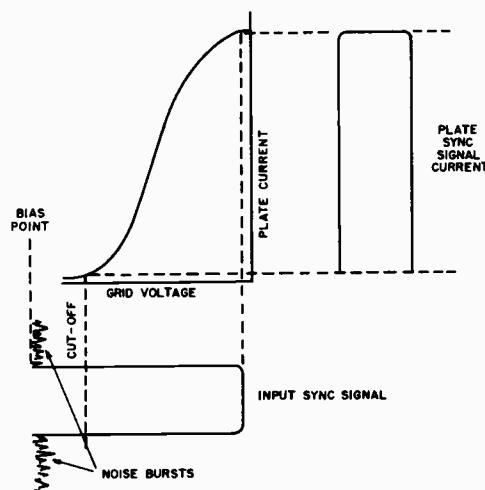

Figure 12. Graph of grid-voltage plate-current waveforms of V214B.

In addition to its action in eliminating extraneous signals the second horizontal clipper serves as a cathode-follower stage. The output signal is developed across the cathode resistor, R294. Although the output signal of a cathode follower is slightly less than its input signal, it has a low output impedance which minimizes losses in the interchassis cable.

Vertical Sync Clippers

The vertical-sync signal is separated from the horizontal-sync and video signals in the first vertical-clipper stage (V212B). The composite-video signal is applied to the grid of the first vertical-clipper through resistor R269 as shown in figure 8. In conjunction with the input capacity of V212B, R269 forms a network which attenuates the horizontal-sync and video signals as shown in figure 13. In addition this network integrates the vertical-sync signal as shown in figure 13.

The grid voltage for V212B is that portion of the video-amplifier plate voltage appearing across R228 as previously explained in the discussion of the sync amplifier.

To insure good vertical-sync stability noise bursts are prevented from affecting the cathode bias of V212B. This is accomplished in the following manner:

1. The first vertical clipper is designed so that its conduction is relatively small. This is accomplished by the use of a high value of plate load resistance (R260).

2. As previously mentioned the horizontal-sync signals are attenuated at the grid of V212B. As a result the main signals causing conduction are the vertical-sync signal and any noise bursts that may be present at the grid of V212B.

3. Since the vertical-sync pulses occur for only a small percentage of each vertical field, the cathode bias produced by each vertical pulse is relatively
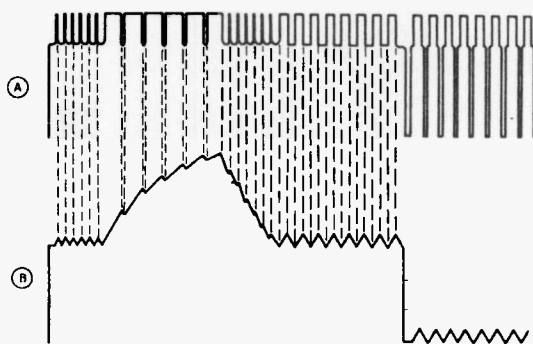
Figure 13. The effect of R269 and the input capacity of V212B upon the composite video signal. A— Expanded view of a portion of the composite video signal appearing at the V212A side of R269. B— Expanded view of corresponding signal appearing at the grid of V212B.

small. Ordinarily this would permit noise bursts occurring between vertical sync signals to produce an additional cathode bias.

4. To prevent this condition the cathode bias for the first vertical clipper is obtained from the cathode of the sync amplifier. The value of cathode-bypass capacitor C230 has been chosen so that charges produced by horizontal-sync and noise pulses are dissipated through resistor R267.

As a result the cathode bias of the first vertical clipper is maintained at a relatively constant value. The cathode bias is sufficiently greater than the positive grid voltage to bias the tube beyond cut-off, as shown in figure 14.

The integrated vertical-sync signal appearing at the plate of the first vertical clipper is applied to the grid of the second vertical clipper through C236.

The second vertical clipper (V213B) removes extraneous signals which may have been superimposed upon the vertical-integrated-sync signal or upon the vertical-blanking pedestal, as shown in figure 15.

This is performed by biasing the tube in its saturation region. The grid bias is obtained by applying 145 volts positive to the grid of the tube through resistor R273. As a result the grid draws current producing a voltage drop across the grid resistor R273. The positive 145 volts is sufficiently larger than the voltage drop produced across this resistor to bias the tube in its saturation region, as shown in figure 15. As shown in figure 15 this results in the removal of the upper and lower portions of the sync signal.

To improve the vertical-sync stability on weak signals positive feedback is provided between the plate of the second vertical clipper and the grid of the first vertical clipper. A portion of the sync signal appearing at the plate of the second vertical clipper (V213B) is applied to the grid of the first vertical clipper (V212B) by means of R271, C268, and R268.

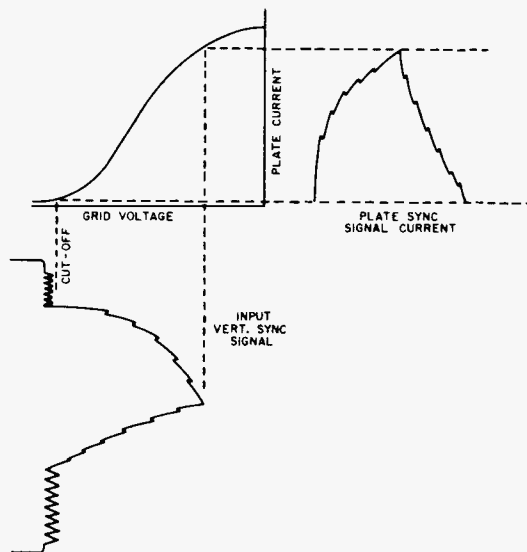The video signal appearing at the grid of V212B

Figure 14. Graph of grid-voltage plate-current waveforms of V212B.

is prevented from feeding through the feedback network to the plate of V213B by means of C267, connected between the grid circuit of V212B and ground. C269 serves to bypass to ground video information that appears in the second vertical-clipper plate circuit.

Resistors R299 and R298 located in the plate circuit of V213B form a voltage-divider network. This network attenuates the integrated vertical-sync signal to a level suitable for application to the filter network on the sweep chassis.
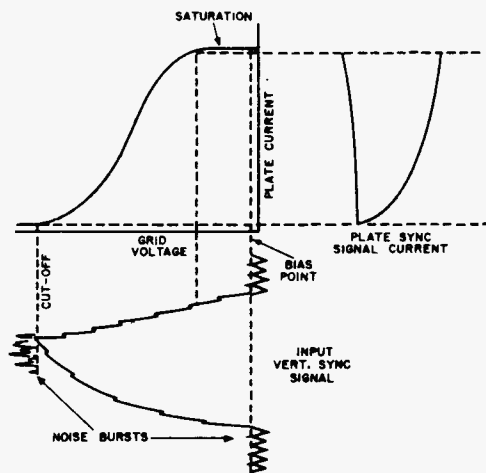

Figure 15. Graph of grid-voltage plate-current waveforms of V213B.

VERTICAL SWEEP CIRCUITS.—The purpose of the vertical-sweep circuits is to generate a sweep current synchronized with the vertical-sync signal in order to deflect the electron beam in the CRT.

The circuits employed consist of an integrating network, a blocking-tube oscillator, and a vertical-sweep amplifier.

To obtain a linear vertical sweep, a combination sawtooth square-wave signal must be applied to the vertical-deflection coil, as shown in figure 16. The sweep signal is generated by the vertical blocking-tube oscillator, and is amplified to a level suitable for application to the vertical-deflection coil by the vertical-sweep amplifier. The sweep-frequency signal is synchronized with the vertical-sync signal of the trans-
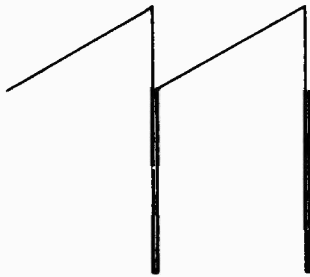
Figure 16. Vertical sweep voltage.

mitter, by the signal at the output of the integrating network.

The integrated vertical-sync signal at the output of the second sync clipper is applied to the integrating network (R326 and C327), through a differentiating network consisting of R349 and C323, as shown in figure 17. Stray capacitance in the interchassis cable distorts the leading edge of the vertical-sync signal. The differentiating network eliminates this distortion. Before the integrated sync signal is applied to the BTO it is further integrated by a cascade network consisting of R326, C327, R328, C303 and C326.

This final integration removes irregularities in the sync signal providing a clean pulse, as shown in figure 17, for application to the BTO.

The operation of the blocking-tube oscillator shown in figure 17 is a follows:

1. When the power is applied to the circuit, the BTO tube conducts and current flows through the secondary winding of T302. This current sets up a magnetic field around the secondary winding of T302. The field induces a voltage into the primary winding. The polarity of the primary winding is such that a positive voltage is applied to the BTO grid. This positive voltage causes an increase in plate current which in turn reinforces the positive grid voltage. Eventually the grid is driven positive with respect to the cathode and draws current, causing the grid side of C326 to become negatively charged. When the plate current reaches saturation, the magnetic field around the secondary winding of T302 becomes stationary and the voltage across the primary drops to zero.

2. Since the grid is no longer positive, the negative charge across C326 begins to dissipate itself through R329 and the parallel network, R242 and R247A. The discharge current through R329 causes the grid of V306A to become less positive, reducing the plate current of the tube. As a result, the field around the secondary winding begins to collapse. This collapsing field induces a voltage across the primary, opposite in polarity to that originally produced, causing the grid to become more and more negative. The process continues until the grid is biased beyond cut-off. The tube is maintained at cut-off by the charge built up across C326 during the period when the grid was drawing current.
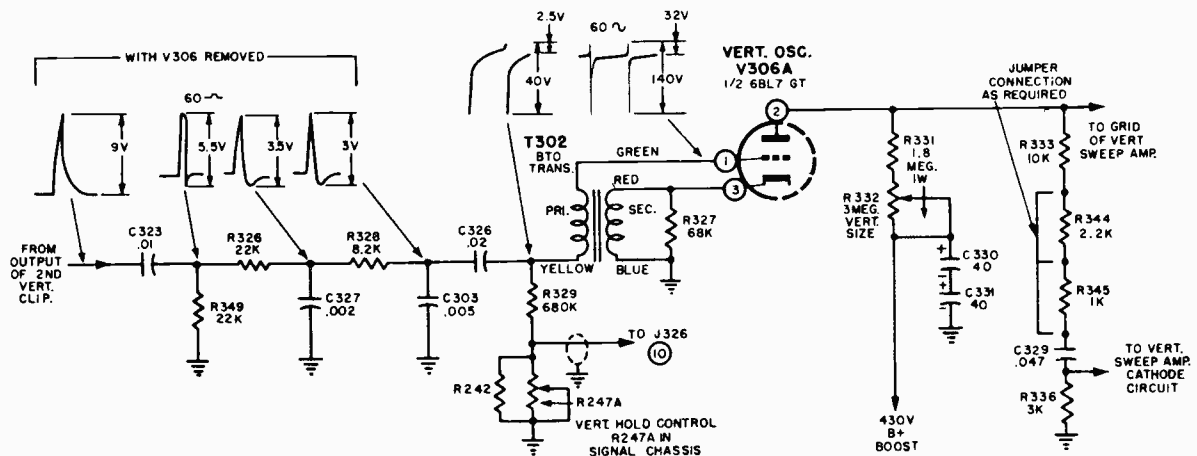
Figure 17. Schematic diagram of vertical integrating network and blocking tube oscillator.
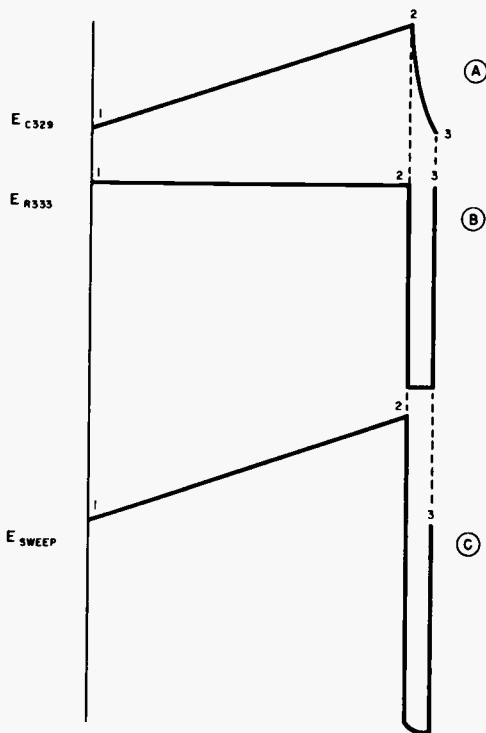
Figure 18. Vertical sweep signal voltage developed across wave shaping network. A— Voltage across C329. B— Voltage across R333. C— Resultant sum of voltages.

Since oscillation cannot occur again until the charge across C326 is dissipated through R329, R242 and R247A, the free-running frequency of V306A is determined by the values of these components.

The values of these components are chosen so that the free-running frequency of the oscillator is adjusted slightly lower than the frequency of the vertical-sync signal. Thus, before the charge across C326 is dissipated sufficiently to permit V306A to conduct, the vertical-sync pulse drives the grid above cut-off and the next cycle begins. Consequently the operating frequency of the oscillator is controlled by the vertical-sync signal.

The action of the blocking tube oscillator produces the vertical sweep signal across the wave shaping network consisting of R333 and C329. During the non-conducting period of the oscillator tube C329 is charged by the B+ source through R332, R331, and R333. This charge occurs during the interval from point 1 to 2 in figure 18A. The charging current of C329 produces a voltage drop across R333 similar to that shown in figure 18B (points 1 to 2). As the tube conducts C329 is discharged through R333 and the oscillator tube as shown in figure 18A (points 2 to 3). During this period the discharge current of C329 produces a voltage drop across R333 opposite to that produced by the charging current as shown in figure 18B (points 2 to 3).

As shown in figure 18C the vertical sweep signal is the resultant sum of the voltages across C329 and across R333.

Resistors R344 and R345 are inserted in the wave shaping network to obtain good vertical linearity. If improper vertical linearity is obtained at the top of the picture the jumpers across these resistors are removed during production.

The vertical-sweep signal is amplified by the vertical-sweep amplifier to a level suitable for application to the vertical-deflection coil. The signal appearing across the wave shaping network is applied to the grid of the vertical-sweep amplifier, V306B, through C328, as shown in figure 19.

The vertical-sweep amplifier includes provisions for controlling the linearity of the sweep signal appearing at the output of the stage. This is accomplished by the use of R336 which is located in the cathode circuit and is used to vary the cathode bias of the tube.
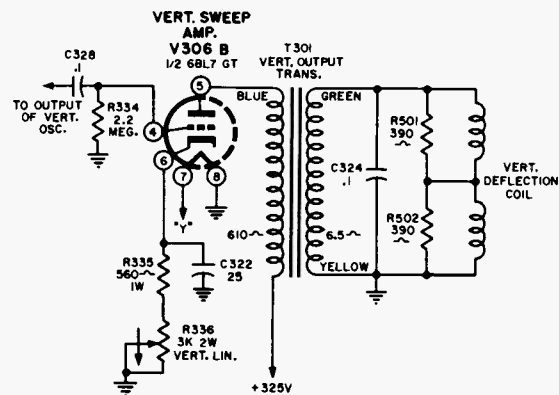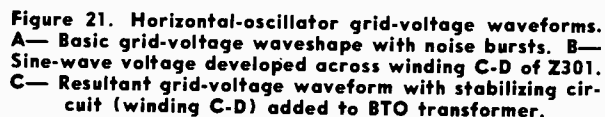

Figure 19. Schematic diagram of vertical sweep amplifier.

The vertical-sweep signal appearing at the plate of the vertical amplifier is applied to the vertical-deflection coil by means of the vertical output transformer T301. The transformer matches the high plate impedance of the 6BL7 to the low-impedance deflection coil.

Since the vertical and horizontal deflection coils are wound close together some of the horizontal sweep energy appears in the vertical deflection coil. This energy can disturb the interlace of the vertical-sweep signal. To prevent this condition C324 is connected across the secondary of the vertical output transformer. The value of C324 has been chosen so that any horizontal sweep energy present in the vertical-deflection coil will be bypassed to ground. Resistors R501 and R502, connected across the vertical-deflection coil, prevent the coil from ringing during the period following the vertical retrace time.

Figure 20. Schematic diagram of horizontal a-f-c circuits.

HORIZONTAL AFC SYSTEM.

The horizontal AFC system used in the RA-160 and RA-162 operates on the pulse-width principle and performs two functions: it generates the initial horizontal-sweep signal; and it stabilizes the horizontal oscillator at the frequency of the transmitted horizontal-sync signal (15,750 cps).

The initial voltage for the horizontal sweep is generated by the horizontal blocking-tube oscillator (V301B in figure 20) whose operating principle is similar to that of the vertical blocking-tube oscillator previously described. The only difference between these circuits is that the secondary of the BTO transformer is in the plate circuit of the horizontal oscillator, as shown in figure 20, while the secondary of the transformer is in the cathode circuit of the vertical oscillator.

The horizontal-sweep signal is generated across capacitor C333 through resistors R330 and R323. C333 charges when V301B is cut-off and discharges through V301B when the tube conducts. The saw-tooth voltage developed across C333 provides the necessary grid drive for the horizontal deflection amplifier, and also serves as a frequency comparison voltage in the control-tube circuit.

As shown in figure 21A noise bursts appearing on the grid-voltage waveform can disturb the frequency stability of the oscillator. To increase the noise immunity of the oscillator a frequency-stabilizing network, consisting of winding C-D in parallel with C309, is added to the tank circuit of the oscillator. This parallel network is shock excited by the grid and plate voltages and produces a sine-wave voltage as shown in figure 21B. When the sine-wave voltage is added to the grid-voltage waveform, the resultant

Figure 21. Horizontal-oscillator grid-voltage waveforms. A— Basic grid-voltage waveshape with noise bursts. B— Sine-wave voltage developed across winding C-D of Z301. C— Resultant grid-voltage waveform with stabilizing circuit (winding C-D) added to BTO transformer.

oscillator grid voltage appears similar to that shown in figure 21C. Since the rising portion of the grid-voltage waveform is no longer nearly parallel to the tube cut-off level, noise bursts are prevented from triggering the oscillator, as shown in figure 21C.

To synchronize the horizontal-oscillator with the 15,750 cps horizontal-sync signal, an automatic-frequency-control system is required.

The frequency of the horizontal-blocking-tube oscillator may be controlled by varying its grid-voltage. This can be accomplished by placing a variable positive control voltage in series with the grid resistor (Rg) of the oscillator, as shown in figure 22A. The positive voltage reduces the negative voltage on the grid of the tube, during the period of cut-off, and the tube conducts sooner than it normally would. As a result the frequency of the oscillator is increased. This action is illustrated in figure 22B. Note that a low positive control voltage will decrease the oscillator frequency. This characteristic of the blocking oscillator is employed in the RA-160 - RA-162 to provide automatic-frequency-control of the horizontal sweep.

As shown in figure 20 the positive voltage used to control the BTO is obtained from the cathode of V301A. This tube functions as a control tube. It
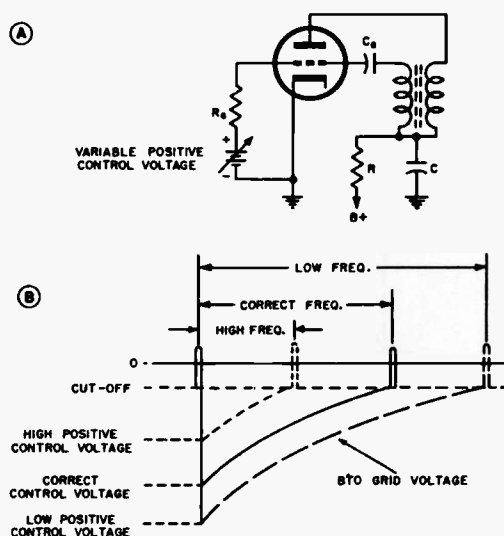
Figure 22. A—Simplified blocking tube oscillator with variable positive control voltage located in grid circuit. B— Effect of control voltage on oscillator frequency.

Figure 23. A— Sync and sawtooth voltages at grid of V301A. B— Resultant sum of sync and sawtooth voltages.

compares the frequency of the horizontal oscillator with that of the incoming horizontal-sync signal and produces a correction voltage at its cathode.

A portion of the boosted B+ voltage is applied to the cathode of V301A through R304. This voltage biases the tube beyond cut-off as shown in figure 23. Both the incoming horizontal-sync signal and the oscillator sawtooth voltage are applied to the grid of the control tube. The horizontal-sync signal is obtained from the cathode of the second horizontal-sync clipper, V214B, and is applied to the grid of V301A through C302. The sawtooth voltage which is developed across C333 in the output of the BTO, is applied to the grid of V301A through d-c blocking capacitor, C311, a phase correcting network consisting of C304, R308, and grid resistor R301, as shown in figure 20. C306A forms a capacitive voltage-divider network with C311. Varying the capacitance of C306A changes the amplitude of the sawtooth voltage appearing at the grid of the control tube. C306A is adjusted to place the peak of the oscillator sawtooth voltage just beyond the cut-off point of V301A, as shown in figure 23. Thus, while neither the sawtooth nor the sync signal alone will cause V301A to conduct, their resultant sum (figure 23B) produces conduction.

The conduction time of the control tube is determined by the *width* of that portion of the combined grid signal which extends above cut-off. The width of this portion of the signal is dependent upon the relative frequencies of the incoming sync and BTO signals, as shown in figure 24.

In figure 24B the frequencies of the signals are identical. In figure 24A the BTO sawtooth is slightly higher in frequency, consequently most of the sync
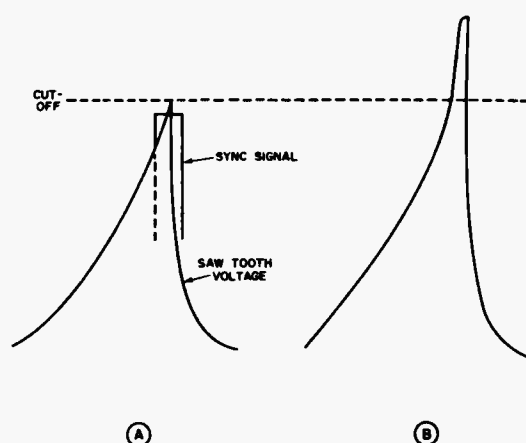
pulse occurs after the sawtooth peak. This results in a reduction in current through V301A, and a similar reduction in the voltage developed across its cathode resistor, R303. In figure 24C the sawtooth is lower in frequency than the sync signal, and the sync signal occurs before the peak of the sawtooth. Thus most of the pulse extends above cut-off, the current through V301A increases, and a larger cathode voltage is produced.

In this manner a voltage which varies with the relative frequencies of the sync and BTO signals is developed at the cathode of V301A. This voltage is applied to the grid of the horizontal-oscillator tube, V301B, through R306. When the oscillator frequency is higher than the incoming sync pulse, the control voltage decreases reducing the oscillator frequency. When the oscillator frequency is lower, the control voltage increases, raising the oscillator frequency.

To minimize the effects of noise bursts on the d-c cathode voltage of the control tube (V301A), a filter network is located in the cathode circuit of the tube. The filter network consists of R305, C305, and C307 as shown in figure 20.

An AFC test point is provided at the rear of the sweep chassis to check the adjustment of Z301. This test point is connected through a 1 $\mu\mu f$ capacitor to terminal C of Z301. When Z301 is properly adjusted the waveform observed on an oscillograph connected to this test point will appear similar to that shown in figure 20.

HORIZONTAL DEFLECTION CIRCUITS.—

The horizontal deflection circuits produce a linear variation of current in the horizontal-deflection coil at the horizontal-oscillator frequency. In addition, the deflection system produces a supplementary B+ voltage, commonly called the boost voltage, plus a high-amplitude pulse used to generate the CRT high
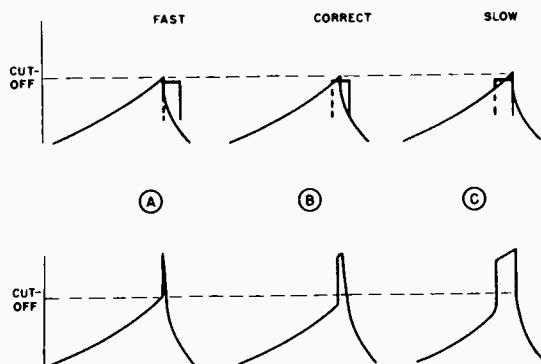
Figure 24. Control tube grid-voltage waveforms for various frequency relationships between the horizontal oscillator and incoming horizontal-sync signal. A—Oscillator fast, B— Oscillator correct, C— Oscillator slow.

voltage. The boost voltage is added to the B+ voltage for application to those stages requiring a higher voltage than that obtainable from the low-voltage supply.

To perform these functions, the required circuits consist of a horizontal-deflection amplifier and a damper stage. In the RA-160—RA-162 chassis a 6CD6 beam-power amplifier is used in the horizontal-deflection amplifier stage and a 6W4 diode as a damper.

The sawtooth voltage produced by the horizontal oscillator is utilized to control the conduction of the horizontal-deflection amplifier. The conduction of the damper tube is controlled by the deflection-coil back e.m.f. and the voltage produced across the linearity coil.

The horizontal-deflection amplifier controls the sweep of the electron beam in the CRT, from the center to the right side of the raster. The damper tube provides the sweep current which moves the electron beam from the left side to the center of the raster.

In addition, the damper stage eliminates the effect of damped oscillations which are generated within the deflection-coil circuit. The current required to retrace the beam is supplied by the electromagnetic action of the horizontal-deflection coil.

To simplify the operation of the deflection system a review of the basic deflection circuit shown in figure 25 will prove helpful. As shown in the figure, a deflection coil, L, with its distributed capacitance Cs, is connected in series with a capacitor, C_E, through the two switches, S_1 and S_2. Assume that the deflection coil, L, is positioned so that it will control the CRT beam which normally strikes the center of the screen. In addition assume that the capacitor C_E has an initial charge on its plates.

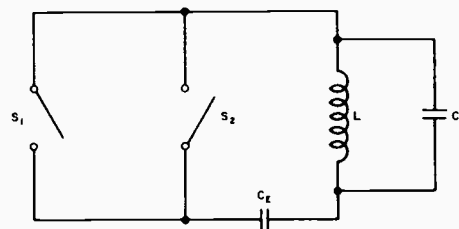To obtain a uniform horizontal sweep, the following operations must be performed:

Figure 25. Basic horizontal-deflection circuit.

1. Switch S_1 is closed and a discharge current flows from capacitor C_E through the deflection coil, establishing a magnetic field around the coil. This field moves the electron beam in the CRT from the center of the screen to the right side (point 1 to point 2 in figure 26).

2. At this point switch S_1 is opened and the magnetic field collapses. As the field collapses the electron beam moves back to the center of the screen (position 2 to 3 in figure 26).

3. Since the switches are both open, the only path for the energy contained in the collapsing field is through capacitor, Cs. As a result, a charge is produced on the plates of Cs.

4. When the field has completely collapsed, Cs begins to discharge through the deflection coil, since this is the only available path.

5. The discharge current of Cs produces a second magnetic field with a polarity opposite to that of the first magnetic field. This second field sweeps the electron beam from the center to the
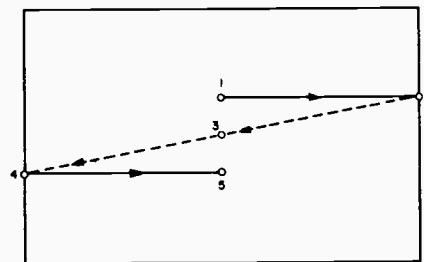

Figure 26. Path of electron beam in CRT.

left side of the screen (position 3 to 4 in figure 26).

6. When the beam reaches the left side of the screen switch S_2 is closed, shorting the deflection coil and causing the second magnetic field to collapse through the switch, charging capacitor C_E. As the second field collapses, the electron beam returns from the left side to the center of the screen (position 4 to 5 in figure 26).

7. Switch S_2 is then opened and the cycle is repeated for each successive horizontal line.
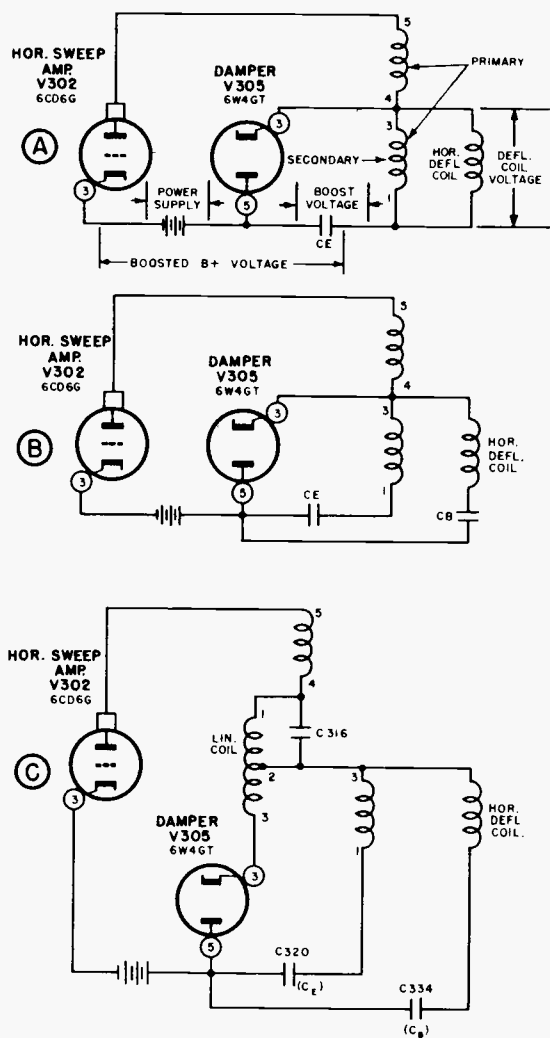

Figure 27. Simplified RA-160 horizontal-deflection circuit.

In the above discussion all circuit losses have been omitted to simplify the operation of the circuit.

Simplified Deflection Circuit

The operation of the deflection circuit shown in figure 25 is similar to that of the simplified RA-160—RA-162 deflection circuit shown in figure 27A. The simplified deflection circuit of figure 27A differs from the basic deflection circuit shown in figure 25 in that switches S_1 and S_2 are replaced by the horizontal-sweep amplifier and damper tube respectively. In addition, an auto-transformer is used to match the high plate impedance of the 6CD6 to the horizontal-deflection coil. Because of its greater efficiency the auto-transformer has replaced the two circuit transformers formerly used for this purpose. As shown in figure 27A a single winding serves as both the primary and secondary of the auto-transformer.

The coil L in figure 25 is replaced by the auto-transformer winding 1-3 and the horizontal-deflection coil in parallel. To prevent direct currents from causing changes in the horizontal positioning of the picture a blocking capacitor, C_B, is connected between the deflection coil and the damper tube plate as shown in figure 27B. This capacitor represents a short circuit at the horizontal frequency.

As previously mentioned, the sweep amplifier serves as switch S_1 and conducts during approximately one-half of the sawtooth waveform, as shown in figure 28B (points 1 to 2).

When power is applied to the circuit the damper conducts causing the B+ voltage to appear at the plate of the 6CD6. When the sawtooth voltage is applied to its grid the 6CD6 conducts. As the tube conducts, a current flows in the inductive circuit, consisting of the deflection coil and the auto-transformer winding (1-3) in parallel. This establishes the magnetic field, around the deflection coil, which moves the CRT beam from the center to the right side of the screen, points 1 to 2 in figure 28A. This action is similar to that described in step 1 of the basic deflection-circuit explanation.

During this period the self-induced voltage in the deflection coil is similar to that shown in figure 28E, (points 1 to 2).

From point 2 to point 3 of the grid-voltage waveform, shown in figure 28B, the output tube is driven into cut-off and the plate current drops immediately to zero, as shown in figure 28C. As a result, the established magnetic field collapses, and the electron beam returns from the right side to the center of the screen, as shown in figure 28A. This action is similar to that obtained when switch S_1 is opened, as described in step 2 of the basic circuit analogy. The rapidly collapsing field induces a high voltage in the deflection-coil which appears similar to that shown in figure 28E (points 2 to 3). In addition, the collapsing magnetic causes the deflection coil to oscillate at its resonant frequency. This action is similar to that of the basic deflection circuit where L and Cs form a resonant circuit, and when switch S_1 is opened the basic circuit oscillates at its resonant frequency.

The first quarter cycle of this oscillation occurs during the time that the first magnetic field collapses. As previously mentioned this action causes the electron beam to move from the right side to the center of the screen as shown in figure 28A (points 2 to 3).

The second quarter cycle of oscillation produces a second magnetic field the polarity of which is opposite to that of the first field.

The second magnetic field is produced in the time required for the second quarter cycle of oscillation and sweeps the beam from the center to the left side of the screen as shown in figure 28A (points 3 to 4).

During this period, the self-induced deflection-coil voltage changes to a negative polarity, as shown in figure 28E (points 3 to 4). The interval between
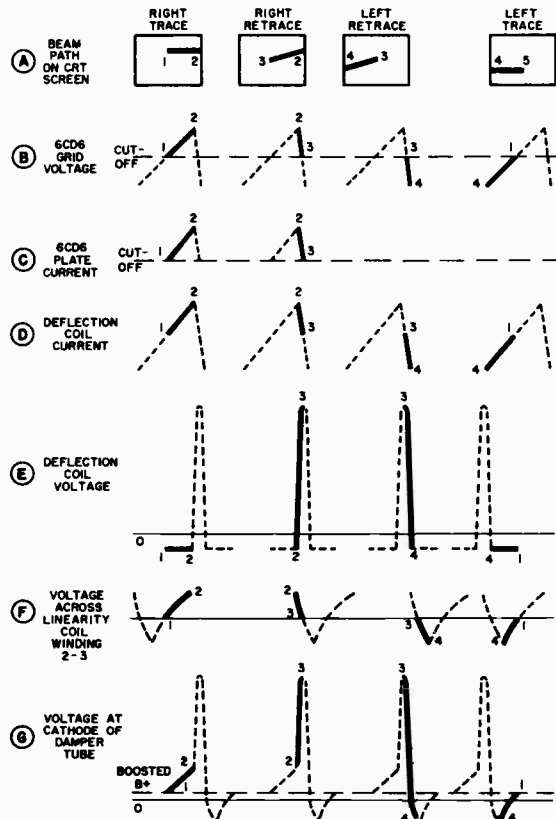

Figure 28. Horizontal-deflection circuit voltages and currents during the instantaneous path of the CRT electron beam.

points 2 and 4 in figure 28A is known as the horizontal retrace period. Television standards require that this period be less than 10 micro-seconds. To accomplish this the RA-160—RA-162 deflection circuit in figure 27B is designed to have a resonant frequency of 70 Kc. This results in 1/2 cycle of oscillation in approximately 7.5 micro-seconds. Consequently, the horizontal retrace period is approximately 7.5 microseconds.

The damping tube serves as switch S_2 (figure 25) and prevents the oscillations from continuing for more than 1/2 cycle. If the oscillations were allowed to continue, the second magnetic field would vary in accordance with the oscillations causing the beam to return non-linearly from the left side to the center of the screen. The conduction of the damper tube causes the second magnetic field to collapse and charge

capacitor C_E. This action is similar to closing switch S_2 in the basic circuit explanation.

As the second field collapses the electron beam returns from the left side to the center of the screen, as shown in figure 28A (points 4 to 5).

To enable the damper tube to serve as switch S_2 (figure 25) some means must be provided to control its conduction. The voltages across the damper tube aid in accomplishing this purpose.

As shown in figure 27A these voltages are the deflection coil voltage, the voltage across C_E, and the power supply voltage, B+.

The voltage across C_E is comparatively small and has relatively little effect upon the conduction of the damper tube. The power supply voltage is applied to the plate of the damper tube which is effectively in series with the plate circuit of the horizontal sweep amplifier. As a result the damper will normally conduct whenever the sweep amplifier conducts. The damper tube will also conduct for the balance of the trace period because the deflection coil voltage which appears at its cathode is negative during this time as shown in figure 28E. Since the horizontal-sweep amplifier provides the sweep current for the first half of the scanning period, it is not necessary for the damper tube to conduct during this period.

To accomplish this an additional positive voltage is applied to the cathode of the damper tube. This voltage is developed across the "linearity coil" which is inserted in the deflection circuit, as shown in figure 27C.

When the sweep amplifier conducts, the 6CD6 plate current passes through the linearity coil winding 1-2. This current establishes a magnetic field around the linearity coil winding 1-2 which induces a voltage drop across the linearity coil winding 2-3 similar to that shown in figure 28F (points 1 to 2). When the 6CD6 is driven beyond cut-off by the oscillator sawtooth voltage, the magnetic field around the linearity coil collapses. This collapsing field causes the voltage induced into the linearity coil winding 2-3 to appear similar to that shown in figure 28F (points 2 to 4). As the damper tube conducts, the conduction current passes through the linearity coil winding 2-3 and a voltage drop, shown in figure 28F (points 4 to 1), is produced. The resultant sum of the linearity-coil voltage and the deflection-coil voltage is shown in figure 28G. Note that the cathode of the damper tube is now negative with respect to its plate only during the left half of the scanning period. As a result, the damper tube will conduct only during that period. The conduction of the damper tube may be adjusted by varying the voltage drop across the linearity-coil. Since the voltage drop is largely determined by the inductance of the coil, this may be performed by varying the linearity-coil inductance.
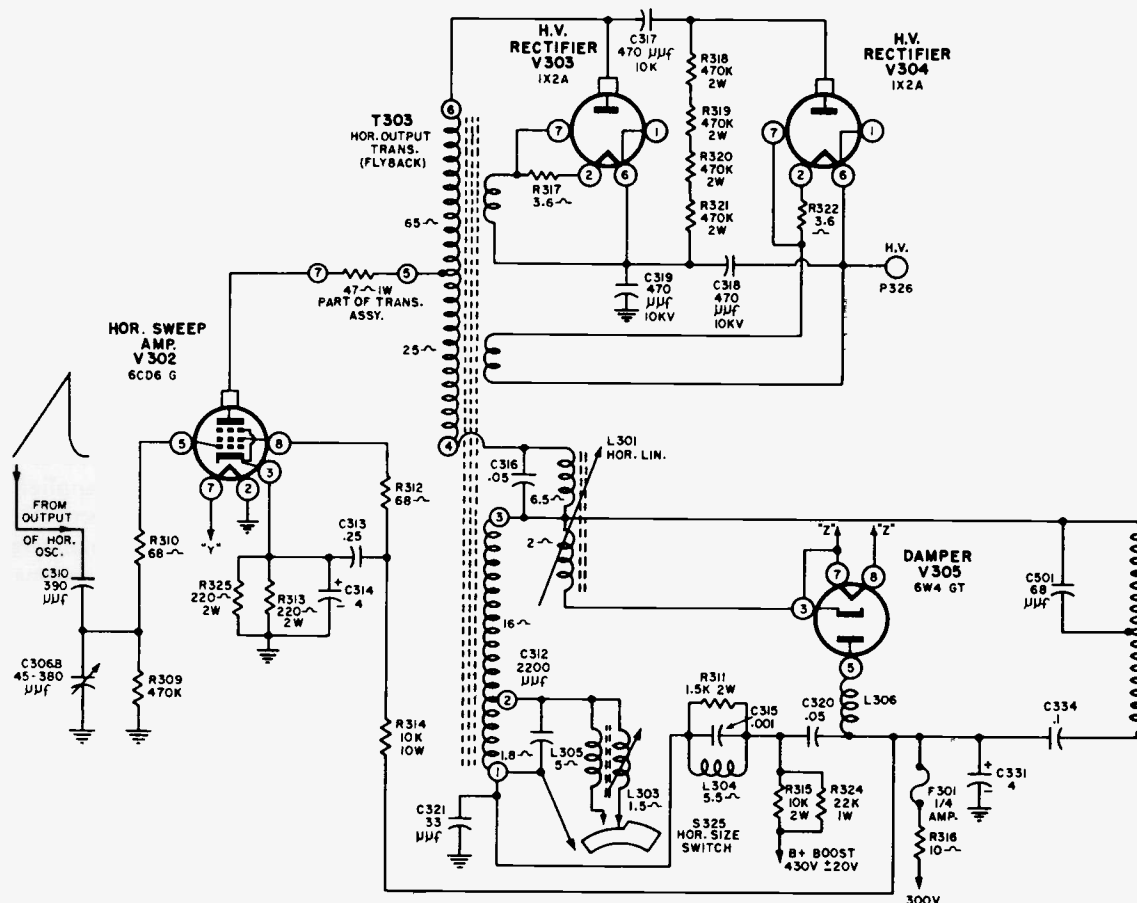
Figure 29. Complete RA-160 and RA-162 horizontal-deflection circuit.

The RA-160 Deflection Circuit

The complete horizontal-deflection circuit, as shown in figure 29, differs from that shown in figure 27C in that some additional components have been included to improve the operation of the system.

As shown in figure 29, the sawtooth voltage produced by the horizontal oscillator and appearing across C306B, is applied to the control grid of the sweep amplifier through R310. C306B varies the amplitude of the sawtooth voltage and is called the HORIZONTAL DRIVE control. This control also affects the horizontal linearity at the center and right-hand portions of the picture.

Two resistors in parallel (R313 and R325) are used in the sweep-amplifier cathode-bias network to avoid the high wattage requirements of a single resistor. These resistors are bypassed by C314 and provide protective bias.

To prevent parasitic oscillations resistors R310, R346, and R312 are used in the control-grid, screen-grid, and plate circuits of the sweep-amplifier stage. These resistors serve to isolate the elements of the tube from their respective circuits.

If the 70 kc. oscillations are allowed to reach the horizontal deflection coil winding they will exhibit themselves as alternate dark and light vertical bars in the raster. To prevent this condition a parallel-resonant trap, consisting of L304 and C315 in parallel, is inserted between the auto-transformer (T303) and the capacitor, C320. A damping resistor, R311, is placed across the trap to prevent it from ringing.

As previously mentioned the transformer and deflection coil circuit are tuned to approximately 70 kc so that the horizontal retrace period will be accomplished in 7.5 micro-seconds. C312 and the horizontal-size coils, in conjunction with the portion of auto-transformer winding between terminals 1 and 2, aid in resonating the deflection circuit at this frequency. To compensate for changes in line voltage a SIZE switch, S325, is used to connect the two size coils individually or together across the portion of the auto-transformer winding between terminals 1 and 2.

There are three positions in which the HORIZONTAL-SIZE switch may be placed. In position No. 1 the horizontal-size coils are not connected to the auto-

transformer winding. This position results in the greatest horizontal size. In position No. 2 the variable size-control coil, L303, is connected across the portion of the auto-transformer winding between terminals 1 and 2. In position No. 3 the fixed inductance L305 and L303 are connected in parallel across the transformer winding.

Some of the horizontal sweep signal is radiated by the damper tube circuit components. To minimize this condition a choke coil, L306, is connected between the plate of the damper tube and its associated circuitry. In addition a bypass capacitor, C321, is connected between terminal 1 of the auto-transformer and ground.

A ¼ amp fuse, F301 is provided to protect the horizontal output transformer from any possible damage. This fuse is located between the damper tube plate circuit and the low voltage supply.

To prevent the horizontal-sweep signal from feeding back into the power supply a decoupling network, consisting of R316 and C331A, is connected between the damper-tube plate circuit and the power supply.

B+ Boost Voltage

The voltage, produced across capacitor C320 by the changing magnetic field of the deflection coil, is useful as a supplementary voltage. This voltage, commonly called the boost voltage, is added to the B+ voltage as shown in figure 27A. The sum of these voltages is applied to those stages requiring a higher voltage than that obtainable from the low-voltage supply.

High-Voltage Circuits

The initial generating signal for the high-voltage circuit is supplied by the horizontal oscillator whose action produces a large positive pulse in the auto-transformer circuit. This pulse voltage is produced during the horizontal retrace period and appears similar to that shown in figure 28E.
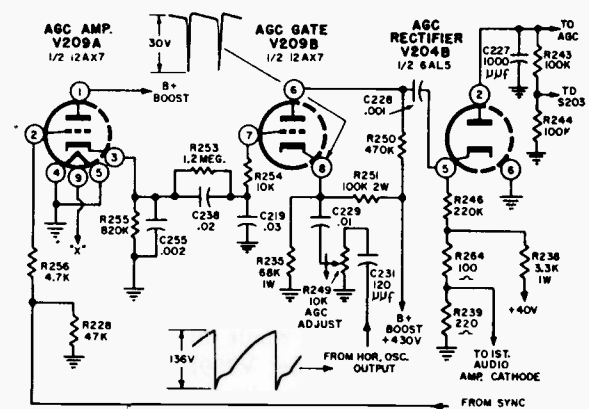
The pulse voltage is increased through the step-up action of the auto-transformer and is applied to the high voltage rectifiers which form a cascade voltage-doubler circuit. In the high-voltage circuits the pulse voltage is rectified, increased, filtered, and applied to the cathode-ray-tube anode. The voltage at the cathode-ray-tube is 16 kv ± 2 kv.

When terminal 6 of T303 is positive, V303 conducts charging C319 to the peak value of the pulse voltage. The charge on C319 is maintained by successive pulses.

Between successive pulses the d-c voltage across C319 is applied to C317 through resistors R318 to R321, as shown in figure 29. The voltage drop across

the resistors reduces the voltage appearing across C317. The voltage across C317 adds to each successive pulse and produces a voltage on the plate of V304 which is slightly less than twice the pulse voltage. This increased voltage causes V304 to conduct, producing a charge on C318. The additive sum of the voltage drops across C318 and C319 results in an output of 16 kv.

AUTOMATIC GAIN CONTROL.—To maintain a constant contrast level with variations in the amplitude of the incoming signal an automatic-gain-control system is employed in the RA-160 - RA-162 chassis. The a-g-c circuits produce a bias voltage which varies with the signal strength. This bias is

Figure 30. Schematic diagram of RA-160 a-g-c circuits.

applied to the r-f amplifier in the tuner, and to the first and second video i-f amplifiers.

The circuits which develop the a-g-c bias consist of an a-g-c amplifier (V209A), an a-g-c gate tube (V209B), and a rectifier (V204B), as shown in figure 30.

The composite signal appearing in the plate circuit of the video amplifier, V205, is applied to the grid of the a-g-c amplifier (V209A) through a d-c coupling circuit, consisting of R227 in series with R256. R256 serves as an isolation resistor between the sync amplifier and the a-g-c amplifier. Since d-c coupling is used, a portion of the video-amplifier plate voltage appears across R228. This voltage serves as the grid bias for the a-g-c amplifier. The sync signal is separated from the video signal by biasing the tube near cut-off. This is accomplished by the cathode resistor R255 bypassed by C255. The action of these components is identical to those in the cathode circuit of V212A (see para. 3.6). Since the cathode voltage is greater than the grid voltage the tube is negatively biased. As shown in figure 9 the bias voltage is chosen so that the tube does not conduct on the video signal. The sync signals which are of a higher ampli-

tude than the video signal, drive the tube above cut-off. Consequently, only the sync signals appear in the output of the stage as shown in figure 10B.

The video signal is eliminated so that the a-g-c bias will be determined by the sync signal only. This is necessary because the average amplitude of the video information, in the transmitted signal, is dependent upon the brightness of the televised material. If the video information were permitted to develop the a-g-c bias, changes in the brightness of the televised scene would produce undesired changes in a-g-c voltage.

Changes in the signal level at the input of the receiver result in changes in the sync signal at the grid of the a-g-c amplifier (V209A). When the amplitude of the sync signal increases, the average current through the tube increases, raising the voltage developed across its cathode network, R255 and C255. When the amplitude of the sync signal decreases, the current through the tube and the voltage at its cathode also decreases. Thus the a-g-c amplifier cathode voltage varies with the amplitude of the incoming signal.

This varying cathode voltage is applied to the grid of the a-g-c gate (V209B) through R253, C238, R254 and C219. These components form a low-pass filter which removes the sync-pulse component of the cathode signal of V209A. As a result the signal applied to the grid of the a-g-c gate, V209B, consists of a positive d-c voltage whose amplitude varies with the strength of the incoming signal.

A portion of the B+ boost voltage is applied to the cathode of the a-g-c gate (V209B). This voltage is obtained from a voltage-divider network consisting of R251 and R235. The positive voltage applied to the cathode is made sufficiently greater than the positive voltage on the grid to bias the tube beyond cut-off As a result the tube will not conduct until a signal of proper polarity and sufficient amplitude is applied to its grid or cathode.

The sawtooth voltage at the output of the horizontal oscillator (V301B) is applied to the cathode of the a-g-c gate (V209B), through a network consisting

of C231, R249 and C229. These components function as a differentiating network which produces the waveform shown in figure 30 at the cathode of the a-g-c gate. The amplitude of the pulse at the cathode is varied by means of R249 which acts as an a-g-c control. The polarity of the pulse is negative and is of sufficient amplitude to cause V209B to conduct. The amplitude of the signal at the plate of V209B is dependent upon the amplitude of the pulse applied to its cathode, and upon the voltage at its grid. Since the amplitude of the cathode pulse is set at a constant value, the amplitude of the *plate* signal varies with the grid voltage. Thus the output of the a-g-c gate is directly related to the strength of the incoming signal.

The signal at the plate of V209B is applied to the cathode of V204B through C228. V204B rectifies the negative pulses producing a negative voltage at its plate. This negative voltage is applied to the grid of the first and second video i-f stages and to the r-f amplifier in the tuner. A voltage divider network consisting of R243 and R244 is employed to reduce the amount of a-g-c voltage applied to the tuner.

To provide a delay in the development of a-g-c voltage, so that a-g-c is not applied to the controlled stages when receiving weak signals, a positive voltage is applied to the cathode of the a-g-c rectifier, V204B. This voltage is obtained from the low voltage supply voltage-divider network.

As an aid in checking the performance of the receiver an a-g-c test point is provided which is accessible from the top of the signal chassis. This terminal is connected directly to the plate of V204B. The a-g-c voltage at this point is dependent upon the strength of the incoming signal and the setting of the a-g-c control potentiometer (R249).

When the receiver is tuned to a station of sufficient signal strength, R249 may be adjusted to produce a maximum a-g-c voltage of approximately 15 volts.

SOUND I-F STRIP.—The RA-160 - RA-162 chassis incorporates a 4.5-mc sound i-f system, consisting of two sound i-f amplifier stages, and a ratio detector. Both sound i-f stages employ 6AU6 sharp cut-off pentodes.
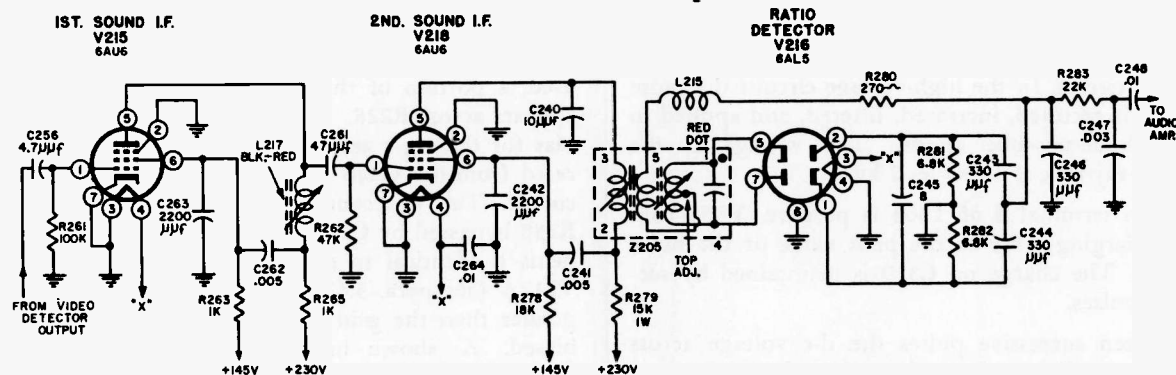

Figure 31. Schematic diagram of RA-160 sound i-f and ratio detector stages.

LESSON 11

UHF CONVERTERS AND TUNERS*

The 70 new UHF channels are in addition to the existing 12 VHF channels and are numbered consecutively 14 through 83. These new channels cover a band of frequencies from 470 to 890 megacycles. The signal transmitted by a UHF station is of the same type as that transmitted on VHF as regards to bandwidth, picture and sound carrier separation, horizontal and vertical sweep frequencies, and other factors. The only difference being that the channel frequencies are higher on UHF than on VHF. These higher frequencies are present only in the UHF RF and mixer circuits; it is here that UHF signal is changed to a signal of frequencies of channel 5 or 6, or directly to IF of the set.

Because of ultra high frequencies used, circuit components take on new shapes and sizes in UHF tuners and converters. Outside of minor repairs such as replacing tubes, checking connections, it is difficult for a technician to repair or align UHF units. Fortunately not much goes wrong with well built UHF converters or tuners, and most factories cooperate by providing fast service on units sent in for repair. Specific service instructions on commercial converters and tuners have been released by many manufacturers and this is very valuable help when actual repair of UHF equipment must be made.*

The tuned circuit used in UHF units employ configurations that provide distributed values of capacity and inductance to resonate at the frequencies required. These shapes may be rolled up lines with a center tuning section, cylindrical rotating type, U-type stator and capacitance rotor used in butter-fly tuned circuits, or specially shaped line with a shorting bar as used in the Mallory Inductuner. Arrangement of parts is used to reduce the length of leads and printed circuits are employed.

In localities where there were no local VHF television station or perhaps only one, the addition of a UHF station is of importance. Sets already in use must be converted to receive UHF, and new television sets are supplied with facilities for receiving channels on VHF and UHF.

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*Parts of this lesson are from "UHF Converters and Fundamentals of UHF Theory," Montgomery Ward.

*Supreme Publications issues a "Most-Often-Needed UHF Converters & Tuners Servicing Information" manual priced at $1.50, postpaid.

In locations where there are no UHF stations, or where several VHF stations provide a variety of programs, there is small interest in UHF and very little work on equipment of this type. In any case, however, you must understand the fundamentals of the equipment used for in time UHF reception will be more important than VHF.

In order to receive UHF signals on a receiver originally designed for VHF reception only or to permit such dual reception from a newer type set, it is necessary to modify, or convert, or employ a tuner of a dual type to permit such UHF reception. All past television receivers and those sold at present, of course, are capable of receiving the 12 VHF channels, and these may be converted to receive UHF in several different ways. Newer sets intended to be used in areas having UHF stations, may be provided by means of one of these methods for UHF reception while they are being built at the factory. The usual methods used are described briefly below.

1. A separate unit is used to convert UHF signals to one of the VHF channels so that they can be received on the VHF receiver connected.

2. Convert UHF signals directly to the IF of the VHF receiver and arrange proper connections and switching arrangement.

3. Convert the RF circuits of the VHF receiver so that a number of UHF channels will be received.

4. Use of a newer type tuner to receive both VHF and UHF signals.

The Mallory TV-101 converter or the Regency RC-600 converter are separate units and would come under the types described under No. 1 above. These units tune the entire UHF band. They have their own

Mallory TV-101 UHF Converter
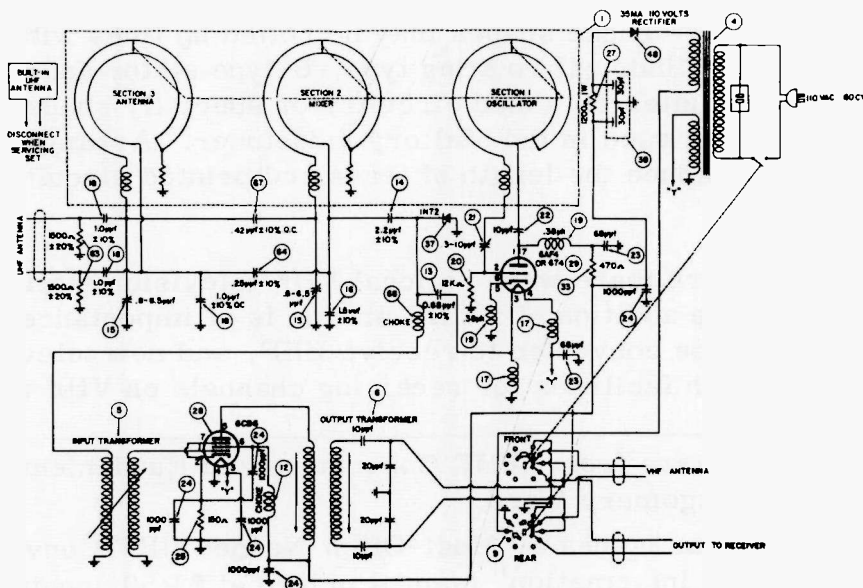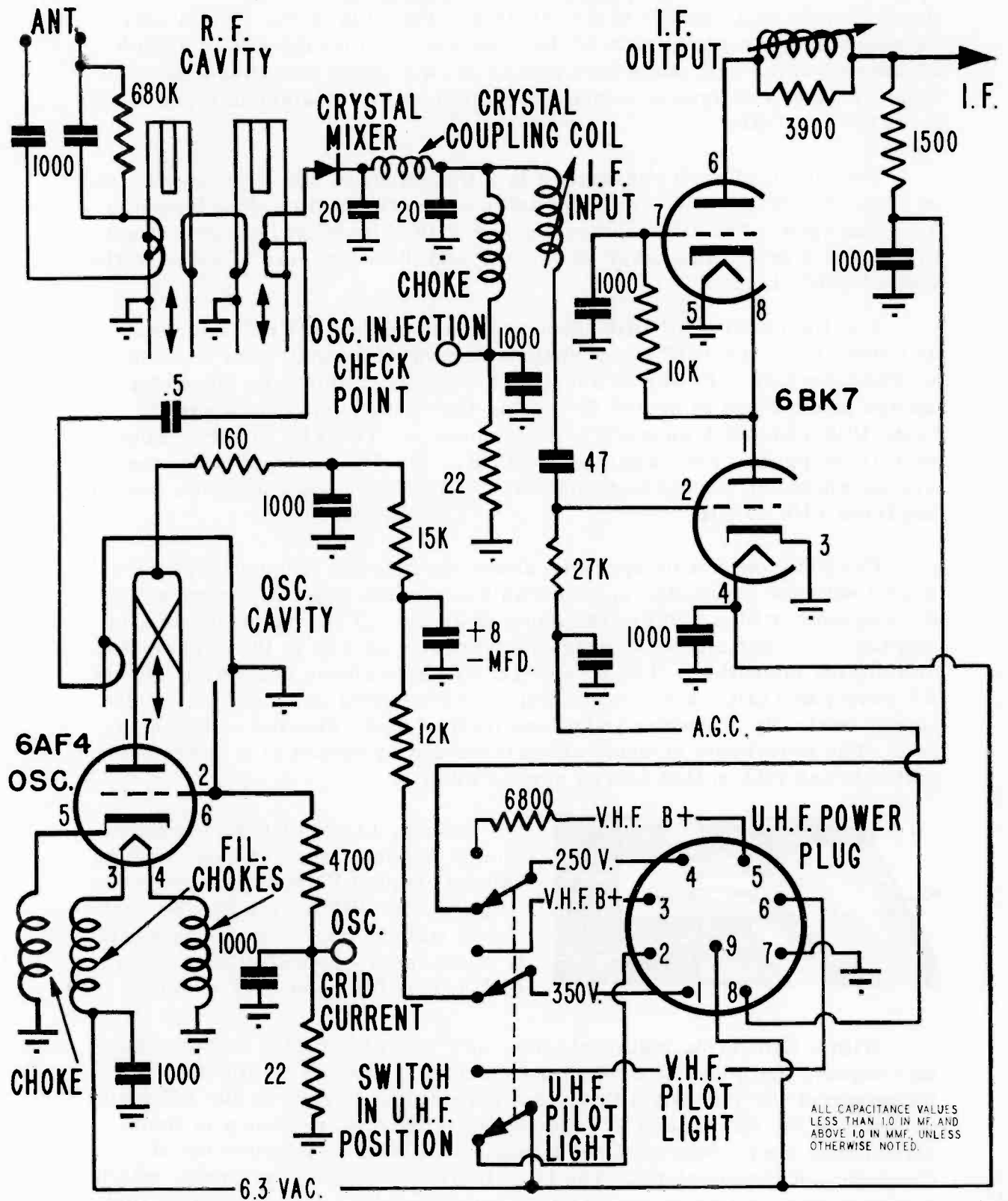
Schematic Diagram of Raytheon 100P UHF Tuner

power supply and connect to the AC line. The plug of the TV set may be connected to a receptacle of the converter so that the single switch of the converter will place both pieces of equipment into operation. The converters of this type also provide switch—over for antenna types used for VHF and UHF.

The output of such converters is either channel 5 or 6 frequency and is connected to the VHF receiver antenna terminals through a length of 300-ohm lead. For UHF reception, the VHF television receiver is set to channel 5 or 6, whichever is vacant, and the converter is tuned to the wanted UHF channel.

The Raytheon 100P UHF Tuner is mounted on the VHF tuner and is driven from the VHF tuner shaft by means of a small gear mounted on the rear cam. Power is supplied to this tuner from the set and a switch is provided to switch B+. This UHF tuner converts directly from UHF channel frequency to IF frequency. The VHF tuner is completely by-passed when switched to UHF. The filaments of both tuners are on whenever the set is turned on. This allows instantaneous switching from VHF to UHF.

The local oscillator operates above the channel frequency which is mixed with the incoming channel frequency in the crystal to produce an IF frequency with a center frequency of 25 mc. This frequency is then amplified in the cascode IF stage to overcome losses in the preselector and mixing operation. The unfamiliar symbols shown next to the words RF cavity and OSC cavity represent a double-tuned coaxial line. This line is basically a quarter wave length tuned stub, shorted at the upper end. The inductance of these stubs is varied by means of a silver plated brass ribbon that moves across them.
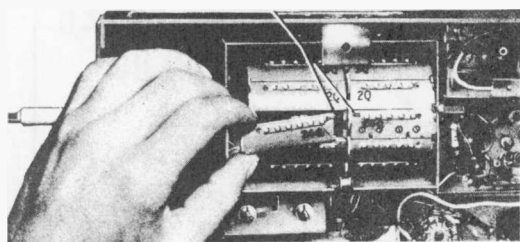
Standard Coil UHF strip conversion is accomplished by removing an unused channel VHF strips and inserting a set of UHF strips for the channel on which UHF reception is wanted. It is necessary to install one set of UHF strips for each UHF channel.

With a UHF strip installed, the tuner operates on the double superheterodyne principle. The incoming channel frequency is mixed with a harmonic of the local oscillator in a germanium crystal in the RF strip to produce the first (new) IF frequency. This new frequency is then mixed with the fundamental of the local oscillator to produce the IF frequency of the receiver. The first IF frequency is a frequency which has been selected so as not to cause interference. To accomplish this, various harmonics of the local oscillator are used.

LESSON 12

TELEVISION TEST EQUIPMENT AND ALIGNMENT

Some of the test equipment you may be using for radio servicing is adaptable to television servicing. Your volt-ohmmeter or your vacuum tube voltmeter will be useful. A high voltage probe may be added for high voltage measurements needed at times in TV work. A tube tester that has a cathode ray tube testing adapter may be already in your possession. An oscilloscope of fairly wide band response is needed for TV alignment, but since such instrument is also useful for radio alignment and audio work, you may have purchased one even before entering television servicing.

For accurate and speedy television alignment a sweep generator and a marker generator are needed. Signal generators designed for radio work usually do not have proper output and controls for television use. There are commercial units that combine both types of generators into a single case, and some even include in the case a suitable oscilloscope.

A marker generator that provides checking frequencies may be called a calibrator. RCA has issued a valuable instruction booklet on the unit of their make and included material on general television alignment practice. It is this material, reprinted by permission of RCA, copyright proprietor, that is presented below. It is an excellent introduction to television alignment and this will be followed in the next lesson with specific alignment instructions on several popular type sets. With this material mastered, you will be ready to align any television set and easily follow any special manufacturer's instructions.

General Application—To align a television receiver, or any other receiver or device employing wide-band circuits, a visual indication of the response of the circuit being aligned is required if the alignment is to be considered acceptable. Visual alignment, fast replacing the older, slower point-by-point alignment procedure, is as rapid as it is effective, and when combined with the use of accurately established marker frequencies, it is precise.

The usual test setup for making a visual alignment is shown in Figure 1. If the amplifier under test happens to be a wide-band intermediate-frequency amplifier, then the sweep generator is normally connected first to the grid of the stage preceding the second detector.

The vertical-input terminals of the oscilloscope are connected across the detector load resistor; the horizontal terminals are connected to a source of deflection voltage usually supplied by the sweep generator. When the sweep generator is tuned to sweep the band of frequencies accepted by the if circuit, a trace representing the response characteristics of the circuit will
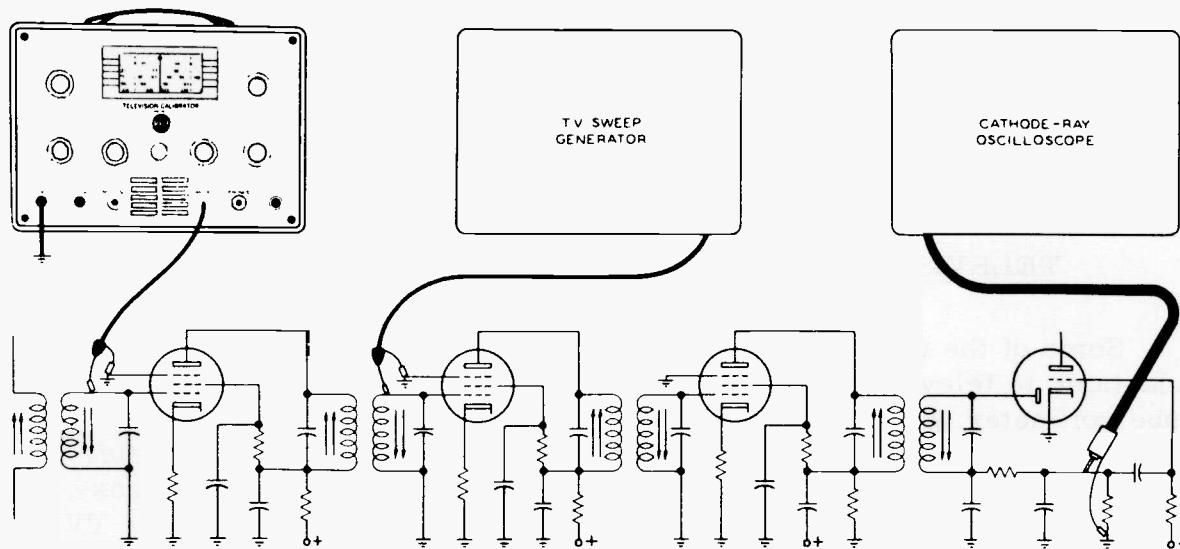
Figure 1. Typical Visual Alignment Setup

appear on the oscilloscope screen. A typical trace is shown in Figure 2A. From this trace, valuable information about the response can be obtained, but if the center frequency of the response, and its bandwidth, are to be determined to any degree of accuracy, a marker must be used. When a source of marker frequencies—the Television Calibrator—is coupled to the input of the amplifier under test, a discontinuity,
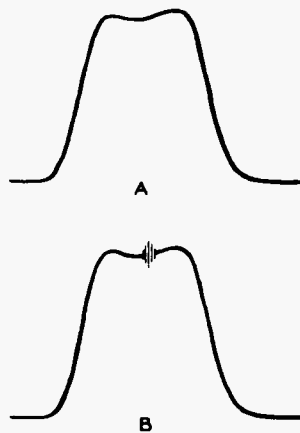

Figure 2. Tuned Circuit Response

or "pip", will be observed on the trace, as illustrated in Figure 2B. If the marker generator is tuned exactly to the center of the pass band accepted by the intermediate-frequency amplifier, then this marker "pip" will indicate the position of that frequency on the trace. Knowing the center frequency, the serviceman then adjusts the final tuned circuit for a trace that is of maximum amplitude, and is symmetrical about the

marker "pip", or has the shape recommended by the manufacturer of the equipment being aligned.

Preceding stages are then adjusted progressively by moving the sweep generator output cable back, stage-by-stage, toward the input of the amplifier while adjusting, stage-by-stage, the individual interstage coupling transformers.

Figure 3 illustrates the position of the marker "pip" relative to the response for various conditions of misalignment. It must be emphasized that once the marker

RESPONSE GOOD, BUT
RESONANT FREQUENCY OF
TUNED CIRCUIT A LITTLE LOW

RESONANT FREQUENCY OF
TUNED CIRCUIT CORRECT, BUT
RESPONSE NOT SYMMETRICAL

RESPONSE GOOD, BUT
RESONANT FREQUENCY
OF TUNED CIRCUIT TOO HIGH
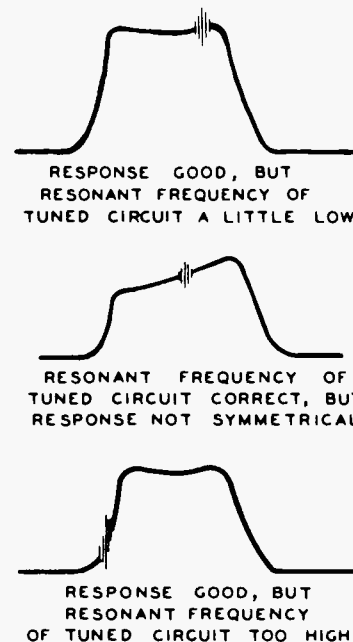
Figure 3. Improperly Aligned Tuned Circuits

generator is tuned to the correct frequency, it is the position of the response which is incorrect, and which must be moved over under the marker "pip" by adjustments of the tuned circuits in the amplifier.

The determination of the bandwidth of an amplifier is another important function of a television marker generators. Figure 4 shows how this is done. After the amplifier is aligned, the marker generator is tuned to a lower frequency, so that the marker "pip" falls on the 70% response point on the low-frequency side
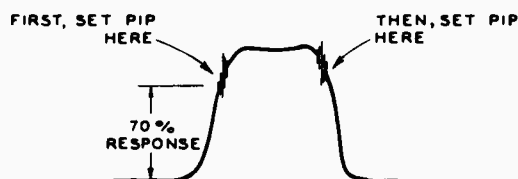
Figure 4. Bandwidth Measurement

of the response curve. The frequency at this point is read from the marker-generator dial scale, then the generator is tuned toward a higher frequency until the marker "pip" rests on the high-frequency side of the curve at the 70% response point. This frequency is also read from the dial scale. The difference between the two frequencies is equal to the bandwidth of the amplifier at the 70% response points.

Bandwidth of a response curve may be determined in another manner with the use of an external variable-frequency oscillator. The output frequency of the

WR-39C Television Calibrator should be tuned so that its marker "pip" falls on the 70% point on one side of the response curve. The output of the external variable oscillator is fed into the MOD IN jack of the WR-39C and tuned to the frequency at which a marker "pip" appears at the 70% point on the other side of the curve.

The frequency as read on the dial of the external variable-frequency oscillator is the bandwidth of the response curve at 70% response.

The application of marker generators to alignment problems has been discussed in the foregoing paragraphs in a very general way to acquaint the reader with the technique.

Since various models of television receivers employ different coupling and amplifier circuits, any one method of alignment, if described completely in this book, would be of little value of the television serviceman. In all cases, before alignment of any television receiver is attempted, the manufacturer's alignment instructions should be consulted. However, since the application of the Television Calibrator to alignment techniques is in all cases simply and clearly indicated, its use can be described in sufficient detail to cover all methods of alignment. Accordingly, the following applications will proceed with the assumption that the other equipment required is set up and operated in conformance with the manufacturer's instructions pertaining to the particular receiver under test, and according to standard visual alignment technique.
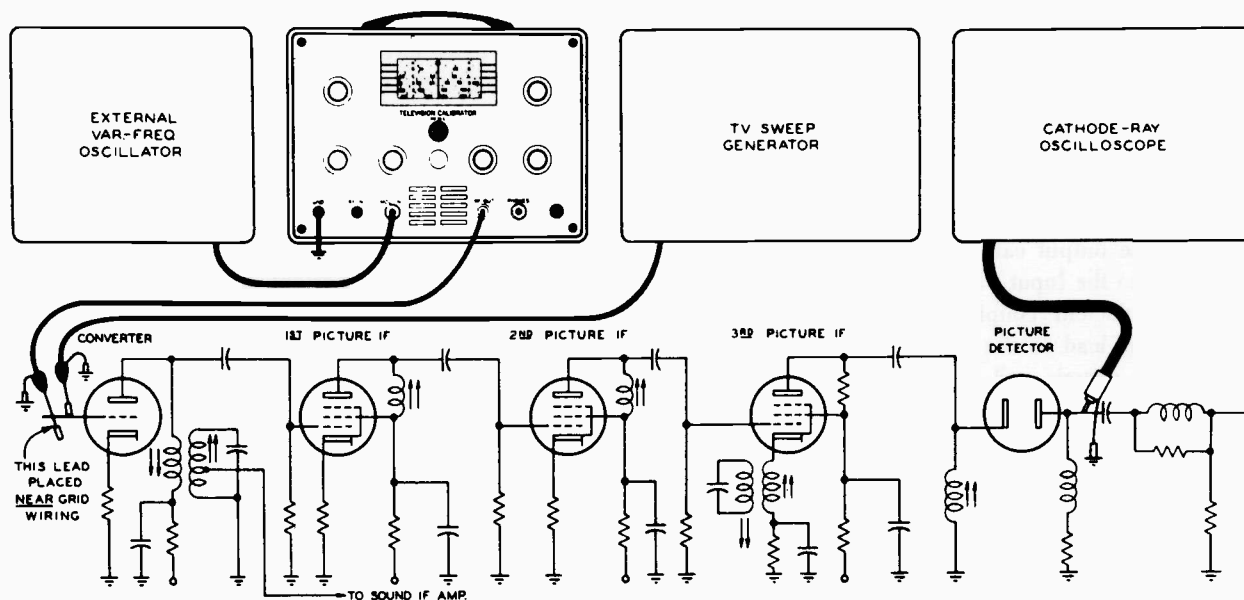
Figure 5. Picture-IF Amplifier Alignment

Aligning Picture-IF Amplifiers—The test equipment and the receiver are set up as shown in Figure 5. When the sweep generator (RCA Television Sweep Generator or equivalent unit) is tuned to sweep the pass band of the picture if amplifier, a trace similar to that of Figure 6 should appear on the oscilloscope screen. This trace is typical of the picture if response of modern television receivers. Since the intermediate frequencies for most television receivers are 25.75-Mc for picture and 21.25-Mc for sound, these frequencies are shown in their proper positions in Figure 6.
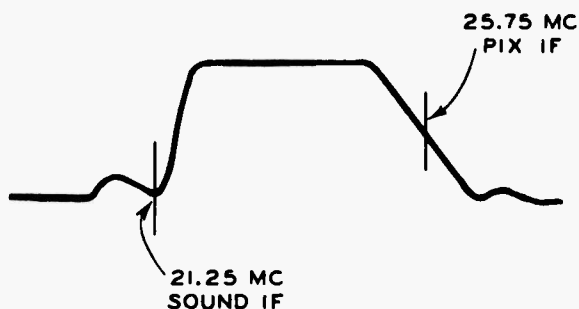
Figure 6. Picture-IF Response

During the alignment of the picture-if amplifier, it is ncessary to know the positions of various frequencies along the response curve. These frequencies are caused to appear as marker "pips" on the response curve. If the television receiver employs standard RTMA intermediate frequencies, then the marker frequencies may be obtained directly from the Television Calibrator.

The following description will assume that the receiver under test employs standard RTMA intermediate frequencies, although under no circumstances does this assumption mean that receivers utilizing other intermediate frequencies cannot be aligned easily with the Television Calibrator.

The instrument is employed as follows:

1. Couple the output cable of the Television Calibrator loosely to the input of the mixer tube (refer to Figure 5). Sufficient coupling is usually obtained when the ground lead on the output cable is connected to the receiver chassis and the "hot" lead is placed near the wiring of the mixer stage. Some television receivers having comparatively low-gain if amplifiers may require tighter coupling. Too much coupling is undesirable, as detuning of the circuit may result. If the curve shape is altered when the marker signal is inserted, coupling is too tight.

2. Set the Television Calibrator frequency exactly on 25.75-Mc as described under "Operation". A

marker "pip" should appear somewhere on the trace. If the oscilloscope used to observe the response curve has a wide-band video amplifier, the combination of marker "pip" and response curve may look like the
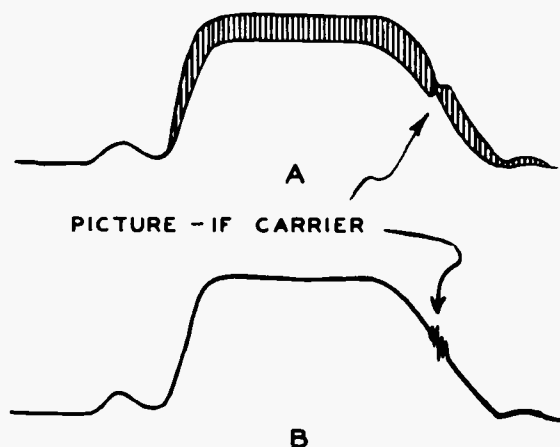
Figure 7. Picture-IF Response

curve shown in Figure 7A. A sharper marker "pip" may be obtained when the high-frequency response of the oscilloscope vertical amplifier is decreased by shunting the vertical input terminals with a small capacitor (about .001 μfd.). The resulting trace is shown in Figure 7B.

3. The position of the 25.75-Mc marker (picture-if carrier) should be at approximately the 50% response point on the slope of the response curve, as shown in Figure 7. The tuned circuits in the picture-if amplifier are adjusted so that the response curve is of the proper shape with the marker "pip" in the position shown in Figure 7.

4. The position of any frequency on the response curve can be determined by placing the marker "pip" at that point and reading the frequency from the tuning dial scale. One important frequency is that where the response just starts to drop off toward the sound-carrier frequency (see Figure 8). If the variable-
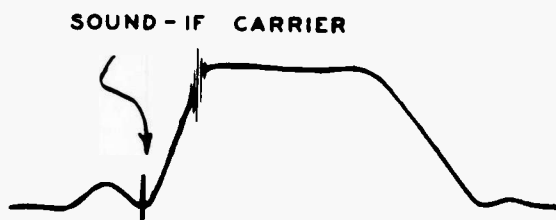

Figure 8. Picture-IF Response

frequency oscillator of the WR-39C is set and calibrated to the picture-if carrier and the external variable-frequency oscillator is set to a frequency which is the difference between the picture-if carrier and the frequency whose marker "pip" is shown in Figure 8, two simultaneous markers will appear. These frequencies are most important in the alignment of picture-if amplifiers and their marker "pips" may be kept in sight constantly to eliminate the necessity of retuning and recalibrating the signal source. Other important frequencies are the trap frequencies shown in Figure 9.

Since the response of the amplifier is very low at the trap frequencies, the marker "pip" will disappear when it is placed on these frequencies; however, these points can be determined on the response curve by placing the marker "pip" first on one side of the trap frequency, then on the other, and interpolating the center frequency.
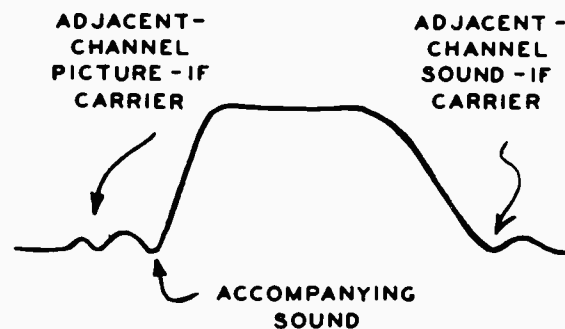
Figure 9. Trap Frequencies

Traps in the picture-if amplifier are adjusted by feeding the output of the Television Calibrator, tuned to the trap frequency, into the if amplifier. Each trap is adjusted for minimum output as indicated by a sensitive vacuum-tube voltmeter connected across the second-detector load resistor. If the output of Television Calibrator is modulated by the internal audio signal, an oscilloscope or the highly sensitive RCA Audio Voltmeter WV-73A may be used as an output indicator.

The general procedure in aligning picture-if amplifiers is first to set the traps and then to align the other circuits in the if-amplifier. Since any adjustment made on these other circuits will in most cases slightly detune the traps, they may have to be "touched up" during the picture-if amplifier alignment. The manufacturer's alignment instructions will again determine the exact procedure to follow.

Aligning RF Amplifiers — The radio-frequency stages of a television receiver should have a pass band of about 6-Mc (Figure 10). The equipment for producing this is set up and operated according to the manufacturer's alignment instructions, and the output of the Television Calibrator is fed into the receiver antenna terminals. Normally, the Television Calibrator is tuned to the center frequency of the channel being aligned, then the tuning adjustments in the rf amplifier are adjusted to produce a response which is symmetrical on each side of the marker "pip."

The output frequency of the calibrator is tuned to either the picture or sound carriers. When either of these frequencies is correctly marked on the rf response curve as seen on the oscilloscope, a marker "pip" appears at the other part of the curve if the output frequency is modulated by 4.5 megacycles.
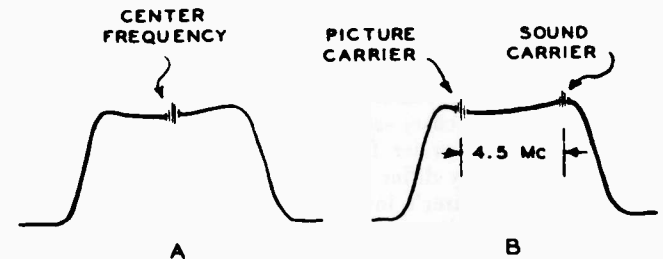

Figure 10. RF Response

Aligning RF Oscillators—The local oscillator in the television receiver can be rapidly and efficiently aligned by feeding the sound-carrier frequency into the input of the receiver and adjusting the receiver oscillator to obtain zero output from the sound discriminator. *This procedure can be followed only after the sound-if system has been correctly aligned.* The procedure follows:

1. Couple the output of the Television Calibrator to the input of the receiver.

2. Connect a VoltOhmyst Electronic Meter*, or equivalent zero-center voltmeter, to the output of the sound discriminator (across the discriminator load resistors).

3. Set the Television Calibrator to 215.75-Mc (channel 13 sound).

4. If the receiver has a fine-tuning control, this should be set at the center of its tuning range.

5. Adjust the channel 13 oscillator trimmer for zero output from the discriminator. Check this point by turning the trimmer through the correct setting. The discriminator output should be positive on one side of the proper adjustment and negative on the other.
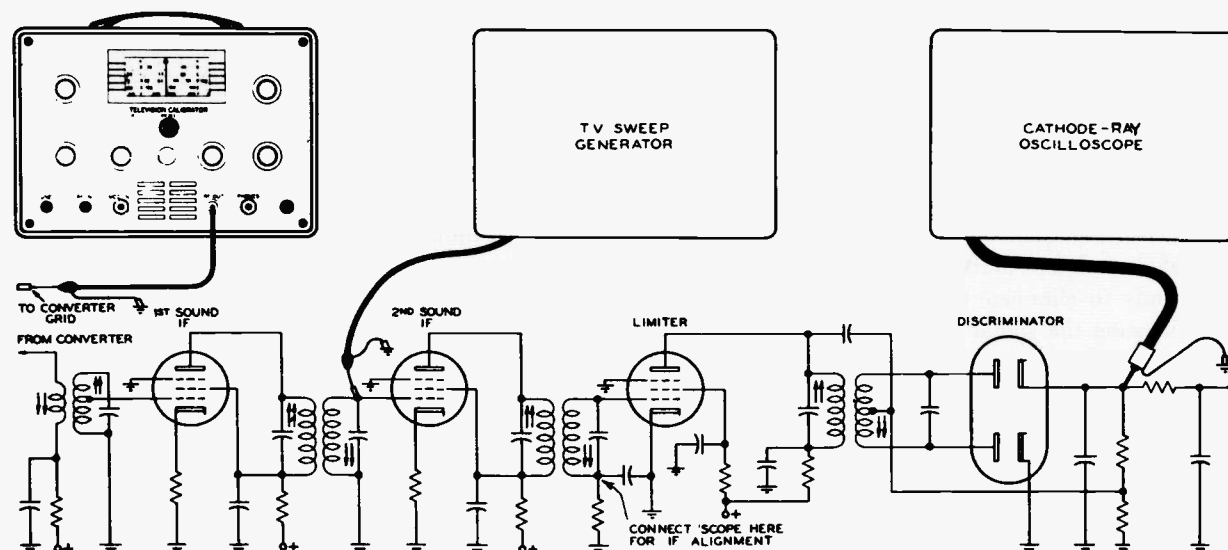
Figure 11. Sound-IF Amplifier Alignment

6. Adjust the remaining channels in a similar manner. In each case, set the Calibrator to the appropriate sound-carrier frequency. Since the order of alignment may differ in receivers of different make, the manufacturer's instructions should be consulted before proceeding.

The rf oscillator can also be aligned by using the calibrator as a precision heterodyne frequency meter. In fact, this method should be used with receivers employing intercarrier sound systems because the method outlined in steps 1 to 6 above is not applicable.

With the heterodyne method, the signal from the oscillator in the receiver is fed to the WR-39C at the RF IN terminal by means of a single wire loosely coupled to the oscillator in the receiver. This signal is heterodyned against the vfo in the WR-39C, and the frequency of the receiver oscillator is then adjusted until the "zero beat" is obtained.

In television receivers where the sound if is higher than approximately 22-Mc and the local oscillator operates on the high side of the carrier, the oscillator frequency will be outside the frequency bands (19—110 and 170—240-Mc) of the WR-39C. In such cases the variable-frequency oscillator of the WR-39C should be tuned to one-half or one-third of the oscillator frequency of the receiver, and the instrument operates on a harmonic of the vfo.

Use of WR-39C on frequencies beyond fundamental frequency range. In applying the WR-39C Television Calibrator to receivers having 41.25 Mc if frequencies, the heterodyne method of tuner-oscillator alignment requires frequencies beyond the normal range of WR-39C dial calibration. To adapt these instruments for 41.25-Mc service, harmonics of the variable frequency oscillators can be used.

Aligning Sound-IF Amplifiers—With the exception of the response curve shape, the application of the Television Calibrator to alignment of sound-if channels follows the same general procedure given in the previous paragraphs on picture if channels. The alignment equipment is set up as shown in Figure 11. The if response, with the superimposed marker "pip," is shown in Figure 12 as being indicative of that to be expected from normal sound-if amplifiers. The width of the pass band can be determined as described previously under "General Application". The usual discriminator characteristic is shown in Figure 13A. Figure 13B shows the usual discriminator response curve with the center frequency (sound-if) modulated by the .25-Mc crystal (CALIBRATE selector set at ".25 MC" position). Three simultaneous markers are provided by modulating the center frequency with the
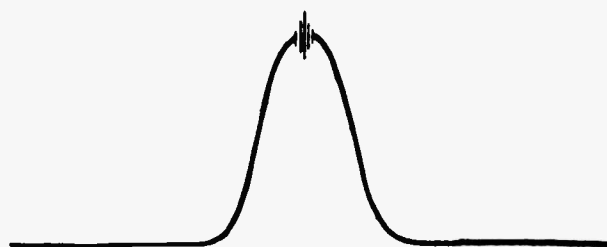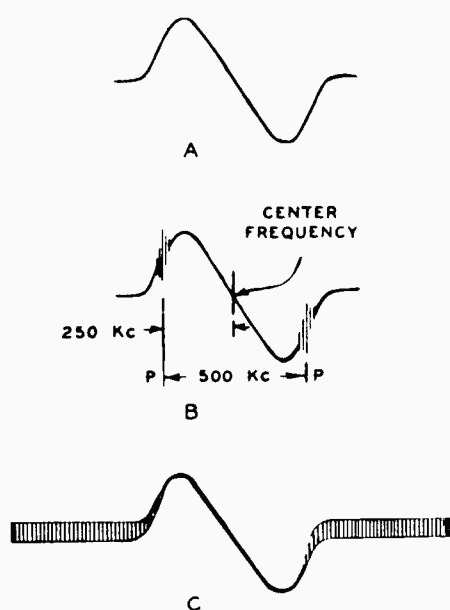

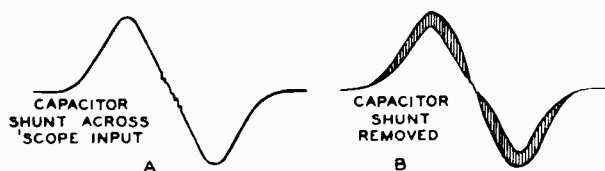**Figure 12. Sound-IF Response**

Figure 13. Discriminator Response

Figure 14. Discriminator Response

Figure 15. Improperly Aligned Discriminator

.25-Mc crystal-oscillator output. These marker "pips" are 250 kc apart and are used to check discriminator bandwidth. The center marker "pip" may not be visible since it is at a point of zero voltage and, consequently, the two visible "pips" will be 500 kc apart. If the small capacitor previously shunted across the oscilloscope vertical input is removed, a trace like that of Figure 14B will appear. Using this trace, the serviceman can determine the important center frequency of the discriminator characteristic with relative ease. Figure 15 illustrates various conditions of discriminator misalignment.

Another method of aligning the discriminator or ratio detector of television receivers is to obtain the usual response such as that shown in Figure 13A. The center frequency (sound-if) is then modulated by an audio frequency.

When the discriminator or ratio detector has been properly aligned, the response curve seen on the oscilloscope will be similar to that shown in Figure 13A.

When the center frequency is other than that provided by the TELEVISION CALIBRATOR, the response curve will be similar to that in Figure 13C.

Television receivers employing intercarrier sound-if stages may be aligned in a manner similar to that described above. Since all receivers of this kind use a sound-if frequency of 4.5 megacycles, it is merely necessary to provide this frequency as the center frequency of the response curve. When the VAR OSC switch is set to the "OFF" position and the CALIBRATE selector is set to the "4.5 MC" position, the RF output frequency is 4.5 megacycles and its output may be controlled by the RF OUT Control. This output is fed into the video amplifier ahead of the 4.5-Mc take-off point. If additional markers are needed they can be obtained by connecting the output of an ordinary rf oscillator to the MOD IN jack.
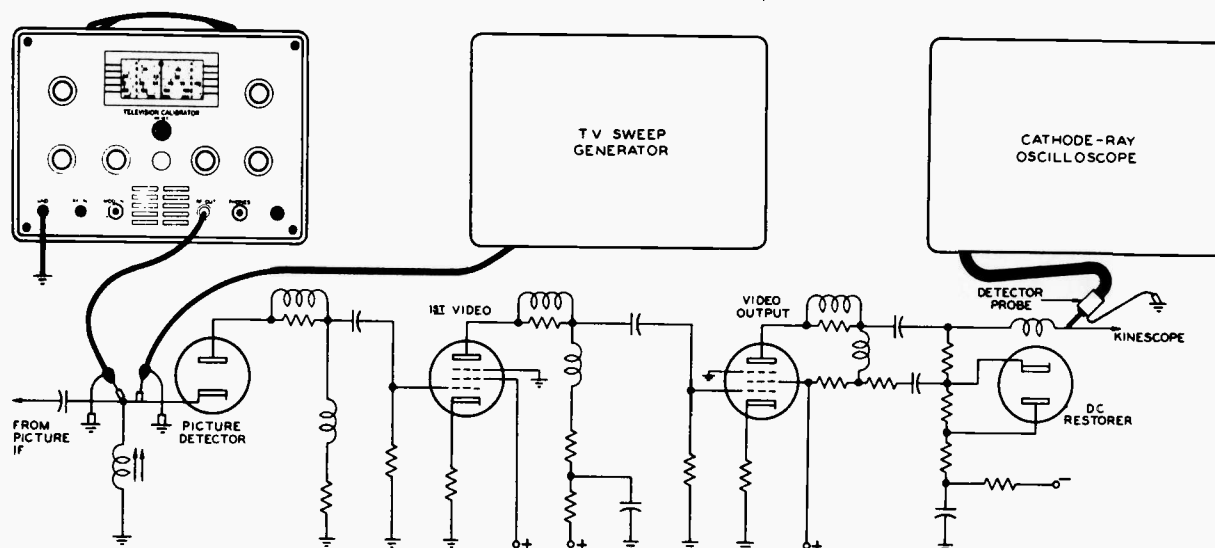
Figure 16. Second Detector and Video Amplifier Response Check

Second Detector and Video Amplifier Response Check—This test portrays on the screen of an oscilloscope a trace which shows the response of not only the video amplifier in a television receiver, but of the second detector and its load as well. Equipment for the test is set up according to Figure 16. The method follows:

1. Connect the outputs of the Television Calibrator and the sweep generator directly to the diode element not connected to the diode load (see Figure 16).

2. Set the sweep generator to sweep an arbitrary band of frequencies, say 20-30-Mc. Tune the Television Calibrator to 20-Mc. (These exact frequencies do not have to be used; it is only necessary to set amplifier can be tested under more nearly actual conditions, since the input capacitance of a well-designed the Television Calibrator to a frequency which is included near the low-frequency end of the band swept by the sweep generator.) Rectification in the second detector will produce, across the detector load, a band of frequencies continuously swept from 0 to 10-Mc. This video sweep is used to check the video-amplifier response.

3. The detector probe of the oscilloscope is connected to the output of the video amplifier at the picture tube. If the oscilloscope is not equipped with a detector probe, then an external detector, using a diode or a crystal rectifier, may be utilized. The detector should have, in addition to good 60-cycle square-wave response, a low input capacitance to preclude any detrimental effect on the video-amplifier response produced by capacitance loading of the amplifier output. When the picture tube is removed from its socket, the detector closely approximates the input capacitance of the picture tube.

4. A trace similar to that shown in Figure 17 should appear on the screen of the oscilloscope. This trace represents the frequency-vs-amplification characteristic of the video amplifier and second detector. Particular frequencies along the response curve can be estimated, since the length of the entire trace is known to be representative of a video-frequency bandwidth equal to the sweep-width output of the sweep generator.

Figure 17. Video Amplifier and Second Detector Response

Adjusting Linearity—When the CALIBRATE switch of the WR-39C is set to .25-Mc, the rf output of the unit is modulated with a 250-kc signal. If this signal is received on a television receiver, a vertical bar pattern (approximately 16 bars) will be displayed on the kinescope. Thus, the WR-39C can be employed as a completely self-contained television signal simulator to check the operation of any television receiver on all channels. The vertical bar pattern will enable one to adjust the horizontal linearity of the receiver to a high degree of accuracy. If an externally generated audio signal of about 1200 cps is fed into the MOD IN jack, then 20 horizontal bars will be displayed on the television receiver kinescope, and vertical linearity can be adjusted.

LESSON 13

ALIGNMENT INSTRUCTIONS FOR FOUR POPULAR SETS

To introduce you to practical alignment of television receivers, instructions for four popular type sets are presented in this lesson. In this group are included a stagger tuned set and intercarrier sets of 25 MC and 40 MC types. This material is reprinted through the courtesy of the respective manufacturers as stated in the introduction to each section.

The material below is applicable to many early General Electric sets. Such sets are described in greater detail in Lesson 9, where an appropriate circuit diagram is also published.

CIRCUIT ALIGNMENT

GENERAL—A complete alignment of the receiver tuned circuits consists of the following individual alignment procedures. These are listed below in the correct sequence of alignment. However, any one section alignment may be performed without the necessity of realignment of any one of the other sectional alignments.

    1. Sound I-F Alignment.
    2. Video I-F Alignment.
    3. R-F Alignment.
    4. Oscillator Adjustments.

TEST EQUIPMENT—To provide alignment as outlined above, the following test equipment is required:

1. R-F Sweep Generator.
  (a) Frequency Requirements.
      20 to 30 mc with 10 mc sweep width.
      40 to 90 mc with 15 mc sweep width.
      170 to 220 mc with 25 mc sweep width.
  (b) Constant output over sweep width range.
  (c) At least 0.1 volt output.

2. Signal Generator—Must have good frequency stability and be accurately calibrated. It should be capable of tone modulation over the following frequency ranges.
  21.8 mc for sound i-f.
  22.9 mc for video i-f marker.
  23.4 mc for video i-f marker
  25.55 mc for video i-f marker.
  26.3 mc for video i-f marker.
  45–88 mc and 174–216 mc for oscillator adjustment and markers for the r-f channel bandwidth measurements.

Fig. 10. Audio I-F Curves

3. Oscilloscope—This oscilloscope should preferably have a 5-inch screen and have good wide-band frequency response on the vertical deflection

4. Crystal Calibrator—This unit is essential to establish calibration check points for the signal generator so as to provide good accuracy of calibration.

ALIGNMENT SUGGESTIONS—All alignment adjustments in the sound and video i-f amplifier, are available from the top of the chassis with the exception of the sound discriminator secondary adjustment and the last video i-f stage. The location of the adjustments is shown in Figure 16. Remove the chassis from the cabinet. When it is necessary to make adjustment from the bottom of the chassis, the chassis may be rested on its side so that the power transformer is down. The following suggestions apply to each individual alignment procedure.

1. Sound I-F Alignment—The sweep generator is connected through a 500 mmf. capacitor to the grid of the tube preceding the sound i-f coil to be aligned. Connect the oscilloscope through a 100,000-ohm resistor across the resistor, R104, in the limiter tube, V18 grid. Insert a 21.8 mc marker signal from an unmodulated signal generator into the grid of V3. Keep the marker signal attenuated so that it just shows a marker on the sweep curve. Adjust L21 and L5, respectively, as you advance progressively one stage at a time, for maximum gain and symmetry of the response curve about the 21.8 mc marker. The curve should be similar to that shown in Figure 10(A). With input at the 1st audio i-f, V22, the bandwidth should be approximately 500 kc at the 70% response point.

    Keep the input of the sweep generator low enough so that the sound i-f amplifier does not overload, otherwise the response curve will broaden out permitting slight misadjustment. Check by increasing the output of the sweep; the response curve on the scope should increase in size proportionally. Set Contrast control at the half-advance position.

    For discriminator alignment, the secondary core of the discriminator transformer, T19, is aligned by using a tone modulated 21.8 mc amplitude modulated signal and listening to the tone at the loudspeaker. This adjustment is made for a minimum tone signal output. Apply the signal generator input to the grid of V22. If the sweep is used for the secondary alignment, the crossover should be symmetrical about a 21.8 mc marker and should be a straight line between the alternate peaks as shown in Figure 10(B). For the discriminator transformer primary alignment, connect the oscilloscope to the junction of C74 and R86. With the same sweep input as in Step 1, adjust the primary adjustment
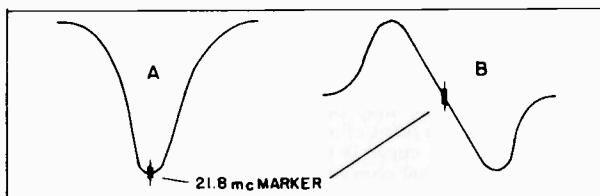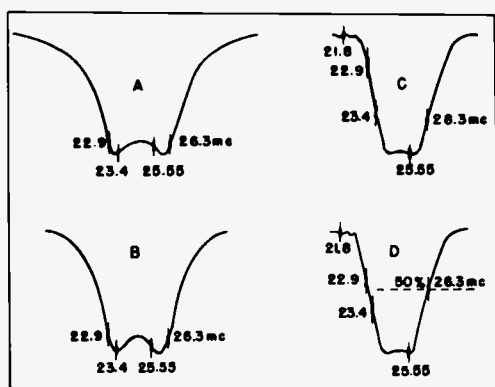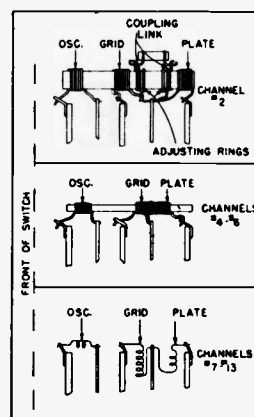
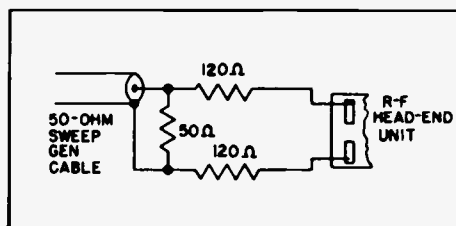Fig. 11. Video I-F Curves

Fig. 12. R-F Coil Assembly

Fig. 13. Sweep Generator Termination

screw for a maximum peak-to-peak amplitude of the response curve as shown in Figure 10(B).

2. Video I-F Alignment—The video i-f amplifier uses transformers which are coupled and loaded to give the proper band-pass characteristics.

Stage-by-stage alignment should be performed so as to duplicate as closely as possible the curves as shown in Figure 11A, B, C, and D. The markers supplied by an accurately calibrated signal generator are used to establish the correct bandwidth and frequency limits. Set contrast control at approximately its mid-position.

Connect the sweep generator to the tube grid preceding the transformer to be aligned. Adjust the sweep width for a minimum of 10 mc about the center frequency of the video response curve. The sweep output cable should be shielded and preferably terminated in its characteristic impedance and then connected with as short a lead as possible through a 500 mmf. capacitor; the ground lead of the cable should be short and grounded to the chassis as near as possible to where the signal is applied. Sufficient marker signal may be supplied in most cases, except at the last stage by merely connecting the high side of the signal generator to the television chassis. At last stage, couple the marker generator through a small capacitor in parallel with the sweep input; keep the input low enough so that it doesn't influence the shape of the response curve.

The primary of the transformer preceding the grid where the signal is applied will act as a tuned trap, placing a dip in the alignment curve as viewed on the scope, unless it is detuned sufficiently to throw it out of the video i-f pass-band. To detune this transformer merely remove the tube which feeds the primary winding.

Keep the output of the sweep generator as low as possible so as not to overload the video i-f amplifier. The Contrast control should be set at about its mid-position during alignment. Prior to the alignment of transformer T11 in step (5), turn the carrier set trimmer, C12, to its minimum capacity.

The response curves shown in Figure 11 are obtained on an oscilloscope connected at the junction of L22 and R24. Use a 10,000 ohm resistor in series with the input lead to the oscilloscope for isolation purposes. Set the Channel Selector switch to receive channel #4.

3. R-F Alignment—The r-f coil and switch assembly is designed for stable band-pass operation and under normal conditions will seldom require adjustment. In cases where it is definitely known that alignment is necessary (such as when the present coil is damaged and has been changed), do not attempt the adjustment unless suitable equipment is available.

The minimum requirements for correct r-f alignment are (1) to provide the correct bandwidth, (2) for the response curve to be centered within the limit frequencies shown for each of the individual channels as in Figure 14, and (3) for the response curve to be adjusted for maximum amplitude consistent with correct bandwidth. To provide these minimum requirements, the r-f coils are overcoupled and loaded with resistance. Tuning of the coils is affected by changing inductance of the individual coils. Except for the Channels #2 and #3 coils, the coupling is fixed by the design of the coil and switch wafers.

The physical assembly of the coils in the band switch locates the r-f amplifier plate coil at the rear of the switch assembly, while the oscillator coil is switched by the front wafer. Three different types of coils are used. These are shown in Figure 12. On all channels except Channels #7 through #13, the r-f, converter, and oscillator coils are wound on a single coil form. Mutual inductance between turns of the converter and r-f coils provides the desired coupling. On Channel #2, the converter and r-f coils are spaced for loose coupling and the mutual is increased by inserting a tertiary link winding between the coils. By adjusting the link, the mutual can be changed and better image rejection of the FM band (88 to 108 mc) signals results. Tuning of the link circuit is accomplished by adjusting two movable copper rings. The Channel #3 plate and grid coils are overcoupled by spacing of the two coils in relationship to each other and are tuned by spacing of the component turns. The Channels #4 through #6 transformers are wound so that the converter and r-f coils are wound as a continuous winding, the a-c ground return for the two coils being a tapped turn on this winding. This tight spacing affords a good uniformity in mutual coupling. The tuning is accomplished by moving turns. The upper six channels, #7 through #13, are tuned by four sets of coils. Each converter and r-f coil is overcoupled to give adequate bandpass so that two channels may be covered by each set of coils except channel #7. Instead of magnetically coupling the r-f and converter coils in relation to each other, they are physically located on the channel switch so that the only coupling is afforded by the common a-c ground return of each coil. This ground return is made through a special shaped metal wafer on the channel switch.

The input sweep signal is applied to the antenna terminal board at the r-f unit. Disconnect the 300-ohm cable between the antenna terminal board and the r-f amplifier input. To prevent distortion of the r-f response curve by standing waves, the unbalanced shielded cable of the signal generator should be terminated as shown in Figure 13. The resistors used should be non-inductive. The marker signal generator may be loosely coupled through a small capacitor to the same point of input as the sweep generator.

The output r-f response curve is taken off at the junction of R5 and C10 through a 10,000 ohm resistor. Disconnect C10. The Contrast control is set for a minimum for all r-f alignments.

For Channels #2 and #3, the r-f coils should be aligned to give approximately the curve shown in Figure 14(A) and 14(B). The

Fig. 15. Focus Control Stringing

Fig. 16. Component and Trimmer Location

Fig. 14. R-F Alignment Curves

"P" marker represents the video carrier marker, while the "S" marker is the sound marker. The frequency of these markers is indicated for each step of the alignment procedure. Adjustment of the bandwidth is made by moving the plate coil closer to the grid coil or vice-versa. On Channel #2, the sliding of the copper rings will give both the required bandwidth and the frequency adjustment. Spread or squeeze turns in plate and grid coils to change frequency. Spreading turns results in a raising of the frequency; while squeezing turns lowers the frequency.

For Channels #4 through #6, the coupling is fixed by the tight coupling between the primary and secondary turns. How-

ever, this can be controlled to a certain degree along with the frequency by either spreading or squeezing the end turns of the combination converter and r-f coil. On the upper four coil assemblies covering the channels #7 through #13, the coupling cannot be changed as it is fixed by the common ground wafer

located between the r-f and converter coil switching wafer. This ground wafer is cut to give the proper amount of coupling at the time of manufacture. Tuning of these upper frequency coils is affected by the brass adjustment screws which form a shorted turn in the coil. The further the screw is introduced into the coil field, the higher will be the frequency and vice-versa.

The variable capacitors C5 and C6 are used to compensate for the slight differences in tube capacities which affect tuning when it is necessary to change the r-f or converter tube in the field. These trimmers are adjusted for Channel #6.

4. Oscillator Adjustments—The oscillator coils for Channels #2 through #7 are adjusted so that the Tuning control, C80, will tune the station at the mid-rotation position for each of these channels. Since the other remaining six channels, #8 through #13, are combined so as to be covered by only three switching positions, the oscillator coils are adjusted so that the Tuning control will tune in the two channels assigned each switch position at two points equi-distant from the two extremes of its rotation. With the Tuning control set to its mid-position, the oscillator coil is adjusted to give a maximum output when a modulated r-f signal at the test frequency specified is fed into the antenna terminals. The oscillator coils are adjusted by spreading turns to raise frequency or compressing turns to lower frequency.

Apply the signal generator with tone modulation to the antenna input terminals and set the generator to the frequency specified in the Alignment Table for each switch position. The signal generator must be very accurately calibrated. This can be done by beating its output against a known channel carrier, or use a station operating on the channel and then tune in the sound.

For output indication, advance the volume control about to mid-position so that the tone modulation or audio modulation on the station may be heard through the loudspeaker.

Below is the manufacturer's suggested alignment for the Air King set described in detail as the first part of Lesson 10. The complete circuit presented there may be of help to you in following alignment information.

Video I-F Alignment

Connect the oscilloscope or the VTVM to the junction of *R118* and *L5*. Adjust the contrast control to its minimum setting. Feed the output signal of the marker generator through a tube shield placed over the mixer tube. *Be certain that this shield is not grounded.*

Set the marker generator at 22.4 Mc, amplitude modulated 30 per cent at 400 cycles. Adjust *TLP1*, the first video i-f coil, which is located on top of the tuner, for maximum deflection on the oscilloscope or VTVM. Repeat this process with the third video i-f coil *L2*. Leaving the generator connected as is, reset its frequency to 24.6 Mc and tune the second and fourth video i-f coils, *L1* and *L3* respectively, for maximum response on either indicating device.

With the sweep generator adjusted for a 10-Mc sweep with a center frequency of about 25 Mc (i.e., sweeping 20-30 Mc) connect the sweep output cable to the mixer tube similar to the method in the video i-f alignment. *Loosely couple* the marker generator to

(A)

(B)
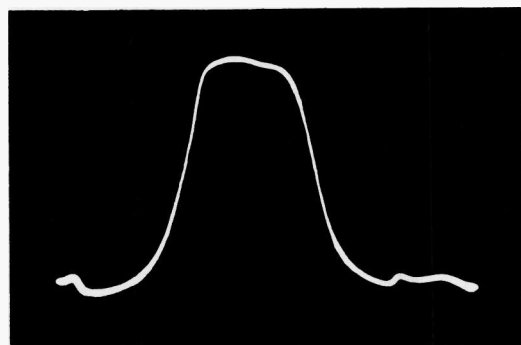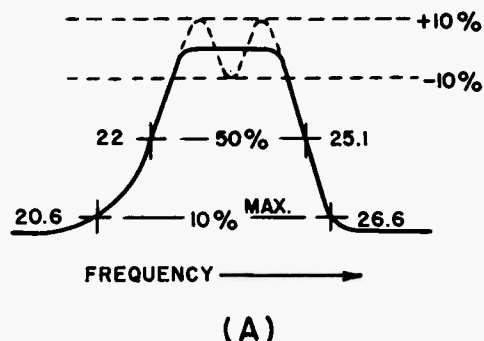
Fig. 10. Over-all video i-f response; (A) drawing showing marker points, and allowable variations in shape, (B) an actual response curve.

the same mixer tube. Inject individual markers of 25.1 Mc, 22 Mc, 20.6 Mc, and 26.6 Mc in the order indicated and note the position of the marker pips on the response curve for each case. If necessary, readjust the four video i-f coils for an over-all picture response as indicated in Fig. 10 (A). The solid line at the top of the curve is the ideal straight line response. The dotted portions of this part of the curve indicate the possible limitations and variations that usually exist and which are permissible for correct alignment. In part (B) of Fig. 10 is an actual over-all video i-f alignment curve taken on a Tele King TVJ chassis.

Sound Alignment

This is the alignment of the 4.5-Mc section of the receiver. For the quickest method of aligning this section, an actual station transmission is used as the basic signal instead of any meter or visual method of alignment. No measuring or indicating devices are needed for this method of alignment.

In order to correctly align coils *L6* and *L20*, an input television signal must be used that is *below* the limiting level of the 6BN6 gated-beam tube. This level can easily be identified by the "hiss" which appears in the sound output. Some method of attenuation must be employed to reduce this signal. Although various methods are possible some sort of attenuator between the antenna and input terminals is preferred. A simple resistance pad similar to that indicated in Fig. 11 will suffice. If not enough attenuation is secured with one pad, add another or more until there is sufficient attenuation. Conversely, in order to properly align the quadrature coil *L9* and the a-m rejection control, *P12*, a signal above the limiting value is necessary.

The sound alignment is as follows:

1. Tune in a station that has a steady signal with no fading. A station with a tone signal (test pattern)
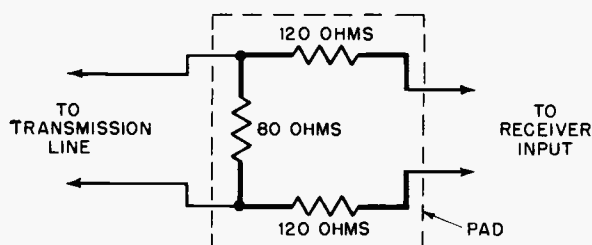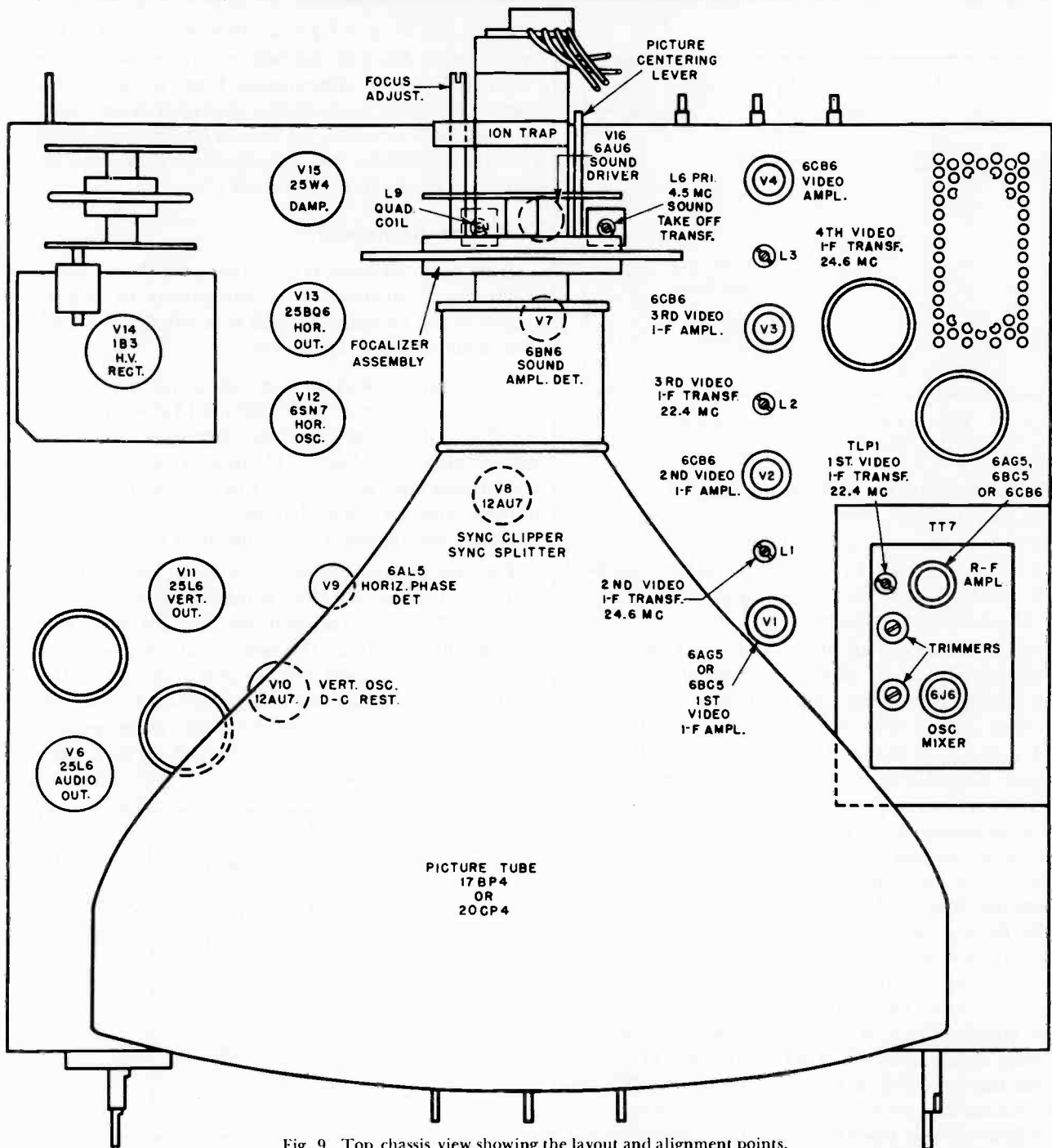
Fig. 11. A typical attenuation pad.

Fig. 9. Top chassis view showing the layout and alignment points.

on the air is preferred, otherwise any available signal will do.

2. Adjust the attenuator until the signal coming in is reduced to the level where a "hiss" is heard with the sound output. Next adjust the primary and secondary of the 4.5-Mc sound take-off coil *L6*. The secondary adjustment of *L6* is made from the underside of the chassis as indicated in Fig. 12; the primary adjustment is made from the top of the chassis. The

4.5-Mc sound driver coil *L20* is adjusted next for maximum sound output regardless of any hiss or buzz. If any of these sound adjustments may cause the "hiss" to disappear, the attenuator should be readjusted so that the "hiss" reappears.

3. When the maximum sound output is attained, adjust the attenuator in the opposite direction so that the "hiss" disappears. This raises the signal above the limiting level of the 6BN6 gated-beam tube.
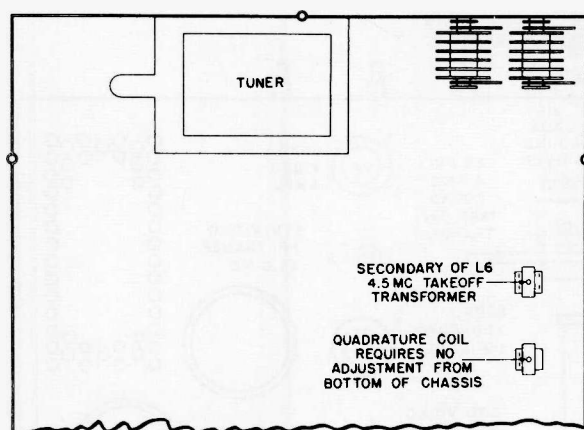
Fig. 12. Underside of chassis indicating location of L6 primary.

4. Next adjust the quadrature coil, *L9*, for maximum sound output. For this, it is recommended that a station of average signal strength in your area be used. The a-m rejection control *P12* is then adjusted until the intercarrier buzz is eliminated. Then repeat the *L9* and *P12* adjustment.

Proper alignment of the sound system can be checked easily at any time by turning the a-m rejection control first to the right and then to the left of the final setting. Whatever happens in one direction, such as the appearance of buzz or decrease of the f-m output, should also occur in the opposite direction. If this does not happen, then realign once again in the same manner as set forth above.

Alternate Method. An a-m or marker generator may also be used to align the takeoff transformer *L6,* and the sound driver coil *L20.*

Set the generator to 4.5 Mc, amplitude modulated 30% at 400 cycles. Connect the output cable of the generator to the junction of the .05 mf capacitor (*C118*) and the two peaking coils *L4* and *L5* in the grid circuit of the 6CB6 video amplifier. Place the vertical input terminals of an oscilloscope or VTVM across the voice coil or the volume control *PD10.* Set the volume and contrast controls at maximum.

Adjust the a-m rejection control for the first maximum response on the oscilloscope or VTVM as the control is turned in a clockwise direction. Lower the generator output until a "hiss" is heard from the speaker. Next peak the primary and then the secondary of the takeoff transformer *L6* for maximum response on the oscilloscope or VTVM. If the "hiss" disappears, lower the generator output until it reappears. Then adjust the sound driver coil *L20* in the same fashion.

The quadrature coil *L9* can then be aligned either by ear as in the first method, or by use of a tone modulated pattern transmission from an actual station. If the latter is available, the input is set above the limiting level of the 6BN6 (no hiss in the output) and the quadrature coil is peaked for maximum response on the oscilloscope or VTVM.

Oscillator Alignment

As far as the r-f tuner is concerned only the oscillator alignment is discussed here. Alignment of the r-f section is not included because it is felt that very seldom will it require alignment.

This tuner employs the principle of incremental inductances as you move from channel 13 down to channel 2. Oscillator adjustments, therefore, are made sequentially from channel 13 through channel 2. No instruments are needed for this alignment, station transmissions on each channel are the only signal sources. The alignment procedure is as follows:

The fine tuning control is first set to the midrange of its adjustment. Set the channel selector switch to channel 13. Adjust the oscillator slug for this channel (see Fig. 13) until the best picture and sound is received. Bear in mind that the a-m rejection control must be properly adjusted beforehand for the clearest sound as discussed in alignment of the sound section. Next, repeat this procedure for channel 12, then channel 11 and so on down the line.
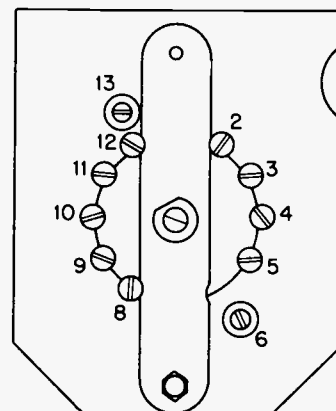

Fig. 13. Oscillator alignment points.

There is no oscillator adjustment for channel 7, alignment of the channel 8 oscillator automatically assures proper alignment of the channel 7 oscillator. After the high-frequency channels are aligned (13 through 7), although each low frequency can be aligned individually, the oscillator slug for channel 6 can be used to shift the complete low-frequency band if desired. Position of all the oscillator slugs for both bands are indicated in Fig. 13.

The alignment information below is for Motorola sets of the inter-carrier type described also in Lesson 10. Refer to this explanation and diagram for reference while studying the alignment data below. Since often the RF and oscillator stages need not be aligned while the balance of alignment is performed, instructions for RF and oscillator alignment is omitted.

AUDIO TAKE-OFF & RATIO DETECTOR ALIGNMENT

Equipment Required:

AM Signal Generator: Accurately calibrated at 4.5 mc
(Optional)
                                Adjustable output

DC Meter: Low range electronic voltmeter

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 mmf capacitor to the grid (pin 1) of the video amplifier tube V-7 (6AH6), and the low side to B-. The following applies whether the station signal or signal generator is used.

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

4. Set the contrast control for maximum gain (fully clockwise).

5. Peak L-20 for maximum reading on meter.

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 (33K) 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-20 and the primary & secondary of T-3, 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 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 its range, the voltage read from one side of capacitor C-60 should be greater than 5.0V.

4.5 MC TRAP ALIGNMENT

1. Connect the high side of the signal generator through a 1000 mmf 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-. Use the lowest voltage scale on the meter.

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

IF AMPLIFIER ALIGNMENT

Equipment Required:

IF Sweep Generator meeting the following requirements:

18 to 30 mc, approximately 12 mc sweep width. Output constant and adjustable to at least .1 volt maximum with accurately calibrated, adjustable markers.

Cathode Ray Oscilloscope: preferably one with a calibrated input attenuator.

If a wide band scope is used, the marker will be more distinct if a capacitor of 100 to 1000 mmf is placed across the scope input. Use the smallest size possible, since too large a value will affect the shape of the curve.

Procedure:

1. Remove high voltage generator tube V-17 (6BQ6GT) from its socket to eliminate horizontal pick-up in the oscilloscope.

2. By means of an external battery, apply a negative 3.0 volt bias from the bottom of the 1st IF tube grid resistor R-9 (6800) to B-.

3. Using leads as short as possible, connect the hot side of the sweep generator to the grid (pin 1) of the 1st IF tube V-3 (6AU6) through a 5000 mmf capacitor (do not use the loose or "spraying" method of coupling). The low side is connected to B-. Set the center frequency of the sweep to about 24.6 mc and ad-

just initially for a sweep deviation of approximately 12 mc. However, a sweep of from 8 to 10 mc may be found better for overall alignment.

4. Using R-27 (100K) as a decoupling resistor, connect the scope between the top of the detector load resistor R-26 (5600) and B-. If a stronger output is required, connect the scope between the picture tube cathode and B-. The curve seen at this position will be the reverse of the polarity shown in Figure 6.

5. Set the contrast control at minimum.

NOTE: If a distorted or unstable picture is seen on the oscilloscope during alignment, it may be necessary to stop the oscillator by disconnecting resistor R-10 (1000) from the plate (pin 6) of the oscillator tube V-2B (12AT7), or by substituting another tube with pin 6 removed.

CAUTION:

1. Do not reduce the oscilloscope gain and increase signal input so that the top of the curve is flattened, due to limiting in the video or scope amplifiers.

2. The dress of plate & grid components in the IF affects tuning. Do not move indiscriminately.

3. On the IF coils and on the traps, the resonance point will be found at two settings of the slug. The correct setting is the one which is found with the greater part of the adjusting screw out of the coil.

NOTE: The 1st & 2nd IF traps are tuned from bottom of chassis, while IF cores are adjusted from the top.

6. Tune the low frequency trap L-14, located on the 2nd IF coil, for maximum attenuation on the curve at 21.9 mc.

7. Tune the high frequency trap L-12, located on the 1st IF coil, for maximum attenuation on the curve at 27.3 mc.

8. Adjust the 1st IF coil, L-11, to place a 26.6 mc marker on the high side of the response curve 60% down from maximum response. See Figure 6.

9. Adjust the 2nd IF coil, L-15, to place a 22.7 mc marker on the low side of the response curve 60% down from maximum response.

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

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.

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

13. Disconnect the trimmer, C-14, in LC circuit in the grid of the mixer tube, or short the trimmer through a 10,000 mmf ceramic disc type to B-.

NO	TYPE	FUNCTION
V-1	6CB6	R-F AMP
V-2	12AT7	MIXER-OSC.
V-3	6AU6	1ST I-F AMP
V-4	6AU6	2ND. I-F AMP.
V-5	6AG5	3RD. I-F AMP
V-6	6AL5	VIDEO DET
V-7	6AH6	VIDEO AMP.
V-8	6AU6	AUDIO DRIVER-LIMITER
V-9	6AL5	RATIO DET
V-10	6J5GT	AUDIO AMP
V-11	6V6GT	AUDIO OUTPUT
V-12	6SN7GT	1ST. & 2ND CLIPPER
V-13	6J5GT	VERT SWEEP GEN.
V-14	25L6GT	VERT. SWEEP OUTPUT
V-15	6AL5	PHASE DET.
V-16	6SN7GT	HORIZ OSC.
V-17	6BQ6GT	HORIZ OUTPUT & H.V GEN.
V-18	6W4GT	DAMPING DIODE
V-19	1B3GT	H.V RECT.

NOTE.- IN EARLY CHASSIS R-104 WAS NOT A PLUG-IN TYPE RESISTOR AND WAS LOCATED ON BOTTOM OF CHASSIS.

FIGURE 4.

TUBE & ALIGNMENT ADJUSTMENT LOCATIONS

TOP VIEW OF CHASSIS
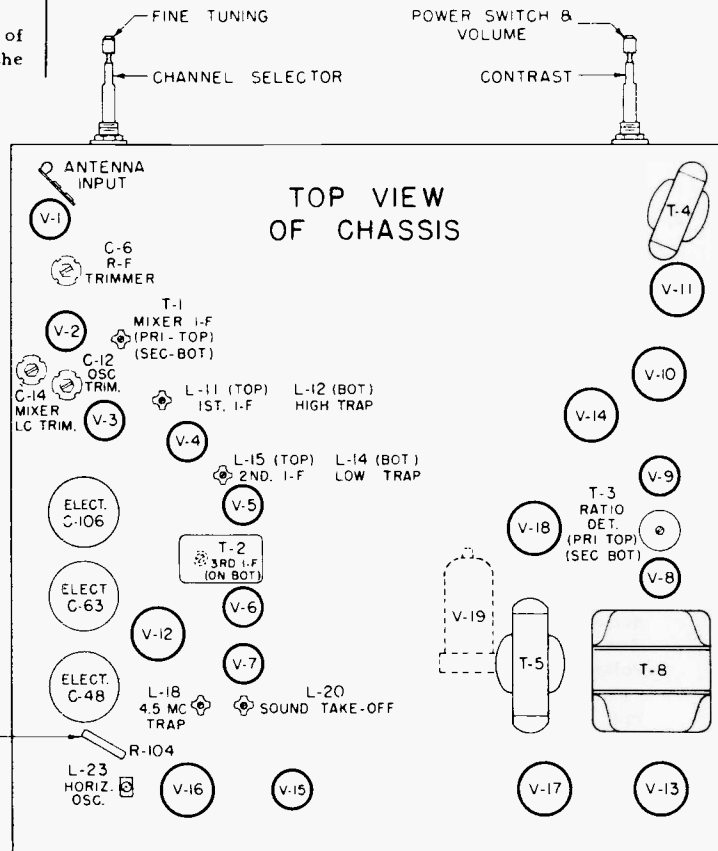
14. Bring both cores of the mixer transformer, T-1, simultaneously from the outside towards the center. The half-way markers should be 26.4 mc and 22.9 mc. See Figure 7.

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 adjusting 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 only difference in the overall waveform should be that the sides of overall wave are steeper. Constant use of the 50% markers (22.9 mc & 26.4 mc) should be resorted 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.

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 battery bias and observing the output response curve on the oscilloscope, as taken between the picture tube cathode and B-. The bandwidth may change with the bias removed but should not change 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.
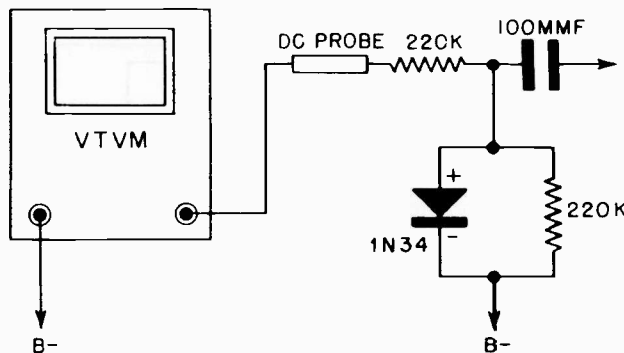
FIGURE 5. ELECTRONIC VOLTMETER CONNECTIONS
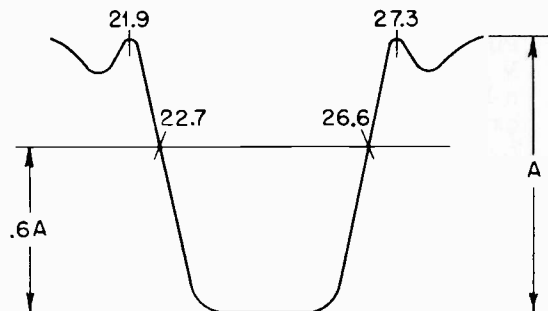
FIGURE 6. IF RESPONSE CURVE

MIXER LC ADJUSTMENT

Reconnect bias removed for regeneration check. Replace trimmer C-14 in LC circuit of mixer grid or remove 10,000 mmf 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 straighten out as 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 straightens out. In effect, the LC circuit is similar to a jack coil when it is within the IF range.

IF SENSITIVITY MEASUREMENTS

IF Stages Only

1. Remove the battery bias from 1st IF tube grid.

2. Connect an AM signal generator, set at 24.6 mc, through a blocking capacitor of 5000 mmf, between B- and the grid (pin 1) of the 1st IF tube V-3 (6AU6).

3. Connect an electronic voltmeter across the video detector load resistor R-26 (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 the plate (pin 6) of tube V-2B (12AT7) or by substituting another tube with pin 6 removed.

6. The signal required to produce 1 volt (negative) above contact potential on the meter should be less than 700 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 mmf capacitor, between B- and the grid (pin 2) of the mixer tube V-2A (12AT7).

2. The signal required to produce 1 volt (negative) above contact potential on the meter should be less than 125 microvolts.
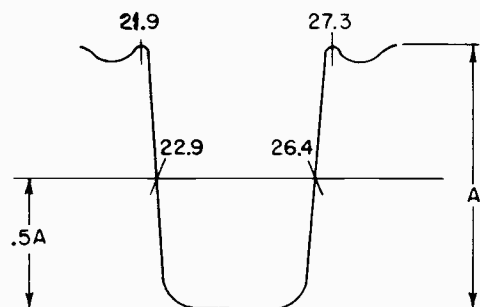

FIGURE 7. OVERALL RESPONSE CURVE FROM MIXER

The alignment for recent Muntz TV sets is presented below. This set is of the 40 MC type. The alignment is condensed in table form. This method of presentation is often used in practical service manuals to give needed information in the minimum of space.

When observing the television receiver band pass characteristics on the scope, it is important to avoid distortion of the response curve which would occur when using an abnormal signal input from the sweep and marker generators.

Always set the generator attenuator below the point where its output voltage starts to alter the shape of the response curve shown on the scope. This applies to both sweep and marker generators.

VIDEO I. F. ALIGNMENT

STEP No.	SWEEP GENERATOR COUPLING	SWEEP GENERATOR FREQUENCY	MARKER GENERATOR FREQUENCY	CHANNEL	SCOPE CONNECTIONS	ADJUST-MENTS Fig. 19	REMARKS
1	Apply sweep to grid of 1st I.F. tube. (Pin #1 of V101-6CB6)	44 M.C. (10 M.C. sweep)	41.25	12	V. input to testpoint "X". Ground shielded lead at both scope and pick-up point. Fig. 19.	D	Check response for curve similar to fig. 4.
2			43			E	Adjustment "D" will place the 41.25 MC trap marker.
3			45			F	
4			44.1			G	Adjust "G" for proper tilt.
5	High side through ungrounded tube shield floating over Osc.-Mixer tube.	44 M.C. (10 M.C. sweep)	47.25		SAME	B	Check response for curve similar to fig. 5. Adjustment "B" will place the 47.25 MC trap marker.
6			45.75		SAME	C, A	Simultaneously adjust "A" and "C" to properly place the 50% marker and curve shape.
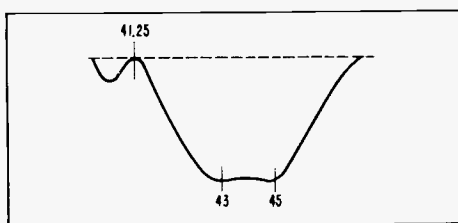
Fig. 4
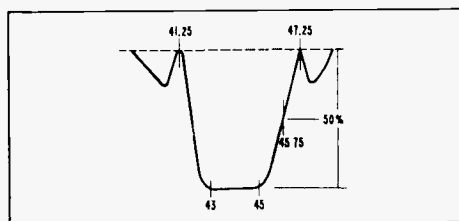
Fig. 5

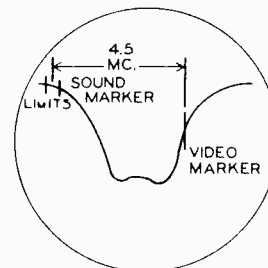## SOUND I. F. AND DISCRIMINATOR ALIGNMENT

STEP No.	SWEEP GENERATOR COUPLING	SWEEP GENERATOR FREQUENCY	MARKER GENERATOR FREQUENCY	CHANNEL	SCOPE CONNECTIONS	ADJUST-MENTS	REMARKS
7	High side thru .1 blocking condenser to Xtal (Y101). Low side to chassis ground.	4.5 MC (100 KC Sweep)	4.5 MC	2-13	Pin 2 of (6T8) V106 and chassis ground. Fig. 7.	J & L106 Fig. 19	Remove C128 (8mf. 100 V 'lytic) ground lead. Adjust for max. symmetrical wave form. Fig. 6. Solder ground lead when completed.
8	SAME	SAME	SAME	SAME	Test Point "T" and chassis ground. Fig. 7.	H Fig. 19	Adjust for 4.5 MC marker in center of symmetrical "S" curve. Fig. 8.
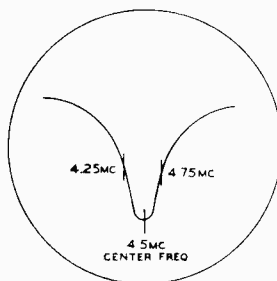
Fig. 6
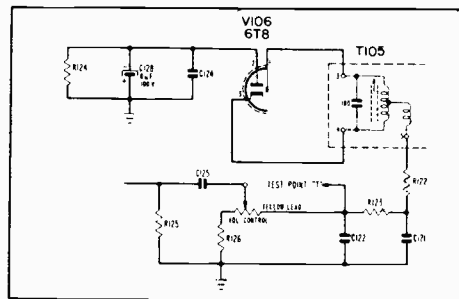
Fig. 7
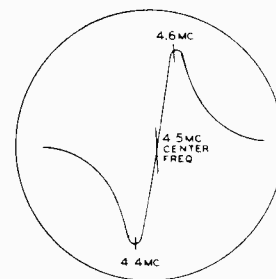
Fig. 8

TUNER ALIGNMENT
R. F. ALIGNMENT

STEP No.	SWEEP GENERATOR COUPLING	SWEEP GENERATOR FREQUENCY 10 MC SWEEP	MARKER GENERATOR FREQUENCY	CHANNEL	SCOPE CONNECTION	ADJUSTMENT	REMARKS
9	Across antenna terminals. An impedance matching network is needed with some generators. Refer to your equipment instructions.	57.50	55.25 59.75	2	Tuner RF test point "N"	PR-0207 Code "S" C220, C203, C206. Align on channel 10 and check all channels. PR-0206 Code "G" C203, C205, C210, C217. Align on channel 10 and check all channels. PR-0212 Code "T". Start on channel 13 and adjust L203, L207, L206. Align incremental loops of the R.F. plate and mixer grid from channel 12 to 7 in that order. Align channels 6 to 2, R.F. plate, R.F. grid and mixer.	Remove 1st IF Amp. Check with response curve Fig. 9 with markers as shown. Consistent with proper band width and correct marker location, curve should have maximum amplitude and flat top appearance. (Full skirt of response curve will not be visible unless generator sweep width extends beyond 10 MC.) Replace 1st IF Amp. tube when alignment is completed.
		63.50	61.25 65.75	3			
		69.50	67.25 71.75	4			
		79.50	77.25 81.75	5			
		85.50	83.25 87.75	6			
		177.50	175.25 179.75	7			
		183.50	181.25 185.75	8			
		189.50	187.25 191.75	9			
		195.50	193.25 197.75	10			
		201.50	199.25 203.75	11			
		207.50	205.25 209.75	12			
		213.50	211.25 215.75	13			

Fig. 9

Fig. 10

PR-0206 OSCILLATOR ALIGNMENT PR-0207

STEP No.	SWEEP GENERATOR COUPLING	SWEEP GENERATOR FREQUENCY	MARKER GENERATOR FREQUENCY	CHANNEL	SCOPE CONNECTION	ADJUSTMENT	REMARKS
10	Use table and instructions in RF alignment chart.				Alignment Test Point "X" Fig. 19	Individual Channel oscillator slugs Ch'annels 2-13 inclusive.	Adjust to place sound and video markers as per Fig. 10.

TUBE LAYOUT AND SIGNAL PATH CHART

CHANNEL SELECTOR

FINE TUNING

VOLUME R1A

CONTRAST R1B

BRILLIANCE

VERT HOLD

HOR HOLD

R3 R15 R21

VERT OUTPUT TRANSFORMER

VERT BLOCKING OSC TRANSFORMER

T5

V8 KINESCOPE

T4

CR1

VERT INT

V3 6BL7GT

T2 POWER TRANSFORMER

R.F TEST POINT

C206

V202 6J6

L211

K203

V201 6BQ7 6BZ7

ANT INPUT

C220 C219

V1 5U4G

T101 1ST I.F. F-TOP F-BOTTOM

V101 6CB6

V107 6W6GT

C1

T7 H.V TRANS

1B3GT

V6

T102 2ND I.F F-TOP F-BOTTOM

V106 6T8

C3

V102 6CB6

T105 RATIO DET TRANS H-TOP J-BOTTOM

T103 3RD I.F F

V103 6CB6

V105 6AU6

V4 6SN7GT

V5 6BQ6GT

F1

V7 6W4GT

L106 SOUND TAKE-OFF COIL

T104 4TH I.F G

Y101 INGO XTAL

V104 6CB6

V2 12AT7

16 K-TOP L-BOTTOM HOR OSC COIL

FUSE (5 AMP "SLO-BLO")

DETECTOR TEST POINT

TO C.R.T CATHODE

T3

DEFLECTION YOKE COIL

CIRCUIT LEGENDRY

R.F SIGNAL

I.F COMPOSITE SIGNAL

VIDEO WITH SYNC PULSES ooooooo

45 MC SIGNAL

AUDIO SIGNAL

A.G.C VOLTAGE

VERT & HOR PULSES

VERT PULSES

HOR. PULSES

HOR DEFLEC CURRENT

FOCALIZER

FOCUS ADJUSTMENT

CENTERING LEVER

ION TRAP

INTERLOCK S1

CHASSIS & SERIAL NO.

RUN NO

POWER EQUALIZER R39

VERT LIN R10

VERT SIZE R13

SPEAKER X1

HORIZONTAL

RANGE C16A

DRIVE C16B

HOR LIN L5

Fig. 19

LESSON 14

ADVANCED TROUBLE SHOOTING BY PICTURE ANALYSIS

Earlier in this course, we considered the use of actual picture faults as a guide to making needed adjustments or finding faulty tubes. With the knowledge of TV circuits gained from later lessons, you are now ready to employ observed picture defects also for locating actual circuits and components that may be the cause of trouble.

In this form of electronic sleuthing, the picture tube may perform the function of an oscilloscope and thus help you rapidly locate faults. After careful analysis of the symptoms indicated on the picture tube screen, the usual test equipment may be used, when required, to find the defective component.

The material in this lesson is reprinted through the courtesy of the General Electric Company and the examples are taken from GE "Stratopower" receiver. The block diagram of this receiver is reprinted below and the circuit diagram is reproduced on pages 160-161. You should study this circuit before proceeding to examples of advanced picture analysis. Of course, this circuit is similar in the main to circuits of other sets of this period and this service material is applicable to practically all modern television sets.

The picture patterns were taken with the receiver controls set for optimum reception. This trouble-shooting information is essentially confined to circuit and component failures.

R F TUNER

DIPOLE ANTENNA TERMINAL

C173 150
R181
R182 3.3 MEG.
3.3 MEG.
C174 150
300 Ω TWIN LEAD

V103B CONV (½) 12 AT7

VOLUME CONTROL

V111B ½ 6T8 AUDIO AMP.
V112 6AQ5 AUDIO OUTPUT

C216 .01
C209
L202 3.3 μh
C213 .05
R213 47

CONSOLE MODELS ONLY

R210 500K
C217
R209 33K
C211 .01 MF

R219 6.8 MEG
R216
R211 1000
C210 .05
R217 470K
R212 220 1W
R214 470 2W

L520I

C404D 20MF

+240V
+250V

TEST POINT V

R204 47K
C212 .002MF 200V
C208 .001MF 200V

V104 6CB6 1ST VIDEO I-F
L154 47.25 MC ADJ. AUDIO TRAP
C165 51
L153
C155 24

BROWN
RED
ORANGE
FIL. 6.3V
WHITE
+140V +250V

L151 47.25MC ADJ. AUDIO TRAP
C175 51
C176 62
L152
T151
T104
R115 1K
C119
C120 800

C152
C153 2.2
470
R153 47
C154 680
R154 1000
R155 5600
R152 20K

1
2
3
4

TEST POINT VII A
AGC
C151 .5MF
R185 1MEG
4.5MC SOUND TAKE-OFF

5
6
7
8

V109 6CB6 AUDIO I-F AMP
V110 6AU6 LIMITER
V111A ½ 6T8 RATIO DET.

T201 4.5MC TRANS.
T203 RATIO DET. TRANS.

C204 3.3
C205 47
C218 10
C219 120
R208 27K
C214 1MF 50V
C215 5000

C202 5000
R202 18K
C201
R201 180
C203 1300

R206 100K
R207 100K
C207 4000
R218 47K
R220 270
R175 2.2 MEG
R183 470K
C301 1MF 50V

R215 100K
TEST POINT VI
R205 27K
C206 4000
+250
+250

VII B TEST POINT

V113A ½ 12AT7 SYNC. AMP.
V113B ½ 12AT7 NOISE INVERTER
V116A ½ 12AX7 CLIPPER

C314 .1MF
R323 1MEG
R303 150K
LOCAL
R328 22K
DISTANCE
R302 2.2 MEG.
R171 2MEG
R301 15K

C302 .01 MF
C303 470
R304 470K
R305 470K
C315 .0047MF

C304
R308 180K
R306 10K
R307 22K

9
10
+240V

+250V

SIGNAL CONTROL AGC (REAR APRON)

R403 1200 1W
C404B 40MF 300V
R404 4K 10W
C411 .05MF
R406 5600 5W

+250V
+240V
+200V
+140V HEAD END

C401 X402 300MF
L401 1H
C403A 125MF 350V
R401 4.6Ω 5W
X401
C402 125MF 350V
F401 1.6A "SLOW-BLOW"
117V-60~

I402 YOKE PLUG INTERLOCK
T401
J401 UHF POWER
S401

HEAD END FIL.
6.3VAC.
V120 6V3
V108 21EP4A
V115 6BX7GT
VIII 6T8
V112 6AQ5

PL401 47

V119 25BQ6
V118 12AU7
V116 12AX7
V113 12AT7
V109 6CB6
V110 6AU6

R402 31Ω GLOBAR SEE NOTE:2
V117 12AU7
V114 12BH7
L402 2.2μh
C406 5000
C407 5000
L4 2.2

C412 800
R407 470K
C415 .05MF
C416 800
C417 800

CHASSIS REAR APRON
C413 800
C405 .05MF
C414 800
R405 470K
CHASSIS FRONT APRON

V107 12BH7
V106 6CB6
V105 6CB6
V104 6CB6
L404 1.4μh
L405 2.2
C408 800
C409 800
C410 800

C368 3300
R360 68K
C354 180 800v

V117A ½ 12AU7 HORZ. PHASE DET.
V118A ½ 12AU7 HORZ. REACT.
V118B ½ 12AU7 HORZ OSC.

C355 1000
R354 560K
R353 100K
C351 .02 MF
R355 1MEG.
C375 .001 MF
R359 33K
R352 120K
R356 220K

C358 470
C359 220
R361 68K
R362 27K
C357 .1MF
R363 100K
C353 100

C360 .0018MF
R364 6.8K
C361 1000
L351 HOR. HOLD

11
+240V
12
13

NOTE: 1. ALL RESISTANCES IN OHMS.
ALL CAPACITANCES IN MMFD UNLESS OTHERWISE NOTED.
2. NORMAL VOLTAGE DROP ACROSS R402 = 10 VOLTS.

RF OR IF
TROUBLES

ANALYSIS

Noise or "snow" in the picture is usually associated with conditions external to the receiver. Although low gain in the r-f amplifier may cause a picture of poor contrast, the "snow" associated with it will decrease proportionately. With the normal receiver gain, a noisy picture will probably be the result of inadequate signal at the input terminals of the receiver and/or station trouble. Inadequate signal to the receiver may be due to the use of a wrong type of antenna for the particular receiving conditions, or due to a defective or improper transmission line, or improper orientation of the antenna.

If a built-in or "inside" antenna is used, it may require relocation of the antenna to provide better noise-free reception.

NOISY PICTURE
(Low Signal Strength)

CHECK FOR: 1. Open input circuit and components of receiver input circuit, such as open capacitors, C173, C174 or open transformer, T100.
2. Defective antenna, or antenna transmission line.
3. Antenna orientation.
4. Open filament, V101

6AB4
IST RF

ANALYSIS

This condition results when the sound i-f amplitude is at too high a level at the video detector in reference to the video i-f frequency. It may also be the result of mistuning the receiver or improper i-f alignment.

The "wiggles" which appear like a busy shifting background are caused by the beat frequency which results from the sound i-f carrier and the video i-f modulating frequencies. These beat frequencies pass through the video amplifier and are impressed on the picture tube. The illustration also shows "trailing whites". This results when the receiver is tuned to give the above condition, which raises the sound i-f on the response curve and lowers the video i-f. The lower video i-f response results in an emphasis of the high frequency response in relation to the low frequencies. This sets up a transient response after any black picture element that results in "trailing whites".

WIGGLES IN PICTURE BACKGROUND,
TRAILING WHITES, SOUND NORMAL.
(Maladjusted Tuning Control)

CHECK FOR: 1. Proper tuning of receiver.
2. Alignment of i-f amplifier and associated traps.

ANALYSIS

This condition is either caused by the AGC voltage fluctuating at a regular low frequency rate or by oscillation in the video i-f amplifier. The flutter caused by AGC action is usually the result of an open or improper value of capacitor in the AGC circuit. Specially check capacitor, C151 for correct value of capacity.

Next check for r-f and video i-f alignment as incorrect alignment may result in overall instability. Make sure that the response curves conform to published alignment data.

Check all filament by-pass capacitors in r-f and video i-f circuits.

**PICTURE
FADES
IN AND OUT**

"MOTORBOAT" OR FLUTTER
IN PICTURE AND AUDIO
(Capacitor C151 Disconnected)

CHECK FOR: 1. Open by-pass, C151 on AGC bus.
2. Open AGC filter capacitor C180.
3. Alignment of r-f and video i-f amplifiers.

ADDITIONAL NOTES:
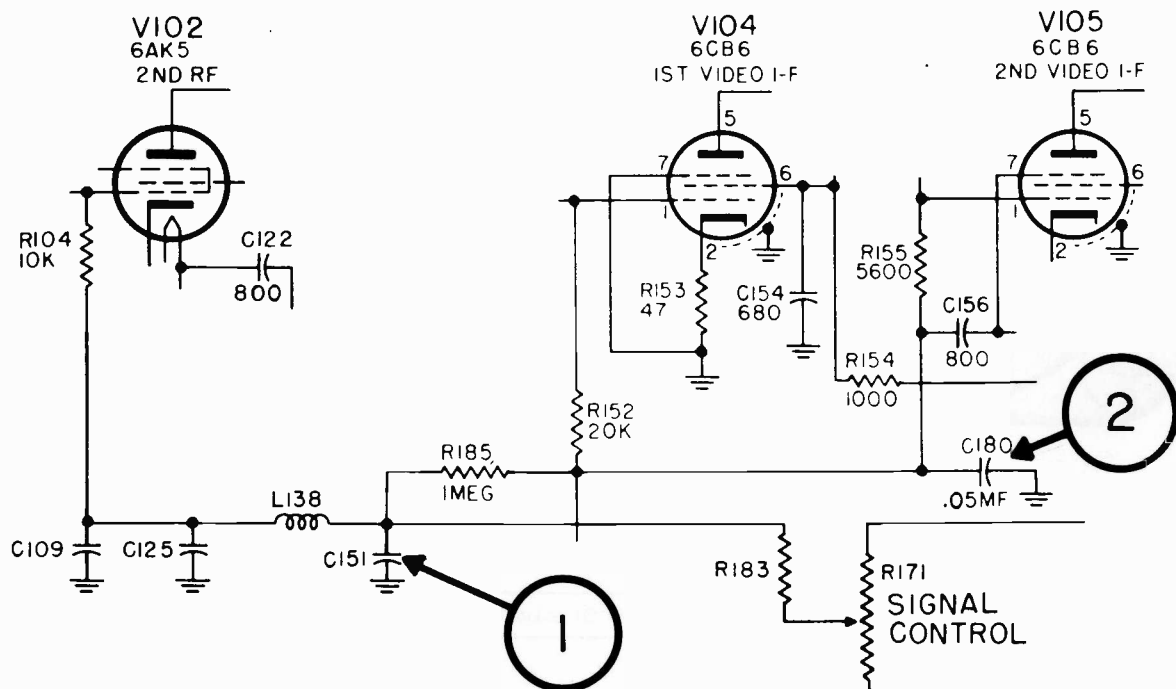
RF OR IF
TROUBLES
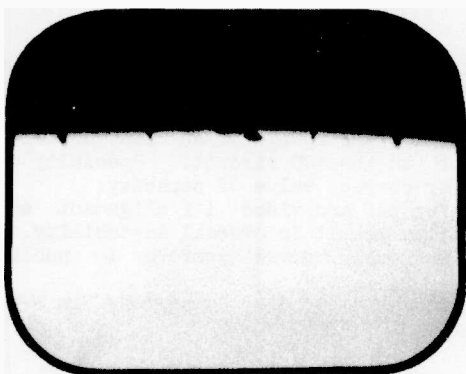
LIGHT AND DARK AREA IN PICTURE, VERT.
SYNC OUT, HUM IN SOUND
(Cathode Of V106 Shorted to Filament)

ANALYSIS.

The condition illustrated is an extremely severe case of hum modulation in the i-f amplifier. In less severe cases, the condition may permit visibility of complete picture except that it may have dark and light horizontal shadow areas. In severe cases the picture will sync out-of-vertical and usually cannot be brought into sync by readjustment of the control. Since this trouble occurs before the video amplifier, it may also be heard in the audio.

Hum modulation in intercarrier receivers is usually due to heater-to-cathode leakage. If heater cathode leakage occurs in the video amplifier or picture tube, the audio system usually will not be affected.

CHECK FOR: 1. Heater-to-cathode leakage, tubes V101, V104, V105, V106, V107 and V108.
2. Defective B+ filter capacitor, C403A.
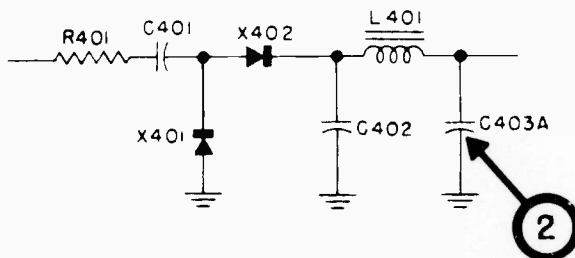
MISCELLANEOUS
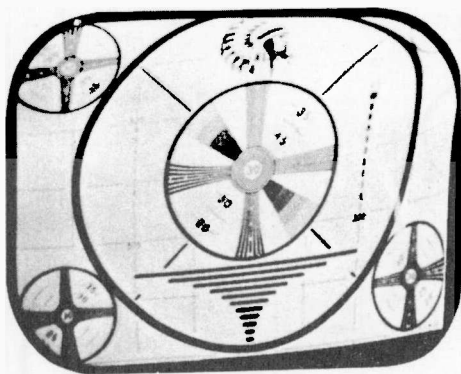
PICTURE PULLED OUT OF SHAPE
ON ONE SIDE OR CORNER
(Maladjustment Of Picture Straightening
Magnets)

ANALYSIS

When a picture is pulled out of shape in one corner or side, it usually indicates improper orientation of the anti-pincushion magnets, the "Picture Straighteners".

CHECK FOR: 1. Proper orientation of the Picture Straighteners.

ANALYSIS

In an intercarrier receiver, as illustrated below, where the sound i-f is taken off immediately after the video detector, the loss of both sound and picture with the raster normal, is probably due to a defect of or prior to the video detector. This may be caused by an inoperative video i-f or r-f stage, local oscillator or converter. A partially operative stage will possibly pass sufficient signal to give weak sound.

First check to see if signal can be passed through the converter stage by applying a video i-f signal to the converter grid. If video i-f and converter circuit is operative, next check for the operation of the local oscillator.

NO SOUND, NO PICTURE, RASTER SATISFACTORY
(DEFECTIVE V103A TUBE)

CHECK FOR:
1. Inoperative local oscillator, V103A.
2. Open video i-f coupling capacitors, C152, C155, C158, C162.
3. Improper or no screen or plate voltage at r-f or i-f tubes due to shorted screen by-pass capacitor or open resistor.
4. Open video detector cyrstal, Y151.

ADDITIONAL NOTES:

VIDEO
AMPLIFIER

ANALYSIS

It will be assumed in this case that the lack of picture is due to a defective video amplifier circuit. Since the sound i-f is taken off at the video detector as illustrated, when the sound is normal, it would indicate that probably the r-f, video i-f, and detector circuits are working properly.

With the receiver tuned to an operating station, check with an oscilloscope where the signal is lost between the video detector and picture tube grid. Use the published waveforms for comparison in regards to shape and amplitude of signal at check points.

Check B+ voltages at the plates. Since the tubes in the diagram below are connected in cascade, tube V107A is dependent upon proper conduction of tube V107B for operating voltages. Check for shorted capacitor, C403C in cathode of V107B. A short at this point would lower the B+ voltage on the plate of V107A. Check for grid-to-cathode short in picture tube.

NO PICTURE, SOUND SATISFACTORY, RASTER
SATISFACTORY
(Capacitor C170 Open)

CHECK FOR: 1.   Open compensating choke, L165.
2.   Shorted capacitor, C403C in cathode V107B.
3.   Open input coupling capacitor, C170 to tube V107A.
4.   Open plate resistors at tube V107A or V107B. Check plate voltages.
5.   Short of grid to cathode in picture tube.

ADDITIONAL NOTES:

VIDEO
AMPLIFIER

ANALYSIS

This condition makes the picture appear out of focus although close examination of the individual line structure of the picture will indicate that the focus is satisfactory. This loss of picture clarity is most noticeable as a blurring of the vertical wedge of the test pattern under normal receiving condition and indicates the loss of high frequencies. The fact that the blacks stand out satisfactorily without trailing whites indicates that the low frequency response is satisfactory.

A loss of high frequencies may be due to a defective component (peaking coil, plate load resistor) in the video amplifier or misalignment of the video i-f or r-f circuits.

Since the compensating chokes in the video amplifier are principally used to maintain the high frequencies, they should also be checked for shorts or open circuit. Also check plate resistor values.

Alignment of the video i-f should be checked to make sure that the bandwidth of the response curve coincides with the recommended curves shown in the service notes.

LACK OF PICTURE DETAIL,
FOCUS SATISFACTORY
(Resistor R170 Increased To 10,000 Ohms)

CHECK FOR: 1. Shorted compensating chokes, L161, and L164.
2. Open chokes L161, L164 and L166.
3. Increase in value of resistors, R162, R167 and R170.
4. Alignment of the video i-f amplifier.

ADDITIONAL NOTES:

VIDEO
AMPLIFIER

ANALYSIS

This condition is the result of a loss of low frequencies in the video amplifier.

It may be the result of too low a value of plate resistance in either of the video amplifier tube sections. Check the resistance value against published data.
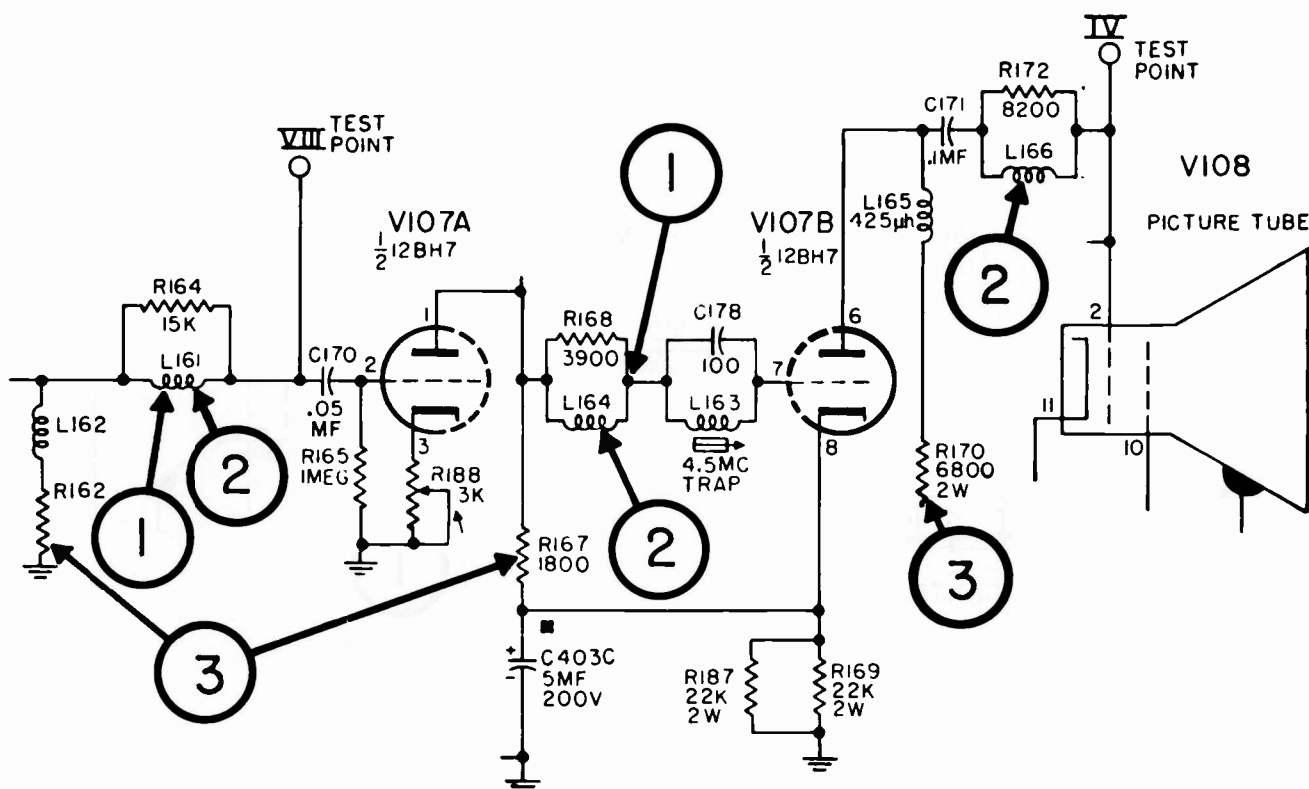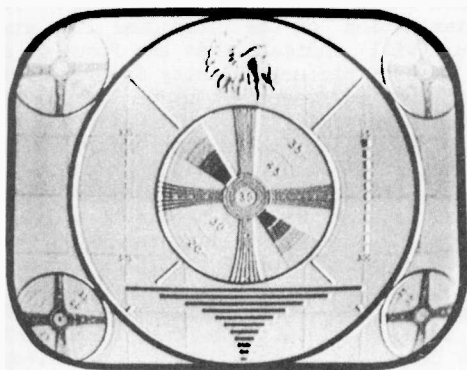
TRAILING WHITES
(Resistor R162 Reduced To 1200 Ohms)

CHECK FOR: 1.   Decrease in resistor values of R162, R170, R167 and R173

ADDITIONAL NOTES:

ANALYSIS

If the Horizontal Hold control will permit a proper horizontal speed condition but the sync is weak or non existant, it usually indicates that the AFC discriminator speed or control tube circuit is defective. First start checking at the discriminator for proper waveform. If the waveform does not check against published data, it may be due to an open or leaky capacitor or defective resistor. Since the discriminator circuit is a high impedance circuit, it may be caused by a leaky capacitor, C368 or C352 or an off-value in one of the resistors. Improper value of bias applied to the control tube will weaken the sync pull-in capabilities of the system.

If the control will not permit the sweep oscillator to go through a synced position as the control is adjusted, a check should be made that the sweep generator is running at approximately the frequency of 15,750 cps. If it is not, check the frequency-determining components of the sweep generator. Check all d-c voltages at the sweep oscillator tube, then check for correct waveform in the signal circuits.

WEAK OR NO HORIZONTAL SYNC; VERT. SYNC, PICTURE AND SOUND SATISFACTORY
(Open Capacitor C368)

CHECK FOR:
1. Sync amplitude at input to discriminator tube, V117A.
2. Bias and plate voltage on control tube V118A.
3. Sine-wave oscillator components, L351, C361, C358, C359 and R362.
4. Leaky or shorted capacitors, C368 and C355.
5. Waveform feedback components, C356, R358, R365 and C352.

ADDITIONAL NOTES:

SYNC
TROUBLES

ANALYSIS

Assuming that the picture and sound information is present, it eliminates the signal amplifying circuits such as the r-f, i-f and video amplifier, as a source of trouble. Since the sync for both the vertical and horizontal sweep circuits is unsatisfactory the logical source of trouble is the clipper or sync amplifier stages which are common to both sync circuits. Because AGC voltage is partially derived from the clipper grid circuit, an inoperative sync amplifier tube will result in too little AGC voltage change, possibly causing picture overload on strong signals.

Since weak sync usually indicates that some sync is available, the best procedure is to first check the sync waveform at the input to the sync amplifier for amplitude and shape as compared to published data, check waveform thru sync amplifier and clipper circuits, measure the socket voltages and resistances and then look for defective components.

WEAK OR NO VERT. AND HOR. SYNC
OTHERWISE PICTURE AND SOUND NORMAL
(OPENED CAPACITOR C314)

CHECK FOR:
1. Open or low capacity of input coupling capacitor, C314.
2. Defective coupling capacitor C302, or C303, to clipper tube.
3. Incorrect value of plate resistance, R307, in clipper.
4. Insufficient amplitude of composite signal applied to sync amplifier from video detector; check video detector circuit.
5. Defective sync amplifier or clipper tubes.

ADDITIONAL NOTES:

ANALYSIS

This condition usually indicates that the vertical sweep generator is not getting sufficient or any sync signal or that the sweep generator is far off-frequency so that it cannot be brought into sync with the signal.

Poor sync may be the result of either a defective integrating circuit which precedes the sweep generator or a defective component in the sweep generator circuit. The latter usually will show up in other ways as improper height, etc.

The most effective trouble shooting is to check the integrated sync signal against published data by means of an oscilloscope. Also check the socket voltages of the sweep generator. Check the approximate operating frequency of sweep generator by observing the station pattern on the picture tube. Rotate the Vertical Hold control to see if the pattern can momentarily be held in proper position vertically.

NO VERTICAL SYNC,
HORIZONTAL SYNC SATISFACTORY
(VERT. HOLD CONTROL MALADJUSTED)

CHECK FOR:
1. Sync pulse at input to sweep generator.
2. Sweep generator frequency, if far off from 60 cps, check sweep generator components. such as C309 and R313.
3. Leakage in feedback capacitor, C308.

ADDITIONAL NOTES:
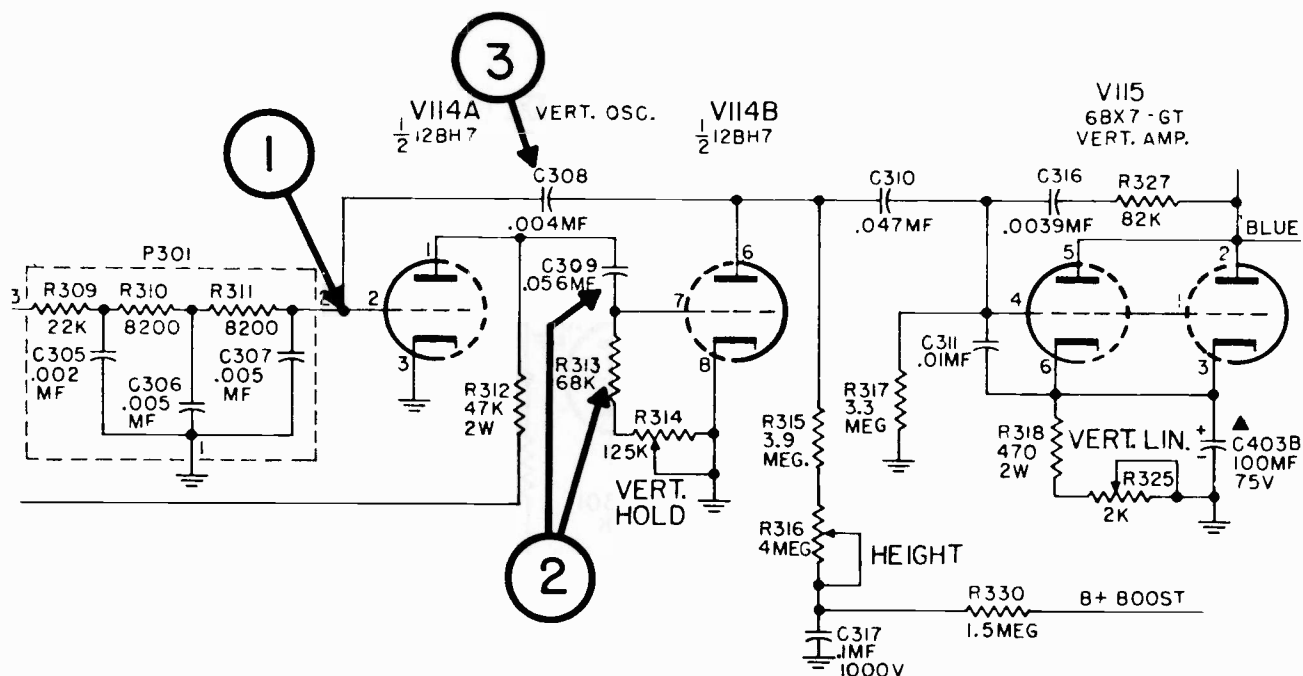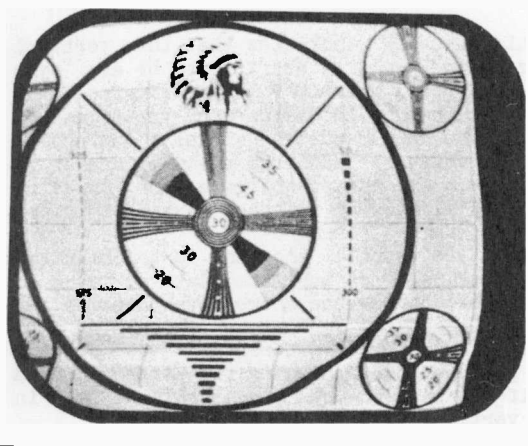
SYNC
TROUBLES

PICTURE DISPLACED TO LEFT
RIGHT EDGE WAVY
(CAPACITOR C303 REMOVED)

ANALYSIS

This is a specific condition caused by a defective capacitor that couples the sync amplifier to the clipper.

Since this capacitor C303 has to pass the horizontal sync pulse, when it is open, the sync pulse will be integrated through the resistor, R304. This integrated pulse causes a delay in the sync which shifts the picture to the left. With the weakened horizontal sync pulse, the sync is influenced by the black transmission of the picture that causes the wavy edge in the picture. It appears as though the "black" picture elements pull the picture out of shape.

CHECK FOR: 1. Open or low value of capacitor, C303.

ADDITIONAL NOTES:

ANALYSIS

This condition is the result of blocking of the horizontal sweep generator. It usually is brought about by improper operating bias on the horizontal sweep oscillator tube caused by open, leaky, or shorted components in the grid bias circuit.

A ready check to determine whether this is the source of the trouble is to observe the waveshape with an oscilloscope across the sine-wave oscillator tank circuit of tube V118B.

If the amplitude and waveshape does not check with published data, the components R364 or C360 should be checked.

HORIZONTAL SYNC OUT,
BRIGHT BAR OR BARS IN PICTURE
(OPEN CAPACITOR C360)

CHECK FOR: 1. Shorted, open or leaky capacitor, C360.
            2. Improper value resistor, R364.

ADDITIONAL NOTES:

SYNC
TROUBLES

ANALYSIS

This condition represents a high frequency "hunt" in the horizontal sweep oscillator circuit.

Although it may be the result of the normal variation in transmitting station pulse generators or in the receiver sweep circuit, it is an indication that the receiver AFC circuit is not functioning properly.

The anti-hunt circuit at the AFC control tube, V118A is shown below and if the resistor R359 or capacitor, C357, were open or considerably off-value, the trouble shown above would result.

"GEAR TOOTH" EFFECT
(OPENED CAPACITOR C357)

CHECK FOR: 1.   Open or low value capacity of C357.
             2.   Open or high resistance of R359.

ADDITIONAL NOTES:

V118A
½ 12AU7
HORZ. REACT.

V118B
½ 12AU7
HORZ. OSC.

R355 1MEG.
C358 470
C360 .0018MF
C359 220
R364 68K
C375 .001 MF
R361 68K
R362 27K
C361 1000
R359 33K
C357 .1MF
R363 100K
C353 100
L351 HOR. HOLD

ANALYSIS

This condition shows a lack of sync system noise immunity due to failure of the noise inverter circuit. This may be caused by excessive inverter cut-off bias or the absence of the required cathode input signal. The picture shown represents a highly exaggerated condition which was done to better demonstrate the effect. This was accomplished by feeding a 1-inch spark signal into the 1-f amplifier, with the noise inverter biased off by shunting R302 with a 100,000-ohm resistor.

NOISE "TEARING" PICTURE
(See text).

CHECK FOR: 1. Low value, R302
2. Open C301
3. Open or high value, R301

ADDITIONAL NOTES:

V113A
½ 12AT7
SYNC. AMP.

V113B
½ 12AT7
NOISE INVERTER

C302   C303

L168   L167   R166

V116A
½ 12AX7
CLIPPER

C177

C169

R303   R328

LOCAL

DISTANT
SWITCH

R302
R301

250V

R171
SIGNAL
CONTROL

R183

R304

R305

C315

R175

R185

C151   C180

TO
VIDEO
1-F GRIDS

C301

A.G.C.
TO
R-F TUNER
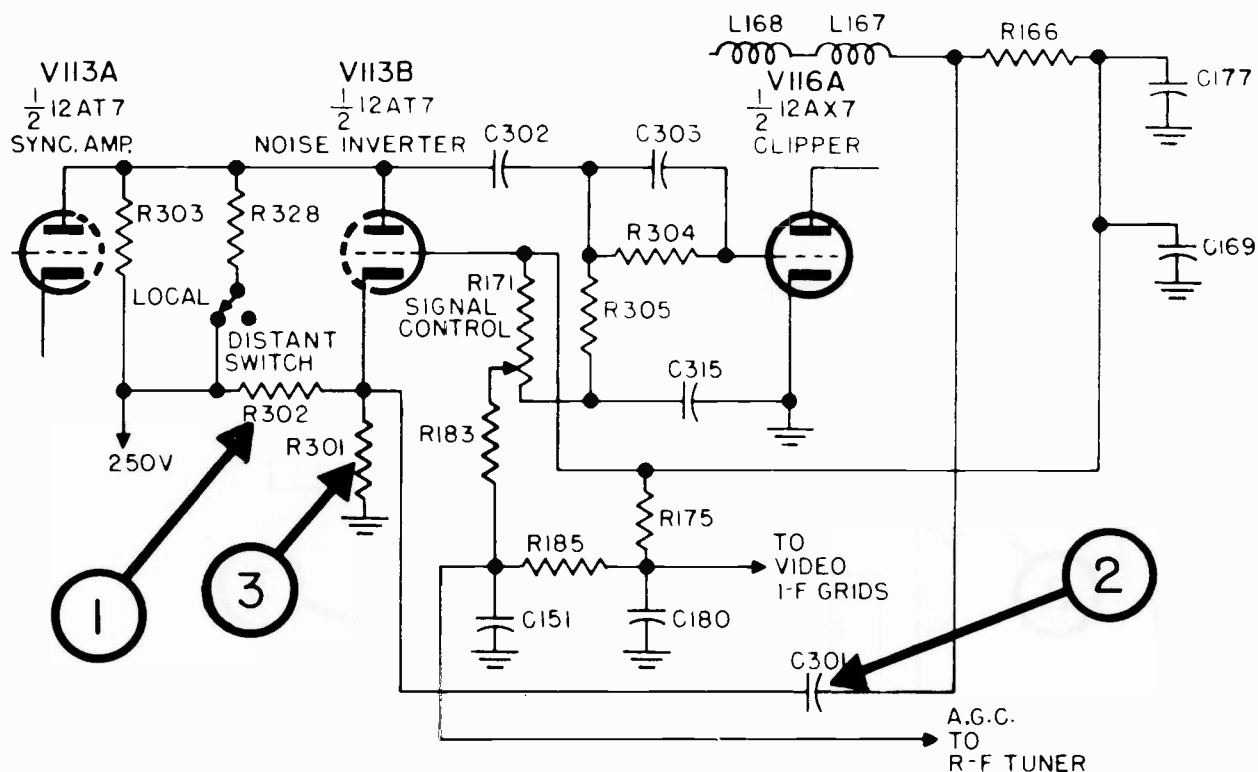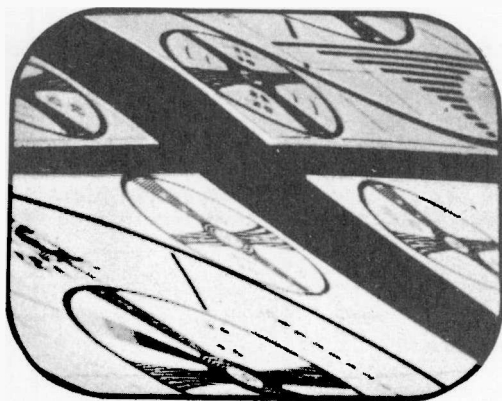
SYNC
TROUBLES

NO HORIZONTAL OR VERTICAL SYNC
(R302 OPENED)

ANALYSIS

This condition, aside from being caused by troubles in the sync amplifier or clipper, may be due to improper noise inverter (canceller) operation. Any component failure which causes an upset of the normal operating bias on this stage will cause it to partially or completely remove the sync pulses from their respective pedestals. The receiver may then lose sync completely or depending upon the degree of difficulty, may attempt to lock on the leading edge of the blanking pedestals. This will cause a shifting or warping of the picture. An oscilloscope connected to test point IX will show the absence of sync pulses which normally would be situated on top of the blanking pedestals.

CHECK FOR:
1. Open or high value of R302
2. Low value R301
3. Leaky or shorted C301
4. Shorted C169 or C177

ADDITIONAL NOTES:

ANALYSIS

When the picture size is reduced considerably by a component or circuit defect, the vertical linearity will probably also be affected. This is particularly true when component failure in the linearity circuit occurs.

Waveshape analysis by oscilloscope will give the most positive isolation of the trouble. Waveshapes should be taken and compared with the published data. Check all components in the sweep output circuit.

POOR VERTICAL LINEARITY,
INADEQUATE HEIGHT
(DEFECTIVE V115)

CHECK FOR:
1. Low emission of sweep output tube, V115.
2. Improper grid input "drive" voltage at V115.
3. Defective sweep output transformer, T301.
4. Low B+ voltage to sweep output tube V115.
5. Low value of cathode capacitor, C403B.

ADDITIONAL NOTES:
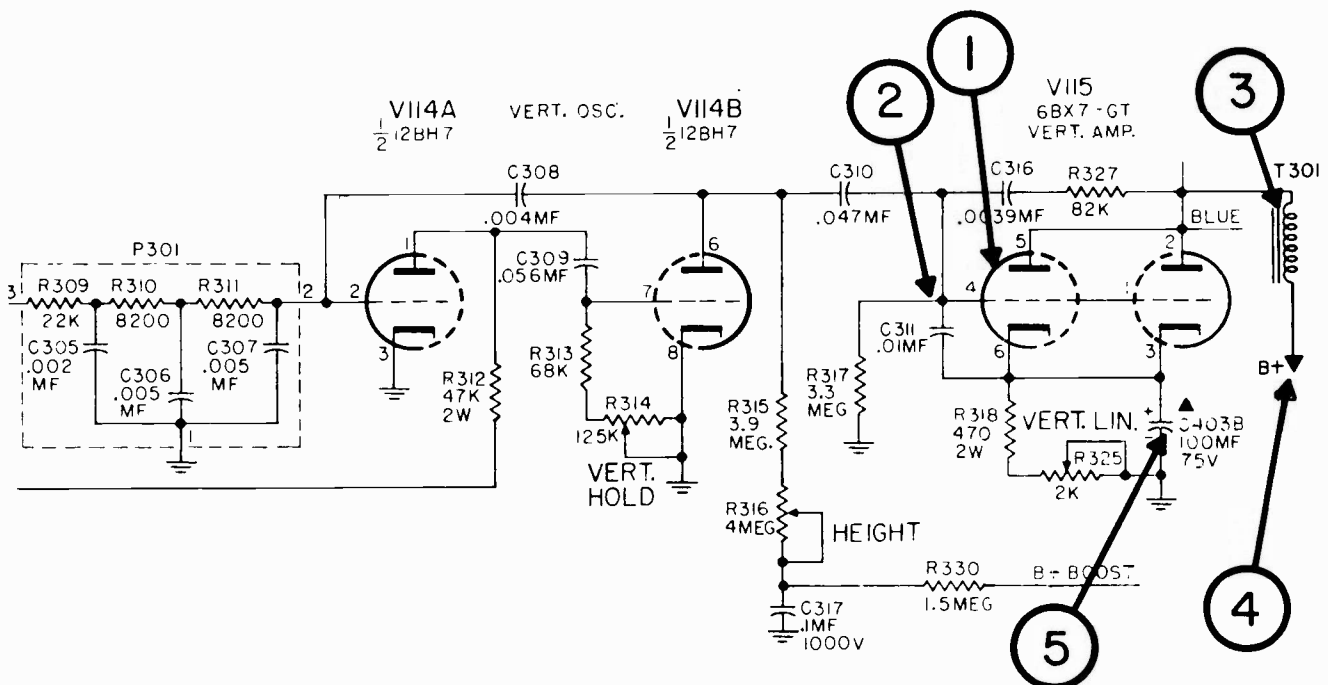
VERTICAL
DEFLECTION
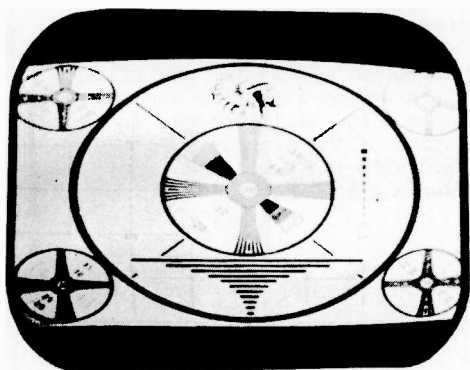
INADEQUATE PICTURE HEIGHT
(MALADJUSTED HEIGHT CONTROL)

ANALYSIS

This condition is either due to low power output from the vertical sweep output tube circuit or to inadequate sweep voltage generated by the sweep oscillator.

First measure the amplitude and waveshape of the sweep generator output by an oscilloscope.

If the drive voltage at this point is normal, then the sweep output stage is probably at fault. This may be due to a defective tube, output transformer or improper operating voltages.

CHECK FOR:
1. Rise in resistance value of sweep generator plate resistor, R315.
2. Defective sweep output transformer, T301.
3. Incorrect value of plate, or grid voltages on output tube, V115.
4. Low value capacitor in cathode of sweep output tube, C403B. (This usually results in poor linearity.)
5. Weak vertical deflection tube, V114 or V115.

ADDITIONAL NOTES:
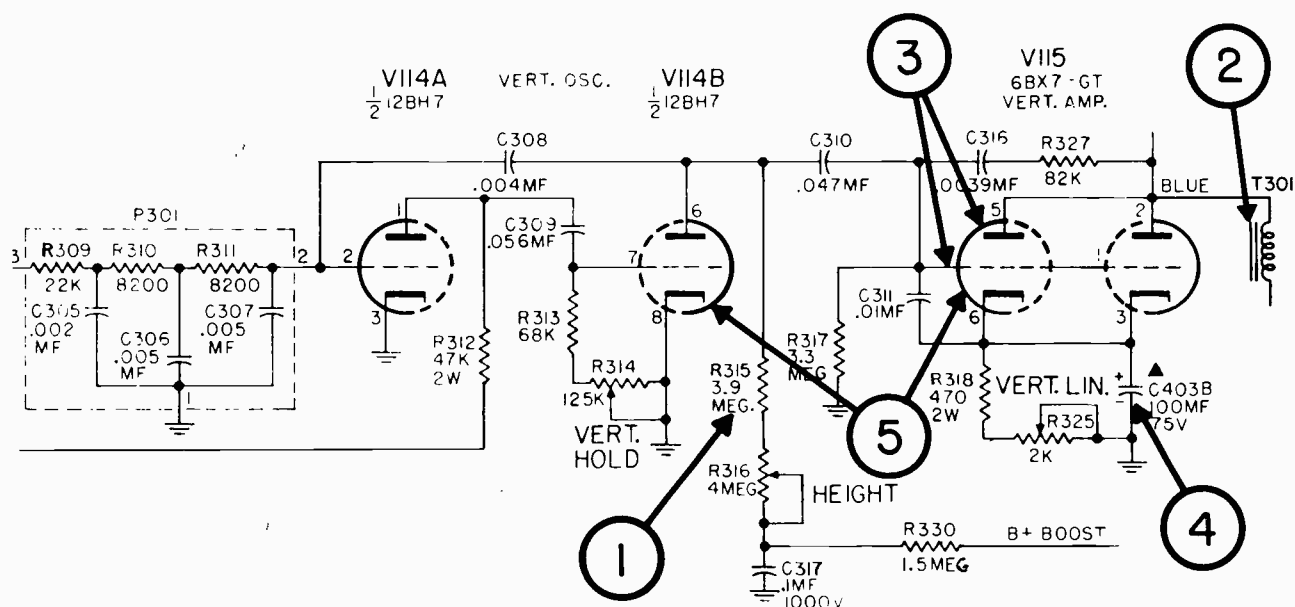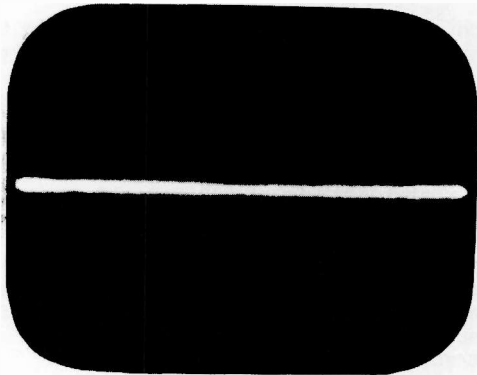
ANALYSIS

A single horizontal white line indicates that no vertical deflection magnetic field is being produced.

This can be caused by a failure in the vertical deflection system such as the sweep generator, the sweep output tube, or an open sweep output transformer or vertical deflection coils of the yoke.

The quickest method of isolating the trouble is to start checking with an oscilloscope at the vertical sweep generator for the proper waveforms and working back through the vertical sweep output circuit.

By noting where the waveform is lost, the trouble may be isolated rapidly.

NO VERTICAL DEFLECTION
(OPEN VERTICAL DEFLECTION COIL)

CHECK FOR:
1. Open vertical deflection coils, D301.
2. Defective sweep output transformer, T301.
3. Vertical sweep tubes, V114 or V115 not operating.
4. Poor contacts in yoke plug.

ADDITIONAL NOTES:
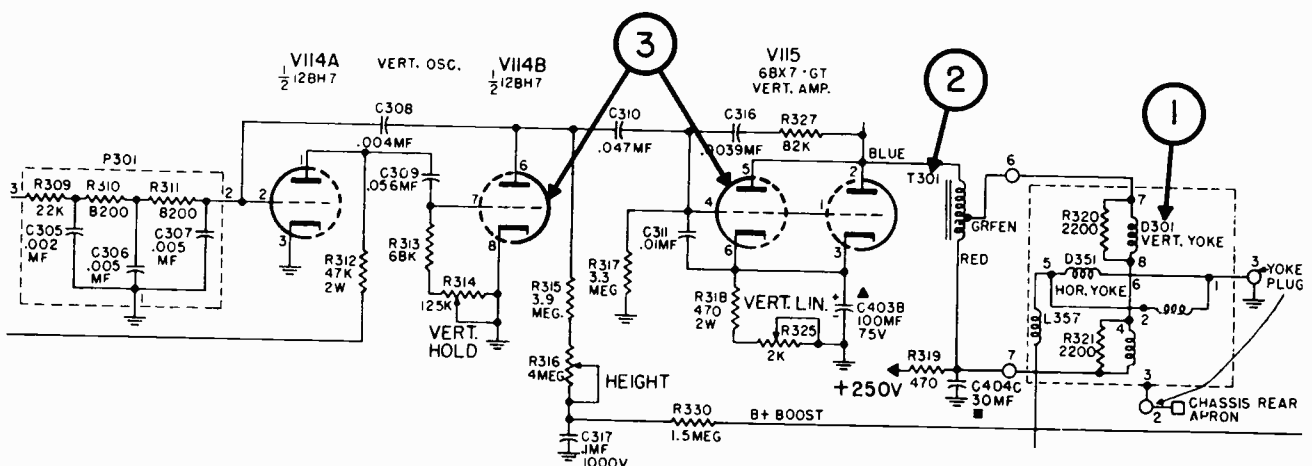
VERTICAL
DEFLECTION
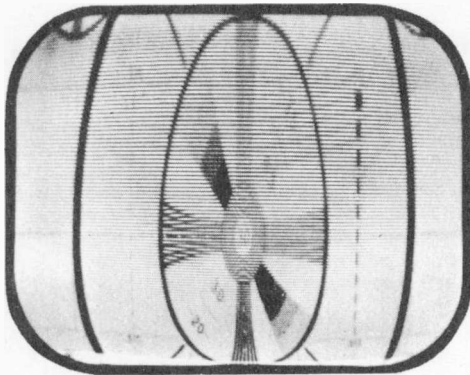
POOR VERTICAL LINEARITY,
FOLD-OVER AT BOTTOM OF PICTURE,
PICTURE HEIGHT EXCESSIVE
(LEAKY CAPACITOR C310)

ANALYSIS

The condition shown in the picture, results when the coupling capacitor, C310, to the vertical sweep amplifier becomes leaky.

This results in B+ voltage through the plate circuit of the vertical oscillator tube being applied through this capacitor to the grid of V115. This increases the height of the picture the same way as a reduction of the resistance in the plate circuit of V114B would do. With any excessive increase in height, the linearity is affected as well.

A similar condition will result when the capacity value of the charging capacitor, C311, is lower than the recommended value. Check by replacing the capacitor with the correct value.

Check socket voltages and waveforms of V114.

CHECK FOR: 1. Leaky capacitor, C310.
             2. Low value of charging capacitor, C311.
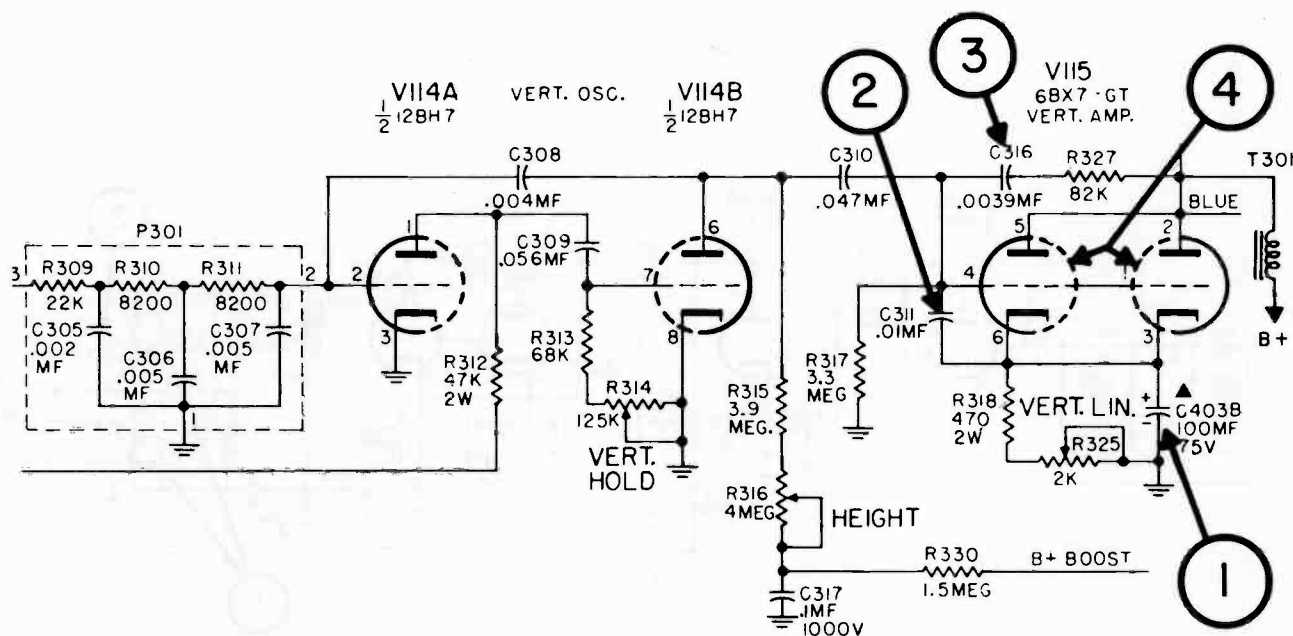
ADDITIONAL NOTES:

ANALYSIS

This results in a portion of the picture being elongated vertically out of proportion to the remainder of the pattern. Although this may be caused by improper operation of any part of the vertical deflection system, in most cases it is the result of improper operation of the vertical sweep output stage.
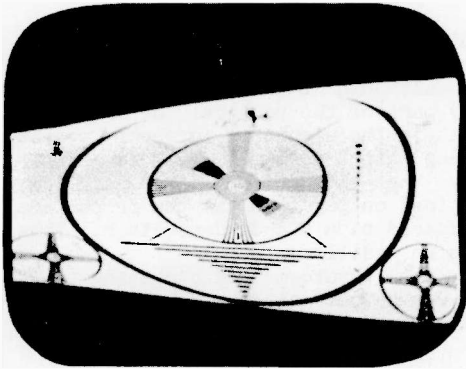
First check that the drive voltage applied to the grid of the vertical output tube has the proper amplitude and shape as compared to a standard receiver. This check may be made with an oscilloscope.

Next check the waveforms and operating voltage at the vertical sweep output stage. Check components in sweep output circuit.

POOR VERTICAL LINEARITY
HEIGHT SATISFACTORY
(MALADJUSTED VERTICAL LINEARITY CONTROL)

CHECK FOR:
1. Linearity control components such as cathode capacitor, C403B, for leakage or improper value.
2. Low value capacitor C311.
3. Leaky capacitor C316.
4. Vertical output tube, V115.

ADDITIONAL NOTES:

VERTICAL
DEFLECTION

ANALYSIS

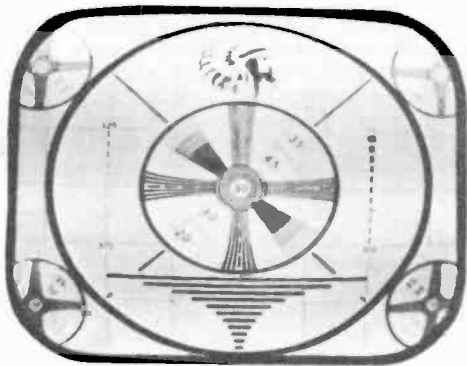This condition indicates that one of the vertical deflection coils is not producing the same amount of flux as the other series coil. This results in a narrowing of the picture at either the left or right side of the screen.

Since the vertical coils usually have a resistor across each series coil, the first check should be for a defective resistor and then check the coil. Shorted turns in the deflection coil will have the same effect but will probably not show up on a resistance check, so that the proper procedure would be to substitute a new yoke. Narrowing of the picture takes place on the same side that the defective coil occupies in the yoke assembly around the neck of the picture tube.

VERTICAL KEYSTONING
(SHORTED VERTICAL DEFLECTION COIL)

CHECK FOR: 1. External short across deflection coils.
                  2. Defective vertical deflection coil, D301.

ADDITIONAL NOTES:

ANALYSIS

Too great a sweep width may be caused by an inoperative (open) width control or too much drive at output tube.

First check that Width control changes pattern size. Check for "drive" waveform at grid of output tube against published data. Low picture tube anode voltage will result in too great sweep width; however, this condition will also cause the vertical sweep height to be abnormally great.

Waveform analysis by an oscilloscope with reference to published data is most helpful in locating the trouble. Check anode voltage of picture tube for proper value.

TOO GREAT SWEEP WIDTH
RECEPTION NORMAL OTHERWISE
(MALADJUSTED WIDTH CONTROL, L352)

CHECK FOR: 1. Open Width control, L352.
            2. Open winding between lugs 6 and 8 in T351.

ADDITIONAL NOTES:
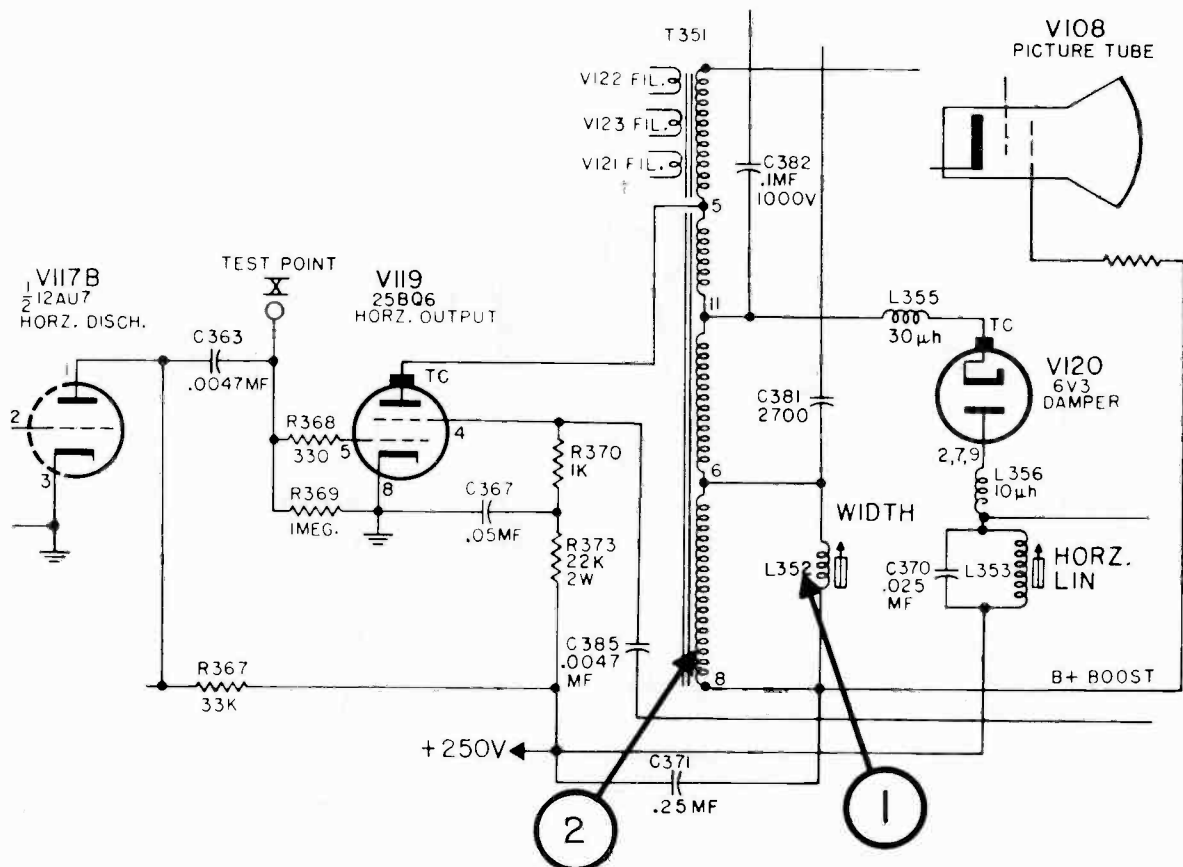
HORIZONTAL
DEFLECTION
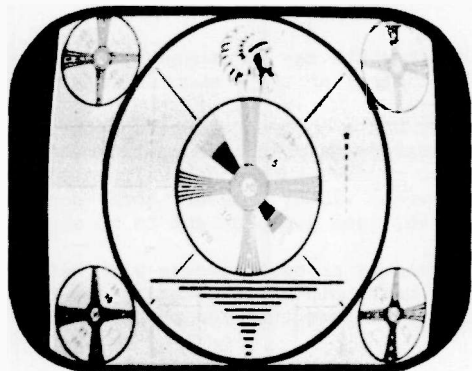
INADEQUATE SWEEP WIDTH
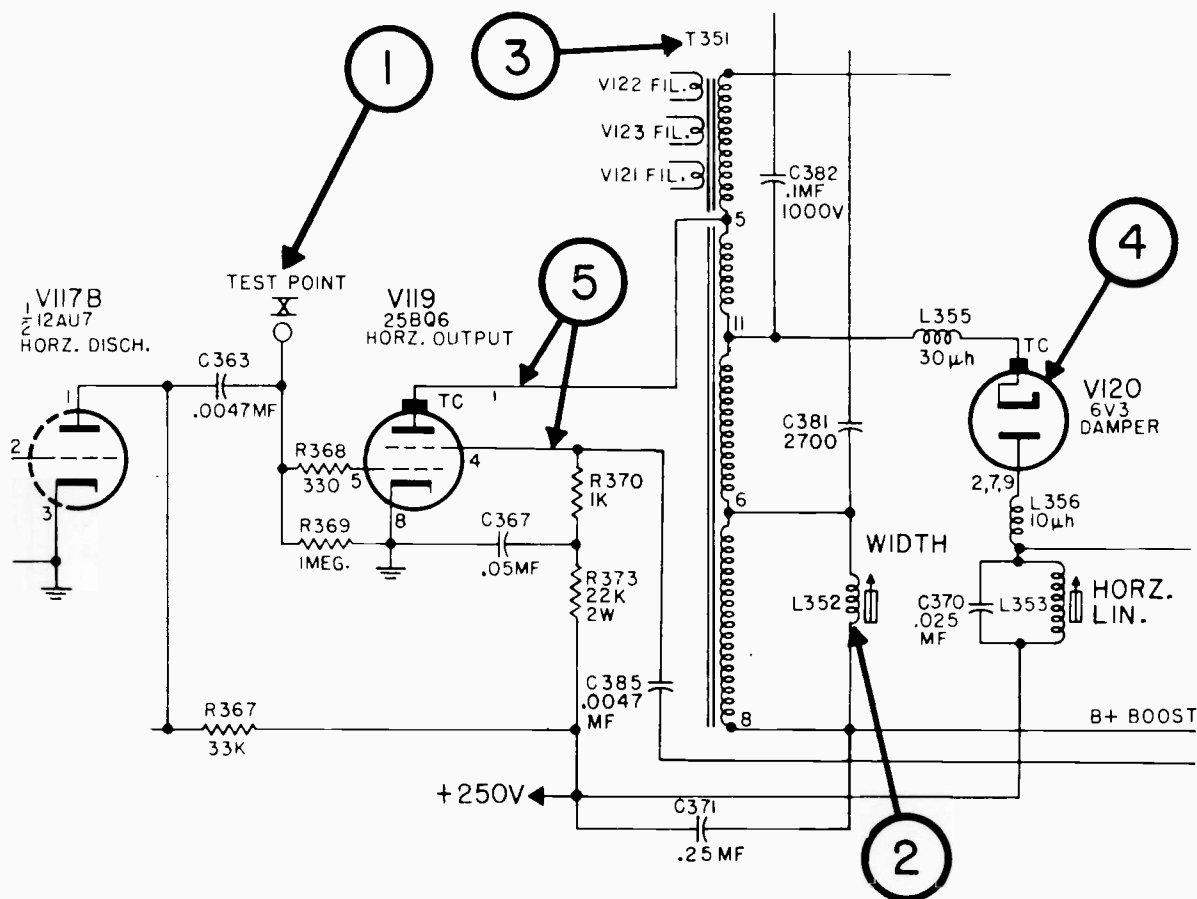(MALADJUSTMENT OF WIDTH CONTROL)

ANALYSIS

Inadequate sweep width indicates low power output from the horizontal sweep output tube circuit or a defective component associated with this output circuit. Since the power output from the horizontal deflection circuit is dependent upon the sweep "drive" voltage applied to the stage, a waveform measurement of amplitude and waveshape should be made with an oscilloscope and compared with published values.
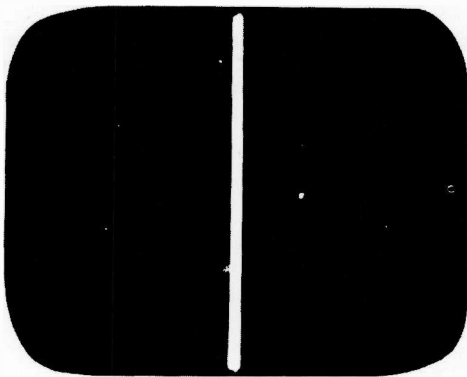
If this checks satisfactory, output circuit components should be checked. Check for resistance changes or defective capacitor values. Waveform analysis at various points of the output circuit will be found most helpful.

Check screen and B+ boost voltages of output tube, V119.

CHECK FOR:
1. Correct waveshape and amplitude of input "drive" voltage at test point "X".
2. Shorted Width Control L352 or defective deflection coil, D351.
3. Defective output transformer T351 - shorted turns or arc-over.
4. Low emmission of damper tube V120.
5. Low B+ voltage to plate or screen of output tubes V117B, V118B, V119.
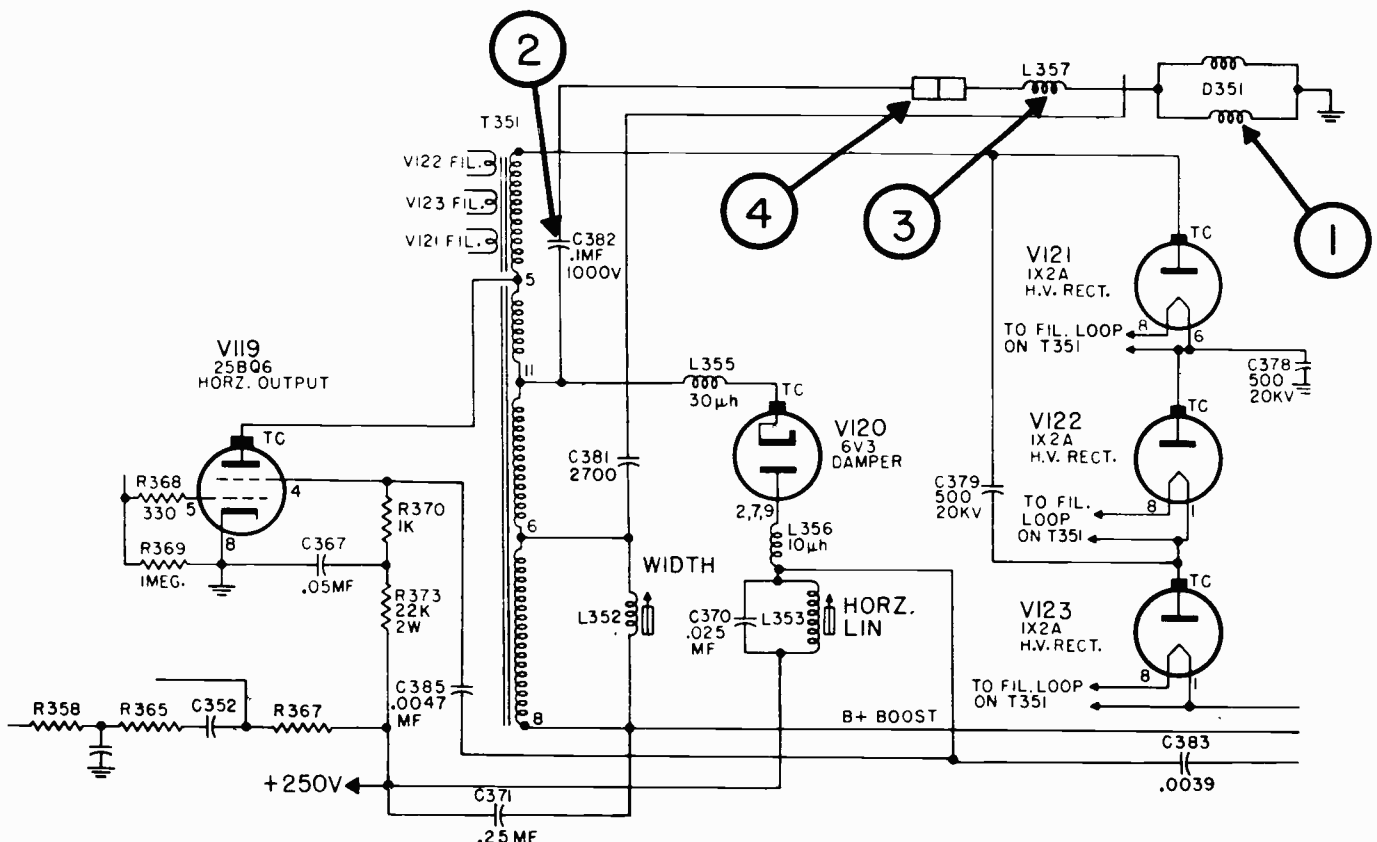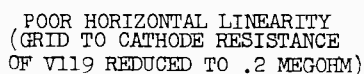
ADDITIONAL NOTES:

ANALYSIS

With the picture tube high voltage derived from the horizontal sweep output circuit, practically all sweep output troubles will result in the absence of high voltage on the picture tube, so that no raster is produced. The only exception to this condition is with an open deflection coil when a single white line as shown will be obtained.
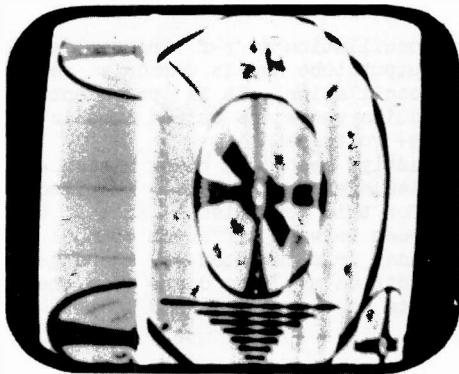
Checking for proper waveform at signal points of the horizontal sweep output circuit will provide the quickest isolation of trouble.

SINGLE VERTICAL LINE IN CENTER,
SOUND NORMAL
(Open Horizontal Deflection Coils)

CHECK FOR: 1. Open horizontal deflection coils, D351.
2. Open capacitor C382.
3. Open choke, L357.
4. Open yoke plug connection.

ADDITIONAL NOTES:

HORIZONTAL
DEFLECTION

ANALYSIS

An elongation of any portion of a test pattern in relationship to the remainder of the pattern is termed non-linearity. When trouble is experienced, first establish whether the linearity control is operating, i.e., changes linearity of pattern.

POOR HORIZONTAL LINEARITY
(GRID TO CATHODE RESISTANCE
OF V119 REDUCED TO .2 MEGOHM)

CHECK FOR: 1. Shorted linearity control, L353.
             2. Defective feed back capacitor C385.
             3. Defective yoke, D351.
             4. Defective capacitors C370, C371.

ADDITIONAL NOTES:

HORIZONTAL LINEARITY POOR,
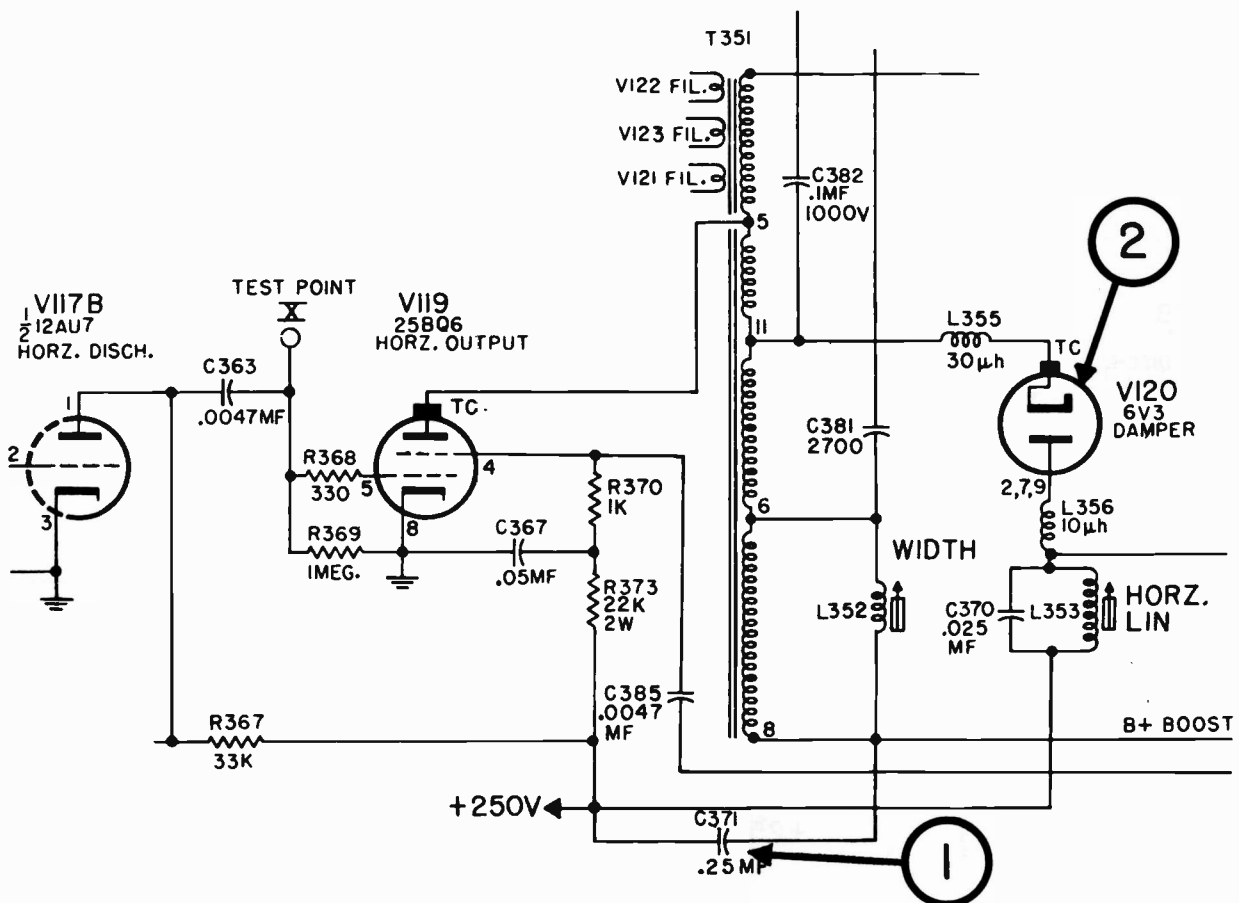BRIGHT VERTICAL BARS, INADEQUATE WIDTH
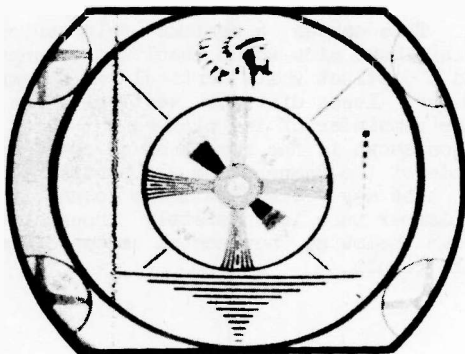(OPEN CAPACITOR C371)

ANALYSIS

This condition is associated with improper horizontal damping. This causes a serious foldover of the picture on the left-hand side which results in elongation of left edge and a distinct white vertical bar appears to the left of center. Less distinct vertical bars may appear across the remainder of the picture.

The condition shown is the result of an open capacitor in the cathode of the damper tube. A partially inoperative damper tube may cause a similar condition although when the damper tube is completely inoperative in the circuit shown below no horizontal sweep output or high voltage will result.

CHECK FOR: 1. Open or low value of capacitor, C371.
                2. Defective damper tube, V120.

ADDITIONAL NOTES:

HORIZONTAL
DEFLECTION

ANALYSIS

This is an oscillation at r-f frequencies of the horizontal sweep output tube and is commonly referred to as a "Barkhausen" oscillation. It is prevalent in horizontal output circuits where the output tube is supplied by relatively low B+ voltages.

It is most readily seen on a blank raster and sometimes disappears when a strong signal is received.

A good check for this condition is that it shifts in position on the screen between different channel positions and also is influenced or eliminated by a change in output tube. This condition may also occur when the deflection system is run to an excessive sweep width.

BLACK "BEADY" VERTICAL LINE
OR LINES, RECEIVER NORMAL
(Defective Hor. Output Tube V119)

CHECK FOR: 1.   Sweep output tube, V119.
               2.   Sweep output transformer, T351.

ADDITIONAL NOTES:
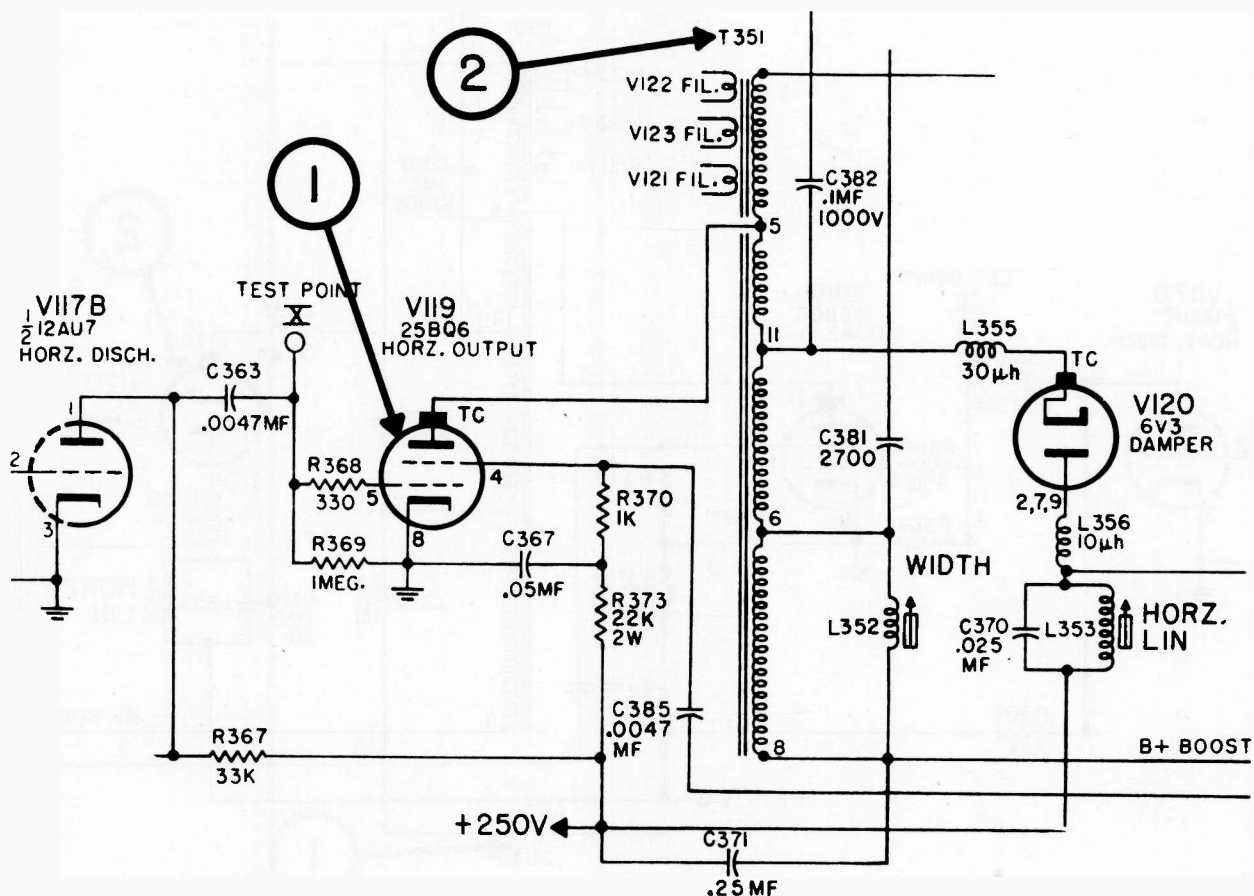
ANALYSIS

It is assumed that the lack of a raster is due to the absence of high voltage at the picture tube 2nd anode. First check for high voltage at the 2nd anode of the picture tube. Check the H.V. rectifier tubes by substitution. If these checks do not indicate the source of trouble, then additional checks in the horizontal sweep output circuit should be made in the order specified.

In making high voltage measurements use a VTVM with a high voltage probe.

NO RASTER - SOUND SATISFACTORY

CHECK FOR:
1. Shorted capacitor, C378
2. Defective sweep output tube, V119 or damper tube, V120.
3. Defective tubes, V117B, V118B.
4. No voltage at T351 primary.
5. Shorted C371.
6. No screen voltage on V119.
7. Proper waveform at grid of V119.
8. Shorted Width control, L352.
9. Open Linearity control, L353.
10. Defective sweep output transformer, T351.

ADDITIONAL NOTES:
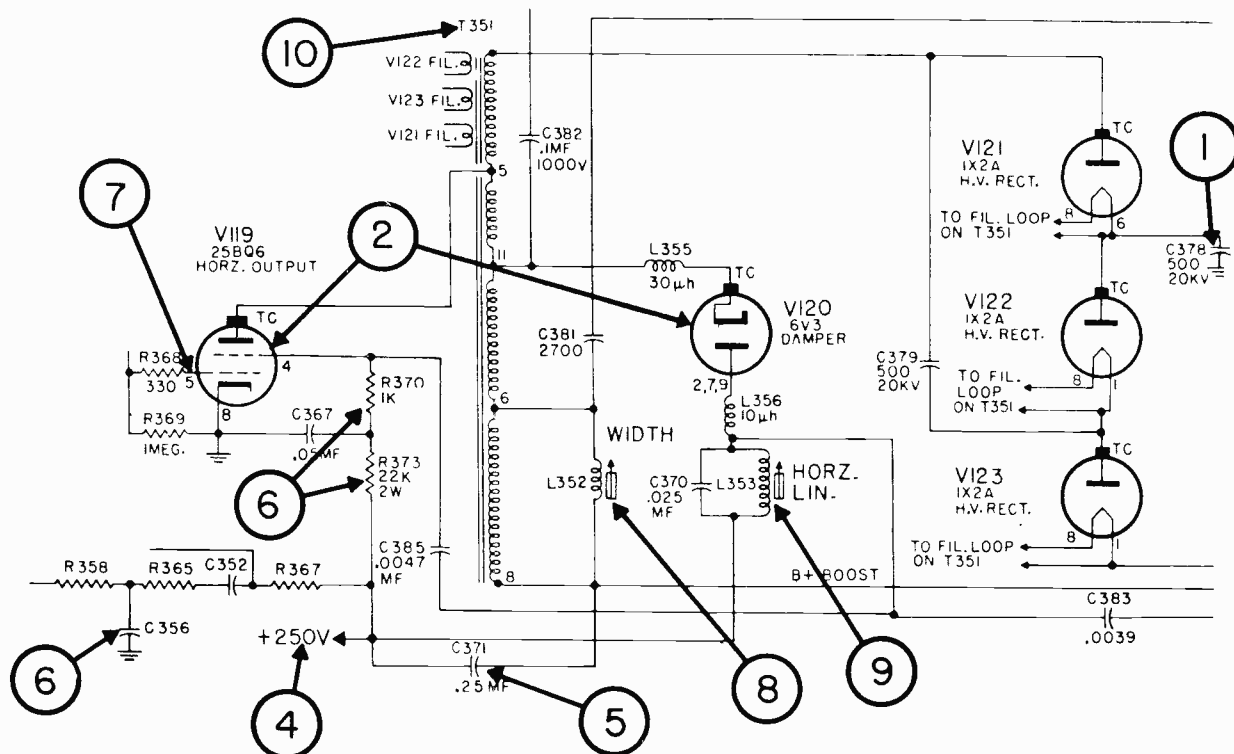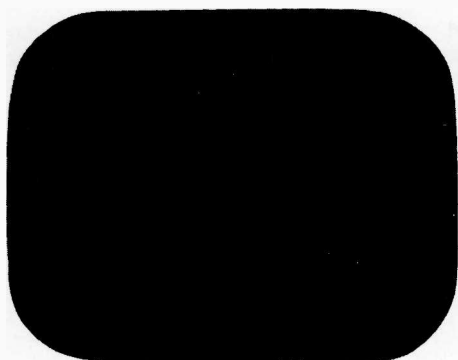
POWER SUPPLY

ANALYSIS

This condition may be due to a defective picture tube, improper voltages applied to any one or more of the picture tube elements, or an improperly adjusted ion trap magnet.

Since the audio is satisfactory, this eliminates a primary power supply failure. However, the trouble may exist in a secondary B+ supply source, such as the B+ boost voltage which is applied to the horizontal sweep output tube and the 1st anode of the picture tube.

As a first check, visually examine the picture tube heater. If it is glowing, the picture tube can be assumed satisfactory, for the moment at least. Next check the high voltage (2nd anode) of the picture tube. If this voltage is normal, try adjusting the ion trap magnet. If adjustment of the trap magnet produces no raster, then check voltages at the 1st anode, cathode and grid of the picture tube. Check for an open Brightness control or open resistor R176. If after checking no definite reason can be found for the lack of a raster then the trouble probably lies in the picture tube and it should be replaced. If in making the foregoing checks,

NO RASTER - SOUND SATISFACTORY

it is found that there is no, or very little, voltage at the 2nd anode of the picture tube, then considerable checking may be necessary in the horizontal deflection system.

CHECK FOR:
1. Open or shorted picture tube heater.
2. No voltage on 2nd anode of picture tube.
3. Improper adjustment of ion trap magnet.
4. Improper or no voltage at 1st anode of picture tube.
5. Improper voltage at cathode of picture tube.
6. Defective picture tube, check by substitution.
7. Shorted capacitor, C369, or open Brightness control, R177.

ADDITIONAL NOTES:
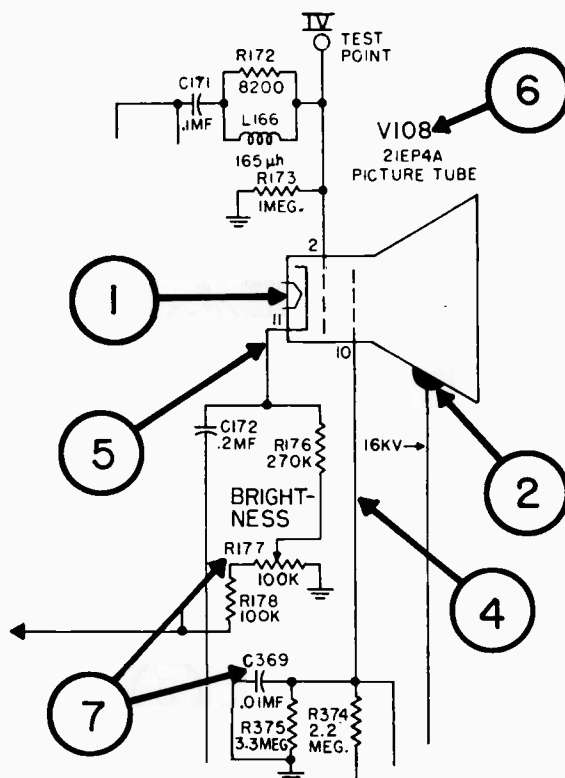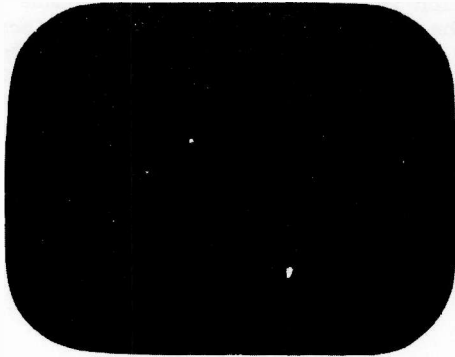
ANALYSIS

This condition usually indicates a power source failure. This may either be in the primary input circuit or due to defective power supply components such as a rectifier unit, filter choke or capacitor. A voltage check will be found most helpful in isolating the trouble; for example check for 115 volt a-c input; check for filament or B+ voltages.

NO RASTER, NO SOUND

CHECK FOR:
1. Power supply interlocks, fuse, or output.
2. Power cord plug and cable.
3. Rectifier components.
4. Selenium rectifier, filter choke.
5. Open tube filament in series filament string.
6. Open input capacitor, C401.
7. Yoke plug not connected.

ADDITIONAL NOTES:

MISCELLANEOUS

BRIGHTNESS CONTROL PARTIALLY OR
COMPLETELY INOPERATIVE
(MALADJUSTED BRIGHTNESS CONTROL)

ANALYSIS

This condition is usually caused by inadequate range of control of the picture tube bias voltage. Since the bias voltage is controlled by the Brightness control, a check should be made of the components in this circuit.

If they are of correct value, check the voltage to the Brightness control circuit. Leakage through the coupling capacitor C171 to the grid of the picture tube will apply B+ to the grid of the pix tube through this capacitor and cause excessive brightness with little or no effect when the Brightness control is turned.

If the above checks do not disclose source of trouble, change picture tube as a "gassy" tube may cause erratic Brightness control operation.

CHECK FOR: 1. Defective Brightness control, R177, or circuit components.
2. Low B+ to Brightness control circuit.
3. Defective (short or leaky) capacitor, C171.
4. Defective (gassy) picture tube.

ADDITIONAL NOTES:

Another

Supreme Publications

Manual