TV

# AUDELS TELEVISION SERVICE MANUAL

PRACTICAL
INSTALLING
TROUBLE-SHOOTING
REPAIRING

by
E. P. ANDERSON

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**PRACTICAL**
**INSTALLING**
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*By*
EDWIN P. ANDERSON

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TELEVISION SERVICE MANUAL



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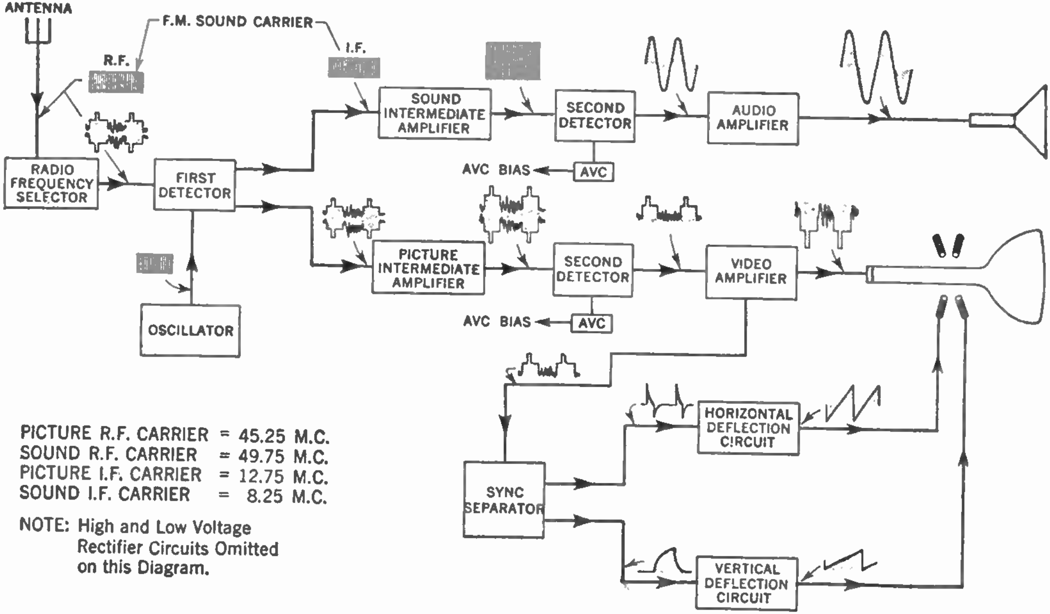


PICTURE R.F. CARRIER = 45.25 M.C.
SOUND R.F. CARRIER = 49.75 M.C.
PICTURE I.F. CARRIER = 12.75 M.C.
SOUND I.F. CARRIER = 8.25 M.C.

NOTE: High and Low Voltage Rectifier Circuits Omitted on this Diagram.

## BLOCK DIAGRAM OF TYPICAL TELEVISION RECEIVER

(For further information on receiver circuit fundamentals, see text.)

# FOREWORD

In preparation of this book the purpose throughout has been to provide a helpful service manual giving information for the television serviceman in determining the causes of faulty reception in television receivers and to enable the serviceman to quickly and efficiently remedy the fault after it has been properly located.

A large number of illustrations of common receiver faults have been given and their causes and remedy clearly explained. The test patterns and their use in receiver fault diagnosis is also fully treated.

Due to the fact that most television receivers require an outside antenna for their proper operation, considerable space has been devoted to suitable antenna arrays, transmission lines and proper installation methods.

The fact that a concise knowledge of television receiver circuits will permit the serviceman to more quickly analyze faults in receiver circuits thus enabling him better to affect the necessary adjustments with a minimum waste of time and effort, has been kept constantly in mind. A step-by-step technical description of typical television receiver circuits has been included.

A great deal of text has been devoted to receiver servicing and alignment including a chapter on television testing instruments, together with their operating characteristics and use.

The present status of color television is fully represented. It explains in great detail the two major systems that are receiving the most considerations in the field of color transmission and reception, together with methods of conversion to enable the conventional black and white television receiver to obtain pictures in color when desired.

Every effort has been made to insure the accuracy of the text material, and a debt of gratitude is hereby acknowledged to the various receiver manufacturers, particularly the *RCA* and *Motorola Corporation*, whose co-operation has been of considerable assistance in the preparation of this book.

EDWIN P. ANDERSON

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**TELEVISION GLOSSARY**

CHAPTER 1

# Placing of Television Receivers

The problem of the proper location for a television receiver is very seldom solved satisfactorily prior to its arrival in the home, and even though a lot of consideration has been given to its proper placement, prior to its actual installation, very few owners find the first choice to be a permanent one.

The proper placement of the receiver, of course, depends upon such factors as the layout of the house, number and size of the individual rooms, the lighting arrangement, location of power outlet, antenna lead-in, etc.

In choosing a location for the television receiver, the following general precautions should be taken into consideration:

1. Do not place the receiver in such a position that direct illumination such as light from a window, falls directly on the face of the screen. A certain amount of background illumination is desirable when viewing over long periods of time to reduce eyestrain.
2. Do not place the cabinet directly against the wall. Leave a two-inch air space so that adequate ventilation will be assured. This will also improve the sound reproducing qualities. The receiver must in addition be installed a sufficient distance from any heating device such as heating radiators, etc., as the effect of heat will impair its operation or even damage the receiver.
3. It is desirable to locate the receiver as far as possible away from sparking or gaseous electrical discharge devices such

as may be found in public places. Such devices are Neon display signs, electrically operated cash registers, etc.

4. If the receiver is to be connected to an outside antenna, proper attention should be given to the location of the antenna lead-in and the power outlet to prevent excessive length of these connector leads.

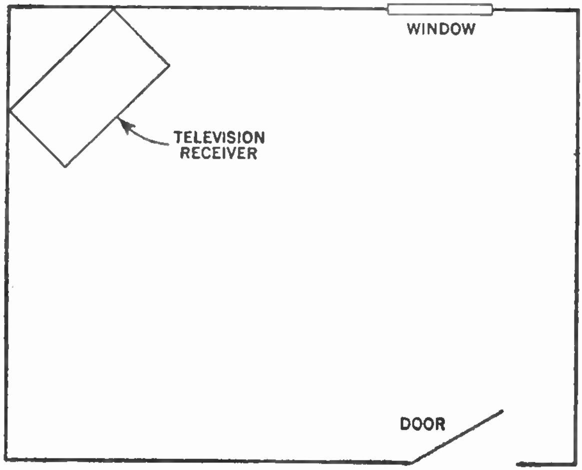



**FIG. 1—Typical receiver location. When selecting a location it is important to keep in mind the necessity for access to an electrical outlet, and the need for an external antenna and transmission line.**

With respect to the decorative scheme of the home, most decorative authorities agree on the following points:

1. The room containing the television receiver should be so planned that viewers can enjoy a program without first upsetting and rearranging the room.
2. Lighting should be arranged so as to prevent the area from becoming completely "blacked out" every time the receiver is turned on and the main light source is turned off.

3. The television receiver should not be so dominant in design or location that viewers have to sit and face it when not in use.

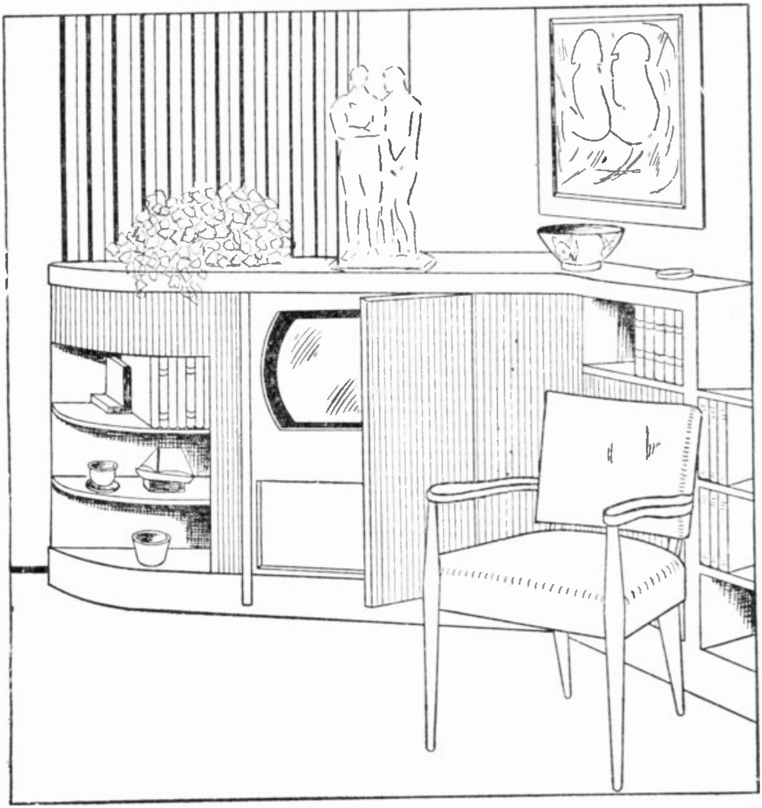


**FIG. 2**—Showing built-in television receiver for special service. Here the tambour-fronted wall unit gives triple use as television cabinet, bookcase and room divider topped with vertical lowered wood slots.

Other factors such as seating arrangements, type of chairs, stools or hassocks to use and their individual characteristics of comfort and convenience must be left to individual taste and suitability. Some owners prefer to have the receiver placed in a corner of the living room, while others will have the receiver mounted on a turntable in a wall to permit viewing from two or more rooms. A viewing scheme such as the latter is shown in fig. 3.

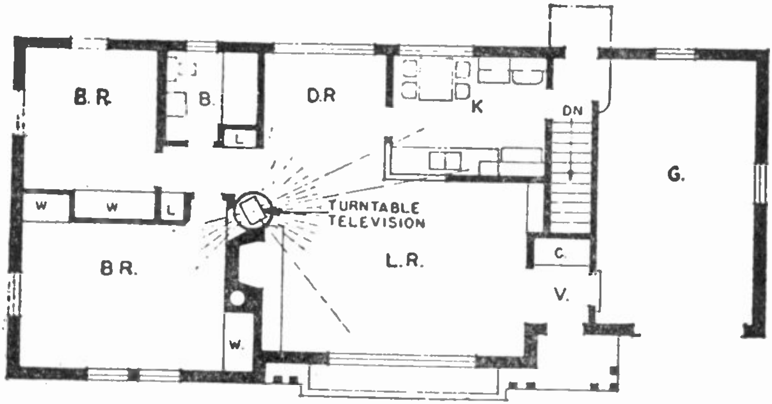



**FIG. 3—Illustrating method of placement of television receiver for viewing in several rooms. Here the receiver is mounted on a 360 degree turntable in the fireplace wall. By means of the turntable the set may be rotated for easy viewing in both living and dining rooms. A slide panel turns picture into the bedroom. Since the kitchen is equipped with a window wall, all that is necessary to view from the kitchen is to pull away the window curtain.**

The hours of usage each day or night, the number of viewers, etc., must also be taken into consideration when placing the set. Whenever possible, the television receiver should be placed in an extra room, a den, library or study (if such be available) or in just a portion of the living room, so that the viewers will not interfere with the non-viewers, and vice versa.

**Television Lighting.**—When the average family purchased its first television receiver, it had acquired most of its viewing experience at the neighborhood movies. The natural impulses, therefore, were to reproduce in the home conditions similar to

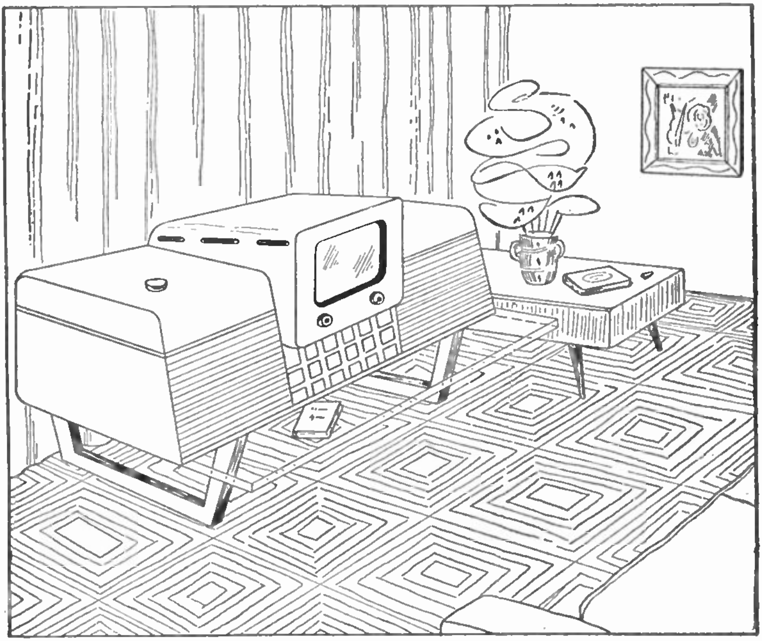


**FIG. 4—Illustrating arrangement of custom built television combination. In this design a radio phonograph, wire recorder and television set combination is given a dominant position in the living room.**

those acquired at the theatre. Hence the television receiver was set up on one side of the living room, the lights were turned off, and the family settled down on the other side of the room to enjoy the show in comfort.

However, it did not take long before the factor of eyestrain asserted itself. The human eye, which can take in a broad scene, does not take kindly to being focused on the tiny bright surface that the average television screen represents.

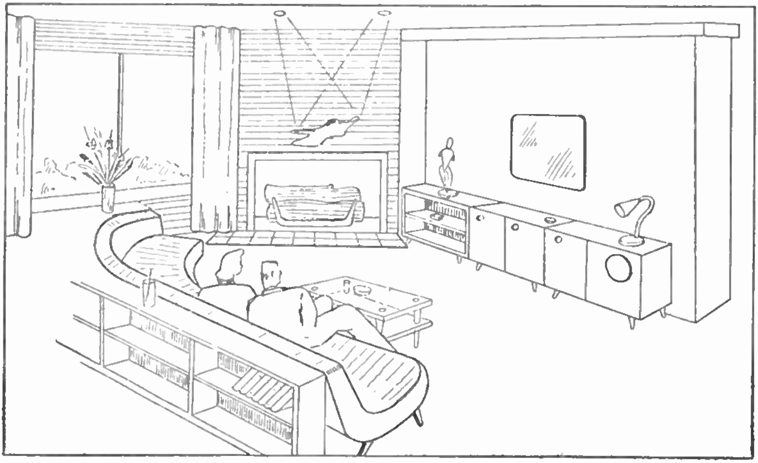


**FIG. 5—Unusual placement of television receiver. Living rooms that are being remodeled offer an unusual opportunity for incorporating a television screen in the wall. In this illustration the fireplace dominates the room, while the television screen is camouflaged by a large wall mirror, while the set is inoperative. Prior to use the mirror is moved down thus exposing the television screen.**

**Picture Tube Glare.**—Adding further to the eyestrain was the bright surface of the picture tube. Manufacturers are trying to diffuse this glare by coating the inner face of the tube with various phosphors. Even if they are successful, the strain which comes from forcing the human eye to focus on a small point in the wide area of its possible vision cannot be completely eliminated.

The moving picture screen is so large that it amply fills the field of vision which the human eye can cover. This leaves the eye free to roam naturally over a wide area, thereby eliminating one source of eyestrain that is a result of prolonged viewing.

Furthermore, light projected into a moving picture screen from a distance is reflected at relatively low intensity. This reduces a second factor that often makes for eyestrain.

**Use of Lights.**—After discovering that television in the dark was not the answer, lights were turned on in the viewing room. Unfortunately this still did not solve the problem satisfactorily.

This time the difficulty arose from a competition between the viewing screen and the light sources to secure the attention of the viewers. Home lamps are commonly high intense points of light. When they fall within the sweep of the human eye, they act as a distracting and annoying influence.

A solution is to focus the light from lamps in such a way that it hits the ceiling at a broad angle and is reflected back on the wall behind the television receiver. This will make the wall glow at a somewhat higher intensity than the surrounding space. It will broaden and soften the edges of the small area of intense light created by the television screen and enlarge the area upon which the eye must focus.

Projection type receivers, having screen areas of two or more square feet, will diffuse light on a larger area than direct view types, and will as well, glow with a lower intensity. These will largely eliminate the problems of glare.

Under these conditions the general lighting as in a moving picture theatre, will be soft and shielded.

Summing up the general discussion of lighting as applied to television reception in the home, the following "don'ts" will be generally applicable:

1. Don't use lighting that gives an architectural feeling in the same room with a television receiver, for it distracts the eye. Cornice lighting is an example of this.

2. Don't stand lamps within the field of vision of those viewing the television screen. The bright surfaces of the lamp shade is a distracting influence.

3. Don't dramatize the television receiver as a piece of furniture by putting a light directly behind it. This will only make the receiver stand out awkwardly in the room and destroy the proportion of harmony of the general decor.

4. Don't turn off all the lights in a room simply because the television receiver is on. Possibly a standing lamp with small bulbs and an opaque shade to cut the light even farther set on the opposite side of the room might result in a satisfactory solution.

CHAPTER 2

# Television Controls; Test Patterns and Adjustments

In common with the conventional radio receiving set, the television receiver requires certain controls for its proper operation.

The various controls on a television receiver may be divided into two classes, depending upon their frequent need of operation. They are:

1. Operating controls.
2. Preset controls (service adjustment controls).

Operating controls are those which control program selection as well as sound and picture quality and their functions are indicated in figs. 1 and 2.

The preset controls on the other hand, are those which usually require adjustment at the time the receiver is installed, but only rarely need attention thereafter.

Because of this, numerous manufacturers of television receivers have only the *operating controls* located at the front of the cabinet, whereas the *preset* or *service adjustment controls* are usually located at the rear of the chassis.

With reference to fig. 1, the operating controls generally consist of the following:

1. On-off switch and volume control.
2. Channel selector.
3. Fine tuning control.
4. Contrast control.
5. Brightness control.
6. Horizontal hold control.
7. Vertical hold control.

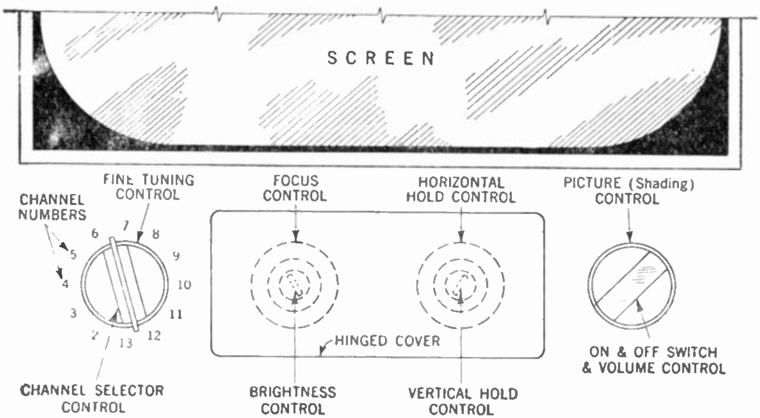



**FIG. 1—Illustrating operating control location in typical receiver. It should be observed that only two dual operating controls are used in normal tuning of a television station. Behind the hinged cover are located two additional dual controls which may be adjusted under certain conditions to improve reception such as when receiving a weak station or in case of extreme interference.**

Depending upon the design of the receiver, only four or five of the foregoing controls need to be operated during normal reception

**Dual Operation.**—In order to simplify the operation, and to improve the appearance of the cabinet as well, numerous manufacturers arrange the control knobs for dual operation; that

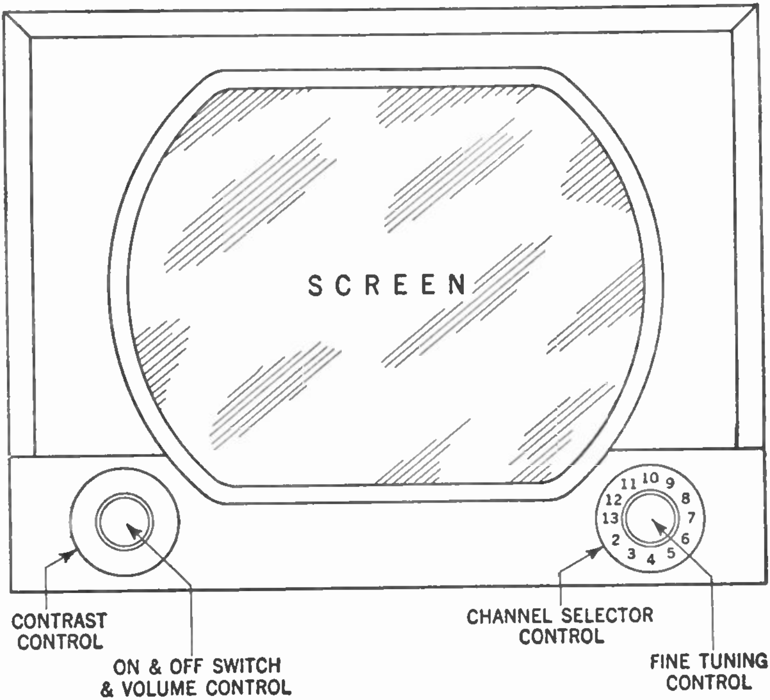



**FIG. 2—Showing front view of another typical receiver with operating control location. These are two dual controls, consisting of a small and a large knob each, on the front panel of the receiver.**

is, the controls are arranged in pairs of two, consisting of a small inner knob and a larger outer knob. Thus, for example, the *channel selector switch* and the *fine tuning control* are commonly of the dual type. The *contrast control* and *brightness control* are similarly arranged, as are the *horizontal* and *vertical* hold controls.

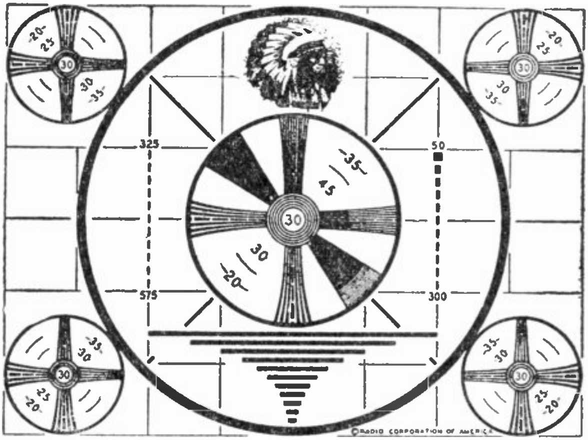



**FIG. 3—Showing typical test pattern with receiver functioning normally.**

Some manufacturers of television receivers arrange such controls as the *horizontal* and *vertical holds*, in addition to *focus* and *brightness control* underneath a hinged cover, since these usually do not need to be reset each time the receiver is operated, but are properly set at the time of installation. The purpose and function of the operating controls are as follows:

**On-Off Switch and Volume Control.**—The purpose of the on-off switch and volume control is to turn the receiver on and off and to adjust the sound volume to a desired level.

**Channel Selector.**—This consists of a simple selector switch by means of which the correct channel number of the desired television transmitter may be selected. The channels presently in operation are numbered from 2 to 13.

**Fine Tuning Control.**—This control turns the receiver for best sound and picture. After the proper channel is selected, adjust the fine tuning control to obtain the best picture quality.

**Contrast Control.**—A variation of the amount of background light or *picture shading* is provided by this control. Adjust to receive picture and obtain correct contrast between light and dark shades.

**Brightness Control.**—This control sets the picture brilliance. The brightness control should not be turned past the point at which the picture begins to grow larger, since detail will be lost due to loss of focus.

**Horizontal Hold Control.**—The horizontal hold is an adjustment of the horizontal picture synchronization circuits. Misadjustment of this control will cause the picture to move either right or left or in extreme cases, it will cause black horizontal lines to appear on the screen. This control should be adjusted until the picture appears and there is no horizontal movement.

**Vertical Hold Control.**—When switching from a strong local station to a weak station, it may sometimes be necessary to make adjustment of the vertical hold control. Principally the vertical hold is an adjustment of the vertical synchronization circuits. Misadjustment of this control will cause the picture to move either up or down. The control should be adjusted so that there is no vertical movement of the picture.

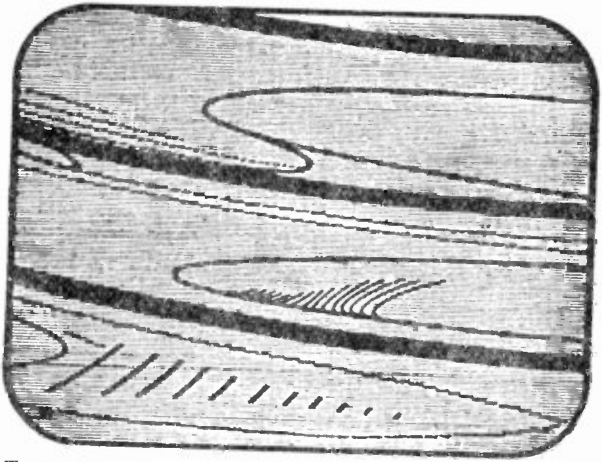


FIG. 4—Test pattern showing horizontal movement. To correct, adjust horizontal hold control.

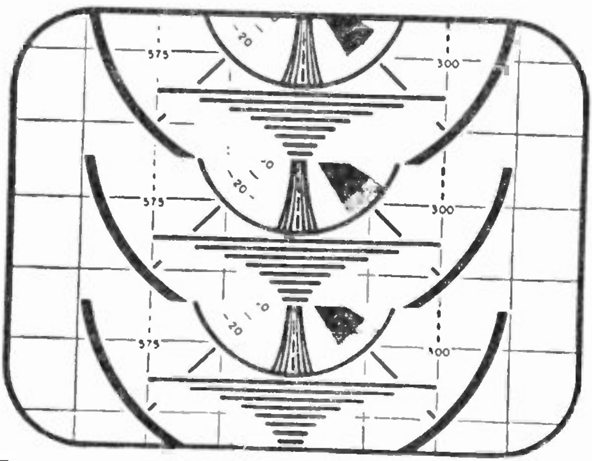



FIG. 5—Test pattern showing vertical movement. To correct, adjust vertical hold control.

## Step by Step Tuning Procedure

In order to select a particular station and to adjust the various operating controls for correct picture and accompanying aural reception, proceed as follows:

1. Turn volume control about one-half turn clockwise. This supplies power to the receiver. Allow about two minutes for the tubes to reach operating temperature.
2. Turn the channel selector until it points to the number of the desired station channel.
3. Turn the tuning control for best detail of the picture.
4. Adjust contrast control to obtain the proper shading in the picture which means it should have good deep blacks, whites and intermediate shades of gray.
5. Readjust volume for most pleasing reproduction.

After the receiver has been adjusted as indicated, the volume control need only be used to turn *on* or *off* the receiver between the desired programs unless some other station is to be tuned in.

Before commencing the tuning operation, however, it may be well to check to be sure that a television transmitting station actually is on the air at the time it is desired to operate the receiver. Program schedules are usually published in the daily newspapers and many television stations will mail advance copies of their weekly broadcast schedule to set owners upon request.

It should also be noted that during intervals in which stations are only televising their test pattern, the sound will only be a sustained note. This test pattern, fig. 6, and special sound transmission is used by television technicians to adjust certain preset controls at the time of installation.

## The Test Pattern

Prior to a detailed discussion of the operation and functions of the *preset controls*, it will be of assistance to know the part test patterns play in the proper adjustment of the receiver.

The function of any test pattern is to furnish an accurate means of comparing the picture that appears on the picture tube with that actually seen by the television camera. If the two were identical, it would indicate completely perfect transmission of the image through the entire transmitting and receiving system. The extent to which it is approximated gives a measure of the quality of the transmission.

The test patterns, therefore, provide a means for the proper diagnosis and adjustments, which may occur in a television receiver. Test patterns are broadcast regularly by most television stations, and assume several configurations of lines, circles and black bars, as shown in figs. 3 and 6.

Such factors as *picture aspect ratio*, *resolution*, *linearity*, *contrast*, and *brightness* in addition to *focus control* may easily be observed by an analysis of fig. 6.

The *aspect ratio* of a picture determines its proportions. By arbitrary choice the television broadcasting stations have settled on the aspect ratio of 4 to 3; that is, a picture whose width is 4/3 as great as its height. Thus, when the aspect ratio of the picture, fig. 6, is correct, the diameter of the large outer white circle (or part of a circle to be exact) is exactly 4/3 of the diameter of the large black circle. If this ratio is not maintained, then the aspect ratio of the picture is incorrect and should be adjusted.

By the term *resolution* is meant the extent to which the picture separates the details of the original scenes from one another.

Vertical resolution depends largely on the following:

1. The number of scanning lines employed.

2. Size of the scanning beams in both the camera tube and the picture tube.
3. Sensitivity of the camera tube, and other elements of the transmitting apparatus.

Horizontal resolution on the other hand is not affected to any great extent by the number of scanning lines and by the characteristics of the camera and transmitter.

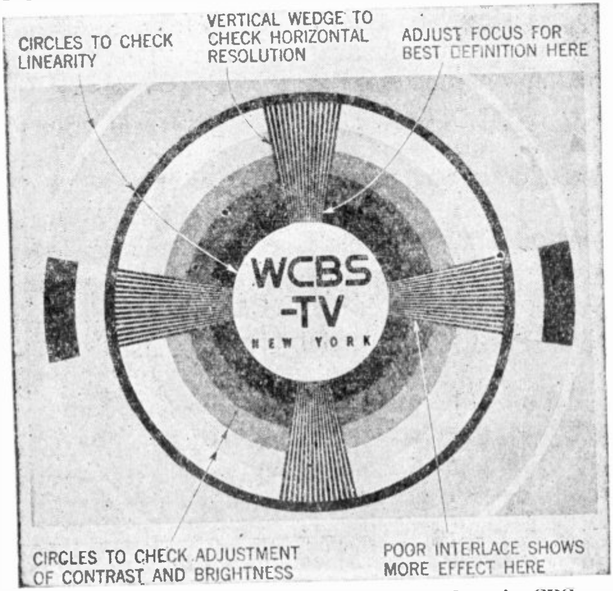



**FIG. 6—Normal (greatly reduced test pattern) as broadcast by CBS.**

A check on the vertical resolution may be made by observing the horizontal wedges of our test pattern, fig. 6. If the lines of the wedges emanating from the central white circle are partially or completely blurred, there is a partial loss of resolution.

In a similar manner the vertical wedges may be used to check horizontal resolution.

*Linearity* refers to the uniformity of distribution of a regular pattern on the picture tube. When the condition of the electron beams on the picture tube are such that the beams do not move at constant speed, the objects in the picture will be distorted in shape, and as a result the picture is said to have poor linearity.

It should be observed that for a completely satisfactory picture, the receiver system should be free from all of the various defects which tend to impair its quality. This includes faulty interlace, improper focus of the beam, 60-cycle power frequency superimposed on deflection voltages, noise and other forms of interference.

*Vertical* and *horizontal linearity* may be checked by observing the large black circle shown on the test pattern. When perfect linearity is present, the circle is geometrically flawless.

*Brightness* and *contrast* must be present in suitable proportions for a pleasing picture. Brightness without adequate contrast actually reduces the clarity of the picture. Contrast depends upon the amount of change of the video voltage applied to the picture tube grid; that is, its peak-to-peak swing. Brightness of the picture depends upon the *d.c.* or average value of the video signal at the picture tube.

*Contrast* and *brightness* correctness may be observed by means of the several concentric circles in the test pattern. These are located between the large black circle and the white circular center area. These are of different shades from light gray to black. When the picture shows tone variations, the brightness and contrast controls are set correctly. If not, they should be adjusted.

Correct *focus control* may be determined by observing the center of the test pattern. When this white circle is perfectly round and sharp, the focus control is properly set. If not, an adjustment should be made.

## Preset or Service Adjustment Controls

These are controls which have been factory adjusted for optimum performance, although it is usually necessary to make some adjustments of these at the time of installation. The service adjustment controls usually consist of the following:

1. Focus control.
2. Vertical size.
3. Vertical linearity.
4. Horizontal size.
5. Horizontal linearity.
6. Horizontal drive.
7. Picture width.
8. Picture height.

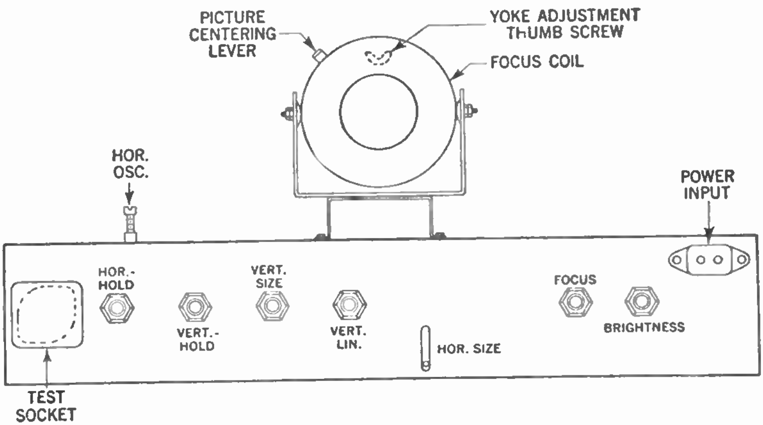



**FIG. 7—Showing preset controls for receiver whose operating controls are shown in fig. 2.**

Depending upon the design of the receiver some of these controls may be located at the front of the cabinet, whereas others may be located in the rear of the chassis.

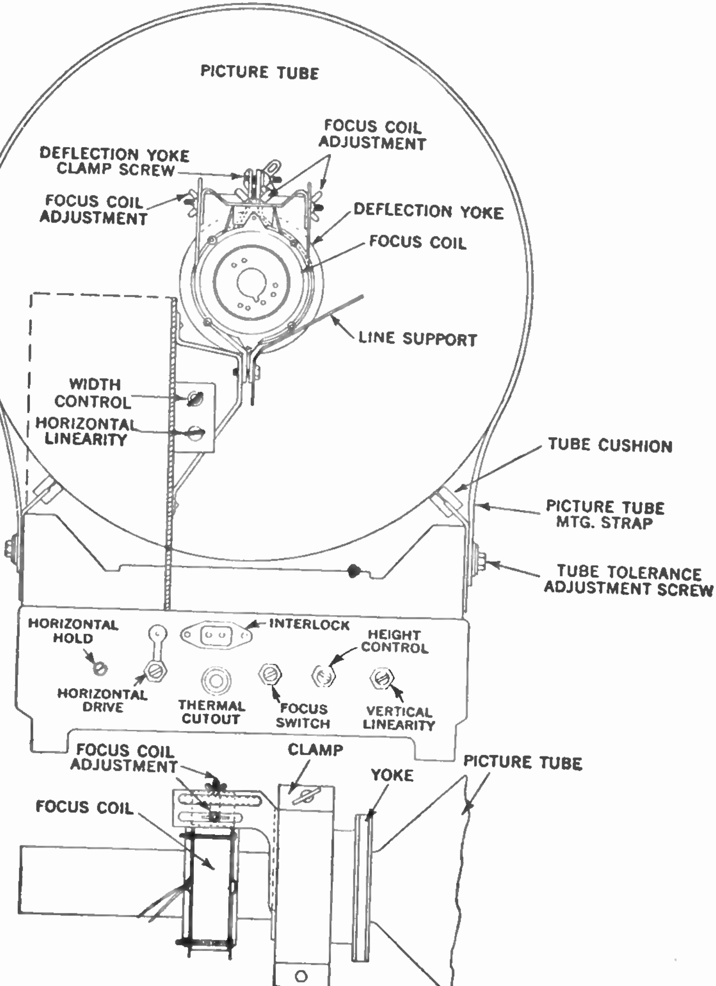



**FIG. 8—Showing preset controls for receiver whose operating controls are shown in fig. 1.**

**Focus Control.**—This control offers adjustment of the sharpness of detail of the picture. At long intervals the focus control may have to be readjusted for best clarity of the picture. This is done by turning the focus control in either direction until the picture shows best clarity. Observation of the picture slightly right of center when making this adjustment gives the most uniform focus. Tune for clarity of small objects or lettering in the picture.

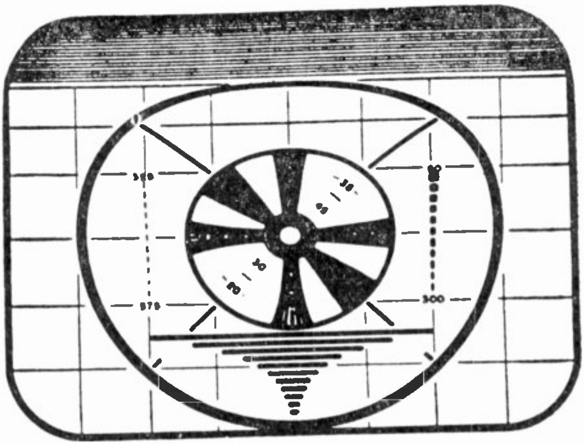


**FIG. 9—Test pattern showing vertical distortion. To correct, adjust vertical linearity control.**

**Vertical Size and Vertical Linearity Controls.**—These controls should both be adjusted at the same time and preferably while a test pattern is being transmitted. The linearity control affects the upper portion of the picture while the size control affects the lower portion. Adjust both controls simultaneously until the test pattern is symmetrical and fills the entire screen vertically. Readjust the vertical hold control if necessary.

**Horizontal Size Control.**—This control should be adjusted preferably when a test pattern is being transmitted. The size control should be adjusted until the test pattern fills the entire screen horizontally.

**Horizontal Linearity Control.**—This control should be adjusted for best possible horizontal linearity. In the event that proper horizontal linearity cannot be obtained by adjusting this control, then change the setting of the horizontal drive control.

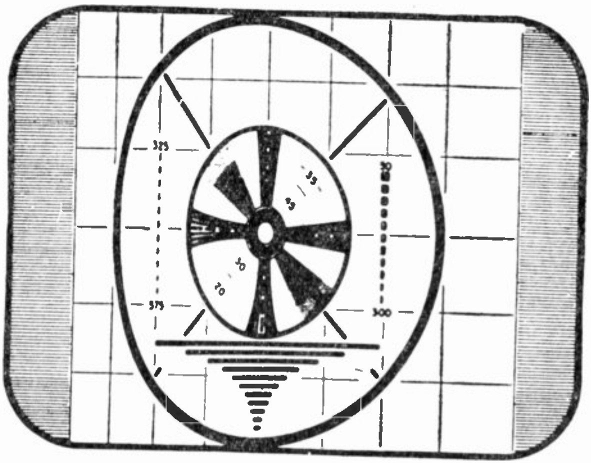


**FIG. 10—Test pattern indicating horizontal distortion. To correct, adjust horizontal linearity.**

**Horizontal Drive Control.**—The horizontal drive should be set approximately one-third of its total rotation from the counterclockwise end of its rotation. If white vertical bars or black beaded lines appear in the picture, the drive control in either direction should be adjusted to remove these white vertical bars or beaded lines.

**Picture Width Control.**—Control of picture size in the horizontal direction is accomplished by means of the width control. If abnormally low line voltage makes it difficult to obtain sufficient picture width when using the width control, then changing of the horizontal drive control may prove helpful.

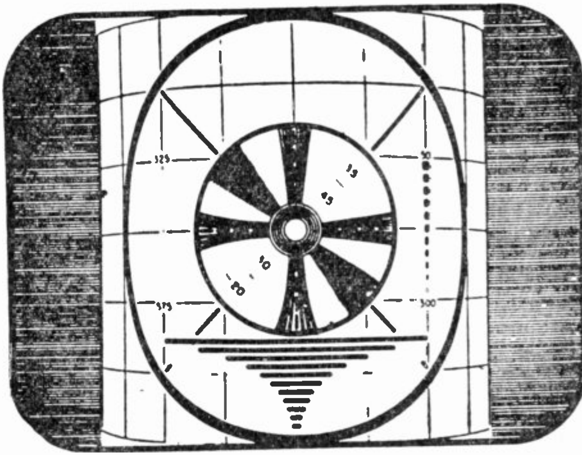


FIG. 11—Test pattern showing picture too narrow. To correct, adjust width control.

**Picture Height Control.**—Control of picture size in the vertical direction is accomplished by means of the height control. Height and width adjustment should be checked for all transmitting stations in order to ascertain that the picture fills the viewing area. It may be necessary to change the setting of the height control after the vertical linearity control is adjusted.

**Straightening Tilted Raster.**—This condition makes the test pattern or picture appear in a slightly tilted position. The remedy consists in a loosening of the deflection yoke locking

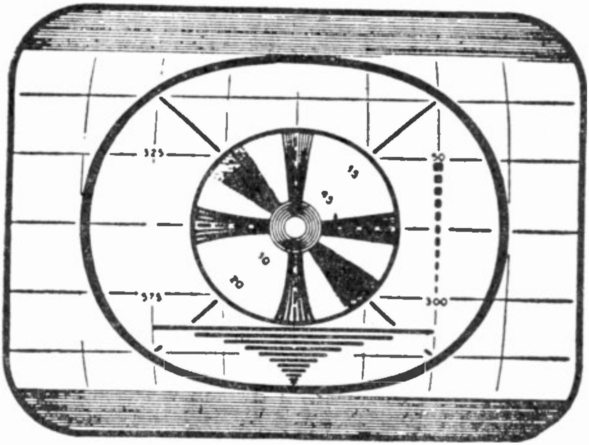


FIG. 12—Test pattern indicating picture too short. To correct, adjust height control.

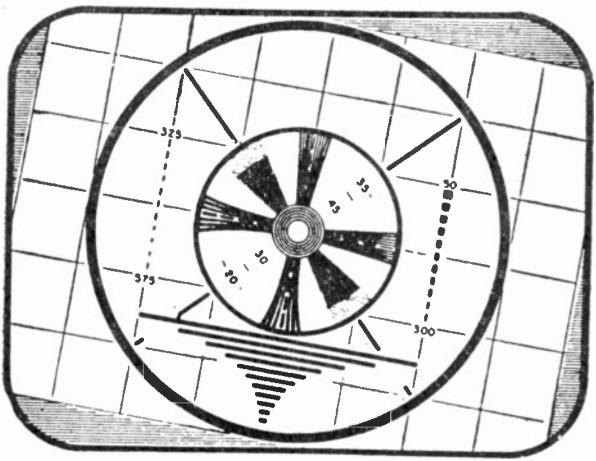


FIG. 13—Test pattern indicating tilted picture. To correct, adjust yoke position.

screw, and in rotating the yoke sufficiently to correct this condition. This locking screw should be retightened after the operation.

**Centering.**—To center the test pattern on the screen, adjust focus coil position. Readjust ion trap for maximum brightness on picture screen. Only in rare cases may it be necessary to rotate the picture tube.

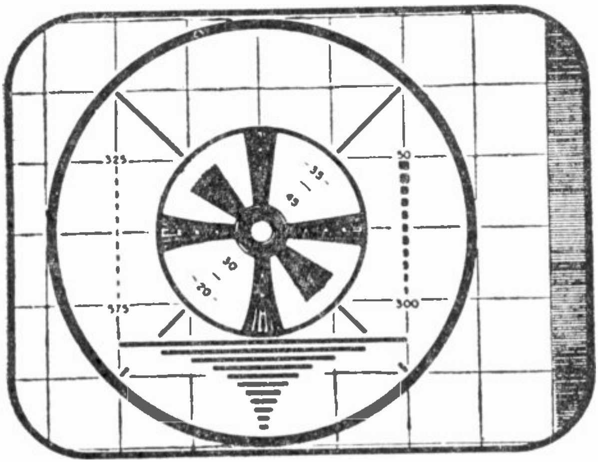


**FIG. 14—Test pattern indicating picture off-center. To correct, adjust focus coil position.**

**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:

1. Make sure that the deflection yoke is positioned as far forward as possible.

2. Reposition the focus coil by readjusting the holding nuts to shift the coil forward.

3. In the event the neck shadow cannot be eliminated by the foregoing procedure raise or lower the entire yoke and focus coil assembly so that focus coil can be repositioned vertically with respect to the tube neck.

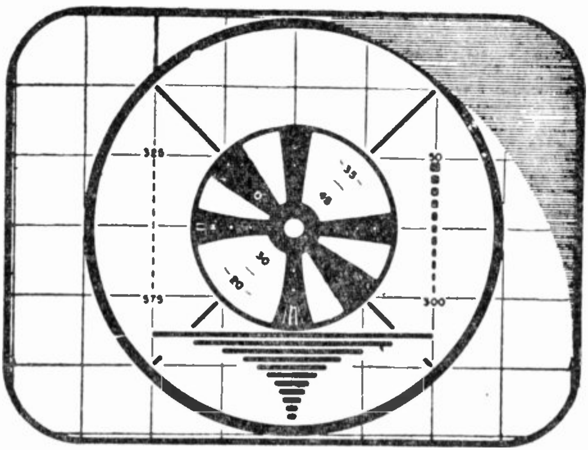


**FIG. 15—Test pattern showing semi-circular shadow. For correction, see text.**

For complete adjustment of ion trap, focus coil and deflection yoke, see pages following.

## Adjustment of Ion Trap, Focus Coil and Deflection Yoke

Although these components are properly adjusted when the receiver leaves the factory, conditions of rough shipment make it possible for these to become misaligned. The following instructions will enable the service man to bring the parts to their

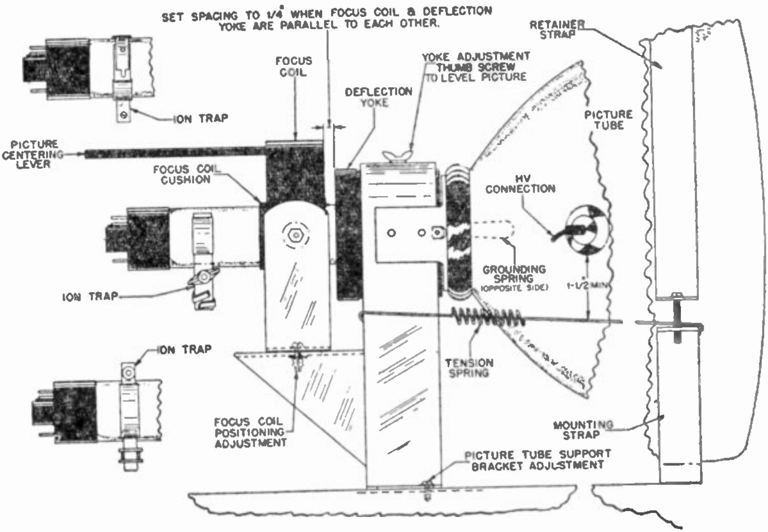
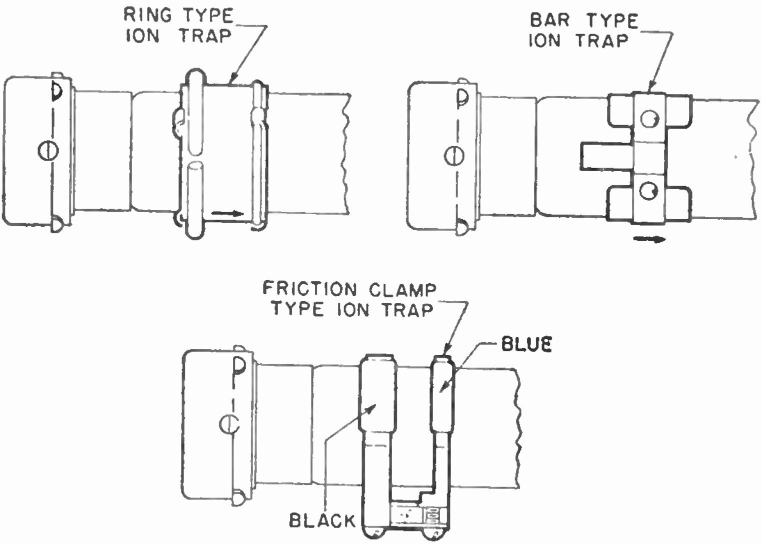



**FIG. 16—Showing typical picture tube assembly with location of ion trap, focus coil and deflection yoke.**

normal setting. See fig. 16 for adjustment locations. A mirror placed in the front of the receiver will make it possible to watch the picture while the adjustment is being made.

**The Ion Trap Magnet.**—The ion trap consists of a coil or permanent magnet fitted on the neck of the picture tube for the purpose of removing ions from the electron beam. The ions removed are molecules of matter which have been excited by the electron bombardment so as to have a negative charge.




**FIGS. 17 to 19—Illustrating various types of ion trap magnets.**

If allowed to remain in the electron beam the ions will eventually cause a dark spot in the center of the picture tube face. There are numerous types of ion traps, all differing in appearance but identical in action.

It is of major importance when installing a television receiver to properly adjust the ion trap magnet on the neck of the picture tube, since improper positioning of the magnet may cause areas of discoloration on the face of the bulb, thus injuring the picture screen.

**Ion Trap Adjustment.**—The ion trap magnet must always be adjusted for maximum picture brightness. With the tube operating and with brightness control adjusted for low intensity, the ion trap magnet is adjusted by moving it forward or backward and at the same time rotating it slightly around the neck of the picture tube until the raster on the screen is brightest.

If, in obtaining the brightest raster the ion trap has to be moved more than one-quarter inch from the internal pole pieces, or if it be pushed against the focus coil, the magnet is probably weak and a new magnet may be required.

As a final check, the ion trap magnet should again be adjusted for maximum raster brilliance, this time with the brightness control set to obtain a raster slightly above average brilliance and with the focus adjusted for a clear line structure to simulate actual operating conditions with a picture.

If the picture tube has been replaced, or the receiver moved to a new location, it is imperative that the brightness control be kept low until after the initial adjustment of the magnet, and also that adjustment of the magnet be made immediately after the receiver is turned on. After the proper adjustment, the ion trap mounting screws should be tightened to prevent shifting.

**Focus Coil Adjustment.***—If a shadow falls on one corner of the picture or if the picture be not properly centered, adjustment of the focus coil will be necessary. To adjust, turn the focus coil adjustment screw in or out until a position is found where the picture is centered and there is no shadowed corners.

*When carrying out this adjustment, extreme care should be exercised so that no abnormal pressure is exerted on the neck of the picture tube.

In performing the adjustment, the screws should be turned so as to move the focus coil about its vertical and horizontal axis rather than closer to or farther from the face of the picture tube.

It should be observed that the tilt of the focus coil is limited by the clearance to the neck of the picture tube. Therefore, it is important for proper picture centering that the deflection yoke mounting bracket be moved forward until the rubber collar firmly supports the flare of the picture tube. It is also important that the deflection yoke bracket be orientated so that the focus coil will have equal tilt up, down, right or left.

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

CHAPTER 3

# Television Interference

After all the necessary adjustments have been made, it may happen that the picture shows certain defects altogether different from those previously described.

A multitude of patterns may be superimposed upon the normal picture. These patterns are produced by man-made disturbances usually termed *interference*.

As evidenced in radio broadcast reception, interference is recognized by a burst of noise or continuous background noise. In television reception, interference is evidenced by a burst of light upon the picture screen, momentary "tear out" of the picture, formation of various patterns on the screen or small spots of light in the picture.

Since television receivers are designed to operate at much higher frequencies than broadcast-band radio receivers, the sources of interference are not the same for the two types of receivers. A television receiver is almost immune to weather produced interference, whereas this type of interference is most common in radio reception.

Some forms of the above mentioned interference are easily identified by an analysis of the interference pattern as formed on the screen, and after they are identified, corrective measures can be applied to eliminate them.

Other types of interference, however, are not so easily identified, and in some cases, there is no known corrective measure.

It is of paramount importance, therefore, that every service technician be thoroughly acquainted with the various forms of interference effecting television reception, and know how to identify each type.

Proper identification may mean success or failure in correcting the trouble, because if there be no clue as to what is causing a particular type of interference, no corrective measure can be applied to it.

**Common Types of Interference.**—Television receivers are greatly affected by man-made noise, arising from various types of electrical apparatus. Following are some types of interference frequently encountered by television service men. These are not necessarily listed in order of their importance or the type of interference which are most commonly occurring. They are:

1. Ignition or spark interference.
2. Diathermy.
3. Germicidal lamp radiation.
4. 4.5 mc sound-beat pattern.
5. Police, amateur broadcast and mobile stations.
6. Two or more TV unsynchronized carriers on same channel.
7. FM transmitter heterodyning with local oscillator.
8. Radiation from the local oscillator in a neighboring FM or TV receiver.
9. Oscillation in video *i.f.* amplifier.
10. Barkhausen oscillation from the horizontal deflection generator.
11. Reflections or ghosts in various forms.

**Ignition.**—Ignition interference from trucks, automobiles and aircraft may be identified by streaks and splashes on the picture. The ignition system of trucks will produce the most intense interference pattern. It usually consists of a series of broken horizontal dark lines, the number of spacing of which depends on the frequency of the offending spark.

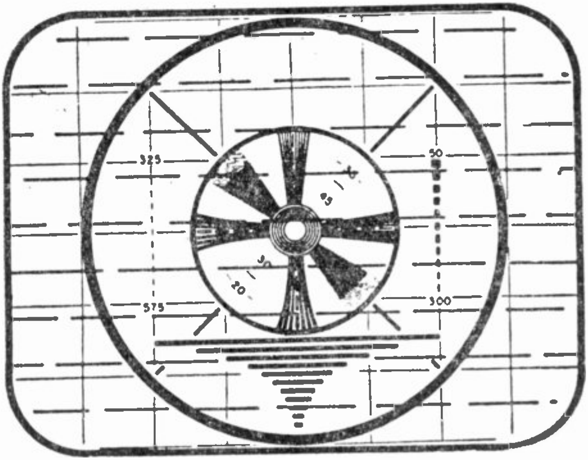



**FIG. 1—Test pattern showing typical auto ignition interference.**

Aircraft in the vicinity may also produce interference which is usually identified by a temporary fluctuating picture, usually lasting only a few seconds. Since the noise from the aircraft is usually heard at the time the fluctuation of the picture occurs, identification of this type of interference is comparatively easy.

Interference of this same type can occur from high voltage and corona discharge in the high voltage supply of the receiver, as well as in high tension lines near the receiver location. In addition, doorbells, buzzers and signalling systems such as teletype machines usually generate an interference pattern similar to that made by ignition systems.

*Corrective Measures.*—At the outset it should be emphasized that there is no clear-cut method whereby all interference problems due to ignition or other causes may be solved. About the only corrective measure with respect to ignition interference is to ascertain that a good antenna is used; that is, one which will result in the best possible signal pickup.

At the time of installation, checks should be made to determine the type of interference, if any, which is present at the particular location.

The antenna should then be located as far as possible from the suspected source of interference. Thus, for example, if the receiver be located near a heavily travelled arterial highway or street intersection, the antenna should always be installed as far from the traffic as possible.

After this has been accomplished, an effort should be made to eliminate the remainder of the interference by manipulating the antenna. Perhaps to increase the antenna height by several feet would assist in eliminating the interference.

In locations plagued by interference, shielded twin conductor cable, or coaxial transmission lines should be used. The use of a shielded twin line gives two-fold protection from noise pickup. *First*, the shield serves to keep the greater portion of the interference from inducing any voltage in the transmission line. *Second*, if balance to ground input to the receiver be maintained, any small interference voltage that is induced in the twin lead will cancel out due to the fact that the interference voltage induced in the opposite conductors of the line will be 180 degrees out of phase and therefore cancel out in the grounded center receiver antenna input inductance.

In cases where a coaxial cable be used (single conductor) the shield should *not* be conducted to one of the antenna terminals, but should be grounded to the chassis of the receiver.

**Diathermy.**—Diathermy interference is caused by unshielded medical diathermy machines and X-ray equipment. It manifests itself in a herringbone pattern or one or two dark bars moving slowly up and down the picture. If the disturbance be extremely strong, the interference pattern will remain stationary while the picture floats in the background.

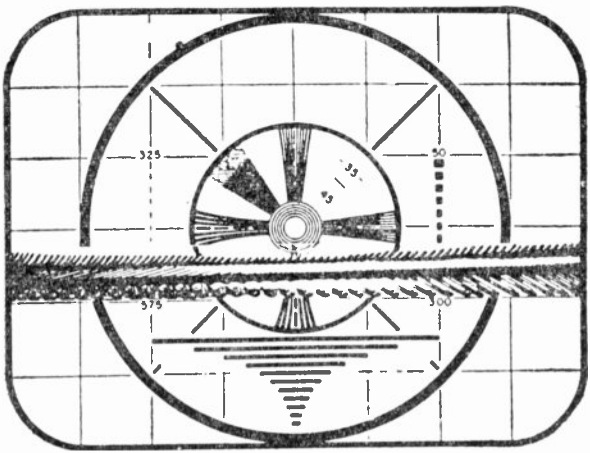



**FIG. 2—Test pattern showing typical diathermy interference.**

Most diathermy machines consist of oscillators using raw 60-cycle *a.c.* on the plates (although some do use self-rectifying oscillator circuits having a 120 cycle component in the signal) distribution of the pattern relative to picture height is usually similar to a 60-cycle hum bar due to the strong *a.c.* ripple in the signal. This "strip" or bar of pattern will vary in position relative to the top and bottom of the picture, depending on the phase relation between the mains supplying the diathermy machine and the vertical scanning frequency of the receiver.

Sometimes if this bar happens to be so phased as to occur near the vertical blanking interval, it will show up as two split narrow "strips" one at the top of the picture and one at the bottom. The fine line pattern within the "strip" will vary in spacing depending on the frequency of the diathermy oscillator; and, as these oscillators are not crystal controlled the fine line pattern will usually vary, assuming various positions between horizontal and vertical.

*Corrective Measures.*—In the case of diathermy interference, corrective measures are practically non-existent, since the signal from a diathermy "transmitter" behaves very much the same as television signals, and is therefore picked up by the receiver antenna.

It is evident from the foregoing discussion that the only permanent remedy against television interference of this sort, is to incorporate signal radiation preventive measures at the source; that is, by proper shielding and filtering of the diathermy machines, by shielding of the room or rooms in which they are operated or both.

**Germicidal Lamp Radiation.**—Fortunately interference from germicidal lamps is not of frequent occurrence. Lamps of these types are used most frequently in hospitals, butcher shop meat counters, refrigeration locker plants, etc., to kill bacteria.

The interference pattern from germicidal lamps is very similar to that originating in diathermy equipment.

*Corrective Measures.*—In interference cases of this sort, the only corrective measures which have been found effective is to replace the offending lamp with a new one. It seems that certain lamps after a period of time increase in efficiency to the extent of killing both the bacteria and television reception.

**4.5 *Mc* Sound Beat Pattern.**—This type of interference may be recognized by a stationary very fine herringbone pattern independent of sound modulation and extending over the whole picture. This is caused by heterodyning between the sound and video *i.f.* carriers.

*Corrective Measures.*—This interference can be eliminated by a fairly high "Q" parallel resonant trap, tuned to 4.5 *mc* and installed either in series with the cathode ray tube grid or in the video amplifier chain anywhere between the video detector and the cathode ray tube grid. Interference of this type will not be noticeable on receivers having a narrow bandwidth in the video amplifier section.

**Police, Amateur Broadcast and Mobile Stations.**—Interference from the foregoing sources usually emanate from transmitters being located in close proximity to television receivers, and resulting in the high signal level being fed into the receiver circuit. The fact should not be overlooked that most video amplifiers will amplify out to approximately 4 *mc* and consequently will readily amplify the signal from a broadcast station if the receiver happens to be in the high signal area very close to the transmitter.

*Corrective Measures.*—Corrective measures consist of judicious use of shielding of the affected parts of the receiver and the use of traps tuned to the frequency of the offending transmitter.

**Two or More TV Unsynchronized Carriers on the Same Channel.**—Interference of this type usually affects reception in fringe areas where the television receiver is located between two or more stations. Sometimes the signal from the different stations are almost equal in strength and as a consequence the receiver cannot discriminate between the transmitters.

*Corrective Measures.*—The only possible solution to interference problems of this sort is to employ an antenna that has practically no back pickup and mount it in a rotating mechanism, so that it can be aimed at the desired station.

**FM Transmitter Heterodyning with Local Oscillator.**—The heterodyning of an FM transmitter with local oscillator, the resultant beat coming in on the lower television channel is another cause of interference. Receivers in most of the larger television areas where powerful FM transmitters are located are usually affected by this type of interference.

It is usually recognized on the screen as an ever changing pattern of parallel lines or sometimes assuming a herringbone characteristic. The pattern will usually change continuously, except when the FM transmitter modulation is off, and the movement of the lines in the pattern will not bear any relation to the accompanying television sound. The number of lines or or bars varies according to the modulation of the interfering transmitter.

*Corrective Measures.*—An effective corrective measure in this case consists of fairly high "Q" traps at the antenna input to the *r.f.* unit of the receiver tuned to the interfering FM signal.

**Radiation from the Local Oscillator in a Neighboring FM or TV Receiver.**—Interference emanating from a source of this type will vary, depending upon what channel the interfering receiver happens to be tuned to and on the nature of the signal it heterodynes with.

It will usually result in a fine herringbone pattern covering the entire picture, although sometimes it will take the form of a ghost picture which seems to float around in the background of a picture tuned in on one of the TV channels.

*Corrective Measures.*—A proved solution for this type of interference is to install a wave trap tuned to the interfering frequency.

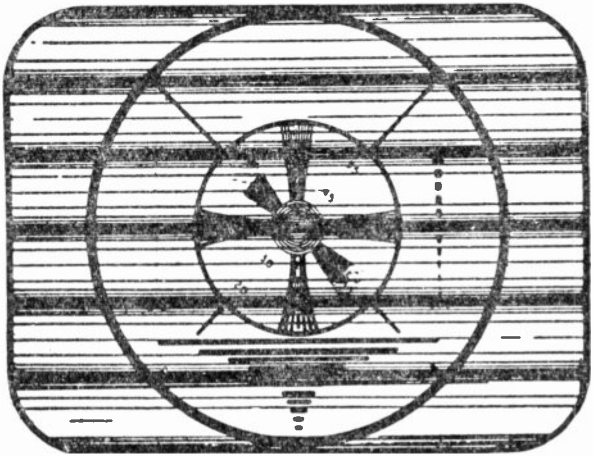


**FIG. 3—Test pattern showing interference caused by incorrect tuning.**

**Oscillation in Video *i.f.* Amplifier.**—Trouble of this nature will usually manifest itself as a pattern of lines that are approximately three thirty-seconds of an inch apart. This pattern will be noticed on all channels and usually only when the contrast control is advanced near or past the mid point of its travel. This trouble can usually be traced to an open 1,500 *mmf.* screen bypass capacitor in one of the video *i.f.* amplifier stages or in receivers employing stagger tuned *i.f.* oscillation can result if several of the stages be peaked too close together.

**Barkhausen Oscillation from Horizontal Deflection Generator.**—Another type of interference that sometimes originates in the receiver horizontal deflection generator will show up as a dark vertical line or a series of lines at either side of the picture. This is known as the "Barkhausen" effect.

If a pattern such as the one described is noticed, bringing a permanent magnet close to the outside of the horizontal deflection tube, will have a noticeable effect on the pattern.

Barkhausen effect is a type of high frequency oscillation that takes place apparently due to the movement of filament electrons that initially overshoot the grid and pass back and forth through the grid before settling on it. The frequency is determined by the distance between the grid and plate and by the velocity of the electrons. The frequency is independent of external tuning circuits.

*Corrective Measures.*—Replacing of the horizontal deflection tube will usually clear this type of interference.

**Reflections or Ghosts in Various Forms.**—Perhaps one of the most prevalent forms of interference is that due to reflections of the picture, generally termed ghosts. Since there are numerous forms of this type of interference they will be treated according to their appearance on the screen.

**The Trailing Ghost.**—This is probably the most common type of ghost and is usually due to a reflection from a building, hill or other structure that reflects the television signal from the transmitter. This reflected signal or "echo" which is usually weaker than the direct signal, arrives at the receiving antenna later than the direct signal, and the ghost or echo will appear, therefore, on the right hand of trailing edge of the picture.

Sometimes there are locations where several reflected signals from different buildings or structures reach the receivers resulting in several ghost images in the picture. These are called *multiple ghosts*. Ghost images can be *positive* or *negative*, depending on the relative phase of the direct and reflected signal.

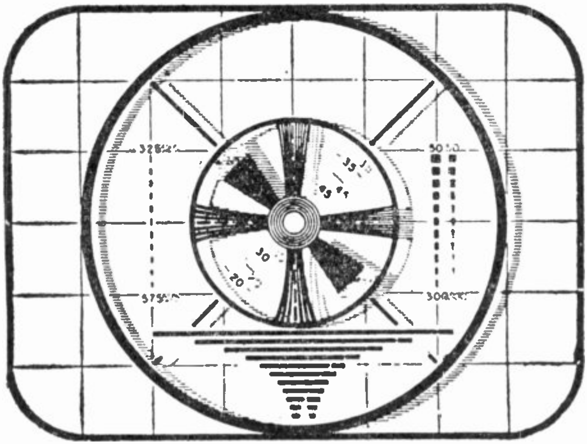


**FIG. 4—Test pattern showing typical multiple images or "ghost."**

The relative phase depends on the location of the antenna. If the antenna be moved some distance out to, or away from the transmitter, the relative phase changes, and the direct and reflected signals either aid or oppose, producing a positive or negative ghost. A negative ghost is one where the image is reversed; that is, the white portions are black and the black portions are white.

*Corrective Measures.*—Where the reflected signal is arriving at the receiver, from the rear, a reflector on the antenna will be helpful because it will minimize the rear pickup of the antenna to some extent. If the reflected signal be arriving at the receiver from one side, it can be minimized by orienting the antenna for least pickup in this direction. In either case a highly directional antenna is desirable. Under some conditions it may be advantageous to orient the directional antenna for maximum pickup of a strong reflected signal, and minimum pickup of the direct signal.

**Source Ghost.**—When the reflected signal arrives at the receiving antenna from the same general direction, relative to the direct signal from the transmitter, the angular difference between the two signal paths being very small, it is impossible to differentiate between the two signals resulting in a ghost image, which is called a *source ghost*. So far there is no known corrective measure for reflections of this type.

**Fluttering Ghost.**—Fluttering ghosts can be observed quite frequently in most of the television areas, and are due to reflections from aircraft flying in the vicinity of the receiver. The relative phase of the reflected and the direct signal arriving at the receiver, changing as the plane moves along, results in the two signals alternately aiding and opposing each other, which produces a fluttering in the picture brilliance and also a flutter in the ghost image. The rate of flutter depends on the position, height, speed and direction of the plane, and changes as the plane progresses in flight.

This type of interference is so prevalent in metropolitan television areas near which are usually located larger airports, with the resultant heavy air traffic, that most television receiver manufacturers are endeavoring to use *a.f.c.* circuits having proper time constant to minimize the fluttering in the picture brilliance.

**Leading Ghosts.**—*Leading ghosts* differ from *trailing ghosts* in this respect: With a trailing ghost, the ghost image is to the *right* of the direct pickup picture, while with a leading ghost, the ghost image appears to the *left* of the direct pickup picture. This type of ghost appears under the following conditions:

1. With the receiver located relatively close to the transmitter, considerable signal pickup occurs in the *r.f.* or mixer circuits of the receiver with a long run of transmission line from antenna to receiver.

2. The signal that is picked up directly by the *r.f.* or mixer circuit appears ahead of, or to the left of the picture from the antenna signal, which is delayed in travelling down the long transmission line. In cases of this type, the signal picked up directly by the receiver will usually be affected by the movement of persons about the room or near the television receiver; and as the signal usually is reflected by objects in the room or nearby structures, multiple ghosts will usually be evident.

*Corrective Measures.*—These consist of reducing the direct pickup in the receiver, by shielding the *r.f.* and mixer circuits and possibly the entire chassis. By disconnecting the antenna from the receiver without disturbing the contrast control setting, it can be determined how much signal the antenna is actually contributing to the picture.

If it be found that multiple ghost images appears and that the antenna contributes very little or nothing to the picture, the pickup from the antenna system should be increased or a defect in the *r.f.* amplifier stage of the receiver may be the cause. It should be obvious that if the *r.f.* amplifier stage of a receiver was inoperative, disconnecting the antenna would not affect the picture because the reproduced image or images, as the case may be, would be due to direct signal pickup in the mixer circuit.

**Tunable Ghosts.**—These are ghosts that vary in number and intensity when the fine tuning control of the receiver is adjusted and are usually caused by incorrect alignment, or possibly regeneration in the video *i.f.* stages.

**Transmission Line Ghost.**—When the transmission line is not correctly terminated by the receiver, a portion of the signal is reflected at the receiver and travels back up the line to the antenna. If the antenna does not correctly terminate the line, a portion of this signal is reflected back and travels down the line to the receiver again, where it produces a trailing ghost.

With normal length of transmission line, the reflected signal takes very little time in travelling up and down the line, so it is only slightly delayed and does not appear as a separate ghost. It merges with the original picture signal and affects the picture quality by effectively widening the vertical lines so that they appear fuzzy.

Only with long runs of transmission line, will the reflected signal appear as a distinct and separate ghost.

*Corrective Measures.*—Proper matching of impedances between the antenna and transmission line and the transmission line and receiver input.

CHAPTER 4

# Interference Traps

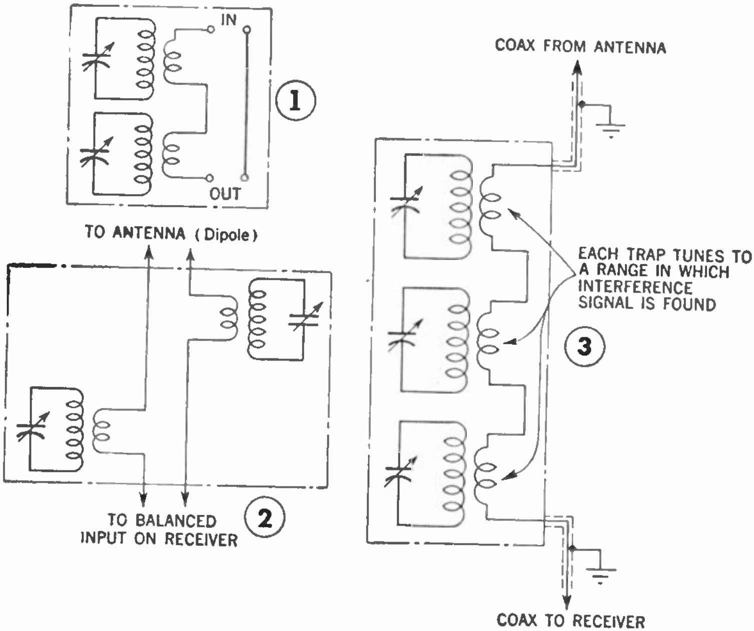
In the foregoing discussion of television interference and its corrective measures, mention was made of the insertion of wave traps. These are used in certain instances of interference, but should be resorted to only where all other corrective measures have failed to remedy the trouble.

**Wave Traps.**—Various types of interference emanating from FM and amateur transmitters and some commercial or police communication systems in addition to radiation from local oscillators of neighboring television receivers, can effectively be suppressed by the insertion of wave traps

Interference conditions of the foregoing type can be corrected by lowering of the input of the receiver at the frequency which causes the interference. A wave trap may be inserted in series with the antenna or it may be built into the receiver as a permanent feature.

Principally a wave trap consists of an LC circuit of fairly high "Q" which will resonate at the frequency it is desired to attenuate. They are often series resonant and inserted in one or both conductors of the transmission line and tuned to any undesired frequency. Figs. 1 to 3 show circuit diagrams of commonly used wave traps.

Fig. 1 shows a circuit diagram of a dual frequency range trap. A similar arrangement can be made by employing several or only one tuned circuit each of which resonates over possible interference ranges.




**FIGS. 1 to 3—Schematic diagram of various types of interference traps. Fig. 1 shows a common available unit. Fig. 2 is a trap designed for balanced input. Fig. 3, is a coaxial connected trap.**

The technique involved in employing these wave traps is that the trap circuit is not inserted in the antenna lead-in in the same manner as is the case with conventional traps. Note that the trap circuit is tightly coupled to the lead-in by virtue of the primary portion of each trap circuit which is actually connected in series with the transmission line. This broadens the band of effectiveness.

If the transmission line be a coaxial element then the two or more circuits can be coupled in series, as indicated in fig. 3.

If the line be parallel to a balanced input, then the two traps can be so wired that one circuit is in each leg and thus will not materially unbalance the antenna circuit. The balanced line connection is shown in fig. 2.

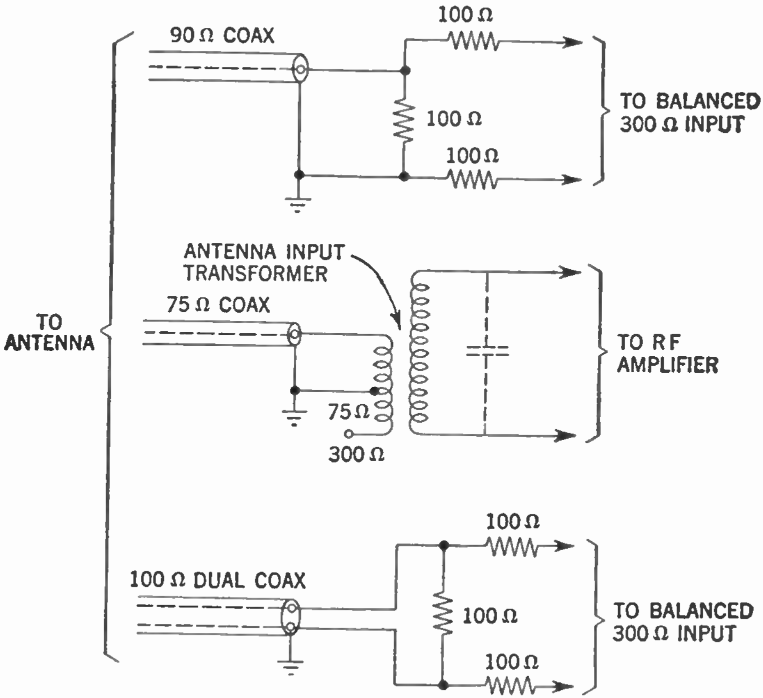
Suppression circuits can also take the form of a parallel resonant circuit which is inserted in the grid coupling system between the *r.f.* stage and mixer and therefore curbs the mixer action which produces the interference in the *i.f.* system.

To construct an effective wave trap it is first necessary to calculate the frequency of the interfering wave and construct or purchase a trap which can be inserted or tuned until the interference disappears. Booster amplifiers, because of their added selectivity, are also employed to suppress signal interference. It is for this reason that booster amplifiers are sometimes employed in strong signal areas.

**Impulse Noise Suppression.**—Impulse noises originating in electrical appliances such as electric cash registers, office equipment, electrical shavers, etc., can best be suppressed at the source. This is commonly accomplished by the insertion of a small 0.03 *mf* capacitor shunted across the line at the input to the device.

For complete noise suppression from large industrial equipment, electrical signs, etc., there are several types of filters on the market consisting of series-inductor and shunt-capacitor combinations available which prevents *r.f.* energy from feeding back to the power line and radiating or feeding directly into the television or radio receiver.

Because of the tendency of numerous noises to enter the television receiver via the power line, a filter inserted between outlet and receiver will in a great many instances, effectively suppress noises emanating from home appliances or industrial equipment operating on the same power line.




**FIGS. 4 to 6—Methods of matching coaxial lines to receiver input.**

In addition to the foregoing, a television receiver located in a noise area, can be protected by means of a coaxial line. This coaxial line can be in the form of a simple line with the proper matching system at its termination to match the input to the receiver, or when necessary, a dual coaxial transmission line can be employed. It should be observed that, whenever a coaxial line covers a considerable span, its shield should be grounded at several points to reduce the possibility of line pickup.

Another point of importance is that the transmission line be of the low-loss type, since in a poor quality high attenuation line reduction of noise pickup is confronted by additional attenuation of the signal, thus nothing is gained. Noise pickup can also be reduced considerably in a 300-ohm line by twisting it every foot or two.

It is a well known fact that neon signs are notorious offenders in the matter of television and radio reception disturbances. The flasher device is nothing but a set of switches and should therefore be treated similarly to that employed to silence other industrial equipment.

Another source of disturbance in neon signs is arching between connections particularly in the electrode housing, or between cable ends. Again interference may be caused by flickering tubing, overloaded transformer, faulty insulation, corona discharges between tubing and ground, loose connections, ungrounded transformer case, etc.

When reception interference has been found to be caused by a neon sign each of the aforementioned trouble sources should be investigated. As a general rule, however, it has been found that the employment of filter units across switch contacts, and also across the primary winding of the transformer will remedy the trouble.

It has also been found effective to install a high frequency choke properly insulated between the letters of the sign. When filters are installed, it should be remembered that the designs of the components employed must be able to withstand the potentials and the current which must flow through them.

In some television receivers a low pitched 60-cycle buzz will be heard from the loudspeaker when a station is tuned in. When there is more than one station locally, switching to these other stations will soon indicate where the difficulty lies. If the buzzing be evident with every station, it is safe to assume that the receiver is at fault. On the other hand, if the buzz is present only for one station, then the receiver is operating normally and the trouble arises at the transmitter. When a community is served by only one station, the best method is to observe whether other inter-carrier receivers exhibit the buzz.

Perhaps the most important consideration in areas plagued by interference and noise is the choice of antenna and its proper orientation. These considerations, however, have been fully covered elsewhere and need no further elaboration in this chapter.

CHAPTER 5

# Television Antennas and Transmission Lines

**General.**—All present day television receivers, irrespective of their location with reference to the transmitting station, require an antenna for their proper functioning.

Television antennas may be classified according to their location as:

1. Built-in antennas.
2. Indoor antennas.
3. Window antennas.
4. Attic antennas.
5. Outdoor antennas.

*Built-in antennas**, as the name implies, are those which are a component part of the television receiver, and are designed by the set manufacturer to function without the aid of an exterior antenna.

*Indoor type antennas* on the other hand are designed for placement in the immediate vicinity of the receiver, and where the dipoles are usually adjustable both as to length and to V-angle.

*Most television receivers are equipped with built-in antennas connected to antenna terminal screws at the rear of the cabinet. In many locations, however, it will be found that an outdoor antenna will provide better reception. In case an outdoor antenna be used, the built-in antenna has to be disconnected from its terminal screws and the outdoor antenna leads connected in its place.

*Window antennas* are designed for mounting on the window sill and its vicinity, and takes various forms depending upon requirements.

*Attic antennas* are designed for mounting in the attic of small dwellings, from which point they are connected to the receiver in the conventional manner.

*Outdoor antennas* are generally designed for installation on roofs of dwellings and are usually supported by a suitable piece of galvanized iron piping or masts whose dimension depends upon the height of the antenna array.

Television antennas may also be classified with respect to their geometrical structure and number of elements involved, as:

1. Dipole antennas (straight or folded).
2. Conical antennas (double or single).
3. Yagi antennas, etc.

Antennas for television reception are manufactured in a great variety of types as shown in figs. 34 to 47, although for average reception in localities fairly close to the transmitter the half-wave matched dipole type with reflector is most generally employed.

The quality of the picture that is reproduced on the screen of a modern television receiver is dependent upon many factors, some of which are beyond the control of the receiver. The information presented here is intended mainly to assist the service man in determining the factor the antenna plays in the normal reception of television.

The strength of the transmitted picture signal that reaches the receiver is a vitally important factor in determining the quality of the picture that is reproduced on the screen. A very weak signal will produce an unsatisfactory picture. In locations where the signal is exceedingly weak the picture will display a milky appearance which is usually accompanied by a "speckled" or "snow" effect.

**Television Transmission.**—The very high frequency waves ed for the transmission of television picture signals acts ite similar to rays of light, in that they do not bend around corners and are reflected by obstacles in their path.

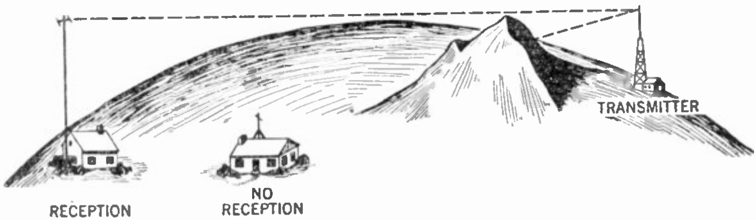



**FIG. 1—Illustrating line of sight transmission. Due to the line of sight behavior of television signals, receivers located in obstructed areas will generally not receive television programs unless precautions be taken in e form of special antennas.**

t should therefore be appreciated that television waves do not follow the curvature of the earth and reliable reception should only be anticipated in the region determined by the "line of sight*" to the horizon in all directions from the antenna tower of the transmitting station.

This region is generally designated as the "service area" of the station and includes an area having a radius of 50 miles

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*The line of sight distance as denoted in television literature is the maximum distance which high frequency radio waves will reach without being impeded by the curvature of the earth. It is illustrated in Fig. 1 and is governed by the relationship

$$d = 1.41 (\sqrt{h_t} + \sqrt{h_r})$$

Where $d$ is the distance between antennas in miles
$h_t$ is the transmitting antenna height in feet
$h_r$ is the receiving antenna height in feet.

or more, depending upon the relative height of the transmitting and receiving antennas, and the terrain between them.

Since signal strength decreases rapidly when the "line of sight" distance is exceeded, it is not possible to reliably predict conditions which might prevail at greater distances away from the transmitter. The technician who installs the television receiver must always carefully check to determine if signals at a particular location are of satisfactory strength.

The characteristic of high frequency television signals which permit them to be reflected from the walls of nearby buildings or other objects, may under certain conditions, create "multiple transmission paths." This would permit the reflected signal to arrive at the antenna a short interval of time later than the signal travelling in a direct path from the transmitter and the effect produced on the picture of the television receiver consists of a multiple image. These multiple images, known as "echos" or "ghosts" may generally be prevented by careful installation and orientation of the antenna.

**Transcontinental Television Transmission Systems.**—Since television transmission is limited to "the line of sight," an efficient relay system is necessary to link the country into television networks. There are two principal systems presently used for this purpose. They are:

1. The underground coaxial cable system.
2. The micro-wave radio relay system.

The coaxial cable system consists principally of a special type of telephone cable capable of passing a wide range of frequencies without the usual prohibitive losses and distortion. For a successful television transmission over longer distances however,

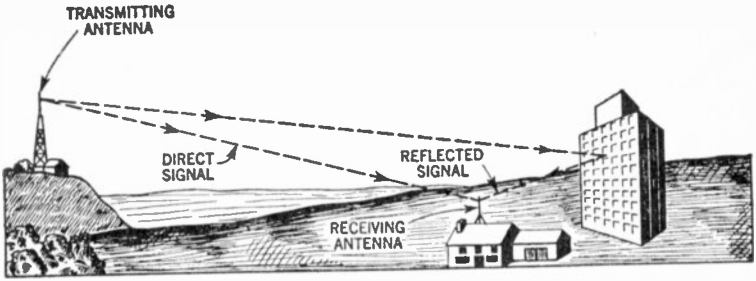



**FIG. 2—Showing reflected signal path, causing multiple image or ghost on television receiver screen.**

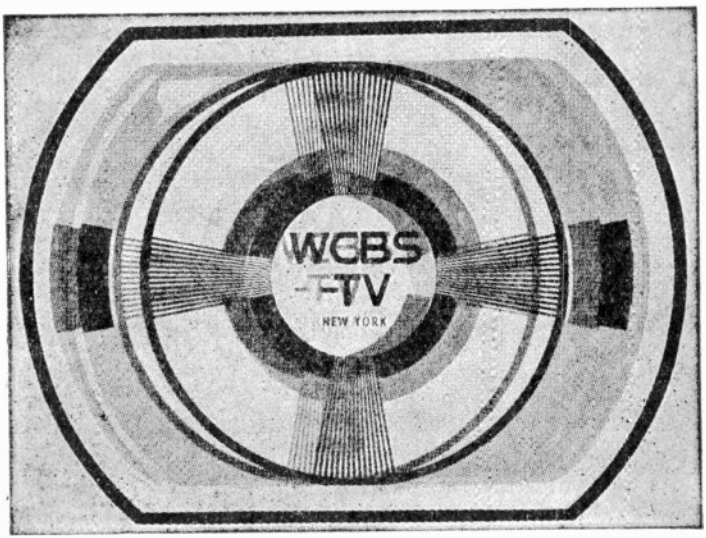



**FIG. 3—Typical test pattern showing "ghost signals" due to reflected waves from intervening structures.**

in addition to the coaxial cable, special repeater amplifiers (relay stations) are required spaced at an equal distance from one another.

The micro-wave radio relay system of increasing the range of television coverage, on the other hand, consists of a chain of towers located 10 to 25 miles apart. Each tower contains receiver to pick up the signal from the preceding tower and transmitter to rebroadcast it to the following tower.

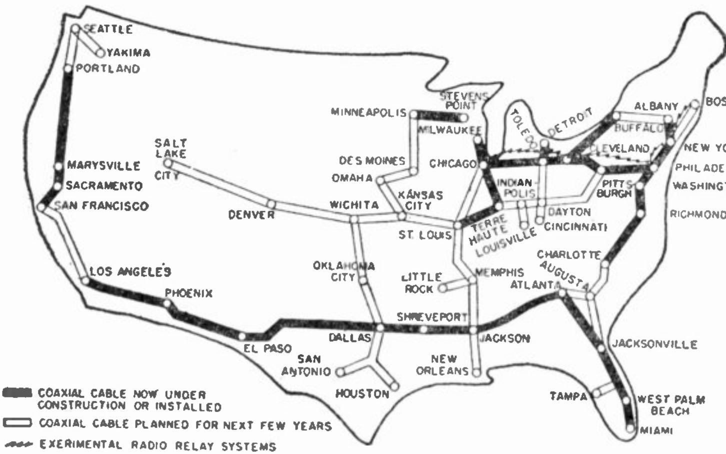



**FIG. 4—Showing present status of transcontinental coaxial cable and radio relay system.**

**Receiving Antenna Principles.**—For best reception each antenna should be selected with reference to distance and other factors covering the particular installation.

Fundamentally the three elements present in any televisi( antenna installation are:

1. Antenna.

2. Transmission line.
3. Receiver.

The function of the antenna is to pick up the signal transmitted from the station and to transmit the signal to the receiver through the connecting transmission line.

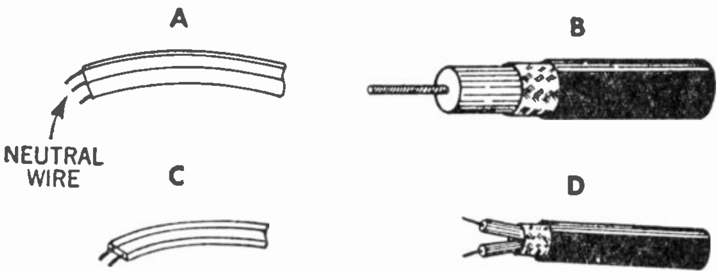
**Transmission Lines.**—There are four general types of transmission lines acting as a transmission link between the antenna and the receiver. They are:

1. The two-wire parallel-conductor type.
2. The coaxial cable type.
3. The twisted pair type.
4. The shielded pair type.

There are several constructional variations in the basic types of transmission lines. Prior to the introduction of the polyethylene dielectric two-wire transmission line, a parallel conductor line in which the two wires (ordinarily No. 12 or No. 14) were supported a fixed distance apart by means of insulating rods called "spacers". The dielectric between the conductors consisted of air.

The modern two-wire transmission line is a parallel conductor line with stranded conductors imbedded in a low-loss insulating material (polyethylene). It has the advantages of low weight, compactness and neat appearance, together with close and uniform spacing. Losses, however, are higher in the solid dielectric than in air, and dirt or moisture on the line tends to change the characteristic impedance. Two-wire transmission lines of this type are available in impedances of 75, 150, and 300 ohms.

The most common type of coaxial transmission line consists of either a solid or stranded wire inner conductor surrounded by polyethylene dielectric. Copper braid is woven over the dielectric to form the outer conductor, and a waterproof vinyl covering is placed on top of the braid. This cable is made in a number of different diameters. It is moderately flexible, and so is easy to install. Coaxial cable is available in characteristic impedances of 52, 72, or 150 ohms.




**FIGS. 5 to 8—Various types of transmission lines. In the illustration A, represents a 300 ohm molded wire line with a third or neutral wire separating the parallel pair. B, coaxial cable with full length polyethylene dielectric. C, typical 300 ohm two wire transmission line. D, shielded parallel twin lead 300 ohm transmission line.**

The air insulated coaxial cable transmission lines have lower losses than the solid dielectric type, but are less used because they are expensive and difficult to install as compared with the flexible type. The common type of air insulated coaxial cable uses a solid wire conductor inside a copper tube, with the wire held in the center of the tube by means of special insulating "beads" spaced at regular intervals.

Most television receiver manufacturers have made provision on the 300 ohm input to allow for the direct connection of 72 ohm cable. This is usually accomplished by the employment of a tap connected to unbalance the input circuit when the 72 ohm cable is attached.

**Practical Antenna Calculation.**—For proper antenna design it is necessary to know the length of the electromagnetic waves involved. In order to determine wave lengths, however, it is necessary to know the speed at which electromagnetic waves travel through free space, and the frequency. In speaking of the frequency of electromagnetic waves we merely mean the number of waves passing a given point in one second, expressed in megacycles (millions of cycles).

Since electromagnetic waves of all lengths move at the same speed, the number of waves passing a given point in one second will be small if the waves are long, and large if the waves are short. Thus, 500,000 waves 600 meters in length will pass a given point in one second at a frequency of 500,000 cycles. Similarly, if the waves were only one meter in length 300,000,000 would pass each second, which is a frequency of 300 *mc*.

The actual velocity of electromagnetic waves is for all practical purposes 300,000,000 meters or 984,300,000 feet per second.

Now, if the speed at which the waves travel is equal to $3 \times 10^8$ meters per second, the distance it will cover in one cycle will be equal to this velocity divided by the frequency in cycles per second, or

$$\lambda = \frac{3 \times 10^8}{f}$$

where "$f$" represents frequency, and the Greek letter *lambda* stands for wave length in meters. Since feet and inches are the measurement used for practical television antennas we obtain:

$$\lambda = \frac{984}{f(mc)} \text{ ft. (approx.)}$$

and

$$\lambda = \frac{11{,}808}{f(mc)} \text{ ins.}$$

Because the length of each quarter dipole element in inches is the dimension most frequently required, we obtain:

$$\lambda/4 = \frac{2{,}952}{f(mc)} \text{ ins.}$$

Due to certain electrical characteristics of the antenna material it has been found that in practice the antenna elements should be somewhat shorter (about 5 per cent) than that given in the foregoing formula. The formula then becomes:

$$\lambda/4 = \frac{2{,}952 \times 0.95}{f(mc)} = \frac{2{,}804}{f(mc)} \text{ inches}$$

From this latter formula it is comparatively simple to obtain the antenna dimension for each frequency, by substituting the proper value in megacycles (*mc*).

Dipole antennas that are to be used in outside installations consist usually, of two quarter wavelength sections of 3/8 in. aluminum tubing or rods.

The following example shows the general procedure when it is desired to calculate the exact length in inches, of each element (quarter wavelength) of a simple half-wave dipole antenna.

**Example.**—*It is desired to determine the length of a quarter wave dipole rod suitable for use on channel four, where the frequency according to the table page* 131 *has an average value of* 69 *mc. What is the dipole rod length?*

**Solution.**—By employing the foregoing formula a substitution of values gives the quarter wave length in inches as

$$\lambda/4 = \frac{2{,}804}{69} = 40 \text{ Approx.}$$

By using a similar procedure, it is a comparatively simple matter to calculate antenna dimension for any desired channel or frequency.

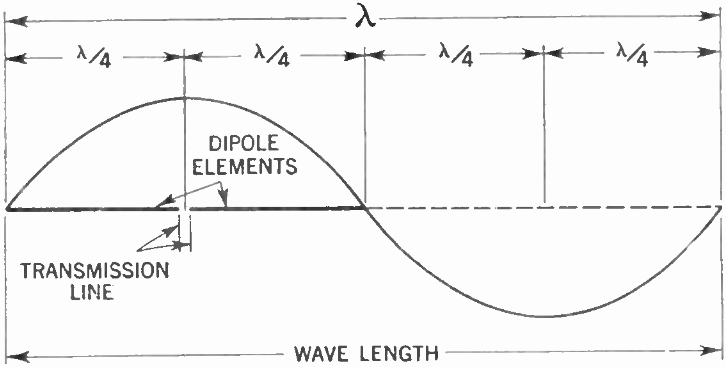



**FIG. 9—Showing relations between wavelengths and length of dipole elements used in television antenna construction.**

**Dipole Antennas.**—The fundamental form of a dipole antenna consists of two single wires, rods or tubings, whose combined lengths are approximately equal to half the transmitting wavelength. It is from this basic unit various forms of television antennas are constructed. It is also variously known as a half wave dipole, half wave doublet or Hertz antenna.

The complete television receiving antenna normally consists of two half wave dipoles (receiver and reflector) mounted in the form of an H on a substantial supporting mast or pole, strapped at its lower end to the building or roof housing the receiver.

The dipole elements are made of steel, aluminum or copper-alloy tubing and surface treated against corrosion. The receiver dipole is equipped with terminals at its adjacent ends for

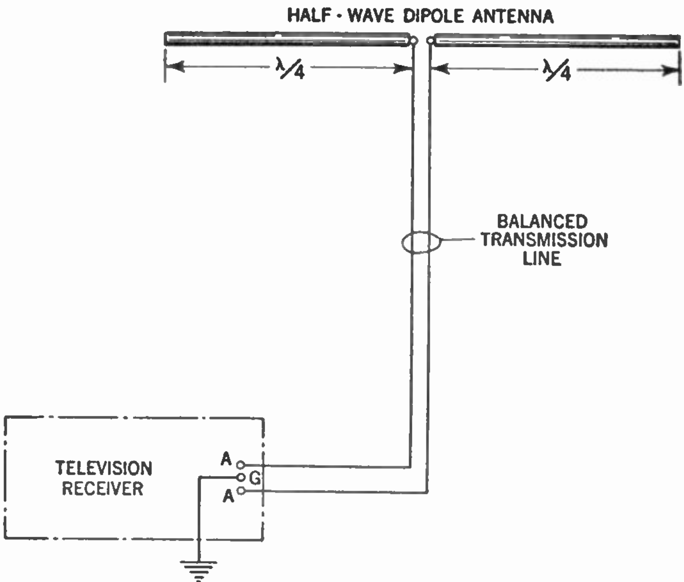



FIG. 10—Showing transmission line connection between a half-wave dipole antenna and television receiver.

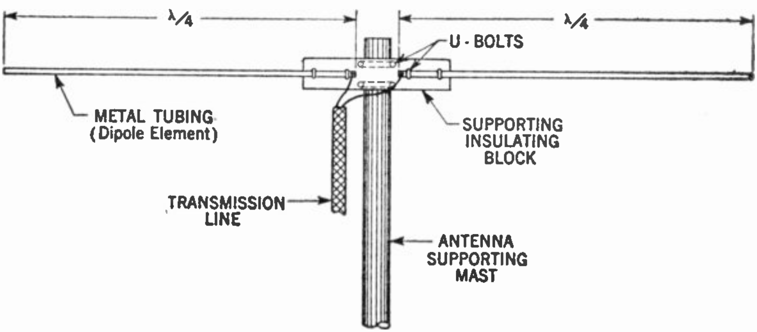



FIG. 11—Illustrating mounting arrangement and connection of half-wave dipole antennas to transmission line.

transmission line connections and must be properly insulated from the mast or supporting structure. The reflector on the other hand, may be joined directly to the antenna cross member, as shown in fig. 12.

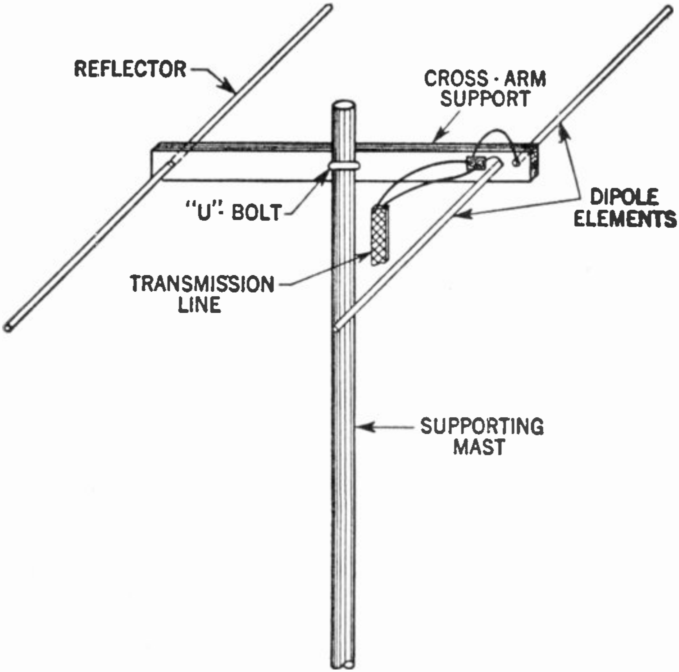



**FIG. 12—Typical mounting arrangement of dipole antenna elements with reflector.**

**Folded Dipoles.**—The necessity for separating, insulating and fitting the receiver dipole at its center, however, tends to weaken and complicate the antenna assembly. Because of this, a considerable simplification may be obtained by employing an unbroken member bent and clamped to the supporting member as shown in fig. 14. A television antenna of this type is known as the *folded dipole type* and is widely used.

The spacing between the folded dipole elements should vary inversely with the frequency, that is, the higher the frequency

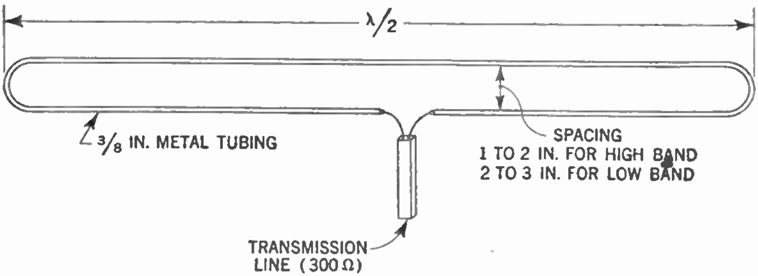



**FIG. 13—Dimensional requirements of folded dipole antenna.**

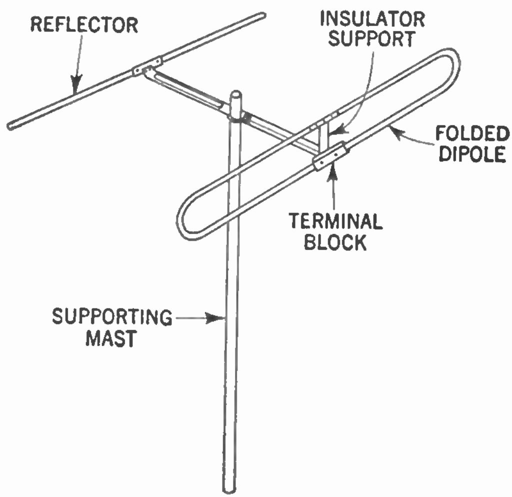
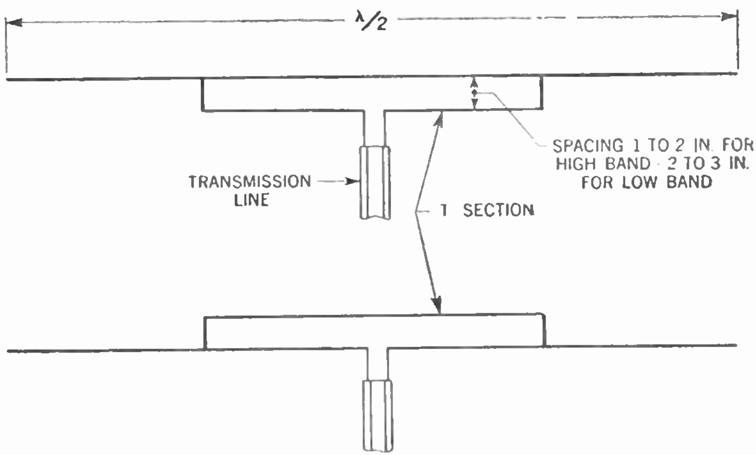



**FIG. 14—Showing mounting arrangement of folded dipole antenna with reflector.**

the smaller the spacing. The element spacing for the center frequency on the low band is usually 2 to 3 inches, and 1 to 2 inches for the high band.

**T-Matched Dipoles.**—A further combination of the common half-wave dipole and the folded dipole has become known as the T-matched dipole type. With reference to figs. 15 and 16




**FIGS. 15 and 16—Showing T-matched dipole antennas. In the illustration both antenna arrangements have identical electrical characteristics.**

the assembly is obtained by cutting the ends of a folded dipole and fitting the remaining stub ends to the bottom element, the T-section having a length of two-thirds the length of the dipole.

There are three principal factors to be considered in the design of a dipole antenna for television reception purposes. These are:

1. The length of the dipole shall be suitable for the particular wavelength in use.

2. The polarization of the transmitted waves shall be that for which the dipole is intended.

3. The directional properties of the dipole shall be such as to receive the desired waves effectively, while being unfavorable towards local interference.

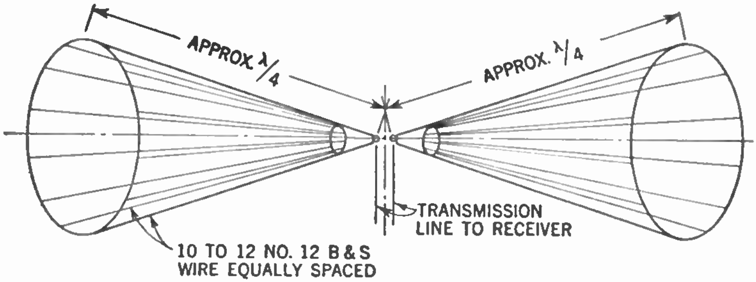



**FIG. 17—Construction principles of conical antenna. The characteristics of the conical type are superior to the folded or straight dipole type of antenna from the standpoint of gain and band width. Actually the best arrangement would be the use of solid closed cones made of copper. This arrangement however, is impractical because of its weight which will be considerably increased in locations where the antenna will be exposed to sleet and snow. A satisfactory compromise employs 10 or 12 No. 12 B & S wire rods to take the place of the solid cones.**

**Conical Antennas.**—An antenna in which the cross-section of each of the two halves increase smoothly outward from the center is termed a "conical" type. Because of its cone-like design, it will receive a very wide band of frequencies. Since this type of antenna has a large cross-sectional area, the length must be considerably reduced to keep resonance at the same frequency. Mechanically, however, problems arise in its construction, and its mounting on the roof will cause considerable difficulties.

In the case of television reception the first requirement should be extended to include the provision of a flatly tuned antenna system, able to respond fairly evenly over the waveband involved and also pick up the FM sound transmission. This compromise is often assisted by choosing the length of the antenna to resonate at a frequency intermediate between sound and video transmission.

The polarization of the waves to be received may be either vertical or horizontal. An antenna placed in the horizontal plane radiates horizontal polarized signals, whereas, an antenna placed in a vertical plane radiates vertically polarized signals.

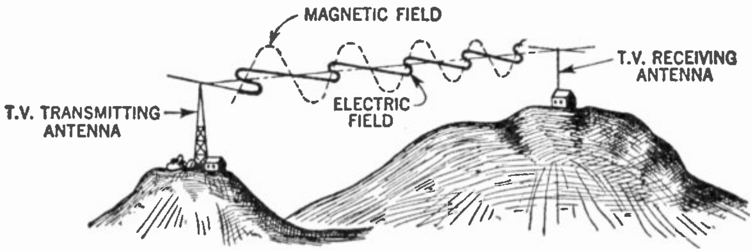



**FIG. 18—Showing magnetic and electric field of horizontally polarized wave fronts.**

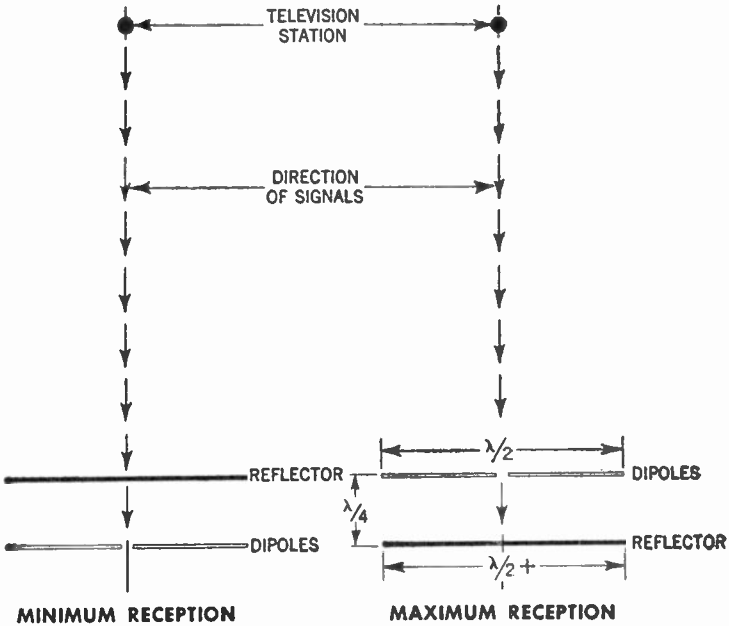
Television transmitting and receiving antennas in the United States use *horizontal polarization* and the receiving antennas are therefore *placed horizontally.*

**Parasitic Elements.**—A parasitic element, as employed in television antennas, is a dipole slightly too long or too short for exact resonance at the desired frequency. It is mounted at some fraction of a wave length before or behind the driven element. Parasitic elements are not cut at the center and are not connected to the transmission line. The center point of a parasitic element is electrically neutral and can be grounded. This is convenient for lightning protection, as it permits making the entire antenna structure of conductive tubing such as aluminum or stainless steel if desired, and grounding the central supporting mast at the base.

Current induced in a parasitic element by the advancing wave front produces a local field about it which couples it to the driven element by reason of their physical closeness. Spacing and tuning of parasitic elements are adjusted so that current produced in them by the received signal produces fields around them which add up in correct phase to reinforce the field of the received signal itself, in the driven element. For signals from the opposite direction, the action is exactly reversed, and the signal is substantially cancelled in the driven element.

**Director and Reflector Elements.**—A director element is about 4 per cent shorter than the driven element for average element spacing, and is mounted on a horizontal support member of wood or metal which holds all the elements in proper relationship. The spacing between director and driven element can vary from about 0.08 to about 0.15 wavelength in practical antennas. Closer spacing will increase the front-to-back ratio, but makes the array tune more sharply, which is bad where many widely separated television channels must be received on a single antenna. Wider spacing helps broaden the tuning of the array, but lowers the front-to-back ratio. It is possible to use several directors properly tuned and spaced in a line ahead of the driven element, but this complexity and expense is seldom necessary or justified.

A reflector element is about 5 per cent longer than the driven element at usual spacings, and is mounted on the supporting bar behind the driven element, the spacing varying from about 0.10 to 0.25 wavelength. Effects of changing the




**FIGS. 19 and 20—Showing location of reflector element for maximum reception. The antenna elements should always be arranged broadside to the transmitting station, with the reflector approximately one-quarter wave length behind the half-wave dipole.**

spacing are quite similar to those produced by similar changes in the director.

The effect of the reflector is critically dependent upon the spacing between reflector and dipole, which as previously noted should be one-quarter wavelength, when radiation from the reflector should exactly reinforce that from the dipole in a forward direction.

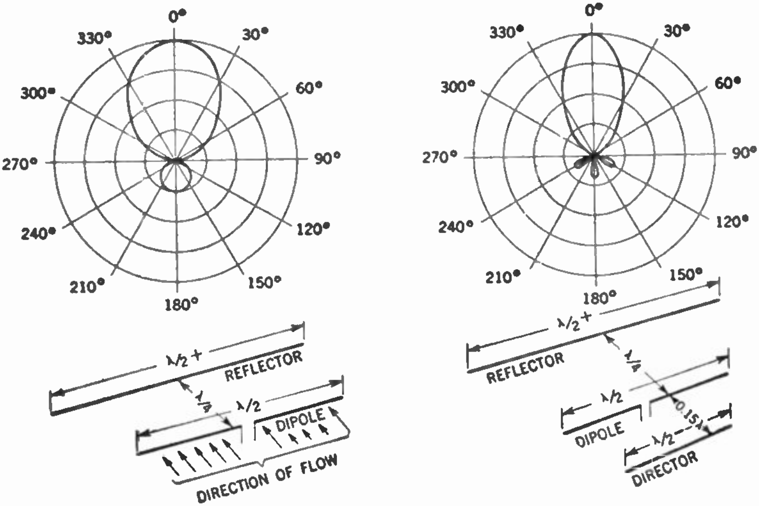
The explanation of this effect is as follows: Radiation from the dipole travels both forward and backward. In the latter direction it reaches the reflector, and induces a current in it. Since the radiation has travelled a quarter wavelength on its way to the reflector, it will reach it 90 degrees lagging in phase relative to that from the dipole where it originated. A current of this phase lag is therefore set up in the reflector, which in turn radiates.

By the time this secondary radiation has returned to the dipole it is a further 90 degrees late in phase, making a total phase lag of 180 degrees, but the oscillations in the dipole will have progressed through a half-cycle during this half-wave time interval, and will be 180 degrees ahead of the initial condition, when the radiation left on its way to the reflector. That is to say, the radiation from the dipole will be a half-cycle ahead of the reference point, while that returning from the reflector will be a half-cycle late, bringing the two to the same point in the period of an oscillation.

Being in identical phase, the radiations from the dipole and reflector reinforce each other in the forward direction, while an extension of the same argument will show that they tend to cancel in the backward direction.

If the current induced into a reflector was as great as that flowing in the dipole, each would produce the same radiated field strength. The forward radiation would therefore be doubled, while that to the rear would be exactly cancelled, giving zero backward radiation.

Since the problem of radiation and absorption by an aerial system are strictly reversible in all ordinary conditions, these directional effects, which are most easily explained when the antenna is regarded as a transmitter, will be exactly similar when it is used for reception, provided of course that waves arrive in the plane in which dipole and reflector are situated.




**FIGS. 21 to 24—Showing typical response pattern of two and three element antennas, respectively. From the diagrams it may readily be observed that each additional parasitic element increases the directivity and narrowness of the antenna response. An antenna array with three or more elements of the single or stacked type are frequently employed in fringe areas where only one transmitting station is normally receivable.**

In practice the resistance of a reflector will never be zero, and while the current in it can be made equal to that of the radiator if both are connected to a feeder, the current in a parasitic reflector must always be less than that in the dipole which gave rise to it. The forward radiation is therefore, never exactly doubled or the backward radiation fully prevented.

**Antenna Directivity Pattern.**—The horizontal antenna dipole is inherently directional, being most effective to signals arriving in the broadside direction and least effective to those arriving from a direction parallel to it. This effect is usually represented in the form of a polar diagram, or directivity pattern, in which the radius of the curve from the center of the antenna elements represent the relative response in any given direction.

The function of an antenna pattern is primarily to enable the service man to evaluate the efficiency of an antenna and assist in the proper orientation of it, on the site of installation.

Plotting an antenna pattern is generally accomplished as follows: A minimum usable value of signal strength is chosen on the basis of what the average television receiver will require for satisfactory reception. Then all the points in the area surrounding the antenna where exactly this value of field strength is found are plotted by bearing from true *North* or some other convenient reference direction, and distance in miles, or some other desired linear unit. With a sufficient number of points plotted, a continuous smoothly curving line is drawn joining them all, and it will be reasonably certain that all the area enclosed by this curve will provide at least the minimum required signal.

In practical service work, directivity patterns are always plotted in terms of voltage gain, as this unit is most convenient to use in connection with the survey meter, which is usually a part of the television service technicians equipment.

Antenna receiving patterns are usually made by rotating the antenna about its vertical axis and plotting values of voltage gain radially outward from the center of each change of angle.

The complexity of an antenna has a direct bearing on its efficiency, as well as its directional effects. Roughly, the voltage developed in the antenna is proportional to the combined length of the element multiplied by the field strength of the signal.

This length is measured in units of half-wavelengths. A reduction in the voltage realized at the antenna terminals results from the mutual coupling of the elements.

A comparison of the theoretical efficiency of various types of antennas are as follows:

| *Elements* | *Type* | *Voltage gain* |
|---|---|---|
| 1 | Simple Dipole | 1.0 (reference) |
| 2 | Dipole and Reflector | 1.6 |
| 4 | 2-Bays | 2.3 |
| 6 | 3-Bays | 2.8 |
| 8 | 4-Bays | 3.2 |

In the foregoing table, the reference value of 1.0 shown for a simple dipole is the universal standard of comparison. This reference dipole is cut to a half-wavelength for each channel measured.

As previously noted, the voltage developed by a half-wavelength antenna is proportional to the length of the antenna. Therefore for purposes of adding additional elements, multiples of half-wavelengths are used.

The receiving antenna height particularly in fringe areas, is an important factor in its efficiency, or signal capture, as shown in figure 25. The possibility of interference is shown by the irregularity of the curve representing signal on the high channel group. This particular effect, however, is not predictable and can only be determined by proper orientation.

The field pattern (directional response pattern) of a typical dipole antenna is shown in figure 27.

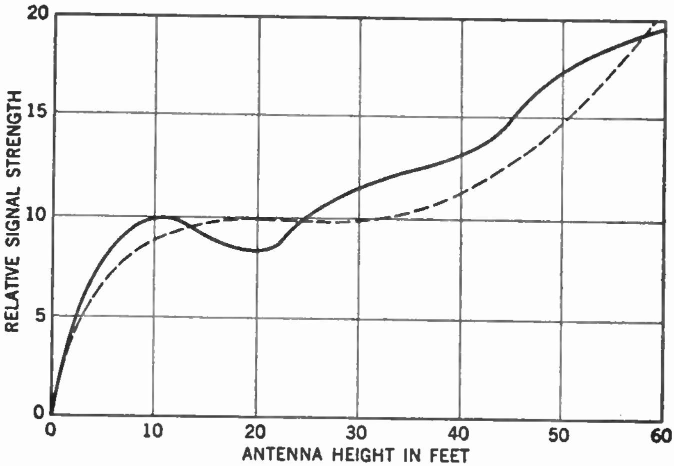
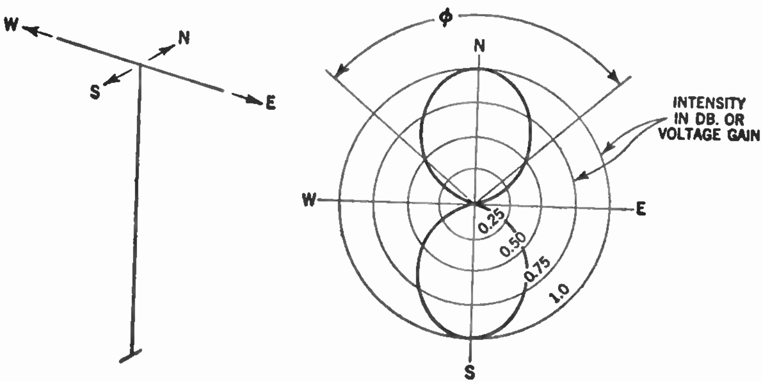



FIG. 25—Showing relative signal strength of antennas per height in feet. The above chart applies to antennas located in fringe areas or at a considerable distance from the transmitting station.



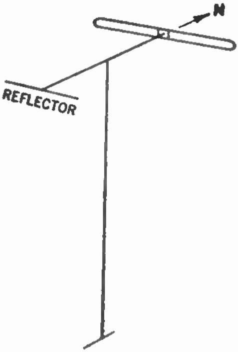

FIGS. 26 and 27—Showing directional response pattern of dipole antenna.

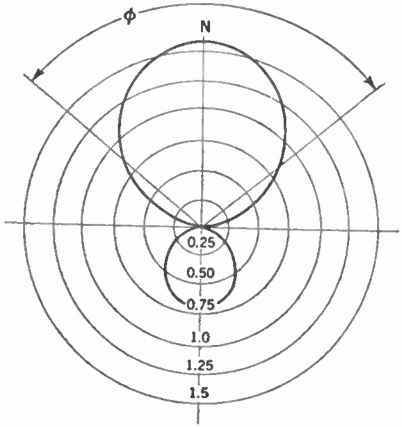
For the sake of simplicity the directions are given as North, South, East and West, in both the schematic antenna and the polar diagram. From this diagram, it will readily be observed that the maximum signal strength will be obtained when the antenna is broadside to the transmitter. Similarly the "signal capture" is not critical over the angle $\phi$, which includes the rotation over which the antenna can be rotated before losing more than half of its effectiveness. In the diagram the concentric circles represent the voltage gain, where unity, or 1.0 is taken as reference for all comparisons.

If a reflector be added to dipole, the gain and directional characteristics of the antenna are changed and the polar diagram will take the form as indicated in figure 29. It will be observed from the diagram that the angle $\phi$, is still sufficiently wide, generally at least 80 degrees.

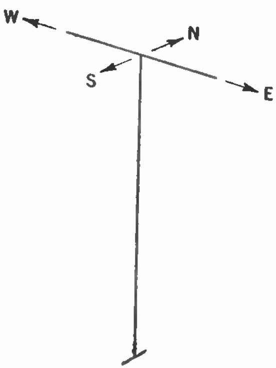
So far, an antenna operating only on the channel for which it was designed has been considered. It is the usual practice to use dimensions which give half-wave dipoles in the middle of the low channels. When used on the high channels, a third harmonic will result, giving an antenna pattern shown in figure 31.

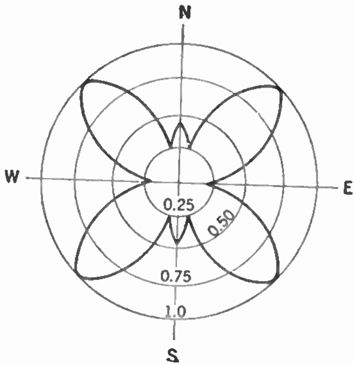
A dipole operated in this way will have six lobes, and unless certain dimensions are revised, these lobes are symmetrical, and oriented as indicated. With reference to the field pattern, these lobes are too narrow and are pointing in a different direction, from that previously shown. This will make orientation difficult, or even impossible if the stations on the high and low channels are in the same direction. From this it follows, that no reliable antenna manufacturer would sell an antenna with these characteristics, without showing the relation of the lobes for each frequency.




FIGS. 28 and 29—Directional response pattern of folded dipole antenna with reflector.




FIGS. 30 and 31—Directional response pattern for dipole antenna showing the necessity for proper dimensioning of antenna elements.

The ratio between maximum and minimum voltage (measured with a voltmeter slid along the line) is called the *voltage standing wave ratio*, abbreviated SWR. It is obtained numerically by dividing the maximum by the minimum voltage. Thus maximum and minimum values of 15 and 5 would mean a SWR of 3.

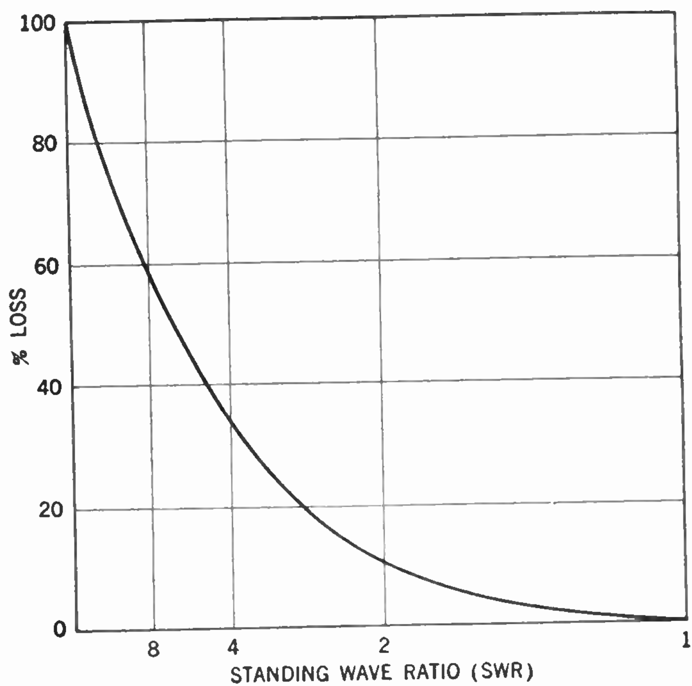



**FIG. 32—Characteristic curve showing relation between voltage standing wave ratio and per cent loss due to mismatch in antenna installations.**

If the SWR be plotted on a logarithmic scale against per cent loss the curve will take the form shown in fig. 32. Here it will be observed that a SWR of two will cause a loss of only 10 per cent, while a SWR of three will cause a loss of 25 per cent.

**Antenna Impedance Matching.**—Impedance matching is a very important factor in antenna installations. When the receiver input matches the impedance of the transmission line, the transmitted signal is completely absorbed and as a result there are no reflections or *standing waves* on the transmission line, and consequently no ghost image. In this connection it should be observed that the antenna impedance is important only from the standpoint of power transfer. It is only when the antenna impedance matches that of the transmission line that maximum power transfer takes place.

A condition which may easily arise is the mismatch of 300 ohms to 72 ohms; this produces a SWR of four and a loss of 37 per cent. This condition will be the result when a 72-ohm antenna is connected to a receiver having a 300-ohm input impedance. Mismatch, and consequent loss of gain also occurs when the antenna and receiver are not connected by transmission cable of proper characteristic impedance.

Impedance matching is most commonly accomplished by the use of the impedance inversion characteristic of a one-quarter wavelength section of cable. This is expressed by the simple relation: Input impedance times the output impedance is equal to the square of the characteristic impedance of the cable used for the one-quarter wave transformer.

That is:

$$(Z_0)^2 = Z_s Z_r$$

Where $Z_0$ = characteristic impedance
$Z_s$ = input impedance
$Z_r$ = output impedance

To illustrate an impedance matching application of a one-quarter wave linear transformer, when using the 72 ohms antenna connected to a receiver having a 300-ohm input impedance, we obtain:

$$Z_0^2 = 72 \times 300, \text{ from which}$$
$$Z_0 = \sqrt{21{,}600}, \text{ or}$$
$$Z_0 = 147 \text{ ohms (approx.)}.$$

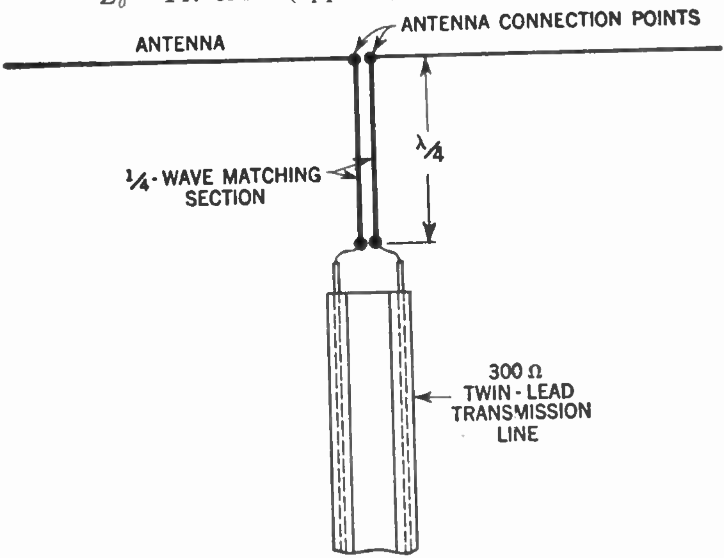



**FIG. 33—Illustrating insertion of quarter wave matching section to obtain proper impedance match.**

From our calculation it will be observed that one-quarter wave section from a 150-ohm twin conductor line will be very close to a perfect match. This should be spliced in between the end of the 72-ohm line and the receiver input with due attention to good connection.

**Fringe Area Reception.**—By the term *fringe area* is generally understood a receiver location which is considered as outside the normal service area of a transmitting station.

Specifically, a fringe area is considered to be the outlying part of a whole general area reached by the television signals from a given metropolitan center, where signals are so weak so as to require the use of high gain antennas, or masts higher than the standard single length or both.

Television reception in fringe areas is generally dependent upon the following factors:

1. Signal to noise ratio in the area.
2. Gain and directivity of the transmitting antenna.
3. Sensitivity of the receiver.

Factors which contribute adversely to distant reception are:

1. Transmitting stations with power of less than 20 *kw*.
2. Transmitting stations with an antenna of less than 1,000 feet in height.
3. Intervening obstructions between transmitter and receiver such as hills; mountains, forests, etc.

Since the gain and directivity of an antenna depends upon the number of dipole and parasitic elements assembled, a fringe area usually requires a somewhat more complex antenna array than that required in the intermediate service area.

The signal to noise ratio in any fringe area can usually be improved considerably by increasing the height of the receiver antenna and by selecting an antenna with a narrow horizontal and vertical pickup pattern. In some cases an antenna system alone will not suffice and an RF booster (preamplifier) may be required to increase the weak signal to usable value.

**Stacked Arrays.**—It has been found that additional antenna gain may be obtained by stacking the conventional dipole and reflector. This consists in arranging one driven element on top of another at a spacing that will cause the signals to be in phase at the terminals where the transmission line is connected to the antenna system.

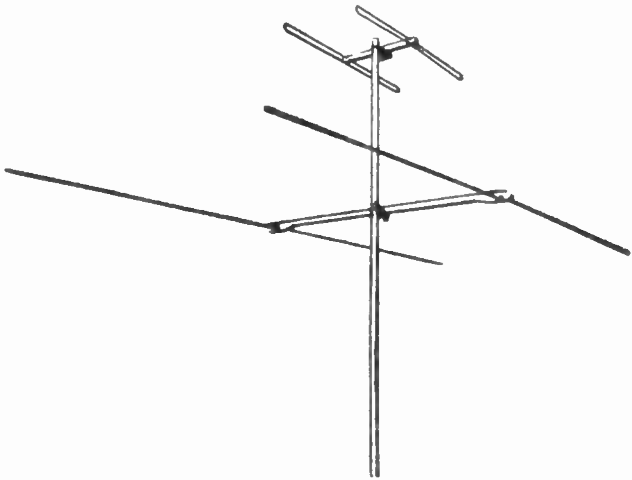
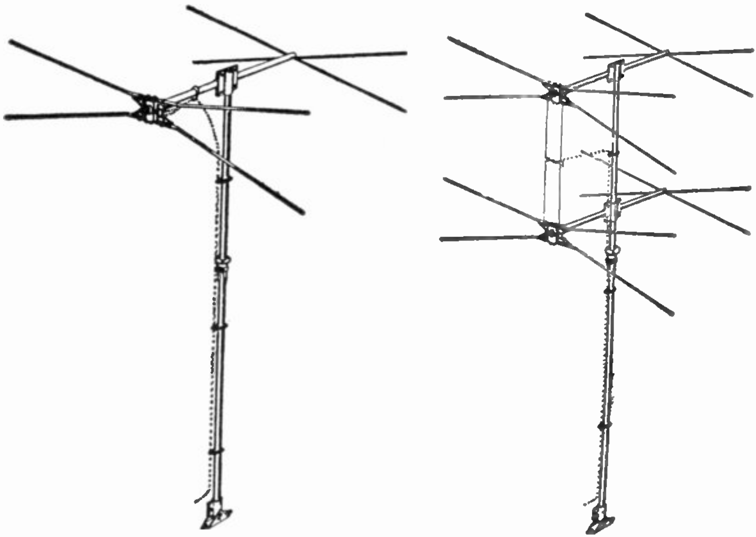


**FIG. 34—Typical high and low band combination antenna.**

There are many types of antennas available for fringe area reception. In general, the stacked dipole and reflector is better than the conical type on the low bands, but it is inferior on the high bands because of the smaller dimensions. It can be made broad-band so that one unit will operate over all the low channels; but for the high channels there must be another set of elements. For this reason, this type is made with two sets of elements, either above each other on the mast, or in line on the same cross-arm. Fig. 34 shows a typical arrangement of this type, which is generally known in the trade as the high-low combination antenna.

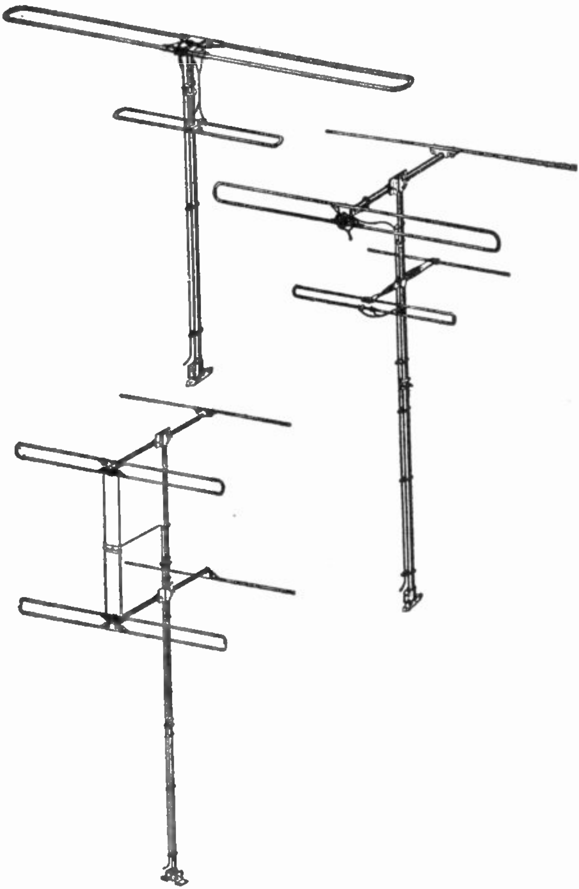
An effective compromise on directivity, gain and band width has been obtained with the introduction of a stacked in-line



**FIGS. 35 and 36—Illustrating two types of conical antennas. These antenna arrays are sometimes termed "fan type" antennas.**

antenna shown in fig. 41. This antenna combines the added signal on two-stacked folded dipoles and reflectors for a single transmission line.

Theoretically, one of the best types of television receiving antennas is the conical type. Because of its cone-like design it will receive a very wide band of frequencies and maintain an almost constant terminal impedance over the entire frequency



FIGS. 37 to 39—Three distinct variations of antennas for fringe area reception. Fig. 37 represents a folded high-low band type; fig. 38, high-low band folded dipole with reflectors; fig. 39, high-gain stacked array.

range it is designed to cover. Two types of stacked conical antennas are shown in figs. 35 and 36.

The Yagi array, fig. 42, is a high-gain antenna. The gain is roughly 2.2 times for one bay and 3.2 times for two bays. It has the disadvantage, however, of being a narrow band antenna, and for full gain a separate array must be used for each channel.

**FIG. 40—Double folded dipole antenna with reflector. An antenna of this type will give an excellent forward gain and high forward-to-back ratio. The antenna requires only one transmission line to receiver and requires no special matching network to give excellent performance on high and low bands. It is used preferably where transmitting stations are located not too far apart.**

The angle of orientation, including the one-half power points is about 40 degrees. It is frequently employed in fringe areas to pick up some station, and for this purpose it is probably the best type available. A typical Yagi type design having two, 4-elements stacked vertically for reception on channel four is shown in fig. 44.

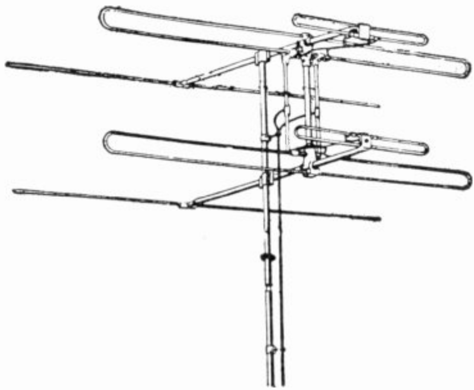
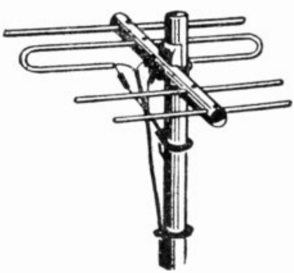
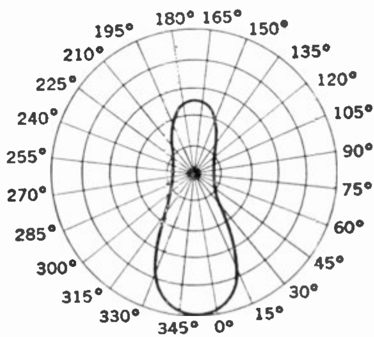


FIG. 41—Typical stacked in line folded dipole antenna array with reflectors.



YAGI ARRAY




DIRECTIVITY PATTERN

FIGS. 42 and 43—Typical Yagi array and associated directivity pattern.

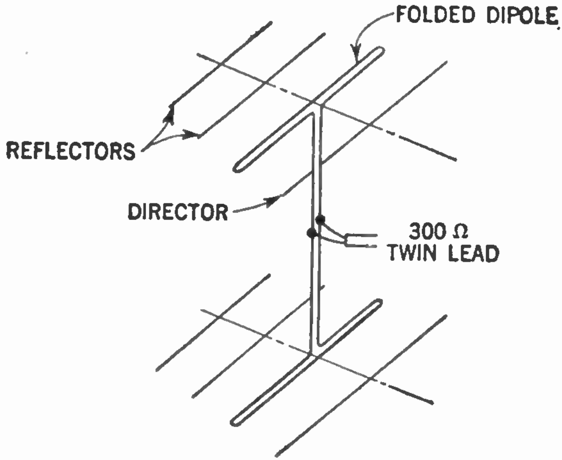
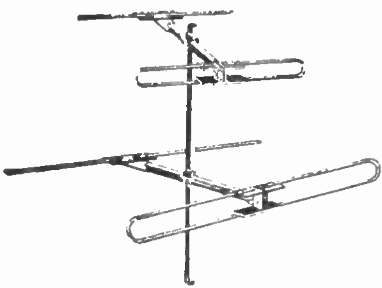



FIG. 44—Schematic diagram showing two, 4-element Yagis stacked vertically. This arrangement forms a highly directional and sensitive antenna. One 4-element array is satisfactory in many areas.



FIGS. 45 and 46—Typical folded dipole high and low band antennas. Fig. 46 incorporates in addition to the folded dipole with reflector for the low band, a Yagi array for use on the high band.

Another type of antenna being used in suburban and fringe areas is an antenna known as the *rhombic*, which has high gain and directive characteristics in the television bands.

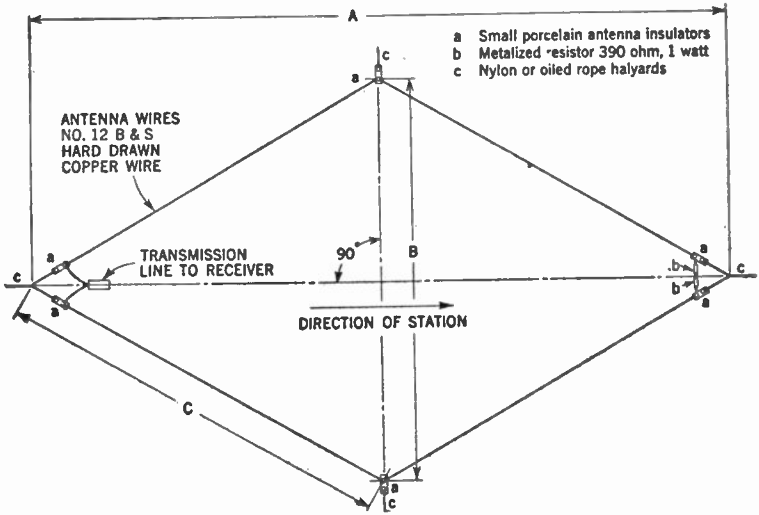



**FIG. 47—Schematic diagram of rhombic antenna layout for unidirectional reception. With reference to the diagram typical dimensions for a high band compact antenna are A = 16 ft.; B = 12.5 ft. and C = 10.2 ft. For a low band compact type the dimensions are A = 45.5 ft.; B = 35.5 ft. and C = 28.9 ft. Dimensional requirements for a high band long legged rhombic antenna similarly are A = 36.1 ft.; B = 18.9 ft. and C = 20.5 ft. For a low band long legged type the dimensions are A = 102 ft.; B = 53.2 ft. and C = 57.6 ft.**

To obtain the best results with this type of antenna, the legs of the rhombic should be made at least three wavelengths on the low bands and five wavelengths on the high bands. Where two-band coverage is required a high-band rhombic can be strung inside a low-band job from the same supports. The separation will be sufficient to avoid undesirable interaction.

Because of its dimensional requirements, the space required for erection of a rhombic type of antenna is somewhat of a handicap, particularly where the home is located on a small area of land.

In the construction of a rhombic the first step is to estimate just how many wavelengths on a leg can be erected on the space allotted. The greater the number of wavelengths, the sharper and more sensitive the antenna will be.

The next step is the orientation; that is, the array should be pointed in the exact direction of the transmitter. This can be determined by means of a suitable map and an accurate compass.

For proper operation a rhombic array must be terminated in a substantially non-reactive resistance of 800 ohms. Satisfactory operation will be obtained by simply connecting in series two 390-ohm metalized resistors of the hermetically sealed type shown in fig. 47. Two in series are preferable to a single resistor having twice the resistance for reasons which need not be discussed here. Care should be taken to make sure that the resistors used are not of the wire-wound type.

Only about 10 per cent loss in signal voltage will result if a rhombic array be fed directly into a 300-ohm line without benefit of a matching transformer. Therefore, while it is possible to construct a matching arrangement which will result in a precise match, the improvement hardly can be considered worth the trouble.

In selecting the most suitable antenna for fringe reception there are no hard and fast rules to follow, since the choice is narrowed down right at the start by the limited signal strength in most instances. In most cases it will be necessary to consider at least a high-low antenna to start with, even in the most favorable locations. In many instances experience will indicate the advisability of choosing the stacked conical type, or the stacked-in-line type. Again, in extreme fringe areas the Yagi array should be considered.

The antenna height must of necessity be given due consideration in fringe areas. In many cases, depending upon the location of the installation, an antenna mast of 30 feet or higher may be required to furnish the necessary signal strength.

From the foregoing it follows that an antenna in a fringe area will be more expensive than that located in the intermediate service area. The stacked-in-line antenna cost almost three times as much as the high-low, and the stacked conical antenna costs almost four times as much.

As a further aid in antenna installation in fringe areas, a detailed road map of the area, together with a compass and radiation pattern of the chosen antenna will prove of real value. *First*, mark the location of all nearby transmitters on the map. *Secondly*, center the radiation pattern over the spot where the antenna is to be installed. In this manner it will be easy to visualize exactly where the major lobes lie in respect to the different stations.

This system has been used successfully to locate the source of reflections and has proved helpful in bringing in a weak channel. If the antenna selected does not have the lobes which point toward all stations, the pattern of another antenna should be studied until the best possible pattern is found, and this antenna should be used.

Radiation patterns for various types of television antennas can usually be obtained directly from antenna manufacturers or from their catalogs and sales literature, and these should be studied in connection with the proper antenna selection.

**Antenna Towers.**—Satisfactory television reception in certain fringe areas (usually 25 miles or more from the transmitter) sometimes require special antenna installations in the form of *towers* in order to gain the necessary height required.

Although several tower kits are now on the market, shipping and assembly difficulties often require a "built-on-the-job" antenna tower.

Prior to building an antenna tower, however, it is necessary to know the minimum height at which the receiver will function satisfactorily. This required height is usually found by attaching the antenna array to a long temporary support (2×2) or other suitable wooden pole and test the reception for the various altitudes and angular direction, keeping in mind that the antenna should preferably be directed broadside to the transmitter for maximum signal strength.

Other methods of determining antenna height consist in attaching the antenna to a suitable search balloon inflated with helium; and flying the balloon to the height at which it is expected to install the antenna.

It is usually found, however, that if the antenna be located 10 feet above immediately surrounded objects, good marginal reception is usually possible. Going up higher with the tower will add little to the signal strength and there will be some loss in the extra length of transmission line. Keeping the lead-in straight and as short as possible, with no contact against drain pipes or other metal objects, will do more to guarantee a good reception than an extra 10 or 20 feet of height. Location of the tower is important, as some positions will give higher signal strength than others.

If it be desired to receive more than one station, some provision must be made for rotating the antenna. It can be turned by hand or with a motor. If a motor is to be used, allowance should be made for mounting it in place before the tower is up in the air, even though it is not going to be installed immediately.

A directional antenna array is usually required for satisfactory marginal reception. While best results will always be secured with an array cut for the particular channel to be received, that is of course not always possible or convenient when more than one station is to be brought in. The usual practice is to cut an array for the middle of the band and to stack an array for the high frequencies above one cut for the low band.

Sometimes it is advantageous to use an array cut to favor the weakest station to be received. Generally speaking, an antenna cut for a high frequency will be of little use in bringing in the lower frequencies. For very distant reception, it is very important to use a directional antenna cut for the particular channel to be received and properly positioned at the top of a solid tower so that it does not sway in the wind. Reception can be ruined if the antenna or lead-in be free to swing back and forth with the wind.

Before building a tower it is necessary first to decide on the type of array that is to be used. Weight is an important factor and will determine the type of mounting to be constructed. This is especially true if a very heavy array is to be used. Some of the lighter antennas can be mounted directly to an antenna rotator motor, but the heavier arrays will require a thrust bearing to take part of the weight and provision for the thrust bearing should be made before completion of the tower.

The assembly of a typical built-on-the-job 20-foot antenna tower section is illustrated in fig. 48. This 20-foot section can easily be extended with a piece of tubing to a total height of 30 feet. Material used in construction is half-inch thinwall conduit, which is readily obtainable everywhere at low cost.

One man can carry the completed ten foot section and the antenna array up on to the roof by himself, and two men will easily be able to handle the twenty foot section. By loosening two bolts, either the ten or the twenty foot section may be tipped over for service and easily raised back in place by two men. The finished tower is climbable, however, and it is possible for two men to climb the twenty foot section and work on it at the same time.

Dimensions of the various parts of the tower are shown in fig. 48. These should be cut from half-inch thinwall tubing, with the braces made a little long and the ends ground to fit. Corner pieces are ten-foot lengths of thinwall tubing. Flatten one end of each corner piece, and drill a three-eighth inch hole for the angle-iron support. Cut four feet from one and one-quarter inch angle iron, and drill three holes in each one as is shown in the illustration. Then, cut a six inch square plate for the top of the tower, and drill four holes to take the half inch tubing and a larger center hole for the section of one and one-half inch pipe that forms an upper bearing for the antenna mast. Make a cup for the lower end of the antenna mast, or a motor mount if the antenna is to be rotated by motor; otherwise it can be turned by hand. Large cotter pins may be used to hold the mast in place.

All joints should be carefully brazed, and care should be taken to avoid burning the thin tubing. To assemble the pieces, select a smooth concrete floor, walk or driveway and start with one side holding the parts in place while making the small tack welds. Tack all of the parts together so that they may be cut loose if a mistake be made, then true up the entire assembly. Use a hammer and large pipe wrench to bend the parts wherever necessary so that the complete assembly results in a straight, true tower that will look right when finished.

After the parts are tacked together, and the tower trued up, go over the welds and fill in all open spaces between the various parts. Use plenty of brass to make good joints. This is im-

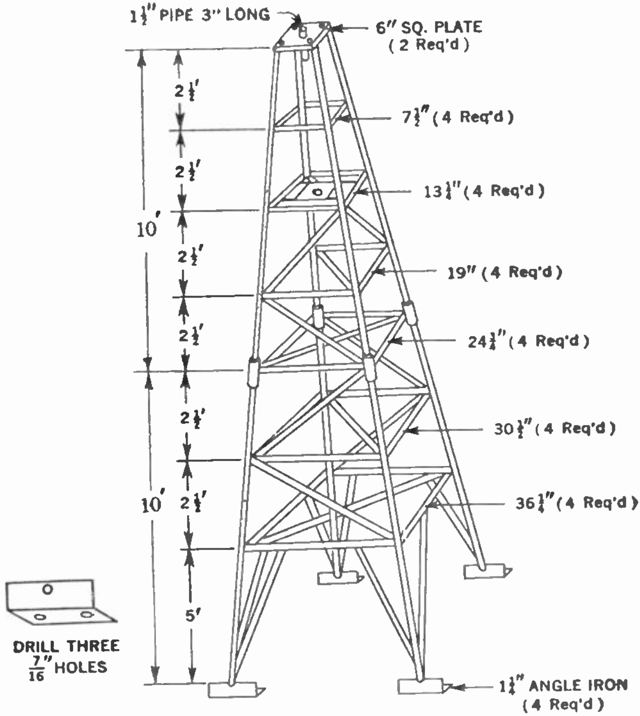



**FIG. 48—Details of construction for a 20 ft. sectional type antenna tower.**

portant, as a poor joint will break loose in a high wind. Test the finished tower by standing it up in the yard and having two men climb it before it is put up on the roof. When installing the tower on the roof, carry it up with the feet bolted in place, but without the antenna array, so that the location of the holes may be marked where the feet are to be bolted to the roof. Use long bolts and pieces of 2×4 lumber inside the attic, if this is at all possible, in preference to lag screws which may easily pull out of roof sheering boards.

After the feet are bolted to the roof, two of the tower legs may be unfastened and the entire assembly tipped over on its side. The antenna array may now be installed while the tower is in this horizontal position and easily accessible.

Weld stand off insulators to the tower to carry the twin-line or coaxial cable used, for lead in, but do not tape the lead in line to the metal tower. Run a number four wire from the base of the tower to a ground stake for lightning protection, using a stake or piece of pipe at least six feet long for the ground, which is very important and should not be overlooked.

Thinwall conduit, either one inch or one and one-quarter inch makes a good mast for supporting an array above the tower, as it is light, strong and cheap. Weld a pipe fitting to one end to attach the antenna, or make a simple clamp for this purpose. Some arrays will be supplied with a short stub mast which can be fitted to the tower, but about one ten foot length is as much mast as should ever be used above the tower; otherwise there will be too much swaying around in the wind.

Where it is desired to locate the antenna tower on the ground, it is necessary to support each leg by means of a concrete foundation of suitable dimensions. The antenna tower structure is then anchored to the foundation by means of preset foundation bolts in the conventional manner.

In addition the tower structure should be properly anchored by means of guy wires, leading from the top section of the tower to ground, or if roof mounted to the roof surfaces. The distance from each guy wire anchor point to the base of the tower should not be less than the height of the tower to which the wire is affixed and should be spaced 120 degrees radially.

Another type of sectional antenna tower built of half inch

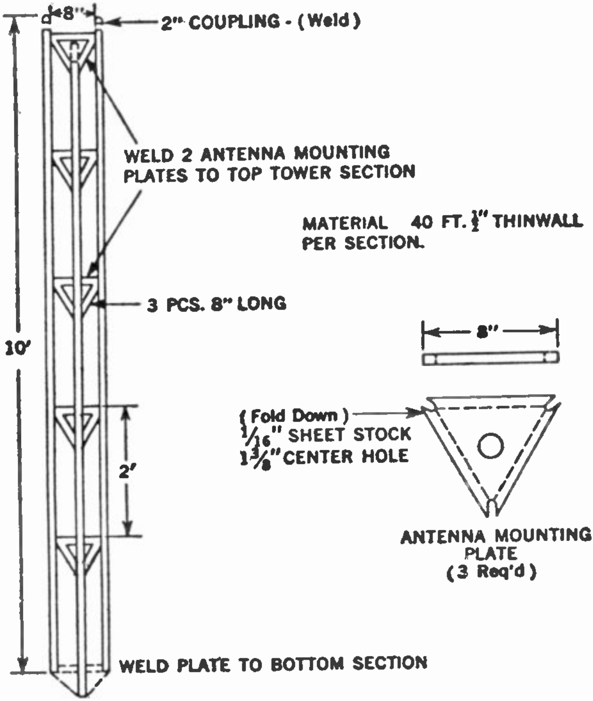



**FIG. 49—Construction details for a 10 ft. section of typical antenna tower. With an antenna tower of this type elevations of up to 50 feet may be reached.**

thinwall tubing is shown in fig. 49. Due to its lightness, however, an antenna tower of this design must be very carefully guyed, particularly when three or more sections are required.

For heights up to thirty feet, a single set of guy wires will suffice, but for greater heights, a double system of guys should be used. With five ten foot sections a height of fifty feet has been reached; this height is considered a maximum when built of half-inch thinwall conduit.

Forty feet of half-inch thinwall tubing will be required for each section. Three ten-foot lengths form the sides, and the other ten foot piece should be cut up into fifteen pieces eight inches long to form the triangular braces. A piece of sheet metal should be cut to form a base for the bottom section, and two triangular pieces must be made with a center hole for mounting the antenna mast to the top section of the tower. This detail is shown in fig. 49. The center hole can be cut with a cold chisel or a torch, and should be just the right size to pass the pipe or tubing used for a mast. Usually one inch or one and a quarter inch thinwall conduit will be satisfactory as a mast to mount the antenna array if no such piece of tubing is furnished with the antenna. If a motor be not used, some simple lock must be made to keep the antenna from turning with the wind after it has been rotated to the correct position. Drill a couple of holes for large cotter pins or stove bolts in the upper mast and these can rest against the triangular plates if no thrust bearing be planned.

To assemble the ten-foot sections, either use short pieces of solid rod inserted inside the two sections of tubing where they join together, or use standard slip joint fittings designed for the thinwall conduit. Either method will make a rigid assembly when brazed together.

Round the ends of the eight-inch lengths of tubing to fit the one-half inch conduit, using a grinding wheel or a large rat tail file. This is not absolutely necessary, but it will make a better job, and the joints will be easier to braze.

CHAPTER 5A

# U.H.F. Antennas

**U.H.F. and V.H.F.**—These are two terms used for identification of television channel allocation. Thus, *u.h.f.* stands for *ultra-high-frequency*, occuping a part of the telecast spectrum between 470 and 890 megacycles. This part of the spectrum is divided into seventy channels for television broadcasting.

V.H.F. on the other hand, is an abbreviation of the term *very-high-frequency*, covering twelve channels extending from 54 to 88 mc. (low band) and from 174 to 216 mc. (high band). The lower band consists of five channels, whereas the higher band consists of seven channels.

With the addition of seventy *u.h.f.* television channels, to those presently used, a total of eighty-two channels scattered throughout the *Country* may some day permit more than 2,000 *television stations* to be on the air simultaneously.

**Need for Different Antenna Arrays.**—With the allocation and use of the *u.h.f.* television band (470 to 890 mc.), most conventional antennas now in use on the *v.h.f.* channels are not satisfactory. This is because their gain is too low at this higher frequency. They also have poor directivity patterns in both horizontal and vertical directions.

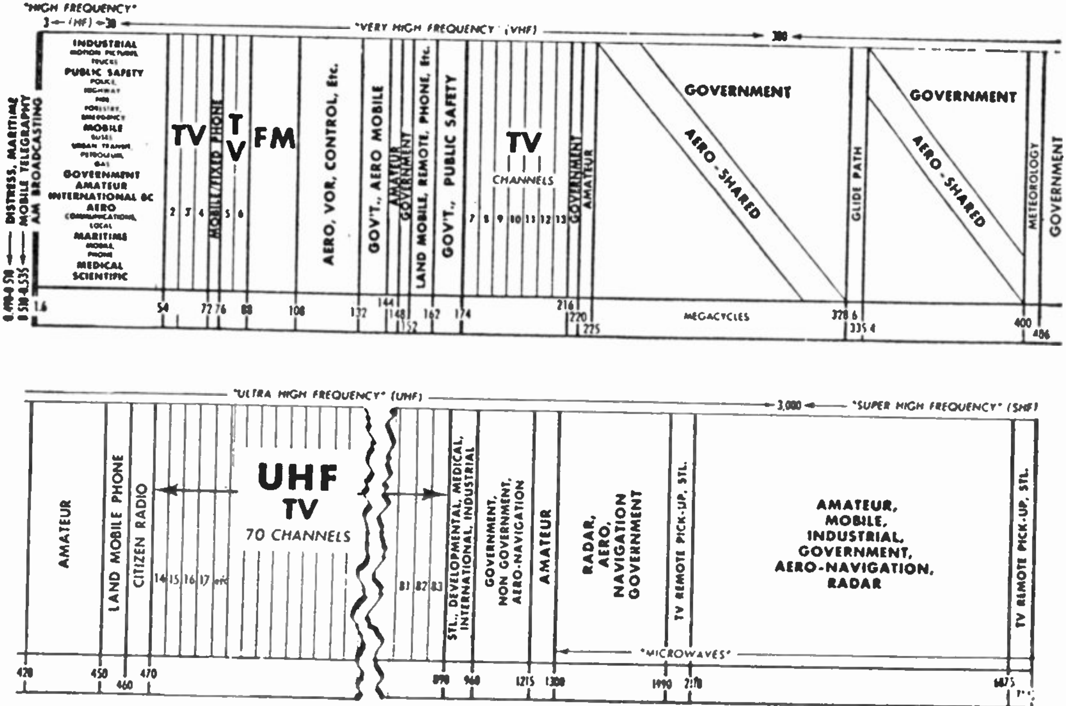



FIG. 1—Chart showing *Federal Communications Commissions* (*F.C.C.*) channel allocations in the high frequency spectrum for television use.

The multiple major lobes are also usually very narrow, several degrees away from the antenna axis and rotate rapidly with frequency. This means that in low signal strength areas, an antenna rotator would be required to locate one of the major lobes. In addition multipath ghost images and undesired signals cannot be reduced or eliminated with an antenna having such poor directivity characteristics.

The signal intensities at the higher frequencies fall off with the distance from the transmitter at a more rapid rate and reflection problems are likely to be greater. Intervening objects such as trees, buildings and the earth also becomes better absorbers and reflectors at the shorter waves.

To deal with these difficulties a number of antennas suitable for *u.h.f.* reception having greater gain and directivity have been developed. Some of these arrays resemble the conventional type used on *v.h.f.*, whereas others will be different.

**Antenna Size.**—Considering the antenna size, it is quite obvious that at *u.h.f.*, the antenna will be much smaller than that used on the present *v.h.f.* frequency, because of the smaller wavelength. Since antennas are cut according to wavelength, this means that the physical dimensions of a half-wave dipole at 550 mc. will be *only one tenth* of what it is at 55 mc.

This smaller physical size is convenient because it permits of easier handling and a simpler supporting structure at a lower cost. It can also be employed to advantage by permitting the addition of more elements to the array.

It is obvious that the greater the antenna area the greater will be the amount of signal energy intercepted, thus fairly elaborate arrays will be more in evidence at ultra-high-frequencies than at the conventional very-high-frequency type.

**U.H.F. Antenna Types.**—Ultra-high-frequency antennas in common with the familiar *v.h.f.* types will differ in their geometry depending upon signal strength and freedom from interference. Thus, in areas of high signal intensity that are free from multiple ghost signals and interference, the simple *u.h.f.* broad band *triangular dipole* will give good service, and provide medium gain and directivity at low cost.

In areas of medium signal intensity that are free of multipath signals and interference, the *dual "V"* or *rhombic types* can be used to good advantage in view of their increased gain and low cost.

In areas where multipath ghost signals and interference are present the antenna must have good directivity characteristics. The *corner reflector antenna* fulfills these requirements and also provides greater gain for use in low signal areas.

In locations where high gain and directivity are desired for the reception of a single telecast station, the *yagi* antenna is a necessity.

**Triangular Dipoles.**—An antenna of this type is shown in fig. 2, and is probably the simplest and least expensive broad band receiving antenna in the 470 to 890 mc. frequency range. The unit is constructed in the form of two triangles from hard aluminum, supported by a suitable insulator, although other materials such as wire screen or metal rods can be used, provided that the conductor spacings are small in comparison to a wave length.

The directional response pattern of the triangular dipole retains its figure eight pattern at both the upper and lower ends of the band. Figs. 3 to 7, shows the familiar horizontal directivity patterns at 100 megacycles intervals.

The impedance of a triangular dipole varies with the corner angle of the dipole section. To best match the 300 ohms balanced transmission lines, the corner angle should be approximately seventy degrees. The total antenna length for greatest overall gain is sixteen inches as shown in fig. 8.

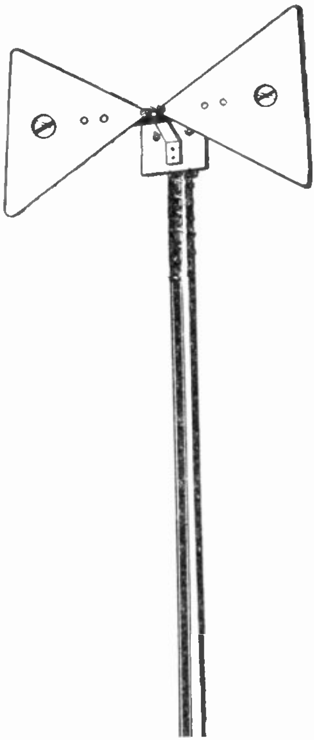
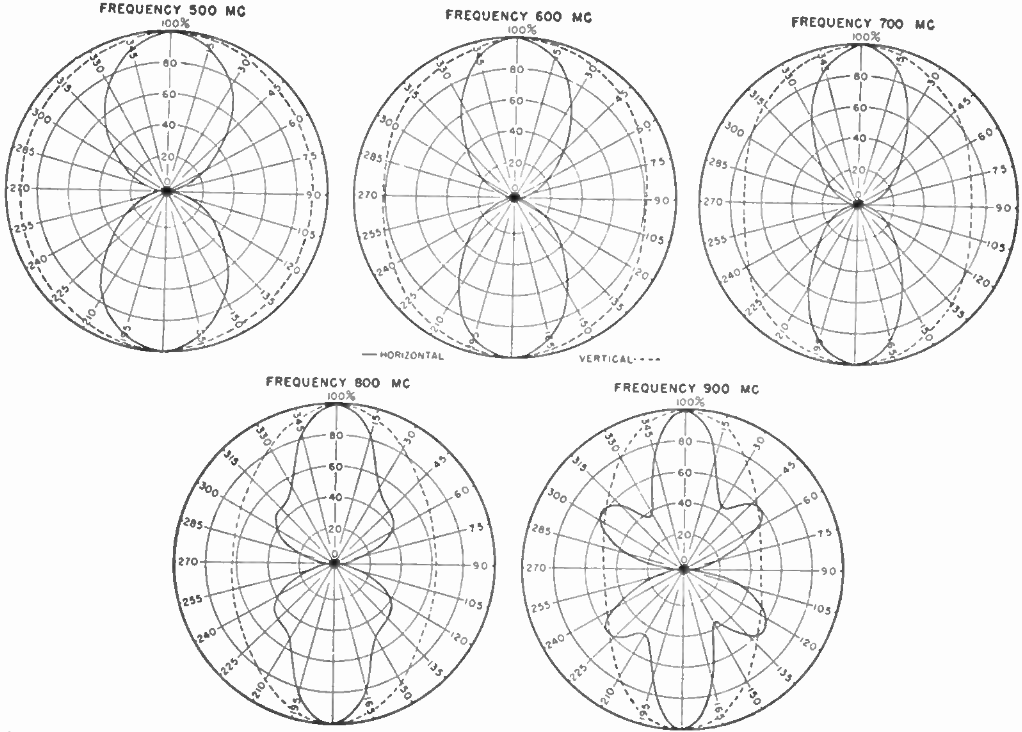


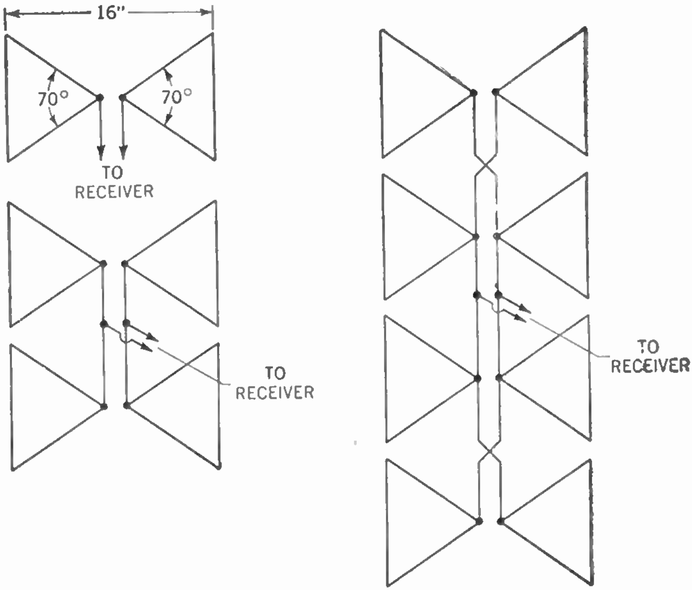
**FIG. 2—Commercial type u.h.f. broad band, triangular dipole antenna.**

To provide increased gain and directivity from the triangular dipole, several units may be stacked as shown in figs. 9 and 10.




FIGS. 3 to 7—Horizontal directivity pattern of a triangular dipole antenna covering frequencies from 500 to 900 megacycles.

When employing a single triangular dipole the 300 ohm transmission line is attached directly to the neighboring ends of the triangular sheets. For the two-stacked array, two small rods connects similar ends together, and the 300 ohms line would be connected to the center points of these rods. When a four-bay array is used the connections shown in fig. 10 gives the best result.




**FIGS. 8 to 10—Recommended dimension of triangular dipole antenna and methods of connections when stacked arrays are employed.**

It should be observed that the matching arrangement used with *u.h.f.* antennas are the same as that used for the *v.h.f.* types.

**Stacked "V".**—Another broad band ultra-high-frequency antenna which has proved to be popular in areas of medium signal strength is the stacked "V" type shown in fig. 11. This antenna has received its name from its similarity to the letter "V".

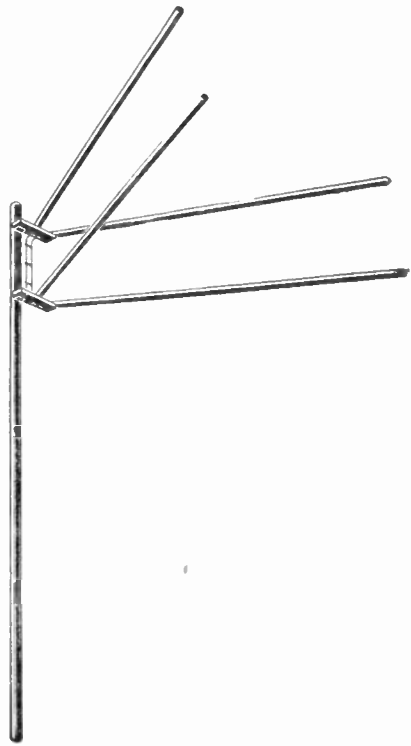


**FIG. 11—Commercial type u.h.f. broad band stacked V-type antenna.**

The antenna elements must be of sufficient diameter to provide the necessary strength against wind, sleet and snow, but for most practical purposes a diameter of from thirteen thirty-seconds to one-half inch have been found to be satisfactory.

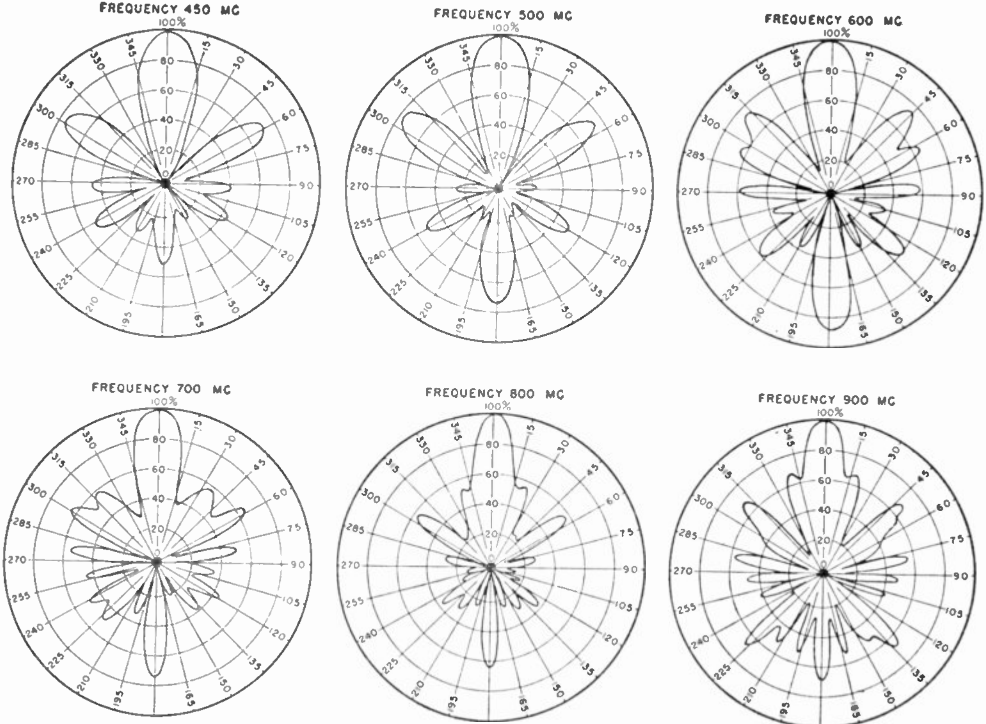
The gain of the "V" antenna is dependent on the leg length and on the angle the two legs make with each other. Since gain increases almost directly with the leg length and the angle the two legs make with one another, it would seem advisable to make each leg as long as possible. However, in extending the leg length, the antenna structure will become increasingly unwieldy, resulting in breakage when exposed to wind, ice or snow.

A good average in leg length is between fifty and sixty inches, with fifty-five inches as a final compromise figure. It will be noted that this is 2.1 waves at 450 mc. and 4.2 wavelengths at 900 mc. The best suitable "V" angle (angle between the legs) lies between forty and sixty degrees and the compromise angle of fifty degrees is most frequently employed.

The "V" antennas are stacked approximately one-half wavelength apart, at the lowest operating frequency and connected with a 300 ohms transmission line which serves as a phasing and matching network. The 300 ohms tubular lead-in connects to the center of the phasing section. Stacking of the antennas provides additional vertical directivity which is helpful in reducing the effect of ground reflections and makes the antenna positioning for minimum reflections less critical.

The simple construction with accompanying low cost, its extremely wide-band coverage, in addition to the fact that its gain increases with frequency, make this antenna popular in areas of medium signal intensity that are free of multipath signals and interference.

The horizontal directivity patterns of a stacked "V" type antenna throughout the *u.h.f.* band are shown in figs. 12 to 17.




**FIGS. 12 to 17—Horizontal directivity pattern of stacked V-type u.h.f. antenna. The patterns shown cove frequencies between 450 and 900 megacycles.**

The patterns have a number of secondary lobes, which become more numerous and rotate away from the forward lobe as the frequency is increased. Multi-lobed polar patterns are typical of long wire antennas such as treated here. The length of the "V" elements must be increased several fold to reduce the amplitude of the secondary lobes.

In this connection, it should be noted that a leg length of fifty-five inches, is close to being a quarter wave length at the lower *v.h.f.* channels, and as a consequence, the stacked "V" type of antenna, will in many instances operate satisfactorily over the complete telecast frequency spectrum.

**Rhombic Antennas.**—The rhombic antenna as used in *v.h.f.* reception, has the disadvantage of consuming a good deal of material in addition to its horizontal space requirement.

In *u.h.f.* reception, however, the rhombic type because of the low wavelength, and smaller dimensions, lends itself to usage in areas of medium to weak signal strength.

Fig. 18 illustrates a typical *u.h.f.* broad band rhombic antenna. The length of each of the four sides shown (also termed legs) should be at least several wavelengths, and is for the particular antenna shown fifty-five inches. Thus, at a frequency of 470 mc. one wavelength equals approximately twenty-four inches and two wavelengths would be forty-eight inches.

The antenna elements should have a diameter of approximately one-half inch, and the including angle will vary with the length of the legs. Thus, for example, for legs which are two wavelengths long, the including angle is eighty degrees, for legs three wavelengths long, sixty degrees, and for antennas having leg lengths of four wavelengths the including angle is fifty degrees.

If the wires opposite the transmission line connection are simply connected together, the antenna is bi-directional, but if, as is more usual, a carbon resistor having a value of 470 to

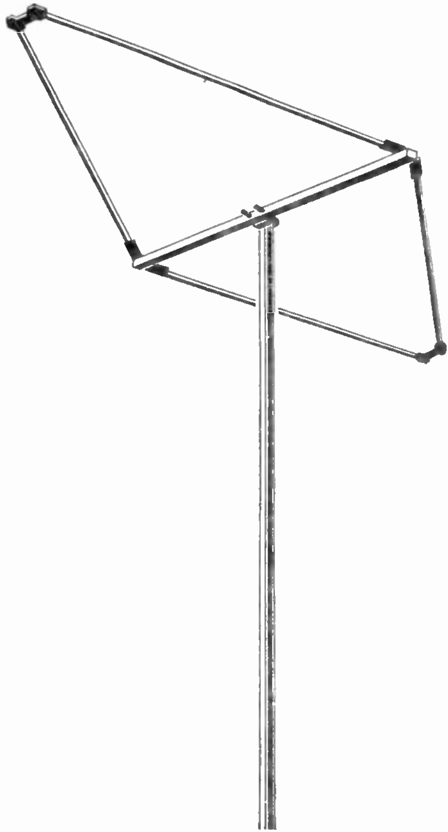


**FIG. 18—Commercial type u.h.f. broad band rhombic antenna.**

500 ohms, be inserted at this point the response pattern becomes uni-directional.

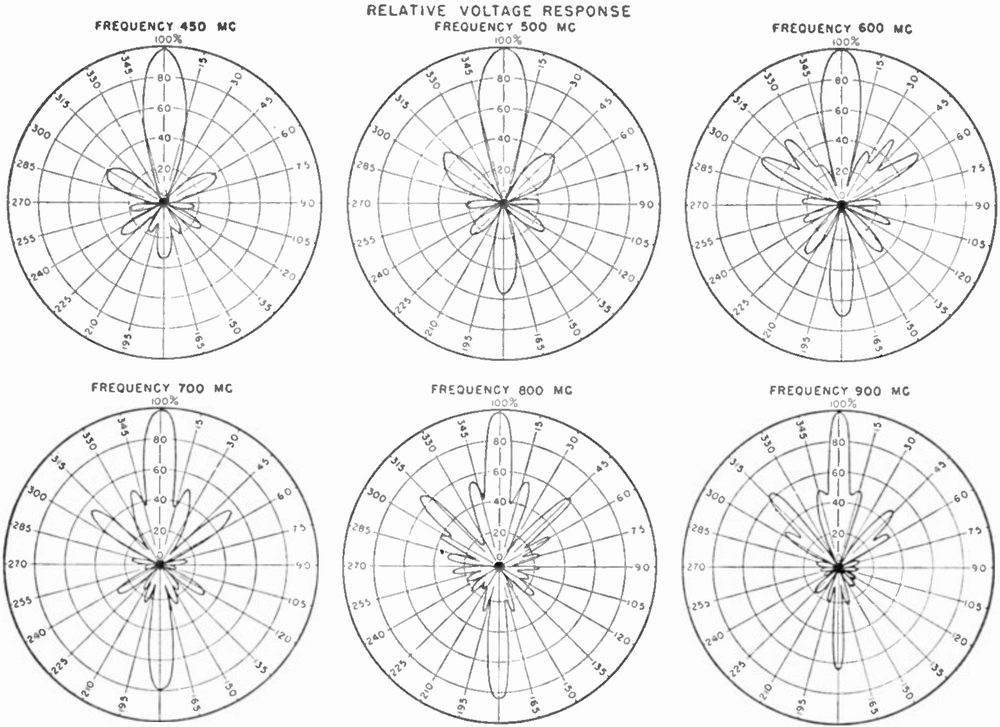
The input impedance of a transmission line terminated in its characteristic impedance is equal to this characteristic impedance for all frequencies. If this transmission line is separated in such a manner as to form the terminated rhombic, the input impedance is changed because the configuration of the conductors is different. The input impedance is no longer independent of the frequency; however, by careful adjustment of the termination it is possible to obtain an input impedance which fluctuates very little with frequency.

Figs. 19 to 24 shows the horizontal directivity patterns of the rhombic. It will be observed that the main lobe is extremely narrow throughout the *u.h.f.* spectrum. The beam width at the low frequency end of the band is approximately twenty-two degrees wide at the half power point. As the frequency increases the beam width becomes less and at 900 mc. is about eleven degrees. Thus, the outstanding characteristic of the rhombic type of antenna is its ability to produce narrow beam horizontal directivity patterns over a wide frequency range.

Stacking of the rhombic can be employed for increased gain in the manner of other arrays. Separation of one half wave length is recommended. This antenna is simple to construct, has good gain, operates over a wide frequency range and is not critical as to dimension or adjustments.

**Corner Reflector Antenna.**—One type of *u.h.f.* antenna, known as the parabolic reflector type, has found increased use in weak signal areas. The parabolic reflector is a well known part of many light fixtures, where it is employed for concentration of light beams.

This useful property when utilized for concentration of *u.h.f.* television signals has provided several antennas of various design for transmission and reception of *u.h.f.* signals.




**FIGS. 19 to 24—Horizontal directivity pattern of rhombic antenna covering frequencies between 450 and 900 mc.**

Because of the somewhat difficult design principles involved in the construction of a parabolic antenna, tests have shown that instead of using curved surfaces, it is possible to use two flat surfaces which are so placed as to intersect each other at

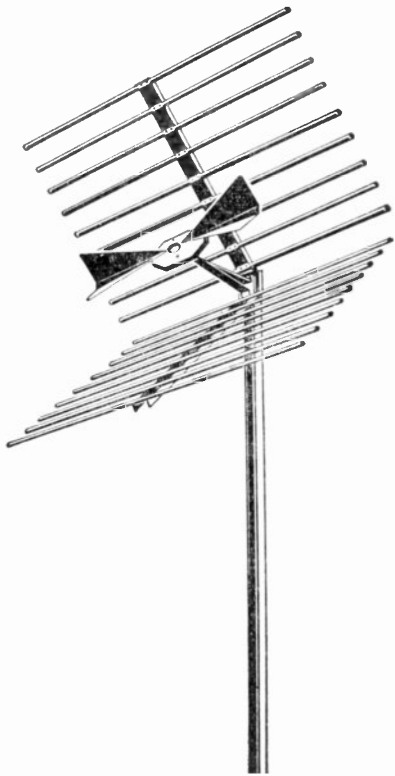
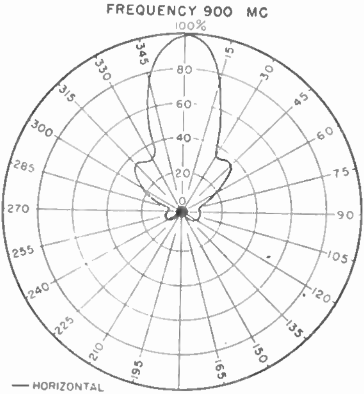


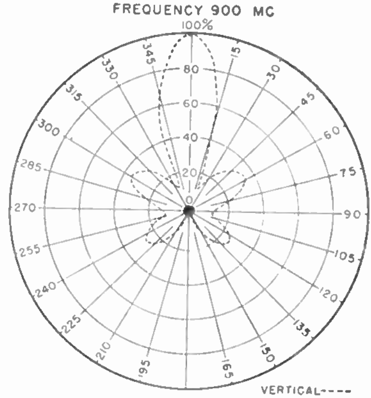
**FIG. 25—U.h.f. corner reflector antenna.**

some suitable angle, forming a corner. An antenna of this type being considerably simpler in design than the parabolic type is known as the *corner reflector type*. See fig. 25.

The reflector grids have an included angle of ninety degrees and are made from hard aluminum tubes; other materials such as wire fencing can be used if desired, providing the wire spacing is small in comparison to a wave length. The driven element usually a dipole antenna, is placed at the center of this corner angle and at some distance from the vertex of the angle. The elements are supported near their centers with ceramic insulators in order to minimize the effect of rain, snow and ice by providing a long, high impedance path shunting the antenna.




SPACING TOO SMALL

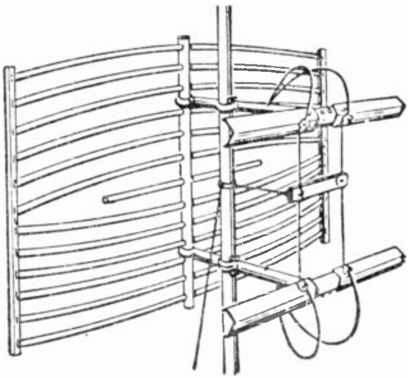


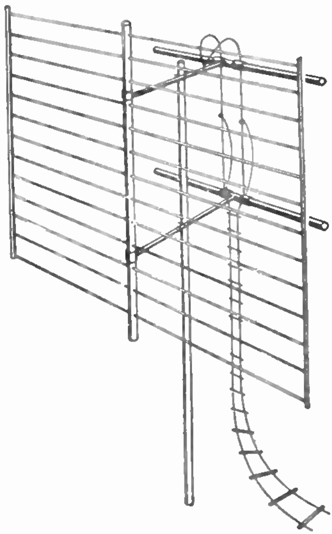

SPACING TOO GREAT

**FIGS. 26 and 27—Directivity patterns of u.h.f. corner reflector antenna showing effect of spacing between dipole elements and reflector vertex.**

The response pattern of the antenna depends not only on the corner angle but also on the distance between the antenna and the vertex of the reflector corner. When this distance is large, that is, large in comparison to the wave length used, a pattern containing more than one main lobe as shown in figs 26 and 27 is obtained. Moving the antenna in too close will affect the vertical response of the array and make it more susceptible to ground reflected signals. Since neither of the foregoing conditions are desirable, the exact positioning of the dipole must be obtained.

The corner angle of a commercial array of the type illustrated is as previously noted, ninety degrees with a similar bend in the dipole element. The reflector bar spacing must be controlled within one-fifth of a wave length at the highest frequency at which the antenna is to be used.





**FIGS. 28 and 29—Typical u.h.f. stacked dipole antenna using reflector screens.**

**Plain Reflector Antennas.**—Reflector antennas for *u.h.f.* reception quite frequency take the form as shown in figs. 28 and 29. Although these differ somewhat in construction, their directivity pattern and cost of construction will be approximately the same.

Each antenna is equipped with two stacked dipoles, and with a sheet reflector made of a series of rods. A phasing section connects the two dipoles and the transmission line is fed at the midpoint of the phasing section.

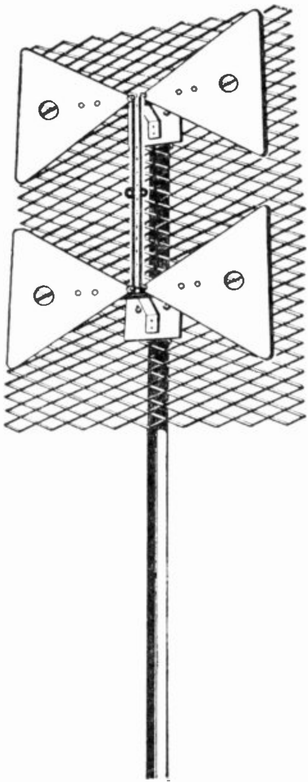


**FIG. 30—Showing a stacked type u.h.f. broad band triangular dipole antenna with reflector screen. A phasing section connects the two dipoles and the transmission line is fed at the mid-point of the phasing section.**

The addition of a reflector to an antenna serves several purposes. It reduces or substantially eliminates reception of any signals approaching the array from the reflector side. This converts a bi-directional antenna into one which can receive signals from essentially one direction. It also increases the gain of the array in the remaining direction.

Mesh screens serve as well as rods or solid sheets as a reflector. The fact that there are openings in the screen does not materially affect its performance as a reflector as long as the openings do not exceed two-tenths of a wave length. Dimensions of the reflector are not critical but the edges should extend for a short distance beyond the dipole elements.

**Yagi Antennas.**—This antenna commonly used in fringe areas at *v.h.f.* frequency, for single channel reception, also provides excellent gain and directivity over a limited band width in the *u.h.f.* part of the telecast spectrum.

Because of its smaller size at *u.h.f.* frequency and simplicity in construction, the manufacturing cost of this antenna is low. Fig. 31, shows a typical design of a six element yagi.

The driven element is designed for use with the 300 ohm tubular transmission line and consists of a folded dipole. The dipole is made from a one-eighth inch diameter rod, while the folded portion is of one-fourth inch diameter. This ratio of diameters is necessary to provide the proper antenna impedance. The one and three-eighth inch diameter mast should be located some distance away from the antenna element so as not to affect its gain and directivity characteristics.

Figs. 32 and 33 shows yagi antenna construction details and power gain. The construction chart tabulates all dimensions for a wood cross arm element support. This is because a metal cross arm of sufficient diameter to support the elements becomes an appreciable percentage of a wave length and will modify the element lengths.

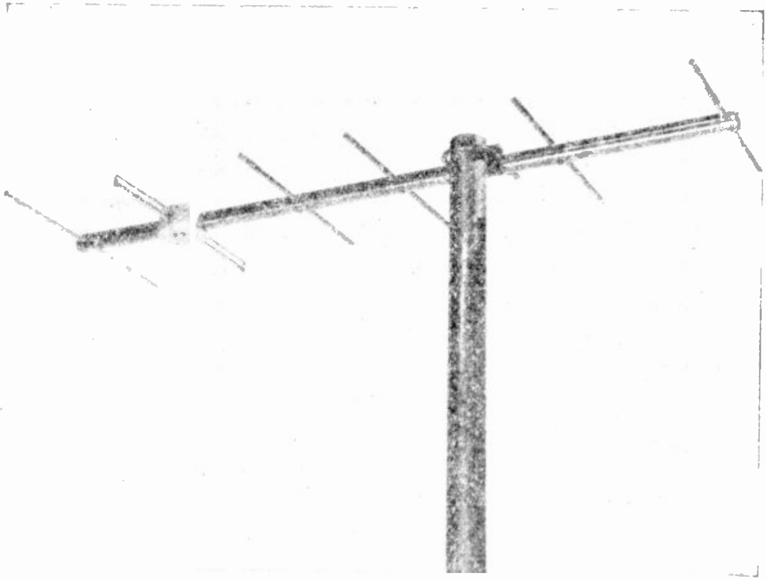
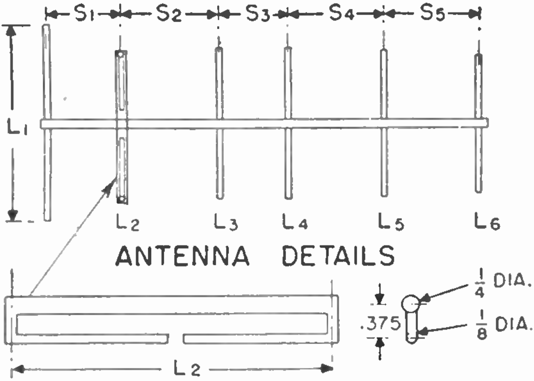


**FIG. 31—Commercial type u.h.f. six element yagi antenna. When used for ultra high frequency reception, groups of from seven to ten channels are received by each antenna.**

The element lengths depend upon the shape of the cross arm selected and method used for attaching to such an extent that final design must be determined after the antenna is fabricated. For optimum gain the lengths must be adjusted to within plus or minus one thirty-second inch.

The power gain curve fig. 33 illustrates the narrow band and high gain characteristics typical of a yagi antenna. As noted,




| | INCHES | FRACTION OF WAVE LENGTHS |
|---|---|---|
| $S_1$ | 4.66 | .213 |
| $S_2$ | 5.25 | .240 |
| $S_3$ | 4.35 | .199 |
| $S_4$ | 6.36 | .291 |
| $S_5$ | 6.22 | .284 |
| $L_1$ | 10.70 | .489 |
| $L_2$ | 9.52 | .436 |
| $L_3$ | 9.25 | .423 |
| $L_4$ | 9.25 | .423 |
| $L_5$ | 9.00 | .412 |
| $L_6$ | 8.92 | .408 |

**FIG. 32—Showing construction details for u.h.f. yagi antenna.**

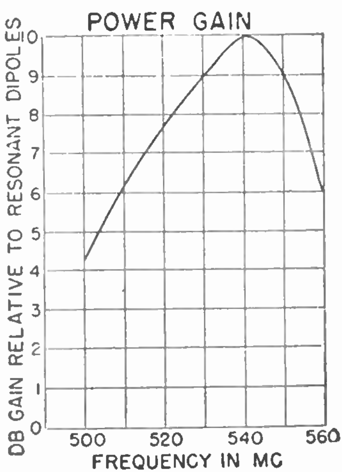
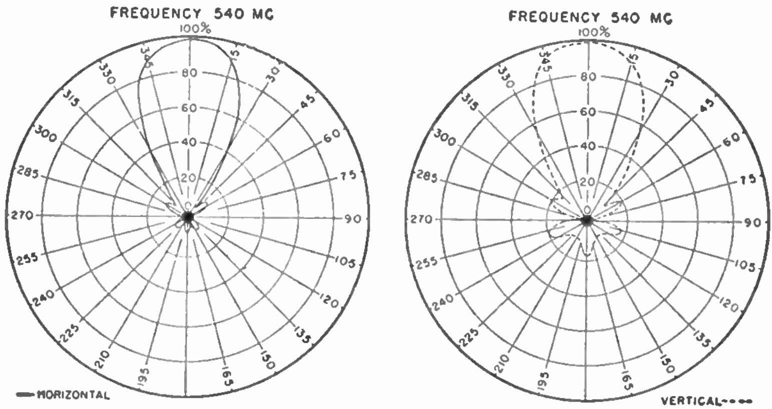



**FIG. 33—Power gain of u.h.f. yagi antenna.**

the unit shown will have a gain of about ten percent at its resonant frequency. The band width at 3 *db.* points below maximum gain is approximately 9.3 percent, which band width is sufficient to accommodate six adjacent channels on the low frequency end of the band and twelve channels on the high.

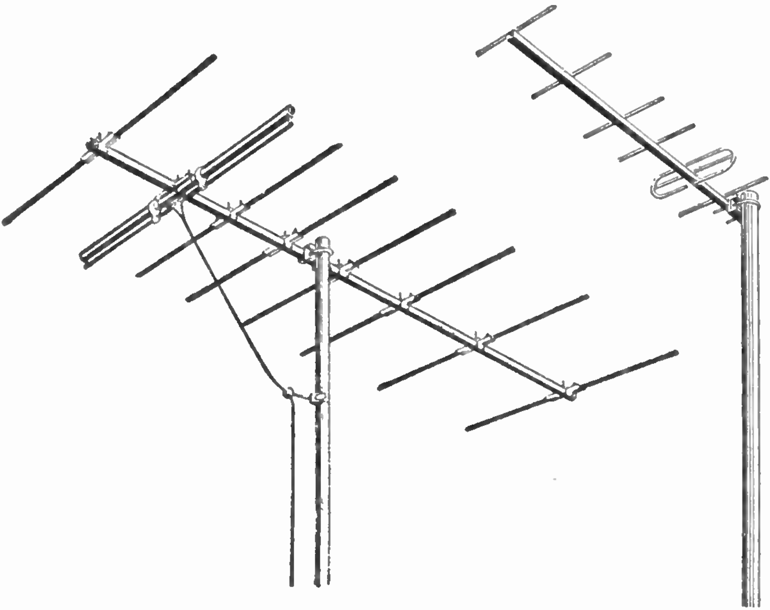
Figs. 34 and 35 illustrate the excellent horizontal and vertical directivity provided by the yagi type antenna. The more elements (directors) that are added to a yagi, the greater will be the gain and also the narrower the beam angle. The input impedance presented by the dipole decreases with the increase in elements.




**FIGS. 34 and 35—Showing horizontal and vertical directivity patterns of u.h.f. yagi antenna.**

**Other U.H.F. Antennas.**—There are numerous antenna types used on the *v.h.f.* television frequencies, which may be adapted for *u.h.f.* reception. They must of course, be tailored for these shorter waves which makes them more suitable for stacking and as a consequence provides greater gain.

An antenna such as is illustrated in figs. 38 and 39 has very favorable characteristics and is of the four-bay folded dipole type. As noted in the illustration each folded dipole has an overall length of one wavelength. Separation of the bays is

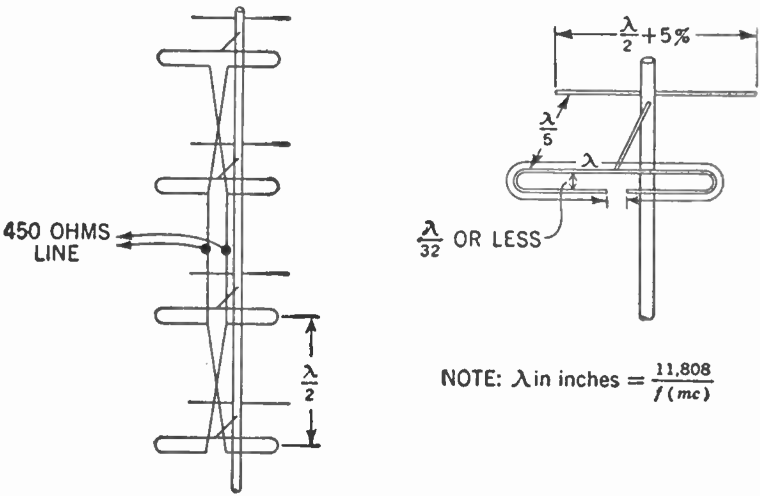


**FIGS. 36 and 37—Showing commercial types yagi u.h.f. antennas giving construction details. The number of elements necessary depends upon the signal strength and other factors. Stacked yagis with six or more elements (directors) are as a rule used only where it is desired to pick up one or more distant stations.**

one-half wavelength while all reflectors are made five percent longer than the folded dipole. The dipole and its adjacent reflector is separated a distance of one-fifth wavelength.

The power gain of this array is approximately twelve *db.* and the directivity of the beam angle is approximately twenty-five degrees. There are several small secondary lobes, which as a rule may be disregarded.

Connection between the several bays is made with commercially available 450 ohms open wire transmission line. The 450 ohms line is also used to bring the signal to the receiver.




**FIGS. 38 and 39—Construction details for typical u.h.f. four-bay dipole antenna.**

Because the attenuation of open wire lines is considerably lower than either the 300 ohms twin-lead or any of the coaxial cables, the 450 ohms line is desirable for *u.h.f.* application.

Since, however, the receiver input impedance are either 300 ohms balanced, or seventy-five ohms unbalanced a mismatch of the system occurs. To effect a match between the foregoing

450 ohms open wire line and the 300 ohms input impedance of the receiver, a quarter-wave line having a characteristic impedance of $\sqrt{300 \times 450}$ or 368 ohms, can be used or the two wires on the 450 ohm line can be tapered and bent inwards as shown in fig. 40, until the impedance they present is 300 ohms. It should be noted that this taper must be made very gradual extending over a distance of two wavelengths.

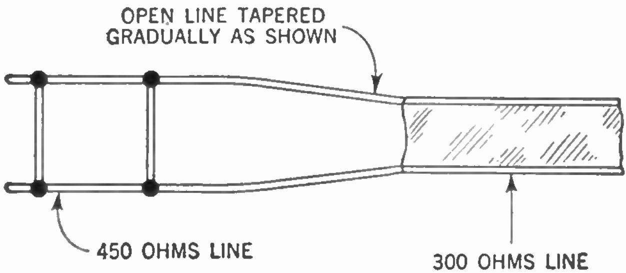



**FIG. 40—Illustrating how a 450 ohms line may be connected to a 300 ohms line without causing a mismatch.**

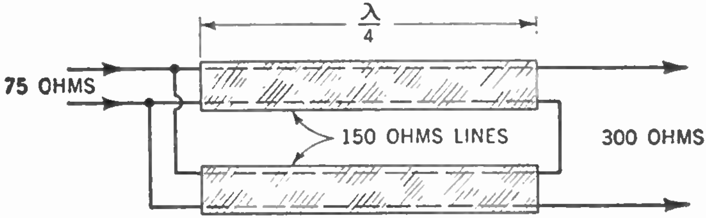
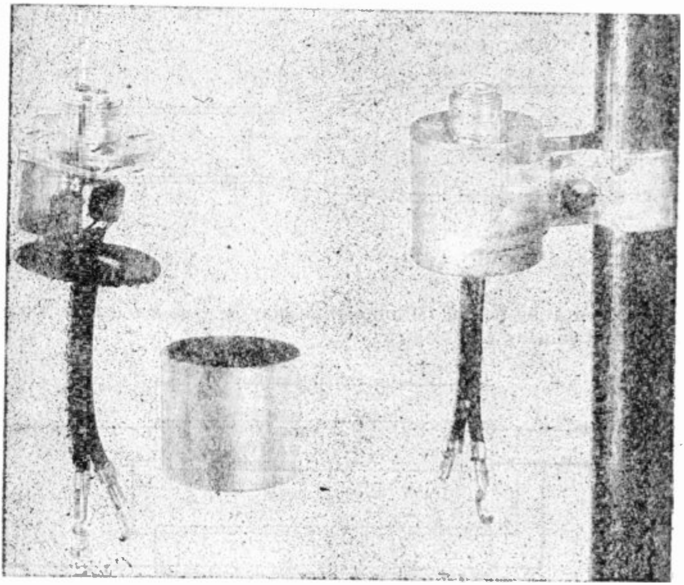



**FIG. 41—Impedance matching transformer using transmission lines. The impedance matching method shown is employed only when it is desired to match 300 ohms at one end to 75 ohms at the other.**

While it is not always necessary to carefully match 450 ohms impedances to 300 ohms impedances, this does not hold true when a seventy-five ohms impedance is to be connected to a transmission line having 300 ohms impedance.

In this instance it is necessary to make a match because of the great disparity between the two values and also because the 300 ohms impedance is usually balanced while the seventy-five ohms impedances are not. There are two popular methods used in overcoming this mismatch. One is to employ a matching network as shown in fig. 41 and the other is to employ a "balun" as shown in figs. 42 and 43.

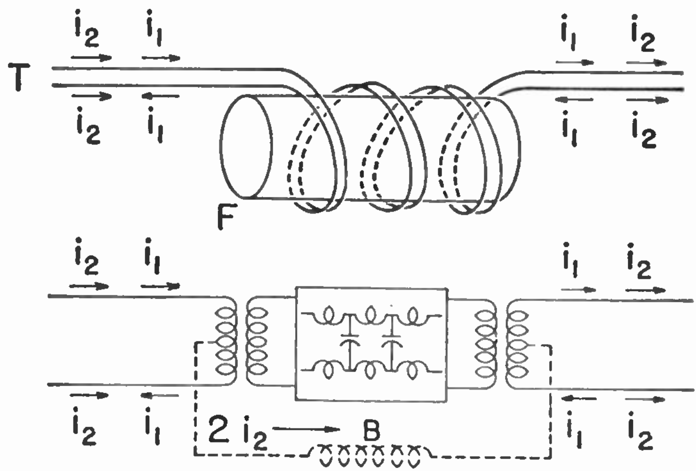


**FIGS. 42 and 43—Showing an u.h.f. "balun" and 4 to 1 impedance transformer.**

The impedance matching transformer fig. 41 consists of two quarter-wave sections of 150 ohms twin-lead transmission line. The length is usually chosen to be one-quarter wave long at the lowest operating frequency.

As noted in the diagram the seventy-five ohms end of the two lines are connected in parallel. Thus, two 150 ohms impedances in parallel produce a resultant impedance of seventy-five ohms.

At the other end of the lines they are connected in series, producing the necessary 300 ohms. The impedance at one end can be balanced while it is unbalanced at the other end and the match is still effective. Because of the simplicity of this arrangement and the ease at which it can be produced, it is commonly used for the purpose described.




**FIGS. 44 and 45—Showing transmission line coil and equivalent diagram for "balun" illustrated in fig. 44.**

Figs. 42 and 43 shows the *u.h.f.* "balun" construction and mounting bracket. There are two coils, each of which can be considered as a transmission line having a surge impedance of 150 ohms and a length of approximately one-quarter wave at the lowest operating frequency. The two transmission lines, or coils, are connected in parallel on one end, forming the seventy-five ohms impedance and in series on the other, producing the 300 ohms impedance.

The transmission line coil and equivalent diagram is shown in figs. 44 and 45. As illustrated the transmission line *T* having a surge impedance of 150 ohms, is wound on the coils form *F*.

The magnetic fields produced by the symmetrical or push pull current $i_1$ neutralize each other, due to the closely spaced conductors of the transmission line. The magnetic fields produced by the unsymmetrical or push push currents $i_2$ are added together and would pass through the transmission line if it were not wrapped to form a coil.

The mutual inductance between the individual turns of the coil act like a conventional choke coil *B* which offers a high impedance to the push push currents. The transmission line coil therefore acts as an ideal transformer which passes the push pull currents and eliminates the push push currents.

CHAPTER 6

# Master Antenna Systems

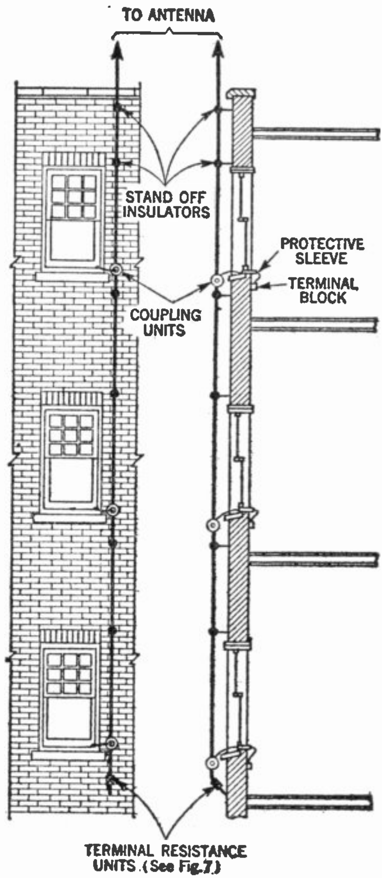
**General.**—The main purpose of a master antenna system is to provide individual antenna outlets for each tenant in multiple dwellings. Anyone who has observed the unsightly multiplicity of individual antenna installations in apartment buildings in and around large metropolitan centers will readily recognize the need for a unified multiple antenna system.

There are presently three types of master antenna system installations being employed in multiple dwellings. They are:

1. Divider-network system.
2. Antenna-array master system.
3. Separate antenna system.

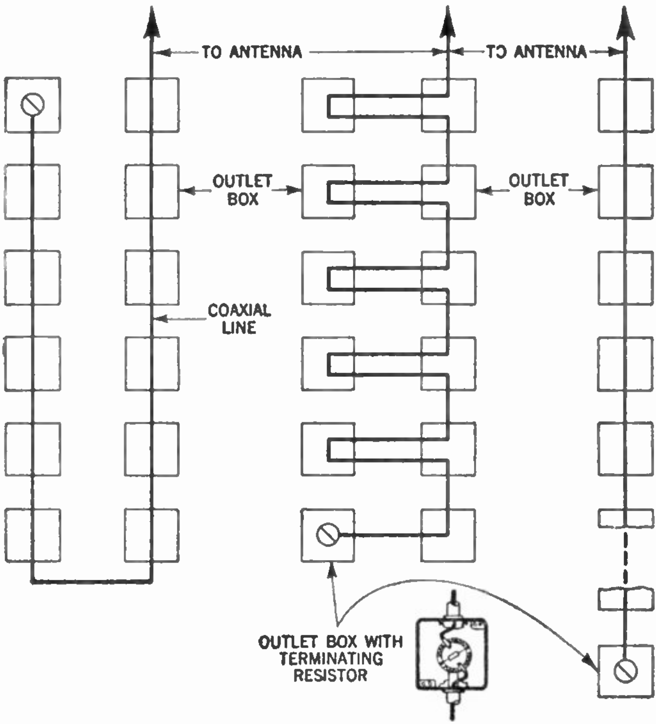
**Divider-network antenna system.**—This system operates from a high-gain antenna able to provide sufficient signal strength for connection to a considerable number of receivers. Since no amplifiers are used, and no power is required a multiple antenna system of this type is low in maintenance and first cost.

A high-low band, folded dipole and reflector antenna is employed when the installation is located relatively close to the transmitter. In less favorable areas, a two-stack folded dipole reflector combination is used for the high channel (7-13) and an additional two-stack folded dipole reflector combination for the low channel (2-6).




FIGS. 1 and 2—Schematic diagram showing installation of multiple outlet divider-network master antenna system, with outside connection to coaxial cable. As illustrated, an outlet coupling unit is connected to the transmission line outside each window. The connection from the coupling unit is then passed through the window sill and connected to terminal block with a 150-ohm transmission line.

The last outlet on the transmission line is equipped with a noninductive terminal resistor which terminates the transmission line in its own impedance.




**FIGS. 3 to 6—Riser diagram of typical distribution system in multiple outlet divider-network, where coaxial cables are run in conduit. It should be noted that in a multiple outlet installation of this type the transmission line must be terminated in a 150-ohm noninductive resistance.**

When an antenna system of this type is installed, each riser has two RG 59/U coaxial cables or one A.A.&K. type DX/150 is placed in a one-half-inch conduit which runs from the antenna to each outlet box.

An outlet coupling unit is provided for connection to the transmission line outside each window as shown in figs. 1 and 2. This coupling unit has a lead-in piece of the 150-ohm transmission line, which is passed through an inlet in the window sill.

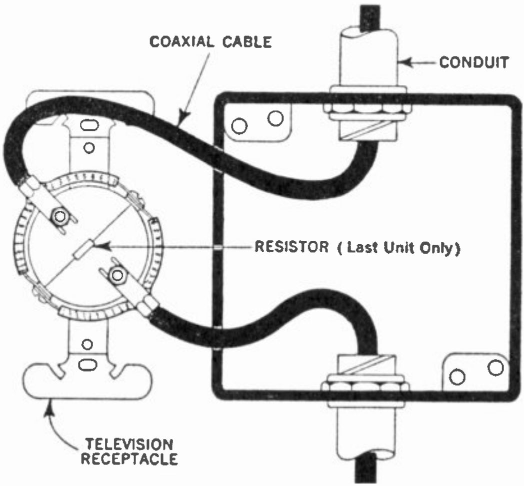
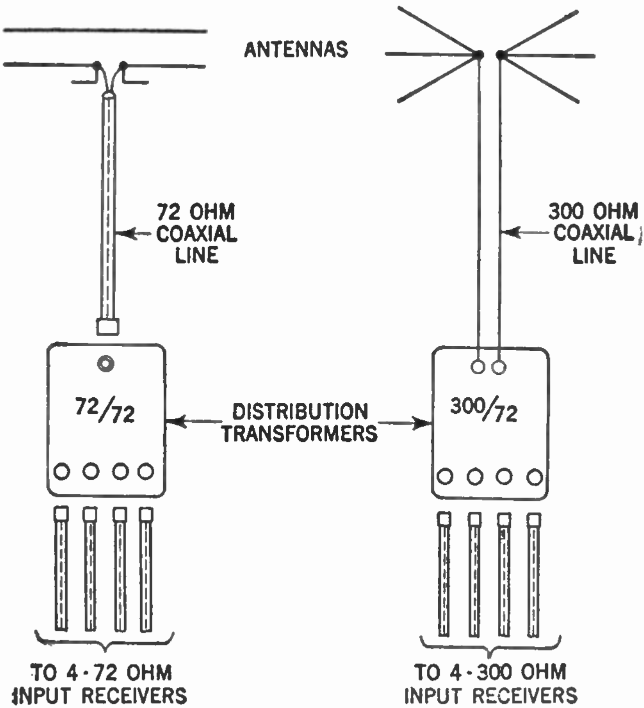



**FIG. 7—Showing terminal box and receptacle for concealed wiring in a divider-network antenna system for multiple dwelling outlets.**

**Antenna-Array Master System.**—This method of supplying multiple antenna outlets in apartment dwellings with sufficient signal strength, employs distribution devices for dividing the antenna signal into four equal parts.

With reference to figs. 8 and 9 the source of the signal differs only in the impedance of the downlead to the antenna. In areas within 15 miles of a metropolitan station, a single antenna array is usually satisfactory and may also be employed in some high locations which are approximately 30 miles from the transmitting stations. Better results, however, can be obtained in fringe areas, when the antenna arrays are stacked.




**FIGS. 8 and 9—Master antenna system diagrams for a 72 and 300 ohm connection.**

In noise areas, or areas disturbed by interference, the antenna system shown in fig. 8 was found to be most effective, since it provided a system which is completely shielded from antenna to receiver. The distribution system used with fig. 8

is illustrated in fig. 10. With this arrangement, the antenna signal, which feeds the device through a single lower coaxial fitting, is divided into four equal parts for distribution to four television receivers.

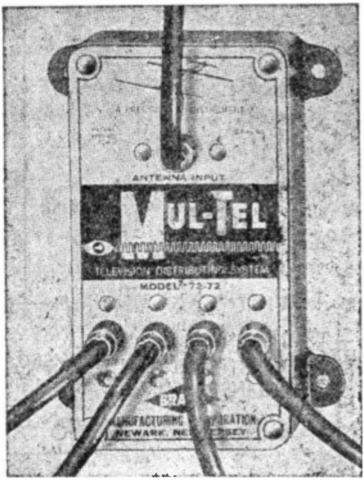



FIG. 10—Showing front view arrangement of distribution transformer with facilities for connection of four television receivers. (Courtesy Brach Mfg. Co.)

In operation the distribution transformer arrangement provides a division of signals into four equal parts with approximately the same attenuation and SWR on all channels. Therefore, all receivers connected have a common signal quality.

While nearly all of the current television receivers can be matched to a 72-ohm coaxial transmission line, there are many receivers which do not have such provision. Accordingly, a unit was developed to provide a match to the earlier type of receivers with 300-ohm imputs to the 72-ohm system.

Incidentally, a short or opening at the television receiver end of the system has very little effect on any other receiver since the reflected signals, due to the condition of the end of the line, are absorbed by the device and have little influence on the performance of the other circuits.

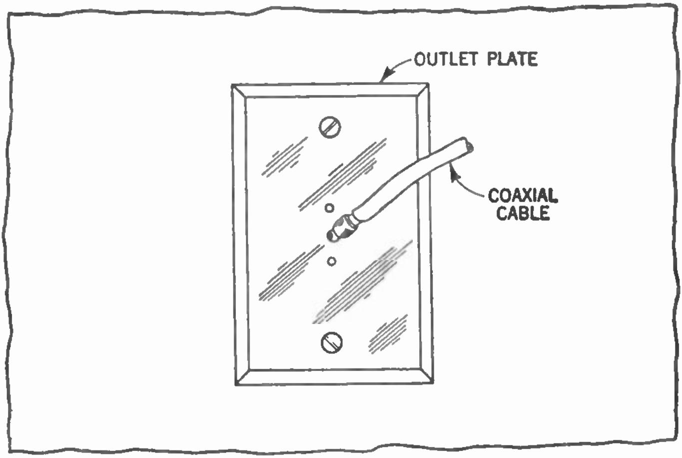



**FIG. 11—Showing outlet plate for permanent installations suitable for use with wire-mold box or standard wall-outlet flush box.**

For a more permanent type of installation, outlet plates of the type shown in fig. 11 can be used. A dummy load is placed in this outlet plate, when no set is connected, to provide a theoretically better distribution balance of the signals transmitted from the device. Dummy loads are provided in the unit for unused circuits in instances where only two or three sets will be fed from the distribution units.

In installing this system, the antenna must be so placed that the highest quality of signal pickup prevails. An antenna which matches a 72-ohm coaxial cable is preferred, as a shielded system will always operate better than one which uses open line and is susceptible to noise pickup.

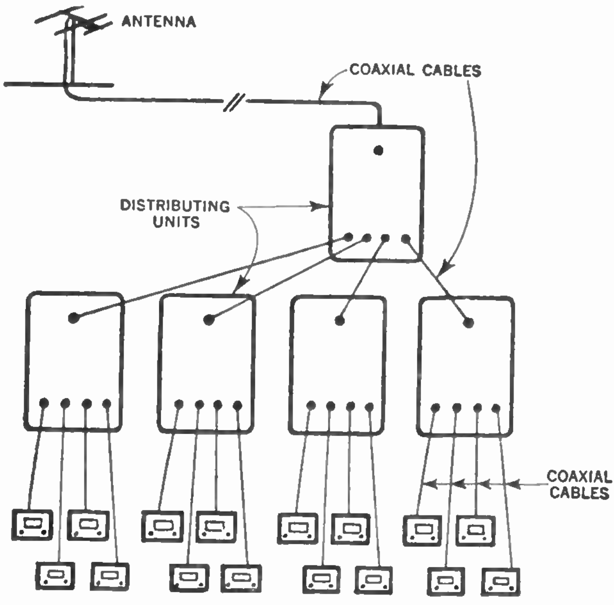



**FIG. 12—Schematic diagram showing master antenna multiple unit system. Distribution systems of this type has found employment by television receiver dealers where a great number of sets must be demonstrated simultaneously.**

The distribution devices must be located in some protected area like a rooftop, penthouse, stairwell, attic or, in the case of the dealer installation, on a wall near the television receiver.

A coaxial cable, of the RG type, conforming to JAN specifications, must be used with the system. In connecting the coaxial cable, two steps should be followed:

1. The center conductor of the cable should be exposed so that it extends through the straight tip end of the coaxial male connector and is available for soldering to the tip end.

2. The shield should then be exposed sufficiently so that a crimp tool can make a pressure contact between the shell of the coaxial connector and the shield of the cable. The outer polyvinyl should be positioned so that it is squeezed into the coaxial fitting by the crimping operation, to facilitate handling of the coaxial cable fitting.

In the event that a crimping tool is not available, both the center conductor and the shield connection can be made by soldering.

The distribution devices should be centrally located in all installations so that all sets will receive approximately the same level of signal. In all installations, the length of the coaxial cable between the television receiver and the distribution device determines the amount of signal which will be available for the television receivers.

**Separate Antenna Systems.**—This system differs from the foregoing multiple antenna systems, mainly in that a separate antenna is provided for each individual transmission channel. A group of pretuned amplifiers, one for each channel, is supplied to provide interference free signals to each receiver outlet.

In addition individual resistance pads at the input of each channel amplifier is provided which enables the antenna technician to compensate for varying signal levels in any location.

In an installation of this type it is important to separate each channel antenna a distance of 10 feet or more, to prevent any mutual coupling between them which may form a distorted

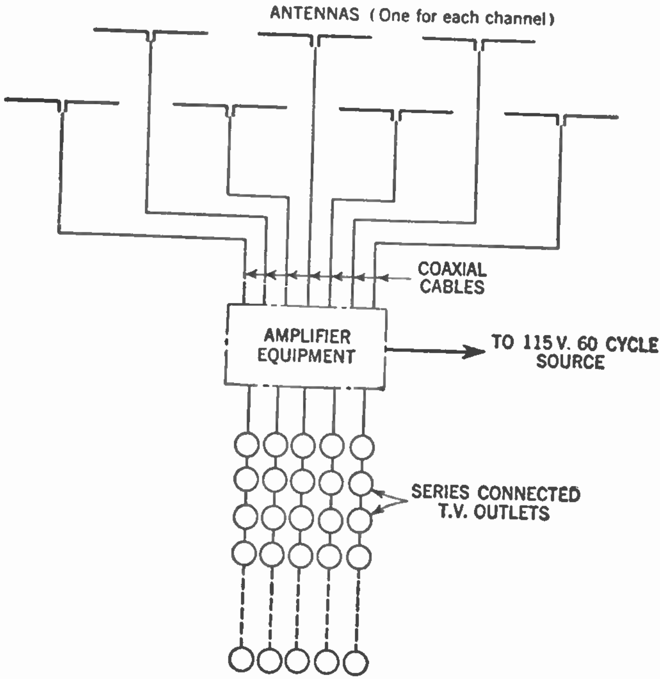



**FIG. 13—Schematic diagram showing multiple outlet system with separate antennas for each television channel.**

picture. Coaxial cables are used to connect the antenna to the amplifiers in order to prevent noise pickup, and to match the input impedance of the amplifiers.

CHAPTER 7

# Antenna Installation Procedure

Prior to making the physical installation of the antenna, it is often necessary to obtain a response pattern. This information is particularly useful when signals are to be obtained from transmitters located at a considerable distance apart. An approximate response pattern can be obtained when the transmitter is on the air by rotating the antenna and utilizing a test receiver and output meter.

**Antenna Installation Tools.**—While antennas used for each individual receiver may differ radically in design and in location with respect to the transmitting station, the fundamental installation procedure in each case, however, is similar.

The necessary installation tools may vary considerably however, depending upon the type of building, whether it be wood, stone or masonry, also whether it be an apartment house or multiple receiver installation, where the cabling or transmission line is placed between the outer or inner walls of the building for concealment.

From the foregoing it follows, that a very large supply of service tools may be necessary in order to be equipped for every service condition encountered. Therefore, no attempt will be made to list all the possible tools and test equipment that a television technician might require in the course of antenna installation and service work.

The following tools constitute the *minimum requirements* only for the average antenna installation:

1. Handtools; such as hammer, hack saw, pliers, screw drivers, etc.
2. Electric drill (slow speed) for one-half-inch masonry drill bit.
3. Electric drill (high speed) for one-half-inch drill bit.
4. Machine screw anchor with lead expansion sleeves one-quarter-20.
5. Tool for expanding sleeve in machine screw anchor.
6. Bolts (galvanized or brass) one-quarter inch.
7. Antenna masts and ground clamp.
8. Phosphor bronze guy wire and porcelain insulators.
9. Coaxial transmission line.
10. Twin lead transmission line (300 ohm).
11. Rawl plugs and tools.
12. Transmission line stand-off insulators.
13. Staples and tacks.
14. Soldering iron.
15. Wood brace and bits.
16. Friction and rubber tape.

In addition to the previously enumerated tools, adjustable extension ladders (50 ft.) are usually carried on the installer's truck to permit entrance to the roof of single family dwellings. In this connection it should be pointed out that particular care should be exercised when employing *current conducting metal ladders* in the proximity of *power lines*. A great number of accidents are caused each year by carelessness, not realizing that when such a ladder (or the person or persons on such a ladder) contact a live conductor electrocution is liable to result.

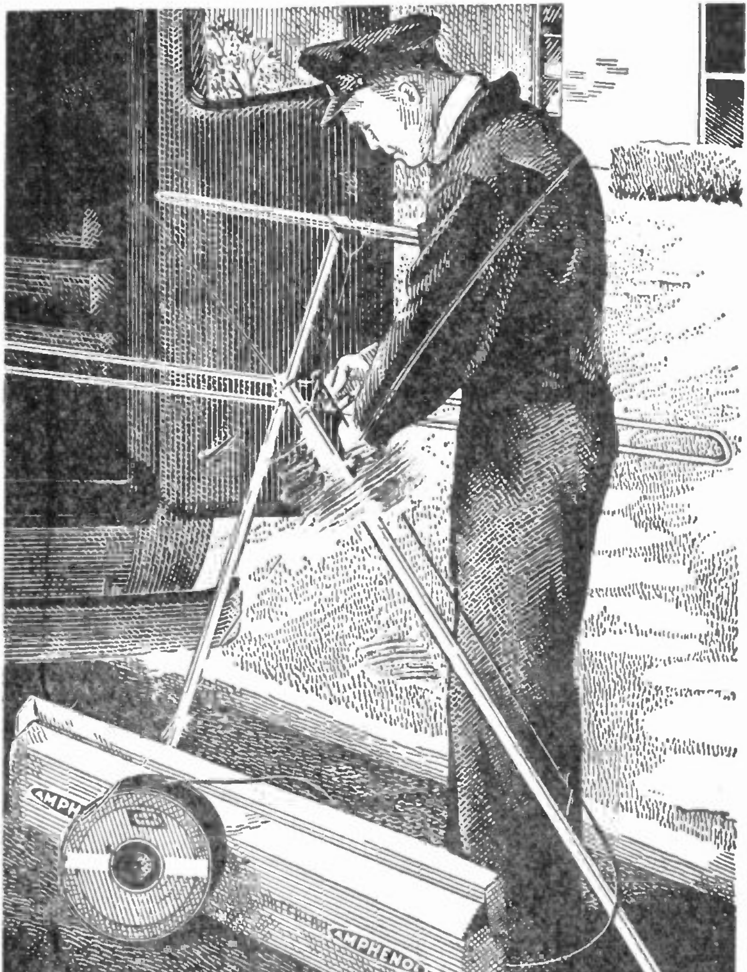
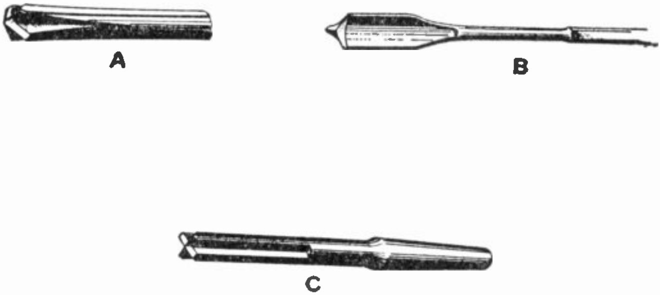
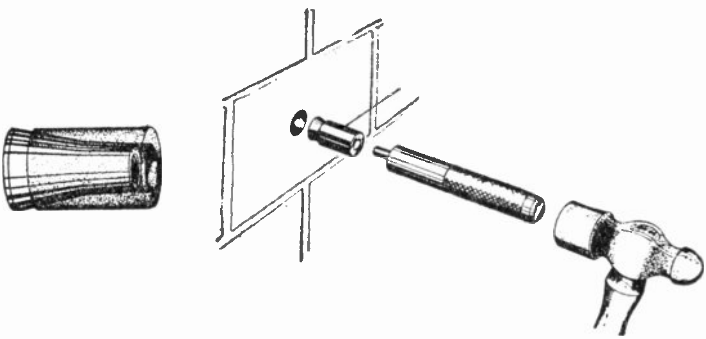



FIG. 1—Illustration showing antenna assembly method. (Courtesy American Phenolic Corporation.)

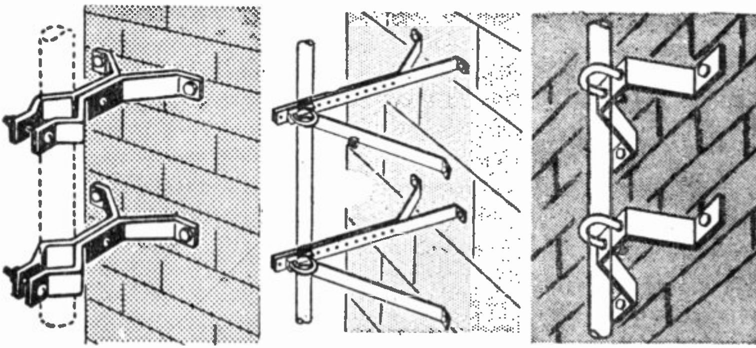



FIGS. 2 to 4—Typical masonry drills. In the figure: A, represents a star drill; B, forged drill and C, diamond "N" drill point.



FIGS. 5 to 9— Showing typical expansion screw anchor used in masonry work, and method of installation. When a hole is completed a one-quarter-20 lead expansion screw anchor is inserted as indicated, after which the lead expansion sleeve is hammered to properly imbed it in the hole. Experience with the expansion tool will soon determine the amount of hammering required. After expansion screw anchors are installed in the masonry, antenna mast clamps can be mounted with one-quarter-inch bolts, and the antenna mast inserted through these clamps which can be selected to fit the particular type of mast being used.

To properly install an outdoor antenna system it is in addition necessary to have some method of communication from the antenna site to the receiver. This communication should be established before the final antenna site has been chosen. A pair of interconnected telephones may be used to conveniently accomplish this purpose. Do not use the antenna transmission line as the means of interconnecting these telephones.



**FIGS. 10 to 12—Various types of antenna mast supports, illustrating methods of securing antenna mast to masonry structures. All supports should be properly dimensioned and anchored to prevent the antenna and mast from turning and excessive swaying.**

**Assembly of an Outdoor Antenna.**—Complete assembly instructions usually accompany each outdoor type antenna kit and these instructions should be followed.

**Locating an Outdoor Antenna.**—Before attempting to install the antenna it is essential to carefully select a position which allows the following conditions to be fulfilled:

1. Absence of obstruction such as buildings, trees, power lines, other nearby antenna systems, etc., between the proposed antenna site and the transmitting antenna.

2. Maximum distance between proposed antenna site and sources of electrical noise such as might originate in ignition systems, elevator relays, diathermy and X-ray machines and arcing from electrical transit systems. Several of these conditions preclude the possibility of mounting the antenna near the edge of the roof adjoining a heavy traffic street even though this site may be preferable with respect to length of antenna lead-in.

3. Greatest possible height above ground level. In general this will allow the antenna to overcome such obstructions as are mentioned in item 1.

After choosing the antenna site in accordance with the foregoing conditions, make an actual test with the receiver to be sure that a satisfactory picture can be obtained from all transmitting stations before attaching the mast to the building. This is facilitated by the use of the intercommunication system between the man on the roof and the man observing the receiver performance in the home.

It is often possible to obtain considerable improvement in performance by moving the antenna location a small distance from the original site. This final test for the most desirable antenna location becomes vitally important in areas where signal strength is low or where reflection from surrounding surfaces produce multiple transmission paths, thereby creating multiple images or "ghosts" on the picture screen.

In areas where the signal strength is sufficient, it may be possible to install the antenna in the attic provided the roof is not made of metal or insulated with metal foil. Should there be any indication that the signal strength is inadequate, the attic antenna installation should not be attempted and an outdoor antenna is definitely recommended.

If the transmitted signal strength be low and surrounding surfaces cause reflections, or sources of electrical disturbances

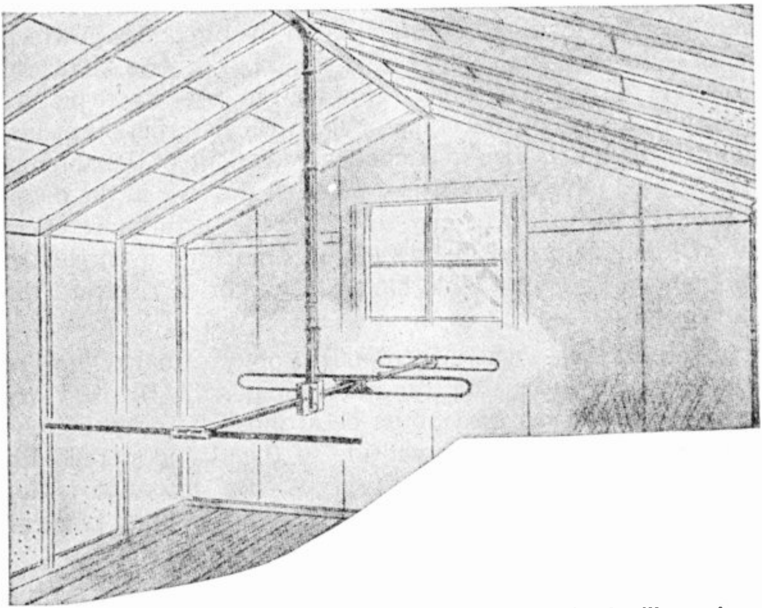


FIG. 13—Typical attic antenna installation. As shown in the illustration a common outdoor antenna type is inverted to suit the available space. An antenna installation of this type should, however, not be attempted unless prior tests indicate sufficient signal strength.

are present, then proper orientation of the antenna becomes of equal importance with that of selecting the correct location.

**Antenna Orientation.**—Since the response of an antenna has a directional characteristic, it is now necessary to orient the antenna for the position that will give the best receiver performance. Here again it is necessary to maintain direct communication with the man observing receiver performance.

In the case where the signal is to be received from only one transmitter, the problem of orientation is relatively simple. Since the antenna is least responsive in the directions in which the rods are pointing, the antenna should in general be placed broadside to the transmitter. However, in cases where picture quality is affected by reflections or electrical disturbances picked up at the antenna, the directional characteristic of the antenna may be used advantageously by pointing the rods in the direction of the disturbance. By so doing, the disturbance effect will be minimized and picture quality improved even though the antenna broadside is no longer facing directly toward the transmitter.

In certain areas, where surrounding objects make "line of sight" reception from the transmitter impossible, satisfactory receiver performance may often be attained by orienting the antenna so that it faces broadside to the strongest reflected signal. Under conditions of this type, best reception is not always obtained with the antenna rods in a horizontal plane or with the mast in a vertical position.

In areas where a number of television stations exist, the problem of orientation becomes more complicated and requires very careful consideration. In such a case, it is necessary to orient the antenna so as to obtain equally satisfactory reception from all stations. Relative signal strength of different stations may require that considerable antenna misdirection be tolerated with regard to a high power transmitter in order to favor reception from a low power transmitter.

Final position of the antenna can be determined only by observing the quality of the picture on the receiver screen.

**Mounting an Outdoor Antenna.**—Various methods of mounting the antenna mast may be used. When using brackets to attach the mast to a wall, be sure that the wall surface of the building is in good enough condition to withstand the strain of supporting the mast and antenna. Spacing between these brackets should be sufficient to hold the mast rigid and should be in proportion to mast height. It is of utmost importance that the mast brackets grip the mast securely to prevent rotation of the antenna due to severe wind storms.

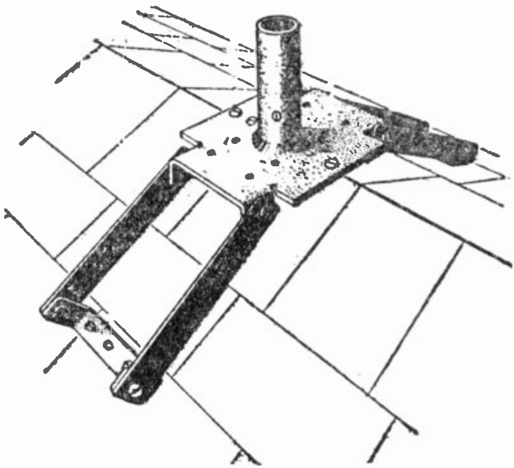


**FIG. 14—Showing antenna mast support suitable for a peaked roof. Additional support in form of guy wires properly attached to the mast and roof are usually required.**

When making a flat roof installation, make sure that the guy wire anchor points are secure and spaced approximately 120° apart. The guy wire clamp holes should point radially outward to the anchor points to prevent a twisting torque on the mast which might cause the antenna to rotate. Turnbuckles placed in each guy wire are recommended for a more rigid installation.

**Safety and Lightning Protection.**—The antenna system should be installed in conformance with local building and fire regulations. Every precaution should be taken to adequately

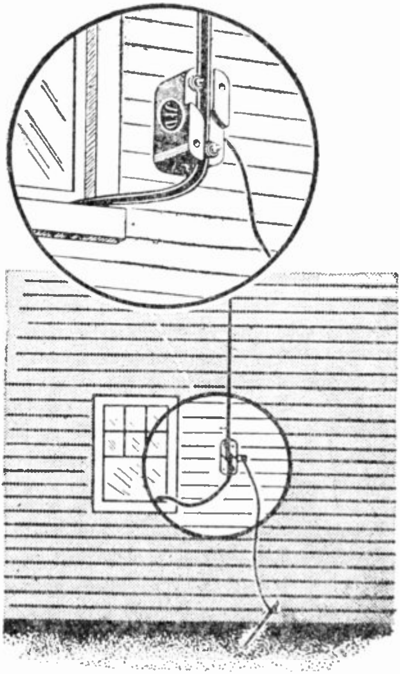


FIG. 15—Showing typical outdoor lightning arrester and method of installation. Here the twin lead transmission line is slipped into the slot on top of the arrester and tightened in place. A 4-foot length of ductile copper ground wire is used when mounting the arrester on outside walls.

secure the mast to the building to avoid danger of antenna falling from the roof; use of guy wires is recommended wherever deemed necessary as an additional safety measure. A degree of lightning protection may be obtained by connecting a heavy copper conductor between the mast of the antenna and a good ground.

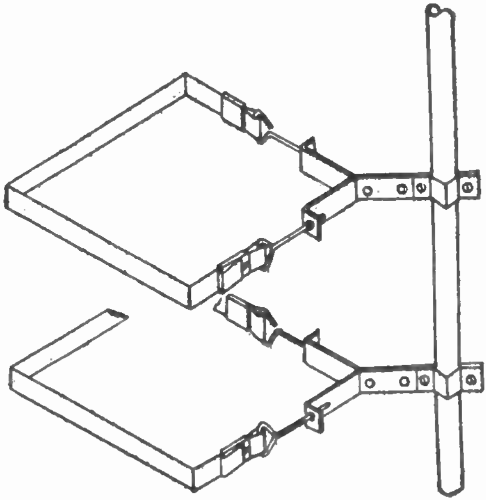
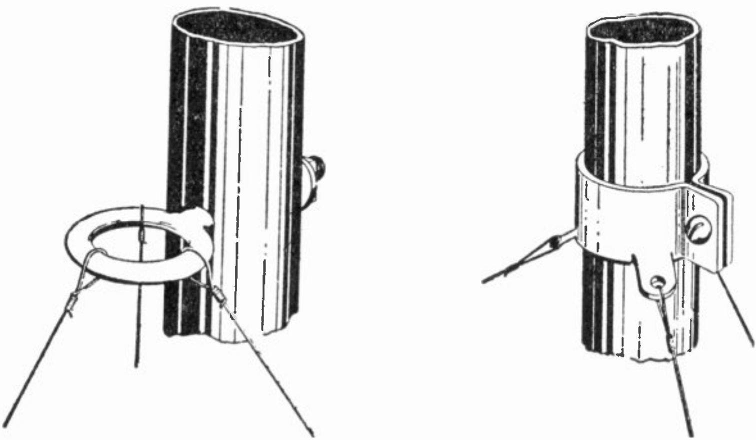


**FIG. 16—Typical chimney mounting bracket. An antenna mounting arrangement of this type consists of two brackets with adjustable eye bolts on each side. The straps are commonly made of three-quarter-inch galvanized steel and the units are riveted with one-quarter-inch solid rivets. The assembly is made to fit masts from one to one and three-eighths-inch diameter.**

**Selecting, Routing and Securing Transmission Line.**—A properly selected and installed transmission line is as important to the quality of the antenna system as the antenna itself. An improperly installed line causes reflection and high losses. Reflections in the line make it impossible to obtain clear pictures, and in severe cases, the reflections cause "smears" so that the picture appears out of focus even though the receiver is perfectly focused. In general, the longer the transmission line, the more care required in installation.

Most television receivers have a 300-ohm input circuit which is balanced to ground and intended for connection to a 300-ohm antenna system. Failure to observe proper impedance match between antenna, transmission line and receiver will result in less energy delivered to the receiver and undesirable effects of noise and interference may be accentuated.



**FIGS. 17 and 18—Showing methods of guy wire attachment to antenna mast. Antenna masts should be properly dimensioned, anchored and secured to enable it to withstand all loads, not only that of the antenna structure, but also of additional loads due to wind, sleet or snow. Particular attention should be directed towards the possibility of turning and excessive swaying, since this will tend to impede its effectiveness.**

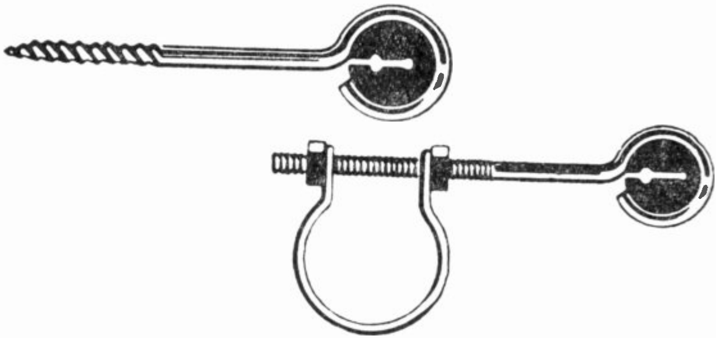
**Types of Transmission Line.**—Low loss "ribbon type" (300 ohm) transmission line is intended for use in a normal installation. However, under conditions where man-made interference may be picked up by the transmission line itself, shielded cable may be used to alleviate this condition. It is recommended that twin conductor cable be used if shielded transmission line is required. This cable is balanced with respect to ground and its characteristic impedance (300 ohms) provides an exact match for direct connection to receiver input circuits.

**Length of Line.**—The length of the transmission line should be kept as short as possible. The longer the line, the greater the opportunity for man-made electrical disturbance to introduce undesirable effects. Attenuation of the line, though low, will reduce the energy fed to the receiver in direct proportion to length.

**Splicing the Line.**—If it becomes necessary to splice on an additional length of ribbon type line, care should be exercised to avoid a mismatch at the splice. This is done by stripping the two lines back about one-half inch and then twisting the respective conductors together so that the insulation of one butts directly against the insulation of the other.

If the splice be made with too large or too small a space between parallel wires, the line impedance will be changed at this point and serious reflections may occur. The twisted pairs should be soldered, avoiding excessive heating which will soften the insulation. Clip the protruding solder joints short and cover the splice with an insulating tape intended for high frequency purposes. Splicing of a shielded cable is not recommended; use special connectors available for that purpose.

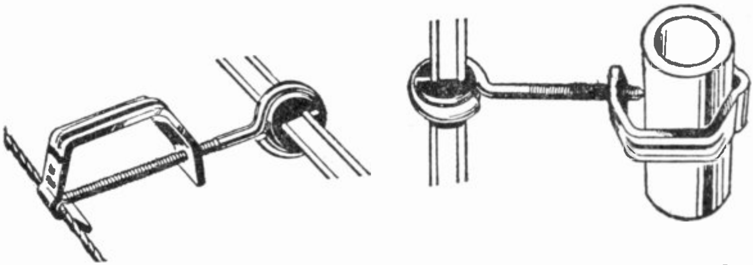
**Routing and Securing.**—It is well to carefully consider the best route for the transmission line with respect to length and electrical disturbance shielding. A compromise must usually be made on the length so as to be able to take advantage of the shielding effect of the building against such disturbances as ignition noise and arcing from electrical transit systems. Whenever possible, the line should be run in a vertical direction so that rain, sleet, and snow will have less tendency to cling to it. If a horizontal run be necessary, it should be made under an eave or other protection. *Never run the line inside of metal pipes.*



**FIGS. 19 and 20—Typical transmission line stand-off insulators. These insulators take various forms depending upon type of transmission line used and method of fastening.**

The transmission line must not be allowed to make extensive contact with any surface (especially metal). Stand-off insulators provide a means of supporting the line as well as maintaining proper spacing from surrounding surfaces. They may be screwed directly into wood without the aid of any other mounting device; however, when mounting in brick or stone, it is necessary to use some type of expansion plug.

If the weight supported by these stand-offs is small, the plug hole may be drilled in the mortar, provided that this mortar be well bonded. It is preferable to drill the plug holes in the brick or stone proper, making sure that these holes are deep enough to accommodate the full length of the plug. The insulator should grip the transmission line and support it in both the vertical and horizontal direction. The line should be pulled tight so that a heavy wind will not cause it to swing against surrounding objects.



**FIGS. 21 and 22—Showing methods of securing transmission line stand-off insulators depending upon conditions encountered.**

Occasionally it will be physically impossible to install a stand-off insulator on the edge of a protruding parapet. Under such conditions it will be necessary to place some form of abrasion resistant sleeving around the transmission line, holding it in place with tape. In locations where electrical noise creates an interference problem, the noise pickup may be minimized by twisting the line about one turn per foot between the supporting stand-off insulators.

Various methods of bringing the transmission line into the house will occur to the installation man and consequently no specific instructions will be given. Irrespective of the method selected, best practice requires that precautions be taken to minimize contact of transmission line with surrounding surfaces and to properly seal the point of entry with a suitable mastic. *Do not attempt to use any special lead-in devices at the window.*

After the line has entered the home it should be routed by the shortest possible path to the receiver, taking special precaution to avoid contact with pipes, radiators or other metal objects. The line should preferably be supported by indoor type stand-off insulators as it is routed around the floor molding of the room. However, it may be tacked to the molding if run be short and relatively few tacks are required.

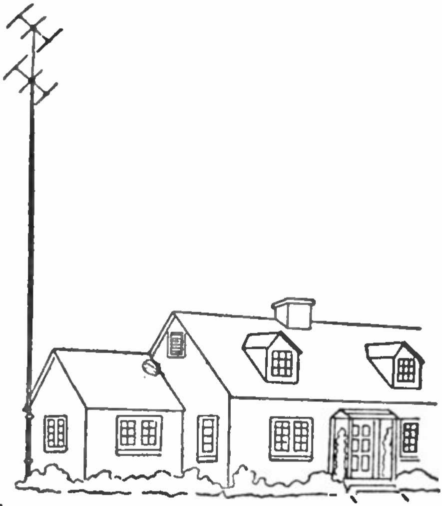


**FIG. 23—Typical antenna arrangement suitable in fringe areas and other locations where conditions require considerable antenna height.**

**Connecting Line to Receiver.**—A terminal strip will be found on the rear of the receiver cabinet. Connect the transmission line to these terminals. Under certain conditions improved reception results from reversing the connection of the line to these terminals, so it is suggested that picture quality be observed for both conditions before making a permanent connection of the transmission line.

When using twin conductor type shielded cable, observe the following instructions for proper connection: Solder a pigtail of braided wire to outer copper shield of the cable; provide this pigtail at point of connection to the antenna as well as on end which connects to the receiver. That will facilitate connection of shield to antenna mast and receiver chassis. Tape the end of cable with insulating tape (intended for high frequency application) to prevent moisture from entering cable. Attach a crimp type soldering lug to each inner conductor making sure to crimp lug around polyethylene so that inner conductor will not have to support the weight of the cable. Solder inner conductor to lug, using a minimum amount of heat.

## Code Specifications

Portions of Article 810 of the National Electrical Code which apply to Television Receiver installations are quoted herewith for your information.

### Antenna Systems—General

**8111. Material.** Antenna, counter-poise and lead-in conductors shall be of hard-drawn copper, bronze, aluminum alloy, copper-clad steel or other high strength, corrosion-resistant material. Soft drawn or medium drawn copper may be used for lead-in conductors where the maximum span between points of support is less than 35 feet.

**8112. Support.** Outdoor antenna and counter-poise and lead-in conductors shall be securely supported. They shall not be attached to poles or similar structures carrying electric light or power wires or trolley wires of more than 250 volts. Insulators supporting the antenna or counter-poise conductors shall have sufficient mechanical strength to safely support the conductors. Lead-in conductors shall be securely attached to the antenna.

**8113. Avoidance of Contacts with Conductors of Other Systems.** Outdoor antenna, counter-poise and lead-in conductors from an antenna to a building shall not cross over electric light or power circuits and shall be kept well away from all such circuits so as to avoid the possibility of accidental contact. Where proximity to electric light and power service conductors of less than 250 volts cannot be avoided, the installation shall be such as to provide a clearance of at least two feet. It is recommended that antenna and counter-poise conductors be so installed as not to cross under electric light or power conductors.

**8114. Splices.** Splices and joints in antenna and counter-poise span shall be made with approved splicing devices or by such other means as will not appreciably weaken the conductors. (Soldering may ordinarily be expected to weaken the conductor. Therefore, when soldering is employed, it should be independent of the mechanical support.)

**8115. Structures.** Metal structures supporting antennas shall be permanently and effectively grounded.

## Antenna Systems—Receiving Station

**8121. Size of Wire Strung Antenna and Counter-Poise.**

(a) Outdoor antenna and counter-poise conductors for receiving stations shall be of a size not less than given in the following table:

| Material | Minimum Size of Conductors When Maximum Open Span Length is Less than 35 feet | 35 feet to 150 feet | Over 150 feet |
|---|---|---|---|
| Aluminum alloy, hard drawn copper..... | 19 | 14 | 12 |
| Copper-clad steel, bronze or other high strength material.................... | 20 | 17 | 14 |

(a) For very long span lengths larger conductors will be required, depending on the length of the span and the ice and wind loading.

(b) **Self-Supporting Antennas.** Outdoor antennas, such as vertical rods or dipole structures, shall be of noncorrodible materials and of strength suitable to withstand ice and loading conditions.

**8122. Size of Lead-In.** Lead-in conductors from outside antenna and counter-poise for receiving stations, shall, for various maximum open span lengths, be of such size as to have a tensile strength at least as great as that of the conductors for antenna as specified in section 8121. When the lead-in consists of two or more conductors which are twisted together or are enclosed in the same covering or are cocentric, the conductor size shall, for various maximum open span lengths, be such that the tensile strength of the combination will be at least as great as that of the conductors for antenna as specified in section 8121.

**8123. Clearances.**

(a) **On Buildings—Outside.** Lead-in conductors attached to buildings shall be so installed that they cannot swing closer than two feet to the conductors of circuits of 250 volts, except in the case of circuits not exceeding 150 volts, if all conductors involved are supported so as to insure permanent separation, the clearance may be reduced but shall not be less than four inches. The clearance between lead-in conductors and any conductor forming a part of a lightning rod system shall be not less than six feet unless the bonding referred to in section 2586 is accomplished.

(b) **Antenna and Lead-Ins—Indoors.** Indoor antennas and indoor lead-ins shall not be run nearer than two inches to conductors of other wiring systems in the premises unless,

1. Such other conductors are in metal raceways or cable armor, or
2. Unless permanently separated from such other conductors by a continuous and firmly fixed nonconductor such as porcelain tubes or flexible tubing.

## Protectors

**8141. Lightning Arresters—Receiving Stations.** Each conductor of a lead-in from an outdoor antenna shall be provided with a lightning arrester approved for the purpose, except that if the lead-in conductors are enclosed in a continuous metallic shield the lightning arrester may be installed to protect the shield or may be omitted if the shield is permanently and effectively grounded. Lightning arresters shall be located outside the building, or inside the building between the point of entrance of the lead-in and the television set or transformers, and as near as practicable to the entrance of the conductors to the building. The lightning arrester shall not be located near combustible material nor in a hazardous location.

**8151. Material.** The grounding conductor shall, unless otherwise specified be of copper, aluminum, copper-clad steel, bronze, or other corrosion resistant material.

**8155. Run in Straight Line.** The grounding conductor shall be run in as straight a line as possible from the antenna mast and/or lightning arrester to the grounding electrode.

### Grounding Conductors—Receiving Station

**8161. Inside or Outside Building.** The grounding conductor may be run either inside or outside the building.

**8162. Size of Protective Ground.** The protective grounding conductor for receiving stations shall be not smaller than No. 14 copper or No. 12 aluminum or No. 17 copper-clad steel or bronze, provided that where wholly inside the building it shall not be smaller than No. 18.

**8163. Common Ground.** A single grounding conductor may be used for both protective and operating purposes. If a single conductor be so used, the ground terminal of the equipment should be connected to the ground terminal of the protective device.

### Interior Installation—General

**8181. Radio Noise Suppressors.** Radio interference eliminators inter-ference capacitors or radio noise suppressors connected to power supply leads shall be of a type approved for the purpose. They shall not be ex-posed to mechanical injury.

It will be noted that a lightning arrester is not required under paragraph 8141 when the lead-in conductors from antenna to entrance of building are protected by a continuous shield which is permanently and effectively grounded. Such requirement would, therefore, be met by proper grounding of the outer shield of the regular coaxial cable. Installation men should be particularly cautioned to comply with paragraph 8123 and to refrain from the use of insulators or cable clips installed on or in buildings by telephone or lighting companies.

CHAPTER 8

# Television Broadcasting

**General.**—Broadly speaking, television may be said to be a means of vision obtained of a distant object by means of various devices identified as the *transmitting* and *receiving apparatus*. The problem of television therefore is fundamentally:

1. Converting light signals into electrical signals.
2. Transmitting the signals to a distant station, and
3. Converting the transmitted electrical signals back into light signals.

With reference to figs. 1 and 2 the steps required to pickup transmit and reproduce a television picture are principally as follows:

The video signal (picture signal) released by the *iconoscope** camera fig. 1 is a series of electrical charges which represent the light distribution of the object being televised. Light reflected from the face of the object is collected by the lens system and focused on the plate of the television camera tube. This plate is covered with a material, which in effect, forms an innumerable quantity of minute photoelectric cells and is called a *mosaic*. This mosaic is swept or scanned by a thin stream of electrons from the electron gun incorporated in the camera.

*The name *Iconoscope* relates to a type of television transmitting tube invented by Dr. V. K. Zworykin of the Radio Corporation of America. The word *iconoscope*, taken from the Greek word "*icon*" meaning "image" and "scope" meaning observation.

**Scanning Method.**—The scanning in the case of the iconoscope, is accomplished by deflecting the electron beam electromagnetically by means of coils external to the tube. These coils are excited at frequencies which cause the point of impact of the electron beam to move across the mosaic in approximately a horizontal line at a uniform speed, then fly back and scan another line, and so on until the entire mosaic has scanned 525 lines in the desired sequence. This complete scanning is repeated at the rate of 30 frames per second. Thus, in modern television systems, scanning consists of 525 horizontal lines, which are covered 30 times per second, making a total of $525 \times 30$ or 15,750 lines scanned per second, and 60 fields (two fields per frame).

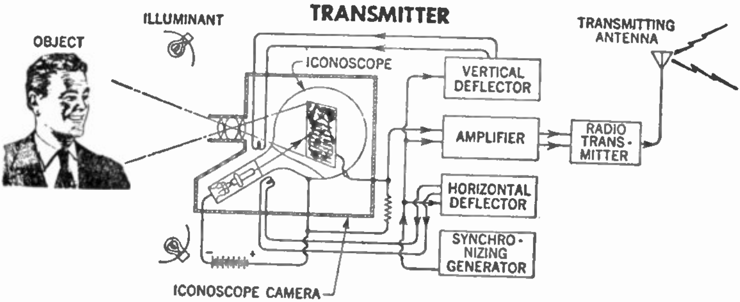



**FIG. 1—Schematic diagram of simplified television transmitting system. (Sound portion of system not shown).**

When the electron beam falls upon an illuminated portion of the mosaic, current will flow through the output circuit of the iconoscope. When it falls upon a partially illuminated portion a smaller current will flow, and when it falls upon a dark portion very little current will flow.

In this manner, current pulses will be generated which will correspond in time sequence to the light and dark areas of the televised image as they are scanned by the electron beam.

The resulting voltage pulses, termed video signals, are then amplified and combined with special artificially manufactured signals for controlling the timing of the kinescope (receiver picture tube) deflection circuits and for extinguishing (blanking) the kinescope electron beam during the return time. The resulting composite signal is then used to modulate a high frequency transmitter.

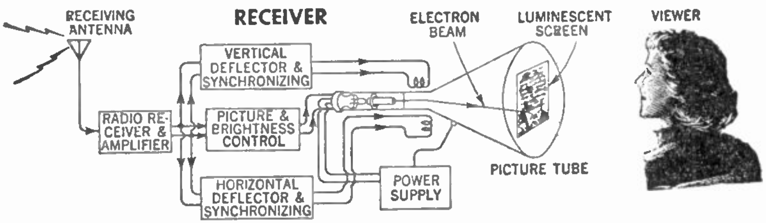



**FIG. 2—Schematic diagram of simplified television receiving system. (Sound portion of system not shown).**

In the standard interlaced scanning system, scanning of the horizontal lines is not performed in sequence, but the odd-numbered lines are scanned first, that is, 1,3,5, etc. and then the beam returns and scans the even-numbered lines, before the complete scene is scanned. Starting at the upper left extremity of the picture, as in fig. 3 line No. 1 is scanned. Instead of proceeding then, with line No. 2, the scanning spot drops two spaces and No. 2 is omitted. This is because the downward rate has been doubled—60 instead of 30 *c.p.s.* Line No. 3 then comes under scansion, followed by numbers 5,7,9 and every odd numbered line of the picture. Upon reaching the bottom of the picture, the scanning spot moves again to the top of the picture and begins another scanning field which is displaced from the first by the width of one line so that now lines 2,4,6,8 and all even numbered lines are scanned.

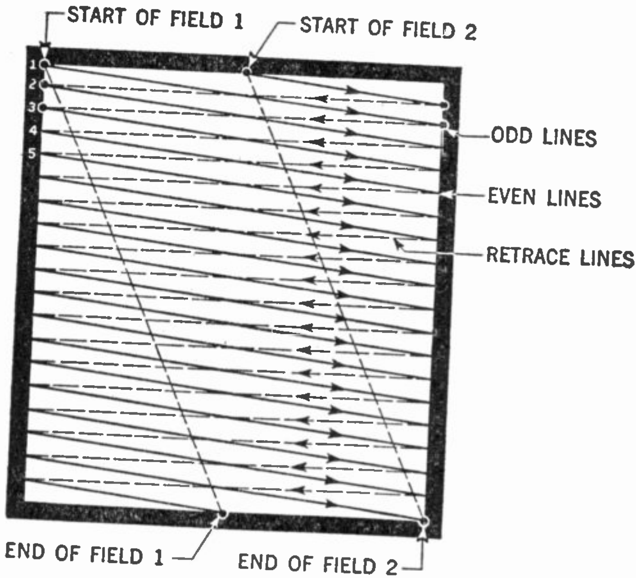



**FIG. 3—Scanning raster showing interlaced pattern.**

Since each field is completed in one sixtieth second, both fields consume one thirtieth second. Thus, 30 complete pictures are scanned in one second, each having been broken up into two projections as a means of flicker reduction.

Given a line frequency of 15,750 and a picture repetition rate of 30 *c.p.s.* the number of lines per picture is 15,750/30 or 525 lines, the number of lines per field being 262½.

Approximately 490 of these lines are active, the remainder occurring during the vertical retrace period during which time the viewing tube is blanked out. It is necessary of course, that complete synchronism be maintained between scanning at the transmitter and at the receiver. To effect this, synchronizing pulses are transmitted along with the video signal which locks the receiver oscillators, vertical and horizontal, into step with those at the transmitter.

**Frequency Bands.**—The F.C.C. (*Federal Communications Commission*) has up to the present time assigned two bands for television broadcasting. The frequencies of these bands are considerably higher than frequencies used in ordinary broadcasting. The low band covers frequencies from 54 to 88 mc. and the high band covers a frequency range of from 174 to 216 mc. The lower band consists of five channels as follows:

| *Channel Number* | *Frequency (Megacycles)* |
|---|---|
| 2 | 54-60 |
| 3 | 60-66 |
| 4 | 66-72 |
| 5 | 76-82 |
| 6 | 82-88 |

The higher band consists of seven channels and each channel has the following frequency allocation:

| *Channel Number* | *Frequency (Megacycles)* |
|---|---|
| 7 | 174-180 |
| 8 | 180-186 |
| 9 | 186-192 |
| 10 | 192-198 |
| 11 | 198-204 |
| 12 | 204-210 |
| 13 | 210-216 |

From the foregoing it will be observed that a single television channel is 6 mc. wide, in contrast to the entire commercial broadcast band, which is one mc. wide. Also one broadcast channel is only 10 to 20 *k.c.* wide. The reason for the wide television channel is because of the necessity to transmit video information with clarity and sharpness. It also serves to illustrate that video information must be transmitted on very high frequencies to obtain a satisfactory ratio of carrier frequency to bandwidth.

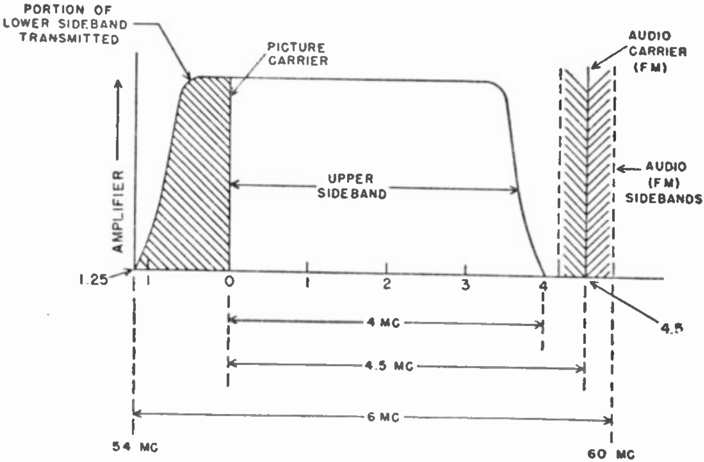



**FIG. 4—Showing signal distribution in standard television channel.**

**Standard Television Channel.**—A standard television channel is illustrated in fig. 4. As previously noted the bandwidth of each television channel is 6 mc., and both the video and sound signal must be transmitted within this limit. The amplitude-modulated picture signal is always at the low frequency end of each channel allocation and occupies approximately five and three-quarters mc. of the total six mc. bandwidth.

The frequency modulated sound signal is always at the high frequency end of the six mc. bandwidth and covers approximately one-quarter mc. or 25 *kc*.

An unusual feature of the amplitude-modulated picture signal is that the high frequency sideband is four and one-half mc. wide whereas the low frequency sideband is only one and one-quarter mc. wide. This unsymmetrical distribution permits transmission of a better definition picture using only a total bandwidth of six mc.

Such transmission of the picture signal and one sideband, as effected in television practice, is termed *vestigal sideband transmission* wherein the greater portion of the lower sideband is removed by a filter network.

**Television Signal Components.**—For successful transmission, the television signals must be separated into its components. Three types of information are transmitted on the picture carrier. They are:

1. The picture or video signal.
2. The synchronizing pulses (horizontal and vertical).
3. The blanking pulses (horizontal and vertical).

In the foregoing *the picture signal* consists of a progressive series of impulses which convey the light distribution to the scene to be televised.

*The sync signal* consists of a series of rectangular pulses, the function of which is to keep the iconoscope and kinescope (camera and receiver picture tube) locked in synchronism and to prevent the displacement of the pattern on the picture screen.

*The blanking signal* series of rectangular pulses are of longer duration than the sync pulses and as their name implies their function is to block out the fluorescent screen during all retrace intervals, making the retrace line invisible.

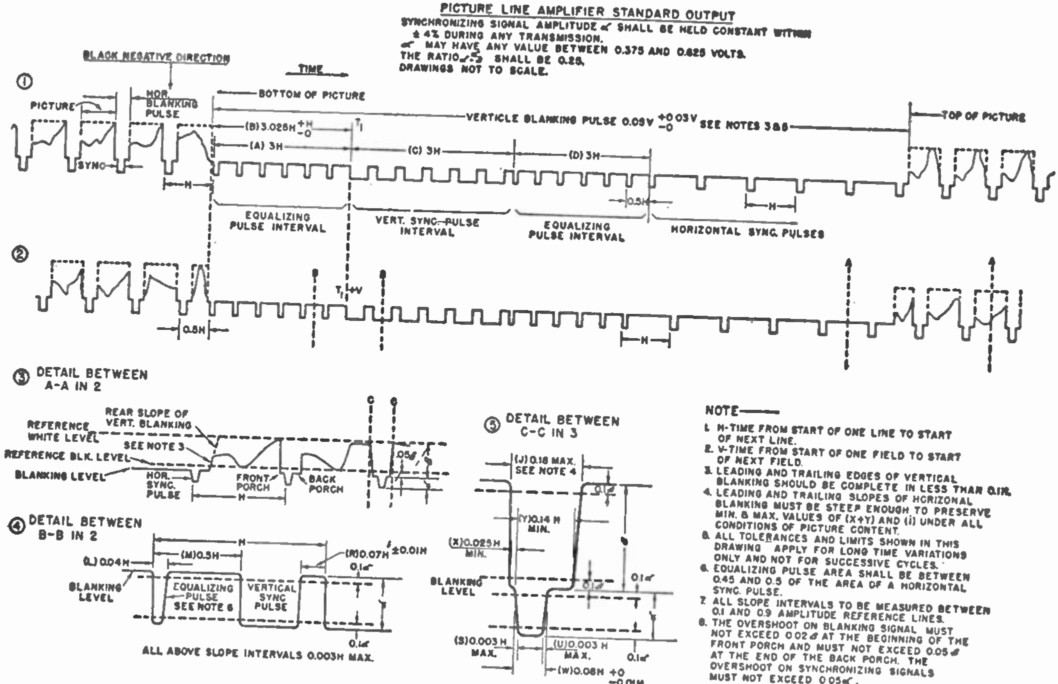



FIG. 5—Showing R.M.A. composite television signal for two successive fields. These wave shapes are for 525 lines per frame, 30 frames per second, 60 fields per second interlaced. The two wave shapes differ because of the requirement for interlacing. At the left are shown the last few lines of each field. At the end of each line is shown the horizontal blanking pulse. Details of composite signal are shown in the lower part of the illustration.

Another or fourth group of signals are termed equalizing pulses. These are of shorter duration than are the sync pulses and are transmitted to insure uniform spacing of the interlaced scanning lines, and to prevent loss of synchronism of the horizontal circuits during the retrace intervals between fields and frames.

In the composite standard video signal fig. 5, particular attention is directed to the polarity of transmission. An increase of signal power represents a dark portion of the picture, known as negative polarity of transmission. It is to be noted that the black level represents a portion of the viewing tube screen in which light is absent, that is, the beam has been blanked out. The synchronizing pulses represent a further increase of transmitter radiated power and so a darker spot upon the screen. However, since the beam has been wholly cut off at the black level and the screen is void of light, it cannot be affected by further cutoff and so the sync pulses produce no visible result. Their purpose and effect is evident, however, at the receiver scanning generators which are locked into step by these pulses. It is seen also that the sync pulses alone are not relied upon to blank out the beam during the retrace period. A blanking pulse serves this purpose, the sync pulses being superimposed upon the blanking pulse.

Should one long unbroken pulse be transmitted for vertical synchronization, the horizontal sync pulses during this time would be absent. During that time the horizontal (line frequency) scanning generators at the receivers would lack synchronization and drop out of step. In order that horizontal synchronization be maintained during the vertical retrace period, the vertical sync pulse is broken by serrations. These serrations then maintain horizontal synchronization during the vertical retrace period.

Between blanking (retrace) periods, the picture is being actively scanned. The picture signal is arbitrarily represented in fig. 5 as an irregular line.

All pulse shapes, their relative amplitudes and their duration are standardized. The only variable is the picture signal which varies from line to line as the subject is scanned.

**Signal Standards.**—Certain detailed facts of American standard television composite signals are given herewith. They are:

| | |
|---|---|
| Channel width | 6 mc. |
| Picture aspect ratio | 4:3 |
| Scanning (interlaced) | 525 lines |
| Horizontal scanning frequency | 15,750 *c.p.s.* |
| Vertical scanning frequency | 60 *c.p.s.* |
| Frame frequency (picture repetition rate) | 30 *c.p.s.* |

**Camera Tubes.**—The two most widely used camera tubes to-day are the *iconoscope* and the *image orthicon*.

The iconoscope, fig. 6 contains the following essential parts:

1. A photosensitive surface on which the image is focused and which generates the photo-current. 2. An electron gun to direct a narrow beam of electrons at the image surface, and 3. A device to deflect the beam rapidly across the image, causing it to strike each element in an orderly sequence.

The first two of the foregoing are enclosed in an evacuated glass envelope, whereas the third consists of deflection coils and their associated circuits outside the tube. The sawtooth currents, which pass through these coils, are of proper frequencies and amplitudes to cause the electron beam to scan the photosensitive surface upon which the image has been focused, in accordance with the standard interlaced scanning pattern.

*Optical System.*—Light is reflected from the objects in the scene to be televised, picked up by a lens, and projected through the flat front wall of the tube on to the image surface. The image is sharply focused so that light from any one element on the scene falls on only one tiny part of the photosensitive image surface.

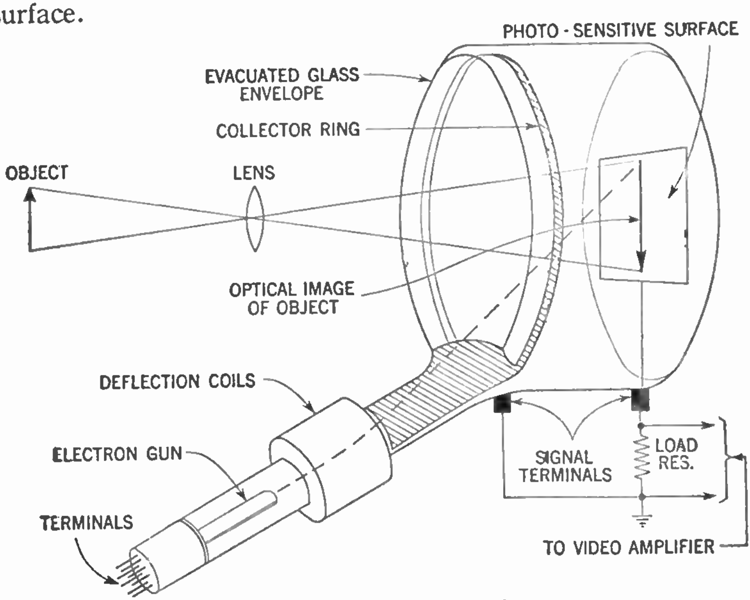



**FIG. 6—Showing arrangement of parts of typical iconoscope.**

The image surface consists of a thin sheet of mica three and one-half by four and three-quarter inches and approximately 0.001 of an inch in thickness. On the side which faces the lens, the mica strip is covered with myriads of tiny light sensitive globules, each of which forms one plate of a tiny condenser and each insulated from the other. On the other side is a flat conducting plate of collodial graphite which forms the signal plate.

The signal plate is connected to ground through a load resistor outside the tube. The actual signal circuit consists of the image surface, signal plate and collector ring.

*The Mosaic.*—The image surface covered with the photosensitive globules is called the *mosaic*. Each globule is made of silver, sensitized with a thin layer of cesium. The globules are not of uniform size, and are not arranged in a regular pattern, but they are so much smaller than the element of the image, that the total sensitive surface of each element is very nearly equal to that of each other element. The largest of the globules is about 0.001 inch in diameter and the scanning beam spot is about 0.008 inch.

Since the scanning beam has a spot size of about 0.008 inch in diameter, a large number of globules are being scanned at one instant. The area covered on the mosaic in any one instant by the scanning beam is called an *element*. The total number of picture elements in a modern television transmitting system is somewhat greater than $2 \times 10^5$.

*Operation*—The operation of the iconoscope is fundamentally as follows: An optical image is focused by a lens upon the surface of the mosaic. Under the lighter portions of the image, the individual silver globule photocells emit electrons, while less electrons are emitted by those under the dark or shaded areas. A loss of electrons constitutes a positive charge attained by the individual globule condensers and so is formed an electronic picture, the charge over any portion of the surface varying according to the amount of light present.

Now the electron beam is caused to scan this surface in the familiar way. As the electron beam strikes one of the surface elements, it supplies to it electrons that it had lost by reason of its photo-electric properties, therefore, the beam in effect, discharges the condenser which is formed by the globule, the mica dielectric and the back coating. In this connection it should be pointed out, that since the lens inverts the image on the mosaic, the scanning process of necessity must start at the bottom of the mosaic.

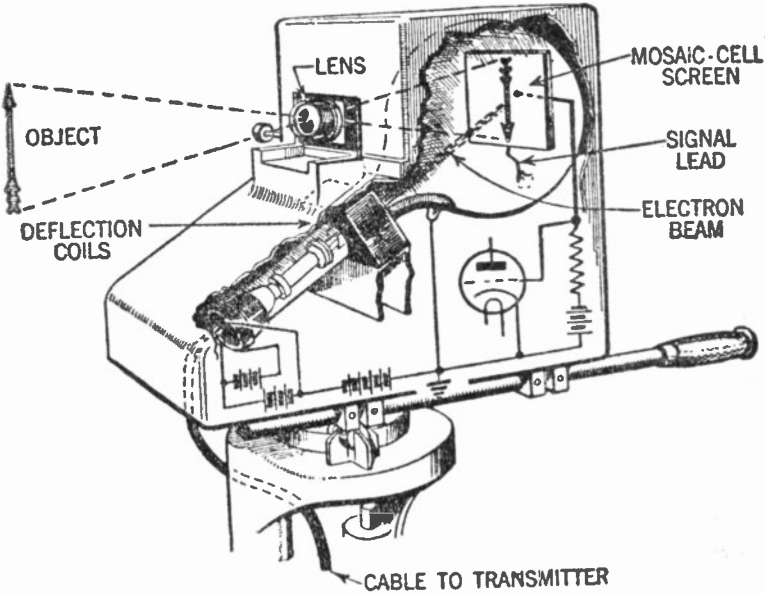



**FIG. 7—Illustrating functional components of iconoscope camera. Roughly the camera consists of a lens arrangement similar to that of the ordinary camera which is focused on the scene to be televised. The image is projected upon the screen of the iconoscope which is mounted in the camera as shown.**

With reference to fig. 6 it will be observed that the condenser discharge current passes through the tube load resistor, the potential thereby developed being applied to the video amplifier.

This potential is a function of the discharge current which, in turn, is a function of the amount by which the silver globules then under the scanning beam have been made positive by a loss of electrons. Since that is determined by the amount of light from the image at that point, it is evident that as the beam traverses the mosaic, a video signal is produced which represents the highlights and shadows of the televised scene.

The collector ring consists of a platinum band mounted on the inside surface of the iconoscope. Its function is to collect the electrons which leave the mosaic surface, in this manner completing the signal circuit through the load resistor.

**The Image Orthicon**—Because of the generation of a spurious dark spot signal resulting in low sensitivity in addition to the requirement of a high value of illumination, the iconoscope is at a disadvantage where it is necessary to work under a low value of illumination, such as that prevailing in all types of outdoor scenes, as for example, at football, tennis, golf games and the like.

Due to the foregoing deficiencies another type of television camera tube has been developed. This tube is called the *image orthicon*, the principle elements of which are shown in fig. 8.

*Performance.*—The image orthicon is a storage type of camera tube, having a sensitivity of from 100 to 1,000 times that of the iconoscope. It can therefore deliver an entirely satisfactory signal, with negligible noise voltage, from scenes illuminated by very low light levels.

The image orthicon achieves its high sensitivity in three ways. They are:

1. By using a conducting photosensitive surface, instead of an insulated mosaic, thereby increasing the photo emission response.

2. By scanning with a low velocity electron beam, thus eliminating the undesirable effects of secondary emission.
3. By using secondary emission at two different points in the tube so as to provide amplification of the signal by a factor of 100 to 500 without the generation of a corresponding noise voltage.

It has two relatively minor disadvantages, that is, the possible resolution of its picture is slightly less sharp than that of the iconoscope, and in addition it is not as well suited to operation at very high values of illumination.

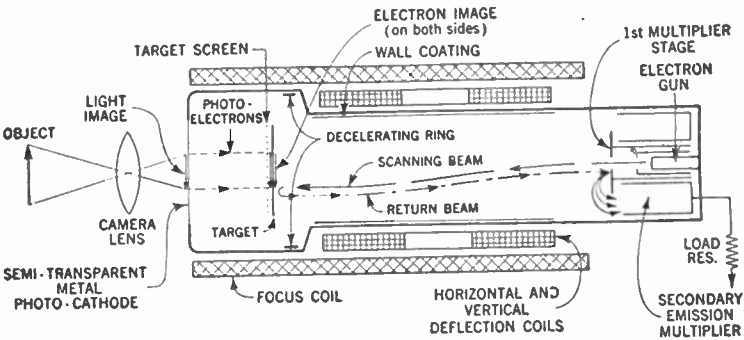



**FIG. 8—Showing essential parts of image orthicon and their arrangement.**

*Structural Details.*—This type of television camera tube is of a very compact design. It is approximately 15 inches in length, its external diameter being approximately three inches. With reference to fig. 8 the following fundamental differences from the previously discussed iconoscope are:

1. The light image is focused on one side of the photo cathode, while photo emission takes place from its other side.

2. The scanning takes place on a separate plate called the target, *not* on the photo emissive surface.
3. The image modulated current, constituting the video signal, comes from the beam electrons returning from the target toward the cathode from which they came.

One other feature in the illustration, is a focusing coil, wrapped around the entire length of the tube.

*The Photo Cathode.*—By observing the left side of the illustration fig. 8 it will be observed that the image of the scene is focused on a semi-transparent metal photo cathode. This represents an important improvement as compared to the iconoscope. A conducting surface like this has a higher photo sensitivity than an insulated surface, such as the globules of the iconoscope mosaic. Note, too, that the cathode is held at a constant potential of minus 600 volts; this is possible only because the photo electrons have a return path through the external circuit, so they are continuously replaced.

The photo cathode is made of such thin metal that light passes through it readily, as through tracing paper. Photo emission takes place from the back surface of the cathode. The emitted electrons are pulled by the strong electric field existing between the cathode and the target screen by reason of the potential difference of nearly 600 volts between them.

The target screen is made of incredibly fine metal wires, having from 500 to 1,000 meshes per linear inch. Better than 60% of its area is occupied by the holes, so the photo electrons can pass easily through it, and do not cast a "shadow" on the target beyond it.

*Operation.*—The operation of the image orthicon is fundamentally as follows: Light from the televised scene is picked in the conventional way by an optical lens system and focused on the photo sensitive surface behind the face of the tube.

The surface elements emit electrons in direct proportion to the amount of light striking them. These electrons, accelerated by a positive voltage and held on a parallel course by an electromagnetic field, flow from back of the photosensitive surface to a target.

Secondary emission from the target caused by the impact of the electrons, leaves on the target a pattern of varying positive charges, which correspond to the pattern of light from the televised scene.

The rear of the target is scanned by a beam of electrons which are generated by the electron gun in the base of the tube. This beam is modulated, as it scans, by the varying positive charges on the target which are representative of the light pattern of the televised scene.

The returning beam with picture information imposed upon it by the varying losses of electrons left behind in the target, is directed toward the first of a series of dynodes (electron multipliers) near the base of the tube. This multiplying process continues with the strength of the signal increasing at each dynode, until it reaches the signal anode and is conveyed to the external circuit.

**Sound Transmitter.**—The sound transmitter associated with the transmitting system is a conventional frequency modulation system consisting of audio amplifier, frequency modulator, high frequency transmitter and high frequency antenna. Thus, at the transmitting station, there are two transmitters, one for the picture signals, and one for the sound.

**Television Broadcasting Practices.**—In the foregoing overall description of a television system no attention has been given to the apparatus necessary in the broadcasting studios for a successful transmission of picture and sound. Most of the apparatus required to produce the conditions described are of necessity extremely complex.

The block diagram of the signal circuits of a typical modern television transmitter is shown in fig. 9. A separate transmitter supplies speech accompanying the scene. A camera selector affords the choice of ten cameras viewing one or more scenes from different vantage points any three of which may be selected simultaneously with control room monitoring of each.

Further selection is made by a channel selector feeding through a fader (volume control) the line amplifier. In addition, provision is made to preview the scene from a given camera prior to switching into the line amplifier.

The line amplifier also serves as a mixer for the injection of synchronization pulses which, along with the picture signal, make up the composite signal of the broadcast. An air monitor shows the picture as it is being transmitted.

The televising of live talent programs presents to the video broadcaster many of the same problems that have confronted the moving picture industry. Rather elaborate backgrounds are frequently necessary and they require the same attention to technical detail and to period authenticity that is evident in well staged plays and in high-grade motion pictures. As the video broadcast must be continuous, unlike the motion picture production which can be interrupted at will, the problems of set lighting and equipment placing require much planning and rehearsal prior to the actual broadcast.

Indoor, as well as outdoor televising usually requires that several cameras be strategically located so as to view the scene from various vantage points without sequential interruption.

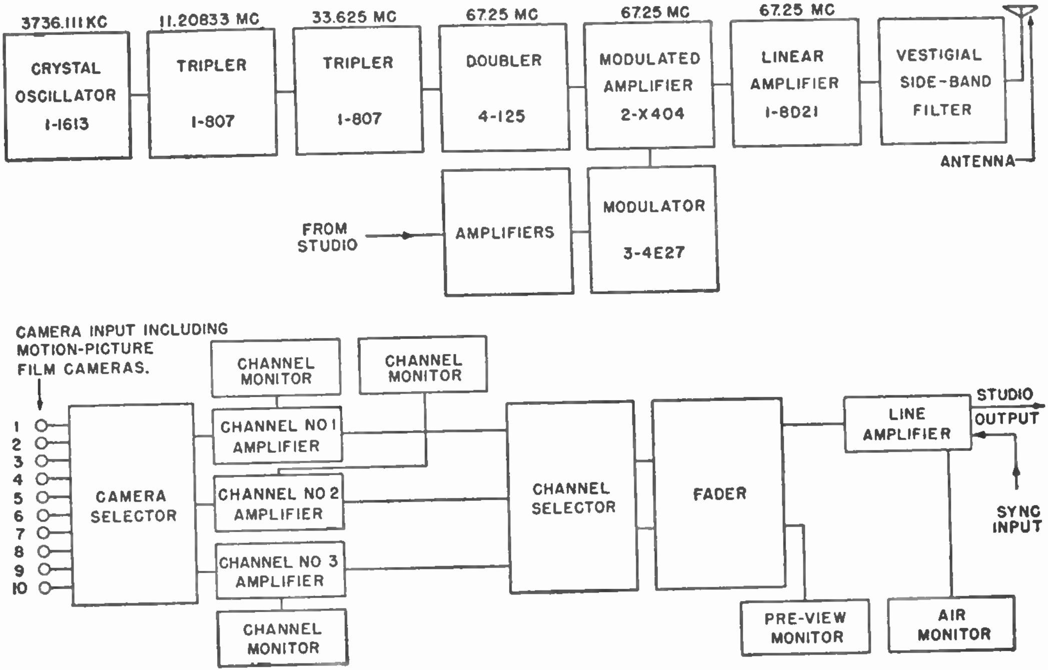



FIG. 9—Illustrating functional block diagram of typical television transmitter.

In addition to the telecasting of live program material, extensive use is made of motion picture film in television programming. For this purpose, special projectors are employed, which by a shutter arrangement, convert the 24 frame per second film projections into 30 frame per second television signals. The film picture is projected directly into the television camera tube, from which the electrical signal is conveyed to the control room over coaxial cable. Sound pickup from the film is in the normal manner.

Since the connection, by coaxial cable, from a remote place to the studio control room equipment is an economic impossibility, small ultra-high frequency radio relay links are employed to relay remote pickups.

The relay equipment is usually contained within a special truck which houses not only the relay transmitter but also complete control and monitoring facilities.

CHAPTER 9

# Television Receiver Circuit Fundamentals

In the previous chapter a general discussion of the various factors affecting television broadcasting have been made. The function of a television receiver is to extract from space the signal transmitted by the broadcasting station, amplify it and employ it to produce visible pictures and audible sound which in all details conform with the original scene at the broadcasting station.

In the television receiver, therefore, the received signal is amplified and separated into its components. The components are amplied and applied in such a way as to produce variations in the intensity of the electron beam of the picture tube which is similar to a conventional cathode ray tube.

In the receiving picture tube, deflection is accomplished electromagnetically with coils external to the tube. The oscillators which furnish the energy for deflection operate at the same frequencies as the deflection oscillators associated with the transmitting camera tube and are held in synchronism by the transmissing synchronizing pulses.

Thus, the electron beam of the picture tube moves in synchronism with the electron beam of the camera tube, and the variations in brilliancy of illumination at the point of impact on the picture tube screen, correspond to the variations in illumination of the respective areas of the camera tube mosaic. In this manner, the image on the mosaic in the camera tube is dissected and the information on each element transmitted separately in a manner which permits the television receiver to take these pulses of information and employ them to produce corresponding variations in illumination on the picture tube screen and thus produce a picture of the original scene.

Present television receiver design practice is to use superheterodyne receivers with antenna and *r.f.* circuits which are sufficiently broad in frequency response to accept the entire pass band covered by the two carriers (sound and picture) and their transmitted sidebands. No separation occurs until after the first detector. The output of a single local oscillator is heterodyned with both sound and picture carrier signals to produce signals of two intermediate frequencies.

By having separate picture and sound intermediate frequency amplifying systems, each of which is tuned to the correct intermediate frequency, the television picture and sound signal may be separated. The sound amplifying system from that point on is in most respects similar to that of a conventional radio receiver.

**Block Diagram of Typical Television Receiver.**—In this connection it should be clearly understood that although television receivers may differ considerably as to circuit design (depending upon the manufacture of the particular receiver), they all operate on the same general principles.

In order to simplify the study of television receiver, it is customary to employ so called "*block diagrams*". By means of these, it is possible to separate the complete circuit into its various sections, each of which have been assigned to its particular function in the complete circuit.

Fig. 1 shows a block diagram of a typical television receiver.

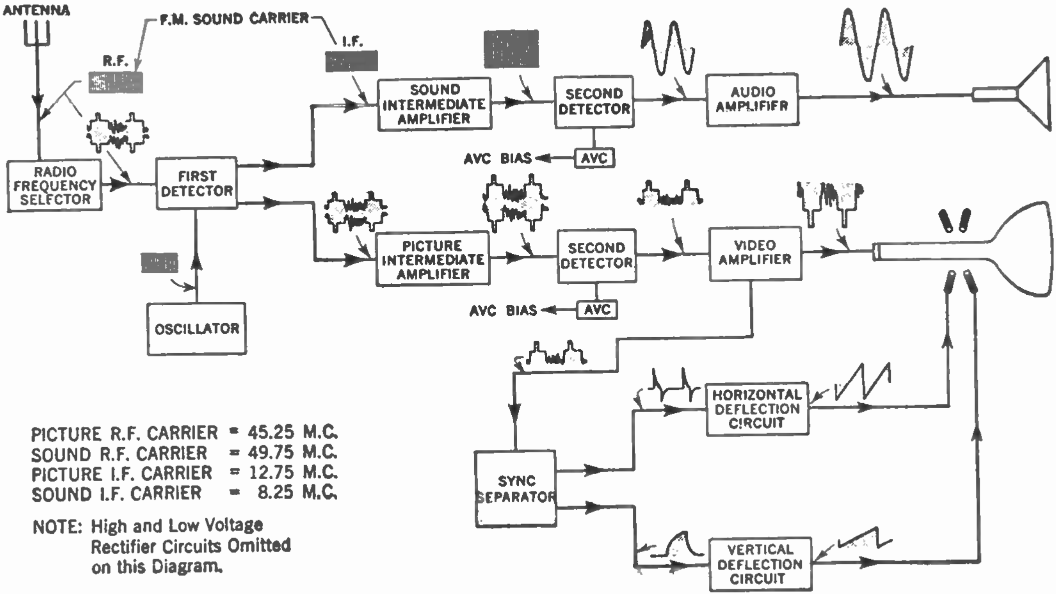



FIG. 1—Block diagram of typical television receiver.

The antenna receives both sound and picture signals. Thus, in a typical transmitter the picture carrier would be 45.25 mc. and the sound carrier 49.75 mc.

The *r.f.* circuits are sufficiently broad to pass both carriers with such portions of their sidebands as are transmitted. These are then passed on to the first detector where they are both heterodyned with a 58 mc. local oscillator signal. This produces two *i.f.* carriers, one at 12.75 mc. modulated with the picture signals, and another at 8.25 mc. modulated with the accompanying sound signals.

The *i.f.* signals with sound modulation are amplified by the sound *i.f.* amplifier, and the *i.f.* signals with picture modulation are amplified by the picture *i.f.* amplifier. In order to prevent cutting of the high frequency side bands in the sound *i.f.* amplifier when the receiver is slightly mistuned, the sound *i.f.* transformers are designed to pass a band up to 100 k.c. wide. As this type of transformer reduces the gain per stage, two sound *i.f.* amplifier stages are used to obtain the necessary amplification. The sound *i.f.* signals are impressed upon the sound second detector and are converted into aduio frequencies in the usual manner. These are then amplified and reproduced as sound by a conventional audio amplifier and loudspeaker.

The picture *i.f.* signals are amplified by a picture *i.f.* amplifier system which is tuned to 12.75 mc. and which passes a band of 2.5 mc. to 4 mc. depending upon the quality of the receiver. For vestigal side band transmission within the band widths allocated for television, this will allow modulation frequencies corresponding to video frequencies up to 4.0 mc. An *i.f.* amplifier which will pass a band of this width must necessarily have a low gain per stage and consequently five picture *i.f.*

stages are used in this typical receiver to secure the desired amount of amplification.

The amplified picture *i.f.* is applied to the picture second detector and converted into the television signal represented on page 134. The output of the picture second detector is supplied simultaneously to the picture *a.v.c.* system, to the video amplifier and to the synchronizing separator. The picture *a.v.c.* system utilizes some of the television picture signal to produce a variable *d.c.* voltage which after suitable filtering is applied as negative grid bias to the picture *i.f.* stage to control their gain.

The video amplifier amplifies the *a.c.* portions of the television picture signal and applies them to the grid of the picture tube to control the relative illumination of the elemental areas and to blank the beam during the return periods. A portion of the output of the video amplifier is rectified by a tube called the "*d.c.* restorer" and the *d.c.* voltage thus produced is applied as variable bias voltage to the picture tube grid. This function is usually referred to as the *automatic brightness control* and is necessary when the video amplifier is not a *d.c.* amplifier in order to reproduce correctly the average brightness or illumination of the scene being televised and to secure correct blanking during the return time.

The synchronizing separator incorporates circuits which separate the synchronizing pulses from the remainder of the signal. The horizontal synchronizing pulses are then separated from the vertical synchronizing pulses by suitable circuits and both are then applied to control the timing of the deflection oscillators with which they are associated.

## Receiver Circuit Description*

As previously noted the block diagram fig. 1 shows each section of the schematic circuit diagram separately. This method will greatly facilitate a study of the various circuit details. The circuits here shown, however, do not represent any certain receiver, but are representative only of a superheterodyne type receiver. Also only those portions of the circuit necessary for an understanding of its functioning are shown, and those portions such as the *d.c.* connections are omitted.

**R. F. Circuits.**—The radio frequency section of the television circuit is shown schematically in fig. 2. The television antenna picks up both picture and sound carriers together with their associated sidebands. Here a manually operated switching system (channel selector) permits the selection of any one of five channels by transfer of input coupler and oscillator circuit connections.

This is illustrated schematically by arrows which may be considered as being connected together mechanically by the dotted lines on the left of fig. 2. The transmission line from the antenna connects to the primary of the proper *r.f.* transformer. Each transformer is designed to be sufficiently broadband in tuning to transmit one of the 6 mc. television bands including sound and picture carriers with their associated sidebands. The secondary of the antenna transformer is connected to the first detector.

*The circuit description on the following pages is given by the courtesy of *Radio Corporation of America*.

**Oscillator Circuits.**—The local oscillator necessary for heterodyne operation is shown in the lower part of fig. 2. This employs the well known *Hartely* type of circuit and its frequency of operation is controlled by the range switch which changes the circuit constants.

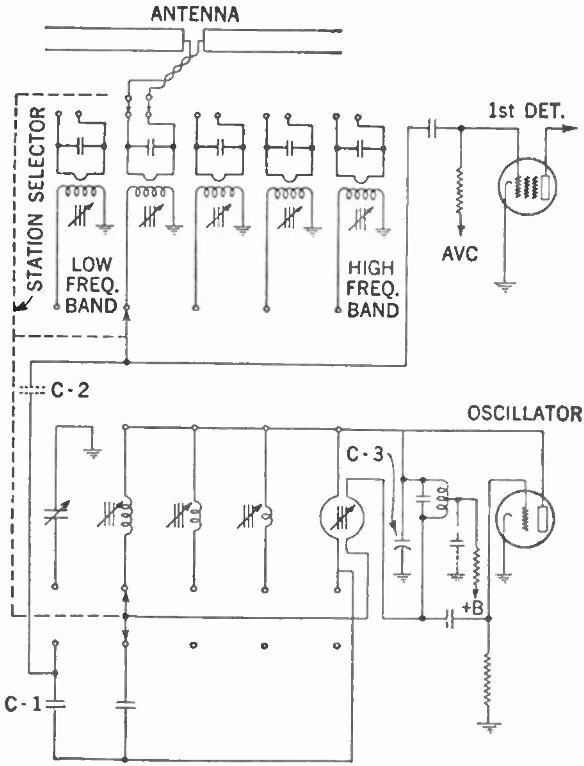



**FIG. 2—Schematic diagram of radio frequency input and oscillator circuit.**

A portion of the tuned circuit is always coupled to the small inductance shown connected to the range switch position at the extreme right. This position is connected through condenser *C-1* to the lower left section of the switch which is also connected through condenser *C-2* to the input of the first detector.

The capacity *C-2* may be a capacitor or it may be obtained by utilizing the interwiring capacity. The small variable condenser *C-3* provides vernier tuning for each position of the band selector switch.

**First Detector and I. F. Amplifiers.**—The first detector together with the picture and sound intermediate frequency amplifying system of the receiver under consideration is shown in fig. 3. As the first detector receives the sound and picture carriers plus the local oscillator signals, two intermediate frequencies will be produced. Since associated sound and picture carriers are always separated by 4.5 mc., two *i.f.* carriers with the same frequency difference will be produced. For a typical case, the picture carrier would be 51.25 mc. the sound carrier 55.75 mc., and the local oscillator frequency 64 mc. These conditions would produce a sound *i.f.* carrier of 8.25 mc., and a picture *r.f.* carrier of 12.75 mc.

The output of the first detector is connected to a filter network where the unwanted frequencies are attenuated and the desired *i.f.* signals are separated. The sound *i.f.* signals are applied to an amplifying system tuned to pass the sound *i.f.* carrier of 8.25 mc. and both side bands. The picture *i.f.* signals are applied to an amplifying system tuned to pass the *i.f.* carrier of 12.75 mc. and the usable side band.

The sound *i.f.* amplifier system is conventional in design with the exception that the transformers are designed to pass a band up to 100 *kc*. wide. This is done so that a normal amount of mistuning will not appreciably effect the sound reproduction.

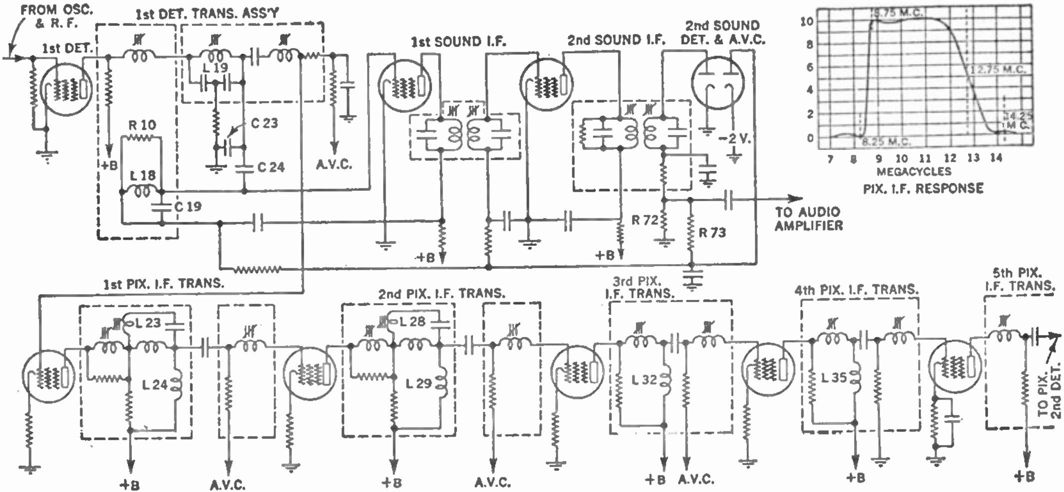



FIG. 3—Schematic representation of first detector and intermediate frequency amplifier.

Furthermore, it also permits adjustment of the oscillator frequency for best picture results without impairing the tonal quality of the sound reproduction. The secondary of the last sound *i.f.* transformer drives the sound second detector. A portion of the *d.c.* drop across the diode resistor is filtered and utilized as *a.v.c.* voltage to control the gain of the sound *i.f.* amplifier.

In this particular example, dealyed *a.v.c.* and residual bias on the sound *i.f.* amplifier tubes are obtained by utilizing the second section of the 6H6 duplex diode rectifier used as the sound second detector and *a.v.c.* tube. The connections are indicated in fig. 3.

When no signals are being received, the cathode will be at a potential of $-2$ volts with respect to the plate. Under these conditions, the diode will be conducting and it will represent a low resistance in the series circuit including *R-72*, *R-73*. As a result most of the $-2$ volts from the voltage divider will appear across the resistors *R-72* and *R-73*, and thus furnish approximately $-2$ volts residual bias. When a signal is received the voltage across *R-72* resulting from signal rectification will be of such polarity as to make the plate of the second diode section less positive with respect to its cathode. Obviously when the voltage across *R-72* resulting from signal rectification exceeds $-2$ volts, the plate of the second diode section will be negative with respect to its cathode, and the diode then will be non-conducting.

It is evident that the bias voltage remains approximately $-2$ volts until the rectified signal produces a voltage in excess of 2 volts across the detector load resistance. Thus *a.v.c.* action is delayed until the signal strength reaches the value required to accomplish this effect.

The picture *i.f.* amplifier in the typical receiver under discussion has five stages. This number of stages is necessary because it is not possible to obtain a high gain per stage when the pass band is approximately 4 mc. as in this example. As the modulating frequencies for the picture carrier will be approximately 4 mc. it is necessary that the picture *i.f.* transformers pass a band of this width if one set of side bands only is to be amplified by the receiver.

The overall response curve of the five picture *i.f.* stages for such a selective single side band receiver is shown in fig. 3. It is necessary that the response be very small at 8.25 mc., so that none of the accompanying sound *i.f.* signals will get into the picture. It is also necessary that the response at 14.25 mc. be very small so that sound signals from the adjacent lower frequency television channel will not get into the picture.

These requirements are accomplished by the use of suitable rejector circuits which must be aligned with a high degree of accuracy. For double sideband transmission and vestigal sideband transmission (where all of one set of sidebands and portions of the other are transmitted) the *i.f.* amplifier response at the *i.f.* carrier frequency (12.75 mc.) should be 50% of the response over the flat response portion covering most of the desired frequency range as shown in the overall picture *i.f.* response curve of fig. 3. The output of the picture *i.f.* amplifying system is applied to the picture second detector where it is rectified or demodulated to obtain the television picture signal illustrated on page 134.

It may be of interest to consider briefly the type of picture *i.f.* coupling transformers used in this typical receiver. It will be noted from fig. 3 that the primary and secondary sections of the first detector first picture *i.f.* and second picture *i.f.* transformer assemblies are mounted within separate shields.

The primary and secondary are not coupled magnetically but are coupled through an impedance which is common to both circuits. The common impedances for the three transformers listed in the foregoing are *C-23*, *L-24* and *L-29* respectively.

At the frequencies involved, stray capacities and the tube input and output capacities become very important factors. These capacities, while not shown diagrammatically in fig. 3, are actually utilized to resonate the circuits at the proper frequencies. In the case of the first, second, third and fourth picture *i.f.* transformers, the signal voltage applied to the grid of the succeeding tube is in each case the voltage developed across the tube input and stray capacity connected to the grid end of the secondary inductance.

The first detector, first picture *i.f.* and second picture *i.f.* transformer incorporate rejector circuits which are resonated to offer rejection at 14.25 mc., and 8.25 mc., respectively. The frequency of rejection is adjusted by varying the inductances *L-19*, *L-23* and *L-28*.

*L-18* and *C-19* (together with a loading resistor *R-10*) of the first detector transformer assembly from a parallel circuit resonant at 8.25 mc. This circuit is connected to the high signal potential end of the common coupling impedance *C-23* by the capacitor *C-24*. Since the parallel circuit is resonant at the sound *i.f.* 8.25 mc., a strong sound *i.f.* signal voltage will be developed across it.

This voltage is coupled to the grid of the first sound *i.f.* amplifying tube. The circuit will not offer much impedance to the picture *i.f.* signal currents and therefore very little picture *i.f.* signal voltage will be applied to the first sound *i.f.* amplifier.

Although the primary and secondary sections of the third and fourth picture *i.f.* transformer assemblies are mounted within the same shields, there is practically no magnetic coupling between them. Most of the coupling is obtained from the common impedance offered respectively by *L-32* and *L-35*.

In the fifth picture *i.f.* transformer most of the primary to secondary coupling is obtained from the common impedance offered between the taps *A* and *C* of the secondary as shown in fig. 4. There is no rejector circuit in the third, fourth and fifth picture *i.f.* transformer.

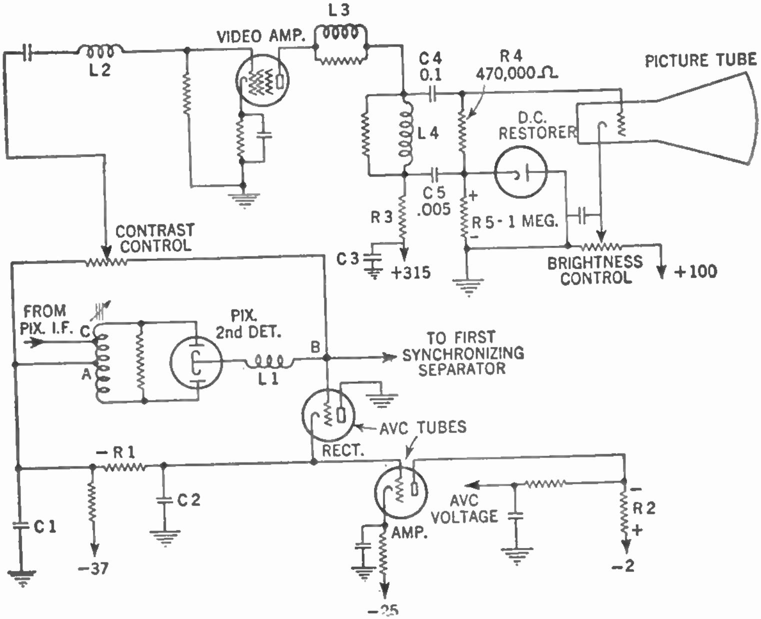



**FIG. 4—Schematic diagram of picture second detector, video amplifier and d.c. restorer.**

The alignment of the picture *i.f.* circuits involves very rigorous standards. The eye is much more critical than the ear and therefore will detect picture defections caused by relatively small deviations in electrical response, whereas the ear ordinarily will not discern defects in the sound reproduction caused by deviations of the same order.

The method of alignment best adapted for field use involves a special wide band frequency modulated oscillator and a suitable cathode ray oscillograph. The response of the oscillator over the range involved must be very uniform and the calibration must be very accurate. The cathode ray oscillograph should use a tube with a screen at least five inches in diameter as otherwise errors in observation may cause serious inaccuracies in alignment.

**Picture Second Detector Circuit.**—Fig. 4 illustrates the picture second detector, video amplifier, picture *a.v.c.* and *d.c.* restorer circuits. Each of these will be discussed briefly. The picture second detector input coil is, in effect, a center tapped auto transformer with its center tap effectively grounded with respect to *i.f.* voltages by the capacitor *C-1*. The primary is formed by the section of the winding between the center tap and the connection shown immediately above it. The ends of the coil connect to the plates of a double diode rectifier. This arrangement provides a balanced full wave video second detector.

When the picture *i.f.* signals are impressed on the diode, the signal appearing across the diode load resistance (in fig. 4, this is the resistance element of the contrast control) will be essentially the same as the standard television signal illustrated in fig. 5, page 134. Thus white in the picture is represented by minimum voltage across the resistor, and black level is always represented by an amplitude equal to 80% of the voltage range, while synchronizing pulses occupy the upper 20% of the voltage range.

One very important factor in the design of the picture second detector and subsequent circuits is the need to consider the polarity of the signal. It must of course be applied with correct polarity to the control grid of the picture tube, as otherwise the reproduced image will be a negative rather than a positive as desired. Furthermore, as previously pointed out, the deflection circuits are controlled by means of synchronizing pulses transmitted along with the picture components.

These signals must be separated from the picture signals, and applied with correct polarity to their respective associated deflection oscillators.

Since each amplifying tube effects a 180 degree phase reversal, it is necessary that the polarity of the coupling to the picture second detector load resistance and the number of stages be such that the desired output polarity will be achieved.

**Picture Automatic Volume Control System.**—There are several distinct advantages obtained from use of automatic gain control on the picture channel of a television receiver. Only a few of these will be mentioned. An *a.v.c.* will maintain the signal level at the second detector substantially constant for wide variations in signal input. While the signal from a given transmitter may not vary greatly within its service area because of natural fading, the signal sometimes may vary greatly because of moving conductors or objects nearby.

When tuning from one station to another *a.v.c.* will maintain proper level without manual readjustment of other controls. Also, with a constant signal level at the second detector the problems of synchronizing pulse separation and gain control are simplified.

The *a.v.c.* system of the picture *i.f.* amplifier differs considerably from that of the sound *i.f.* amplifier. In sound broadcast receivers, it is cutomary to use the filtered *d.c.* drop across the diode resistor as the source of the *a.v.c.* voltage. This is satisfactory because the *d.c.* voltage thus obtained is directly proportional to the average carrier amplitude at the diode. If it maintains the average carrier amplitude substantially constant, then the *a.v.c.* operates as it should.

In the transmission of television pictures, however, the average carrier amplitude varies greatly with picture content, and an *a.v.c.* system operating on the principle of maintaining a substantially uniform average carrier amplitude therefore is not suitable.

The *RMA Standard Television Signal* calls for a transmission system known as *d.c.* negative transmission. Under this system, the carrier always reaches a uniform maximum amplitude during the periods when synchronizing pulses are being transmitted, and a white portion of the scene is represented by minimum or zero carrier condition.

Thus, if there be no fading, the peaks of the synchronizing pulses will always represent some constant amplitude, and they, therefore, form a convenient reference for operating a satisfactory picture *a.v.c.* system.

In the circuit diagram of fig. 4, the *a.v.c.* rectifier tube and its associated circuit components furnishes a *d.c.* voltage which is amplified by a *d.c.* amplifier stage designated as the *a.v.c.* amplifier. The voltage drop across the plate resistor of the *a.v.c.* amplifier is used as an *a.v.c.* bias. The *a.v.c.* rectifier is essentially a peak voltmeter, i.e., the voltage across *R-1* is proportional to the peak amplitude of the signal applied to the *a.v.c.* rectifier.

The condenser *C-2* assumes a charge proportional to the peak amplitude of the applied voltage because the shunting resistance is too high to appreciably discharge the condenser during the period between successive synchronizing pulses. The operation is somewhat similar to that of the first synchronizing separator tube described in the following pages.

It differs in the fact that the time constant of the *R-1*, *C-2* circuit is so long that the voltage across them remains substantially equal to the peak amplitude of the synchronizing pulses as described just previously instead of following the amplitude time characteristic of the synchronizing pulses as in the case of the separator tube.

The cathode of the *a.v.c.* rectifier is direct coupled to the grid of the *d.c.* amplifier which in this particular illustration, is at a negative potential of 12 volts with respect to its cathode. For zero signal conditions, this effectively biases the *d.c.* amplifier tube to cut off and no *a.v.c.* action is therefore obtained until the *a.v.c.* voltage overcomes enough of the residual bias on the *a.v.c.* amplifier to cause plate current to flow. Thus, a desired amount of delayed *a.v.c.* action is obtained.

The plate of the *a.v.c.* amplifier is connected to a potential of $-2$ volts through a load resistor *R-2* and to the grids of the first detector and picture *i.f.* amplifier tubes through a conventional *RC* filter. Thus, an increase in signal beyond the point at which the *a.v.c.* becomes operative causes plate current to flow in the *a.v.c.* amplifier tube and the voltage developed across *R-2* by this current causes the plate of the *a.v.c.* amplifier tube, and therefore, the grids of the picture *i.f.* amplifier stages, to become more negative. Thus, the gain will be controlled to maintain substantially the maximum carrier amplitudes represented by synchronizing pulses.

As was previously pointed out, the gain of the sound *i.f.* channel is controlled by an *a.v.c.* system which derives its control voltage from the voltage drop across the sound second detector load resistor.

Since the recommended standards specify that the picture and sound transmission for any given station shall have the same power output rating, and since the two transmitting antennas are located relatively near to each other, the question might very logically arise as to why the sound *a.v.c.* voltage is not utilized to control the gain of the picture *i.f.* channel and thus make it possible to eliminate the special picture *a.v.c.* system previously described.

Such a system would be very practical if the sound and picture carrier voltages delivered by the receiving antenna system to the receiver input could be relied upon to be of equal magnitudes.

Experimental investigations, however, have shown that a number of factors including the frequency response characteristic of the receiving antenna, location of antenna and transmission line, and others, operate to make the sound and picture input voltages vary as much as ten to one. Obviously under such conditions, the gain of the picture channel might not be correctly controlled by the sound *a.v.c.* system.

However, the expense connected with the special picture channel *a.v.c.* system previously described makes a cheaper alternative desirable in cases where cost is a very important factor. It has been found that one reasonably satisfactory alternative consists of applying the sound *a.v.c.* voltage to the first detector and controlling manually the picture *i.f.* channel gain by means of a variable resistor in the cathode circuit of the first picture *i.f.* amplifier tube.

**The Video Amplifier.**—As previously indicated, the diode load resistor forms the resistance element of the video amplifier gain control potentiometer commonly called the *contrast control.*

The movable connection supplies a portion of the video voltage to a single video amplifier stage as shown in fig. 4.

It is not considered economical in design to secure directly from the picture *i.f.* system sufficient voltage for proper operation of the picture tube and it is necessary therefore, to use a stage of video amplification. Since it is necessary to produce a positive picture on the picture tube viewing screen, the video amplifier input connection at the diode load resistor is of such polarity that the synchronizing and blanking pulse portions of the signal are in the white or positive direction.

The video amplifying stage inverts the signal due to the usual 180 degree phase reversal that takes place in any amplifying stage. This connection then insures that a positive picture signal appears on the picture tube grid so that blacks of the original televised scene appear as blacks and not whites.

The frequency response of the video amplifier must be excellent up to 4 mc. for a high quality receiver. The inductances *L-1*, *L-2*, *L-3* and *L-4* are commonly called "*peaking*" coils. These inductances in association with tube and stray wiring capacities really form a wide bandpass filter network to secure uniform response up to and beyond 4 mc. Furthermore, the video amplifier must have linear phase shift or uniform time delay if the output signals are to arrive at the picture tube in the correct phase relationship.

The signals after being amplified by the video amplifier are coupled to the grid of the picture tube. The variations in video voltage produce corresponding variations in intensity of the picture tube electron beam and therefore corresponding variations in the illumination of the elements of the scene. By varying the video amplifier gain control (contrast control) the contrast can be varied to secure best picture detail and half-tone relations.

**Automatic Brightness Control.**—Since the video amplifier is an *a.c.* amplifier with *RC* coupling, the *d.c.* component of the video signal that represents the average illumination of the original scene will not be passed. Consequently, unless some provision is made to restore it, the picture tube will not receive any information on the average brightness of the scene and the reproduced image therefore will not have the correct average illumination even though the contrast between the illumination of picture elements may be correct. Furthermore, unless the residual bias on the picture tube is adjusted to a point too negative for average conditions, the black portions of the original scene and the blanking pulses will not always drive the grid to cutoff as desired.

The restoration of the *d.c.* component in the typical receiver under consideration is accomplished by means of a *d.c.* restorer tube or automatic brightness control tube as it is commonly called. Reference to fig. 4 will indicate how the tube is applied.

It will be noted that the *d.c.* restorer or automatic brightness control utilizes a diode rectifier. Reference to two typical conditions of transmission may best serve to illustrate how it serves the function intended.

Under the recommended standards, if the scene being televised be completely black, the amplitude of the voltage representing the picture content will be equivalent to the black level. As a result, if the *d.c.* component is removed, the only amplitude excursions from the *a.c.* axis will be those corresponding to the synchronizing peaks which will represent comparatively small amplitudes.

If these small pulses are to drive the grid of the picture tube beyond, cut off, it is obvious that some means must be provided whereby the bias on the grid is automatically adjusted to cut off so that the small negative synchronizing pulses can drive it beyond cut off.

It can be assumed that the initial picture tube bias as determined by the setting of the brightness control is such that with no signal the picture tube is operating at the point of cutoff. Assume now that the condition discussed in the previous paragraph is imposed. Because the signal voltage across the video amplifier plate load resistor is small, only a small *a.c.* voltage will be applied in the series *a.c.* circuit represented by the plate circuit decoupling condenser *C-3* the plate load resistor *R-3*, the 0.005 *mfd.* condenser *C-5*, and the diode rectifier.

When the plate is positive with respect to its cathode, the diode rectifier passes current which charges the 0.005 *mfd.* condenser. During periods when the plate is negative with respect to its cathode the diode rectifier is non-conducting and the condenser discharges partially through the 1-megohm resistor *R-5*.

If the circuit elements be correctly proportioned, the charge across the condenser (and therefore the voltage from cathode to ground) will remain substantially constant during the picture interval between successive horizontal line synchronizing pulses. The effect is to develop across the resistor *R-5* a variable bias voltage which opposes the residual bias effected by the brightness control. If the constants are correctly adjusted this reduction in bias will always be just sufficient to enable the synchronizing pulses to drive the picture tube beyond cutoff.

Another analysis may be made using as an example an all white scene. Under such a condition, the amplitude of the voltage corresponding to the picture content will be a minimum. Consequently, after the *d.c.* component is removed from the signal voltage developed across the picture second detector load resistor, the voltage excursions from the *a.c.* axis represented by the synchronizing and blanking pulses will represent comparatively high amplitudes. Under such conditions the picture tube bias must be automatically reduced by a considerable amount from its correct value for a black scene if the blanking pulses are to drive the tube just to the cut off point and the synchronizing pulses beyond cut-off.

An analysis of the circuit as previously made indicates that the larger voltage excursions or peak amplitudes would cause a greater amount of rectification and therefore a correspondingly greater reduction in picture tube bias. Thus the automatic brightness control or *d.c.* restorer is in reality an automatic bias control which continually adjusts the bias so that the blanking pulses always drive the picture tube grid to the desired cut-off point and the synchronizing pulses drive it beyond cut-off.

A reference to *A*, *B*, and *C* of fig. 5 will serve to further illustrate the need for *automatic brightness control*. In *A*, the picture tube bias has been correctly adjusted for reproduction of a pattern which is all white with the exception of a single vertical black line. In *B*, is shown the application of a signal from a pattern which is all black with the exception of a single vertical white line under the same picture tube bias conditions as for *A*.

It should be noted that in *B*, the synchronizing pulses no longer drive the grid beyond cut-off. In other words black level now occurs at a point where the picture tube still has a considerable amount of illumination. The white line therefore will not appear as a white line on a black background but instead will be reproduced as a white line on a slightly white or gray background. In *C*, is shown the reproduction of the same pattern but with the picture tube bias correctly readjusted to make the black level occur at the correct or cut-off bias point.

The time constant of the *d.c.* restorer circuit should be sufficiently long to maintain the bias substantially constant during

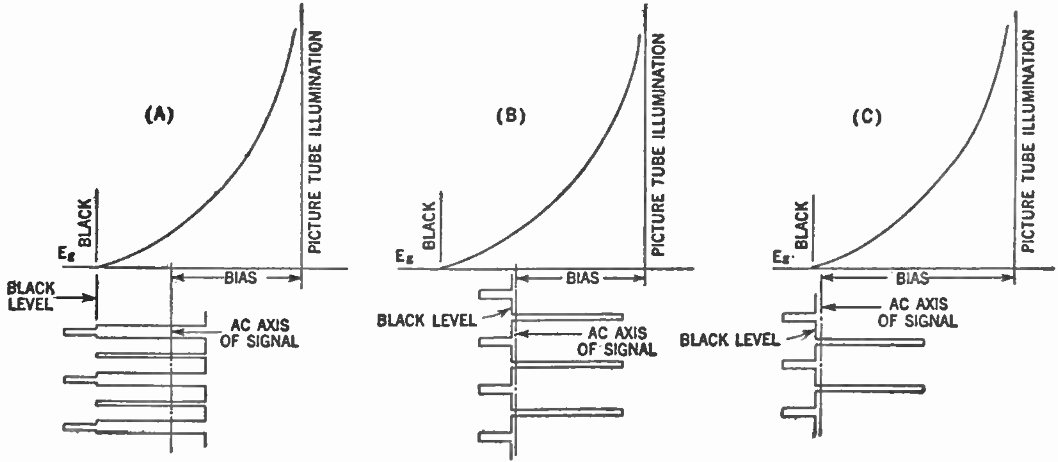



FIG. 5—Showing operation of d.c. restorer or automatic brightness control.

the picture intervals between the horizontal or line synchronizing pulses, but sufficiently short to enable the *d.c.* restorer to follow rapid variations in the average illumination such as occur in motion picture transmission.

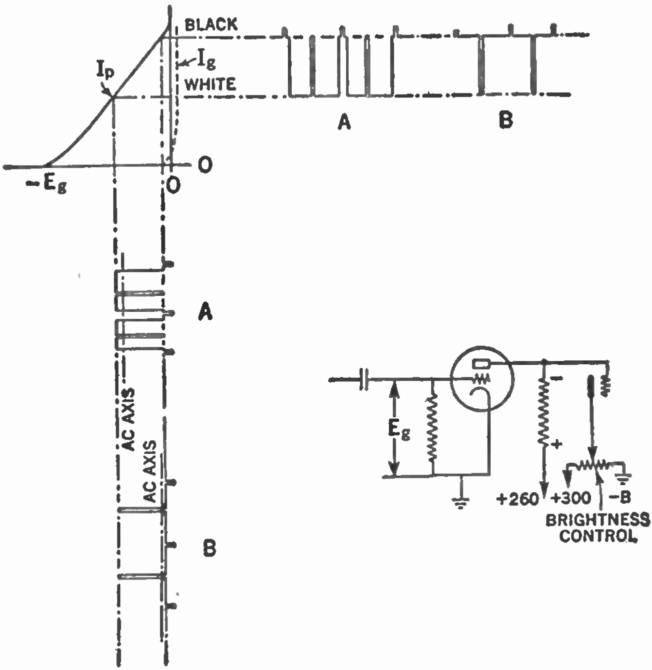



**FIG. 6—Illustrating typical grid leak-condenser d.c. restorer.**

Another method of restoring the *d.c.* component is by reinserting it in the signal at the grid of the video amplifier tube by operating the tube at zero fixed bias. This method is illustrated in fig. 6. The operating bias is then determined by the *d.c.* drop across the grid resistor caused by the grid current.

To keep the grid current small the grid resistor should be large, a half megohm or more, depending on the tube used. The bias generated by the grid current which flows during the occurrence of the synchronizing pulses is maintained by the charge on the grid coupling capacitor.

The time constant of the grid resistance-grid capacitor should be sufficiently long to maintain the bias substantially constant during the picture intervals between horizontal (line) synchronizing pulses, but sufficiently short to follow the variations introduced by the time constant of the *v.f.* circuits preceding this point.

It will be noted in this figure that grid current flows during the peaks of the synchronziing pulses, thus maintaining them at approximately the zero bias point regardless of the position of the *a.c.* axis, and that black level therefore occurs again always at the same voltage level, as it did in the detector diode circuit before the *d.c.* component was lost.

With this method for restoring the *d.c.* components, it is of course necessary that the plate of the video amplifier tube be direct coupled to the grid of the picture tube. In other words, the plate restorer *IR* voltage drop variation, caused by the amplitude bias change, will raise or lower the applied picture tube grid bias.

**The Synchronizing Separator Circuit.**—The signal voltage developed across the picture second detector diode load resistor is also applied to the synchronizing separator circuits which filter out the synchronizing pulses used to control the timing of the deflection oscillators. The signal is applied to the synchronizing separator circuits at the point marked input on fig. 7.

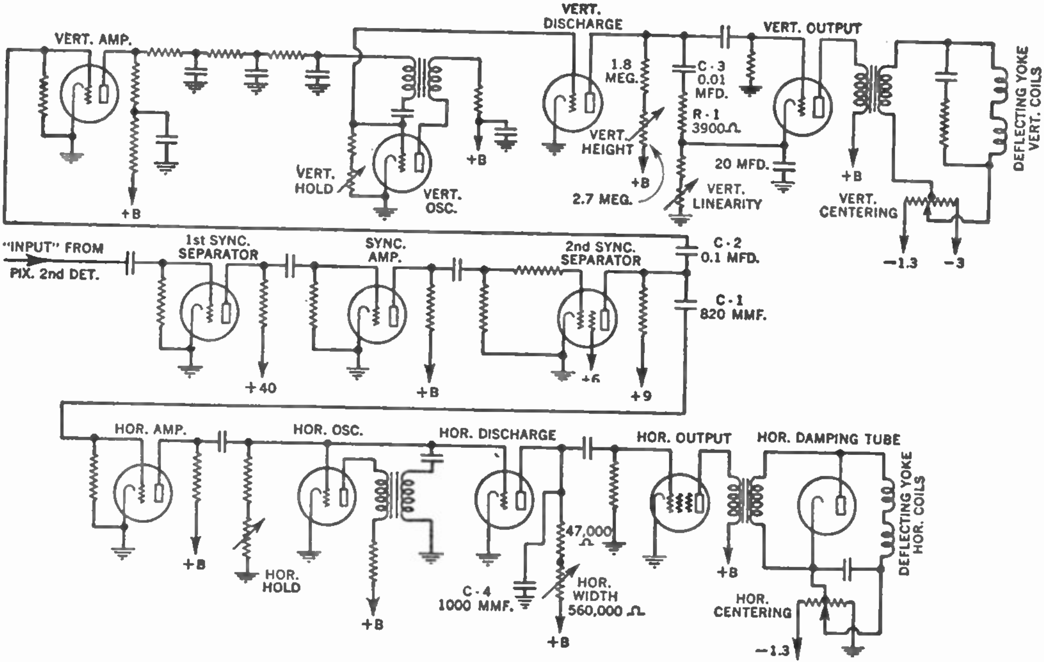



FIG. 7—Schematic diagram showing synchronizing and deflection circuits.

The first synchronizing separator tube operates with a low plate voltage and is grid leak biased to a point where only the synchronizing pulses have sufficient amplitude to cause plate current to flow. This separator tube therefore serves to eliminate most all the picture components from the signal. This type of operation is illustrated in fig. 8.

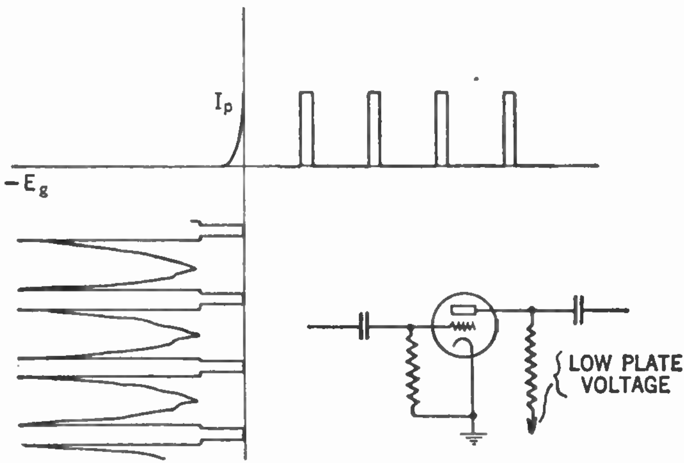



**FIG. 8—Showing operation of synchronizing separator.**

In addition to removing most of the picture components, the first synchronizing separator also inverts the pulses or shifts them 180 degrees in phase as in the case of any amplifying tube. The synchronizing amplifier amplifies and again inverts these pulses, and then applies them to the second synchronizing separator. The action of the synchronizing amplifier must not be confused with that of the first synchronizing separator.

The amplifier uses a relatively high plate potential and, as in the case of the separator tube, is self biased. A stable operating condition will be reached when the most positive amplitude of the applied signal voltage causes just sufficient grid current to maintain bias during intervening periods. The synchronizing pulses will be in the negative direction but will not drive the grid to cut-off.

The second synchronizing separator is a tetrode operated with a low plate voltage and a relatively high screen voltage. It also is grid leak biased.

Under these conditions the tube has a dynatron characteristic and effectively cuts off or clips the tops of the synchronizing pulses as well as effecting further separation of remaining picture components.

This characteristic is desirable in that it removes noise components which may have become superimposed on the synchronizing pulses and limits the amplitude of other noise pulses which may have come through. The pulses in the output of the second synchronizing separator will be inverted and therefore in the negative direction.

As the horizontal synchronizing pulses are of short duration and the vertical synchronizing pulses of much longer duration, they can be separated by filters responsive to wave shape. The horizontal pulses can be selected by means of a high pass *RC* circuit consisting of *C-1* and the grid resistor of the horizontal amplifier.

The action of an equivalent circuit is illustrated in fig. 9. The horizontal synchronizing pulses arriving at the grid of the horizontal amplifier are of negative polarity. The amplifier amplifies and inverts them, and they are then applied with correct polarity to the grid of the horizontal deflection oscillator tube to control its frequency of operation. The front edges of all the synchronizing pulses produce positive voltage peaks which serve to trip the horizontal deflection oscillator.

The timing of the oscillator is thus maintained even during the period of the vertical synchronizing pulses. The type of deflection oscillator used is not tripped by the positive peaks caused by the equalizing pulses occurring between horizontal periods.

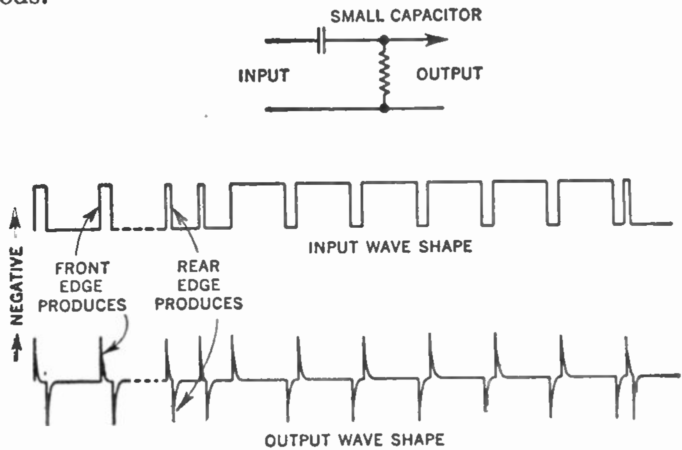



**FIG. 9—Illustrating a typical horizontal pulse selecting circuit and wave forms.**

Since the capacitor *C-2* must be relatively large to transmit the vertical pulses, both horizontal and vertical pulses will be applied to the grid of the vertical amplifier at the top left of fig. 7. Both are amplified and inverted, and then applied to a filter network known as an integrating circuit. In the case of the typical receiver under discussion, the vertical pulse selecting circuit has three sets of elements in cascade.

The action of an equivalent circuit is illustrated in fig. 10. This filter network allows a charge to accumulate on the condenser proportional to the time the voltage is applied. As the horizontal pulses also present are of comparatively short duration their effect will be minimized.

The equalizing pulses (refer to page 134) functions to make the vertical pulses for alternating fields sufficiently alike so that correct interlacing will occur. Since the pulses were inverted once more by the vertical amplifier, the pulses out of the filter will be of the correct polarity (positive) to properly

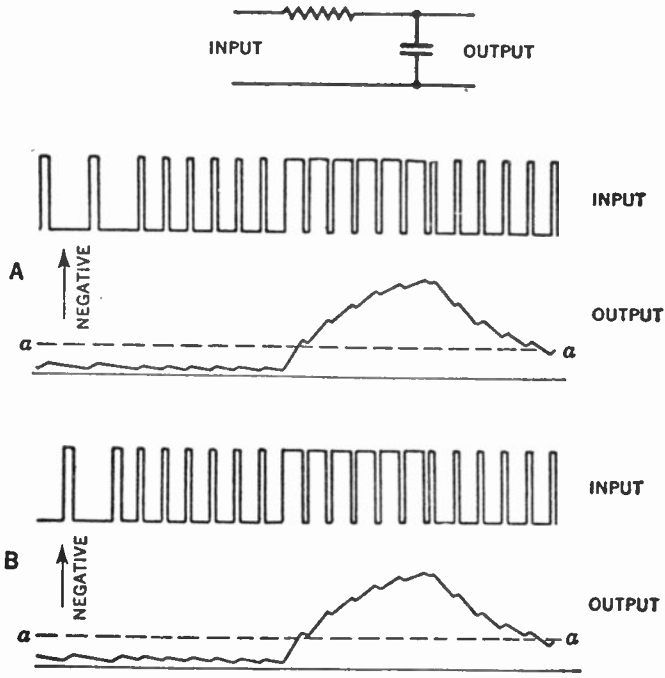



**FIG. 10—Illustrating vertical pulse selecting circuit and wave forms.**

control the frequency of the vertical deflection oscillator to which they are applied.

An alternative method for effecting separation of the picture signals from the synchronizing pulses utilizes a diode rectifier and is illustrated in fig. 11. In this case only the *a.c.* component of the voltage appearing across the second detector load resistor is applied to the diode as indicated. The synchronizing

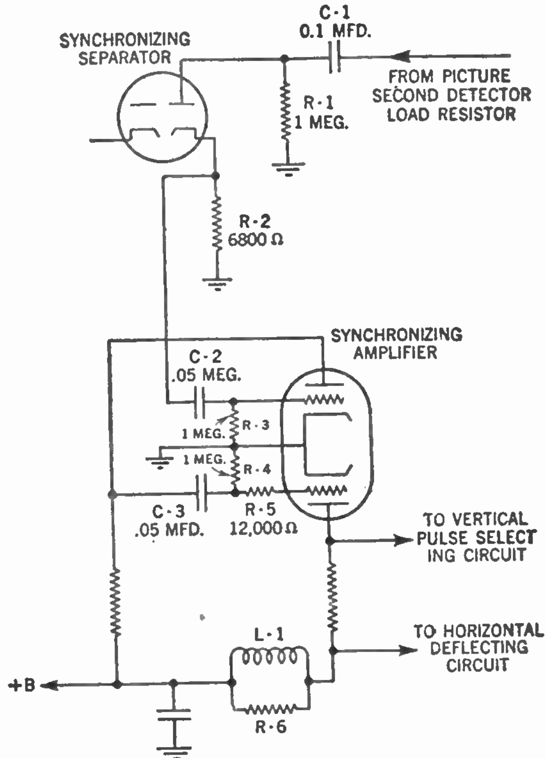



**FIG. 11—Showing typical arrangement of a diode synchronizing separator.**

pulses will represent excursions of voltage in the positive direction (due to polarity of connections to detector load resistor). On positive excursions from the *a.c.* axis of the signal, the diode will be conducting and the condenser *C-1* will become charged. On negative excursions the diode will be non-conducting and the condenser will partially discharge through the resistor *R-1*.

The time constant of the *C-1*, *R-1*, circuit, however, is such that the condenser does not discharge appreciably during the intervals between successive synchronizing pulses, and as a result currents will flow through the diode only during the periods of the synchronizing pulses. The corresponding voltage pulse developed across the diode load resistor *R-2* can then be coupled to the succeeding synchronizing amplifier.

In the two successive amplifying stages of the synchronizing amplifier, the pulses are amplified and rotated in phase 360 degrees. As a result they will be applied with correct polarity to the vertical pulse selecting circuit which precedes the deflection oscillator. Horizontal pulses are selected by the action of *L-1* and *R-6* and having correct polarity, control the horizontal deflection oscillator.

**Blocking Oscillator and Discharge Tube Circuits.**—The operation of a blocking oscillator is shown in fig. 12. It consists of a tube whose grid is transformer coupled directly to the plate. The starting of the plate current drives the grid positive causing grid current to flow. During the time grid current is flowing a negative voltage is built up across *R*, and this charges the condenser *C*. When the plate current ceases increasing and begins to decrease, the transformer drives the grid very negative. The negative charge on the grid and condenser *C* will leak off slowly through *R* and no action will take place until the grid reaches a potential where plate current can again flow. Then the cycle of events is repeated.

The heavy curve shows the natural sequence of grid voltage. However, if at time *S*, a voltage pulse is applied to the synchronizing input which will raise the grid voltage to a point where plate current will flow, the sequence of operations will start at $S$, as shown by the dotted line instead of later as shown by the solid line.

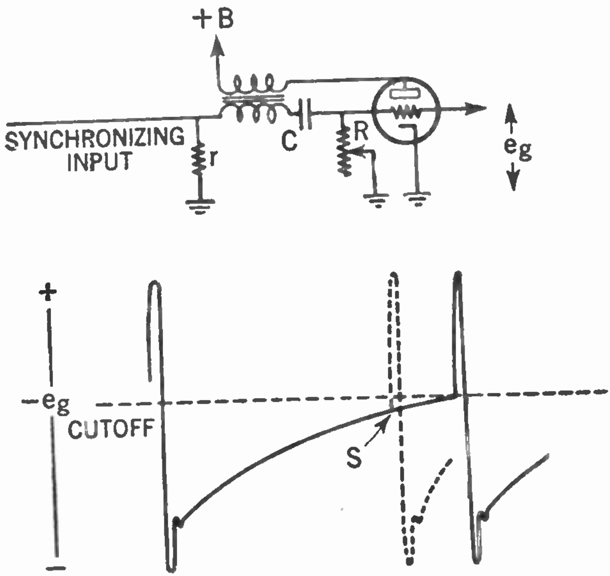



**FIG. 12—Illustrating typical blocking oscillator and wave forms.**

In this manner the synchronizing pulses trigger the blocking oscillators associated with the deflection circuits. It is interesting to note that inherently the blocking oscillator provides some protection from noise pulses. Any noise pulse in the positive direction must be of sufficient amplitude to overcome the negative self-bias on the oscillator before it can interfere with synchronization. Grid resistance $R$ (called the *hold control*) is made variable to allow adjustment of the free running period or frequency of the oscillator.

**Deflection Considerations.**—Before discussing the operation of the discharge tube circuit and the deflection output tubes, it is advisable to first consider the current and voltage requirements of the deflection coils shown in the diagram of fig. 7. A study of the current wave requirements and the voltage waves required to produce the desired current waves will serve to make apparent the reasons for the arrangement of circuit components.

A deflection circuit in a television receiver performs the function of supplying the force which deflects the electron beam in the picture tube. This force must be of such a type that it deflects the beam in the same manner and in synchronism with the electron beam in the camera tube at the transmitter.

For rectilinear scanning this force must have a linear change while the beam is traversing one line (or field, for vertical deflection) sweep and a rapid return to the original condition at the end of the line (or field sweep). Thus the time amplitude wave of the deflecting force is of sawtooth wave shape with a slow linear rise and a rapid fall. The vertical deflection circuit must have a period of 1/60 second and the horizontal deflection circuit a period of 1/15,750 second.

The force producing the deflection may be either *electro-static* or *electro-magnetic*. In the typical example selected, electro-magnetic deflection is used for both horizontal and vertical deflection.

Most technicians are familiar with electro-static deflection through its application in cathode ray oscillographs. For electro-static deflection, a sawtooth voltage wave is impressed on the deflection plates.

Electro-magnetic deflection requires that a sawtooth current wave be passed through a deflection coil arranged around the correct portion of the neck of the tube. The generation of such a sawtooth current wave may require an applied voltage wave of somewhat different form as is evident from fig. 13.

To produce a sawtooth current wave as shown by *A*, through a pure inductance requires an applied voltage wave as shown in *B*. To produce a sawtooth current wave through a resistance

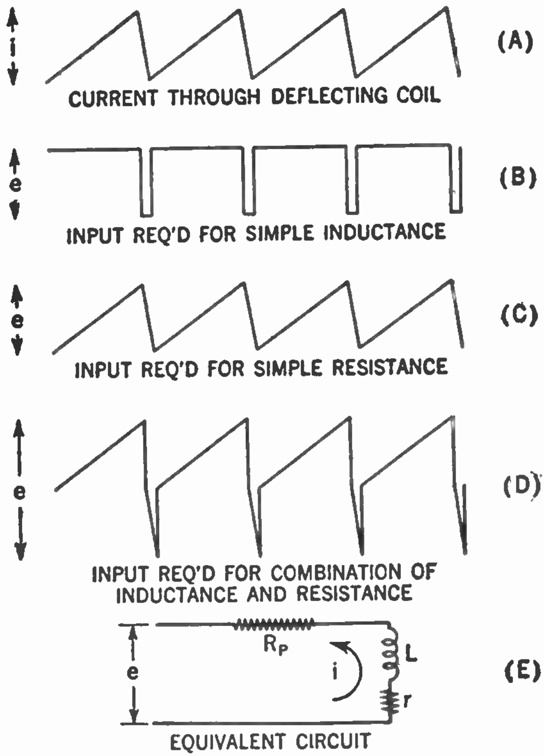



**FIG. 13—Showing typical deflection wave forms.**

requires a sawtooth voltage wave as shown in *C*. If the circuit has both resistance and inductance, the applied voltage wave must be a combination of the waves shown at *B* and C, as shown by *D*, in order to produce a sawtooth current wave.

The deflection current is produced by an output tube to the grid of which is applied a voltage of the correct wave shape to produce the desired sawtooth current wave. The vertical deflection output tube in the typical receiver under discussion is a triode. The vertical deflection coil has a considerable amount of inductance as well as resistance.

The voltage wave required on the grid of the vertical output tube is therefore of the type required to drive a sawtooth of current through a resistance and inductance. The method for generating this special voltage wave will be discussed, in the discharge tube circuits following.

A pentode is used for the horizontal deflection output tube. It is usually biased by means of a cathode circuit resistor which is not by-passed in order to obtain the favorable effects of cathode circuit degeneration. Because the tube has such a high plate resistance and since the inductance of the horizontal deflection coil as compared to the tube's plate resistance is quite negligible, the voltage required on the grid is essentially a sawtooth as shown in *C* of fig. 13.

Also because of the high resistance of the horizontal output tube, it offers very little damping to the inductance of the deflection coil, so that when the current changes abruptly a transient condition is set up which must be damped out. This is accomplished by a diode which acts as a switch to remove the load during the return time while still preventing the transient during the active scanning time.

**Discharge Tube Circuits.**—The operation of a discharge tube is illustrated in fig. 14. The grid is normally biased to cut-off, but is supplied with a positive pulse at the end of each scanning line by the associated blocking oscillator which in turn has been set off or triggered by the transmitted synchronizing pulse.

The positive pulses from the blocking oscillator are shown at the left of fig. 14. During the periods between the grid pulses, the condenser $C$, will be charging through the resistor $R$.

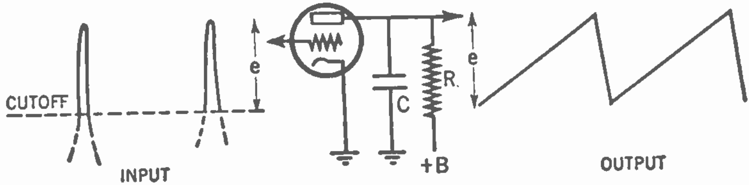



**FIG. 14—Illustrating operation of discharge tube circuit.**

The values of $R$ and $C$ are such that the charge on $C$ never exceeds a small percent of the $+B$ voltage. Under these conditions, the rise in voltage across the condenser will be practically linear, and the wave form of this rising voltage will therefore be substantially equivalent to the rising portion of the sawtooth voltage wave shown for $C$ of fig. 13. When the positive impulses drive the grid to zero or positive potential, the tube becomes conducting and discharges the condenser through the tube. Thus, by alternately charging the condenser $C$, through the resistor $R$, and discharging it through the tube, a sawtooth voltage wave may be generated across the condenser $C$.

This sawtooth voltage wave may be coupled to the grid of the horizontal output tube to produce a sawtooth current wave in its output circuit. In the case of the vertical output tube, however, a voltage wave equivalent to that of $D$, in fig. 13, is required. A wave form substantially equivalent to that of $D$, may be obtained from the discharge tube circuit when a resistor (commonly called a peaking resistor) is placed in series with the charging capacitor and connections made to the terminals of the series combination.

A reference to fig. 7 will indicate that these circuits have been applied in the case of the typical receiver under discussion. It should also be noted that the discharge tube circuits include provisions for varying the height, width and vertical linearity.

The height and width controls are variable resistors in the +B supplies to the discharge tube plates. Since they control the charge which can be built up across the condensers (*C-3* and *C-4* in fig. 7) during a given interval, they control the amplitude of deflection. The vertical linearity control is located in the cathode circuit of the vertical output tube and is adjusted until the desired tube operating characteristic is obtained. The vertical linearity and height controls are to some extent related and if one is adjusted, the adjustment of the other must always be checked. In the case of receivers equipped with one of the smaller picture tubes, the vertical linearity control may be omitted.

In the typical receiver circuits illustrated in fig. 7, provision is also made for horizontal and vertical centering of the picture tube image. As is evident from the diagram these controls make it possible to pass *d.c.* through the deflection coils and thus secure correct centering of the picture.

**The Power Supply.**—In order to supply power to operate the television receiver, two rectifiers are used, a high voltage low current rectifier for supplying picture tube anode voltage and a lower voltage rectifier for supplying plate voltage for the amplifying tubes.

Fig. 15 shows these two rectifiers schematically. At the top of the diagram is shown the high voltage rectifier which supplies voltage for the first and second anodes and the accelerating electrode. The voltage applied to the first anode is adjustable so that the electron beam can be focused to a fine point. As the current consumption of the picture tube is very small, a resistor capacitor filter will give satisfactory filtering.

A half-wave rectifier is used because of the resulting economy and because the filtering problems are not severe when only a

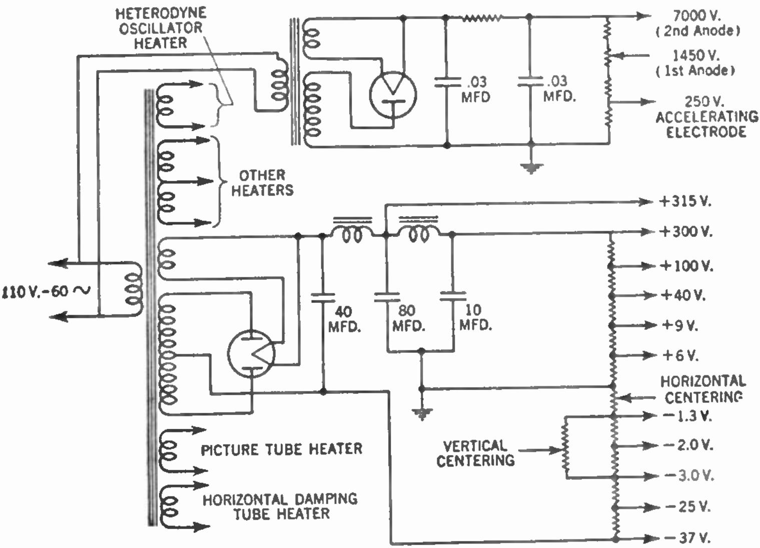



**FIG. 15—Schematic diagram showing typical high and low voltage power supply.**

very small amount of current is required. The low voltage rectifier is conventional except that it has unusually good filtering to insure hum free operation, and has more bleeder taps than usual.

**The Picture Tube.**—The elements in the picture tube and their connection to the high voltage power supply are shown in fig. 16. In addition, the curvature of the electrostatic field is shown. Due to the difference in voltage between different elements, the surfaces having equal potentials will be curved as shown.

The electron stream passing through this curved field will have a tendency to be deflected so that the electrons will tend to cross the equipotential surfaces more nearly at a right angle.

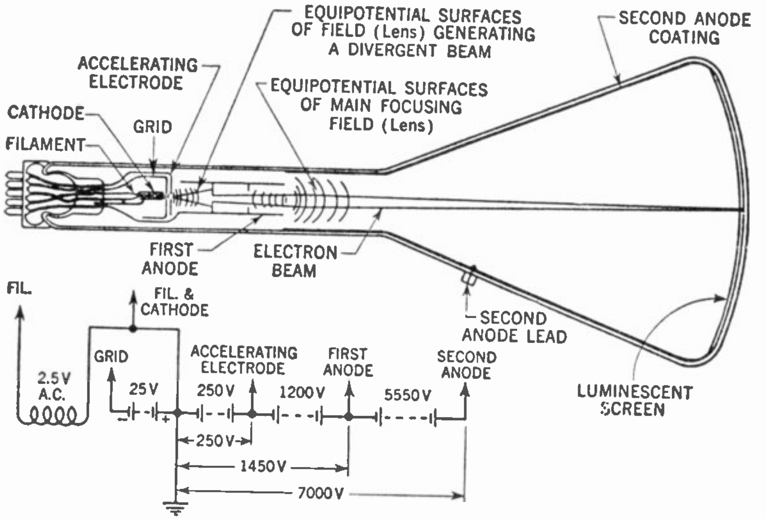



**FIG. 16—Showing elements of the picture tube and connections to the high voltage power supply.**

By proper curvature of the field, the electron stream can be made to come to focus at the fluorescent screen on the end of the tube. In order to make the curvature of the electrostatic field the right amount for proper focus, a variable voltage control known as the focusing control is provided for the first anode. The final adjustment of this focusing control should always be made on a received picture signal.

CHAPTER 10

# Circuit Description of Typical Television Receiver

The material presented under the foregoing heading has been supplied by the courtesy of *Motorola Inc.*, and while this information has direct reference to their *12T* and *12K* model receivers, it will prove helpful to television students and servicemen in servicing other sets since much of this data is of a general nature.

**Chassis.**—Television chassis fig. 1 contains 19 tubes exclusive of the picture tube. The picture, sound and scanning circuits, together with a selenium rectifier, voltage doubler "B" supply, are contained on a single chassis.

**Tuning Range.**—Channels 2 through 13.

**I.F. Frequency.**—*Channels* 2 *to* 6; Sound 21.9 mc.; Picture 26.4 mc.; *Channels* 7 *to* 13; Sound 27.3 mc.; Picture 22.8 mc.

**Antenna Impedance.**—300 ohms.

**Power Supply.**—117 volts, 60 cycles, *a.c.* current only.

**Power Consumption.**—160 watts.

**Audio Output.**—4 watts.

**Chassis Tube Complement**

| Ref. No. | Tube | Function |
|---|---|---|
| V-1 | 6CB6 | *r.f.* Amplifier |
| V-2 | 12AT7 | Mixer-Oscillator |
| V-3 | 6AU6 | 1st *i.f.* Amplifier |
| V-4 | 6AU6 | 2nd *i.f.* Amplifier |
| V-5 | 6AG5 | 3rd *i.f.* Amplifier |
| V-6 | 6AL5 | Video Detector |
| V-7 | 6AH6 | Video Amplifier |
| V-8 | 6AU6 | Audio Driver-Limiter |
| V-9 | 6AL5 | Ratio Detector |
| V-10 | 6J5GT | Audio Amplifier |
| V-11 | 6V6GT | Audio Output |
| V-12 | 6SN7GT | 1st and 2nd Clippers |
| V-13 | 6J5GT | Vertical Sweep Generator |
| V-14 | 25L6GT | Vertical Sweep Output |
| V-15 | 6AL5 | Phase Detector |
| V-16 | 6SN7GT | Horizontal Oscillator |
| V-17 | 6BQ6GT | Horizontal Output and High Voltage Generator |
| V-18 | 6W4GT | Damping Diode |
| V-19 | 1B3GT | High Voltage Rectifier |
| V-20 | 12LP4 | Picture Tube |

**Low Voltage Power Supply.**—The low voltage power supply fig. 2 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 *h.v.* rectifier, which is energized by horizontal sweep current.

One low voltage secondary of *T-7*, the step down filament transformer, supplies filament voltage to all tubes except the audio driver-limiter (*V-8*), the vertical output tube (*V-14*), the picture tube (*V-20*), and the horizontal damping diode (*V-18*).

Since the damping diode (*V-18*) develops a high voltage pulse at its cathode, and its cathode is tied to the filament to prevent breakdown in the tube, it is necessary to provide a separate, low-capacity, well insulated transformer (*T-8*) to heat this filament.

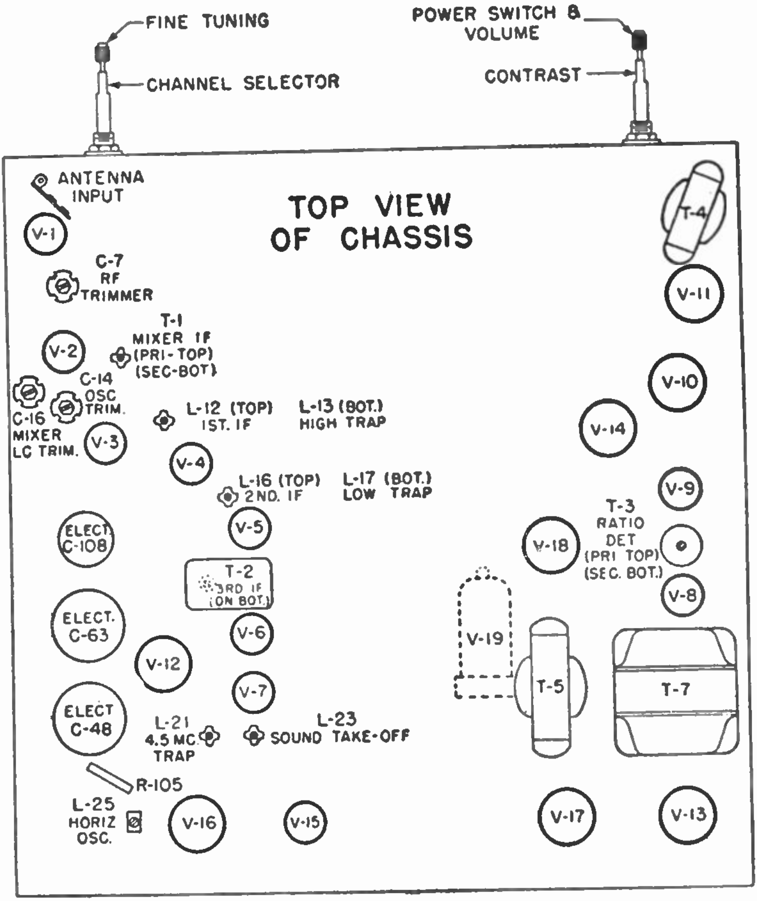



FIG. 1—Top view of typical chassis showing tube and adjustment location.

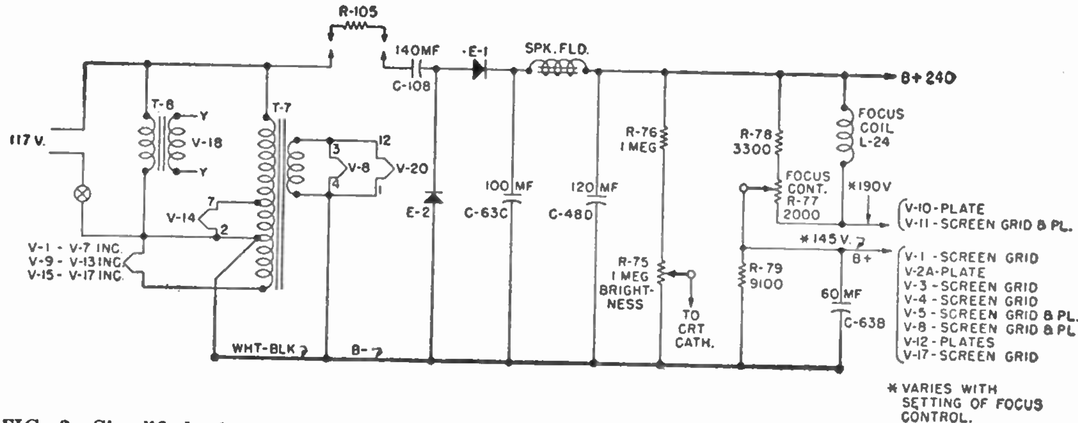



FIG. 2—Simplified schematic of low voltage power supply.

The vertical output tube (*V-14*) requires a 25 volt filament supply, and hence is provided with a separate 25 volt tap on the transformer. *V-8* and *V-20* are supplied by an additional winding, which in sets of late designs, is connected series opposing with the primary to increase the 6.3 volt filament supply voltage slightly to insure that the *r.f.* oscillator will operate on low line voltage.

The "B"+ plate supply uses a voltage doubler. *R-105* is a limiting resistor to protect the rectifiers from initial current surges and also serves as a fuse in case of "B"+ shorts. When the polarity of the applied 117 volts *a.c.* is such as to make the side of the line connected to *R-105* negative, *E-2* will conduct and charge *C-108* (140 *mf.*) to peak line voltage.

On the next alternation, *E-1* will conduct and the voltage applied to it is now the peak line voltage plus the peak charge stored in *C-108*. This results in a charge of about 260 volts on *C-63C* (100 *mf.*). The speaker field is used as a filter choke. The focus coil and the resistor network, which controls the current through it, act also as a voltage divider to supply plate and screen voltages to several tubes, as shown in fig. 2.

Another voltage divider from "B"+ to "B"−, consisting of *R-76* (1 meg.) and the potentiometer, *R-75* (1 meg.) provides a variable bias on the cathode of the picture tube, to serve as a brightness control.

**The R.F. Tuner.**—Fig. 3 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 *r.f.* tube, *V-1*. Optimum antenna coupling for all channels is obtained by the coupling coils *L-5A*, *L-5B*, *L-5C*, 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.

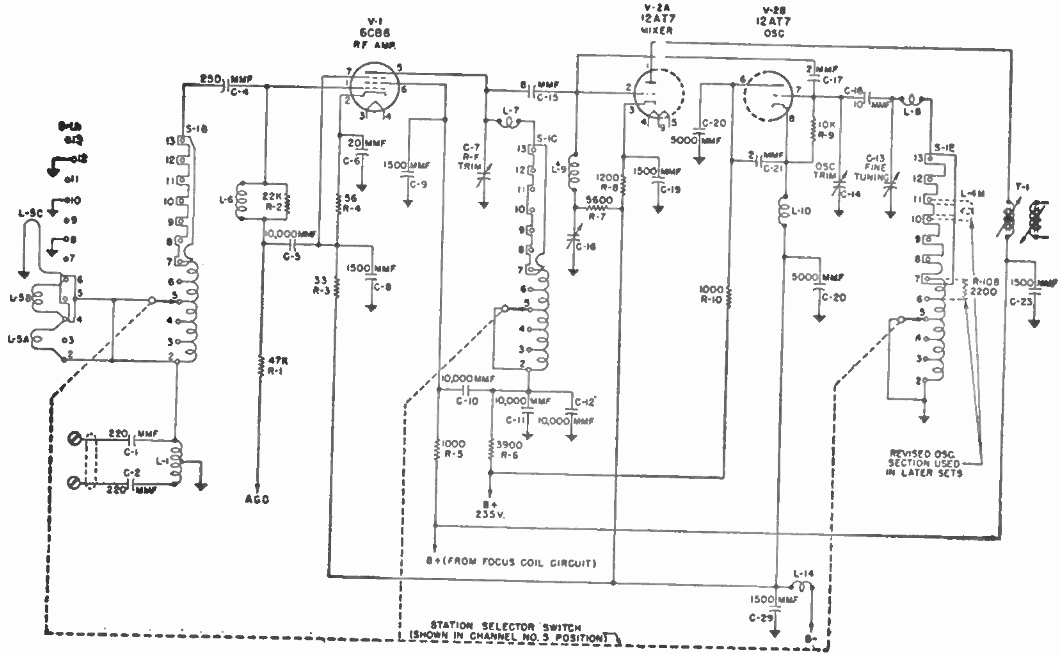



FIG. 3—Simplified schematic of RF tuner.

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 *r.f.* amplifier grid circuit and to tune this circuit for the channel selected. Referring to fig. 3, it will be seen that the switch in progressing from channel 2 to 13, shorts out the unused portion of the secondary winding or stamped metal plate. The bandwidth of channels 7 through thirteen is about 8 mc. The stamped metal plate is carefully designed so that with this bandwidth no alignment adjustment is needed on the high channels.

**R.F. Amplifier.**—The grid of the *r.f.* amplifier *V-1* (6CB6) is returned to the automatic gain control bus through *L-6* 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 sections of the inductance in tuning from channel 2 to 13. In this case, however, a trimmer *C-7* and a choke *L-7* 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 one-half of *V-2* (12AT7). *C-15* (8 *mmf.*) couples the *r.f.* amplifier output to the mixer grid. Oscillator injection is accomplished by *C-17* (2 *mmf.*). *L-9* and *C-17* form a series resonant circuit tuned to the center of the *i.f.* response, to prevent interaction between the *i.f.* 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-8* and *C-14* 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-13* is provided as a fine tuning control for customer use.

The oscillator operates above the *r.f.* on the low channels and below the *r.f.* 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 I.F. Amplifier.**—The *i.f.* amplifier uses two 6AU6 tubes and one 6AG5 tube. Fig. 4 is the schematic of the *i.f.* amplifier. *T-1* couples the mixer plate to the first *i.f.* grid. Coupling between primary and secondary, which are individually slug-tuned, is fixed and is designed for proper bandwidth. The plate choke *L-11*, of the first *i.f.* tube *V*-3 (6AU6), is coupled to the grid coil, *L-12*, of the second *i.f.* tube *V-4* (6AU6) through *C-30* (220 *mmf.*). At *i.f.* frequencies, the impedance of *C-30* is negligible and for all practical purposes, *L-11* and *L-12* can be considered as being in parallel, *L-12* being slug-tuned.

A similar method is used between the second and third *i.f.* tubes. The third *i.f.* plate is coupled to the detector by *T-2*, a unity coupled transformer. The *i.f.* circuits are stagger-tuned for proper bandwith. *L-13* and *L-17* are separately tuned trap windings on *i.f.* coil forms *L-12* and *L-16*, respectively. Together with *C-31* and *C-38*, they form absorption type trap circuits which steepen the high and low skirts of the *i.f.* response for better picture quality and to stabilize the audio response with intercarrier sound.

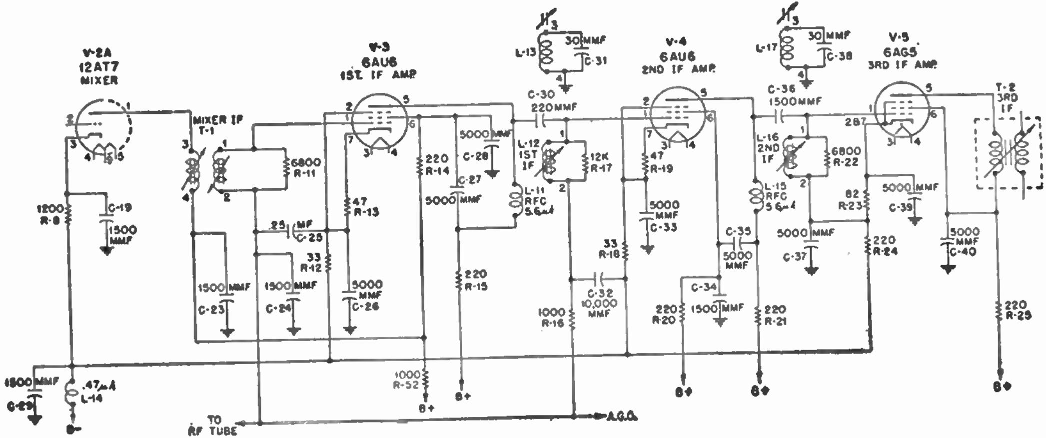



FIG. 4—Simplified schematic of IF amplifier.

Decoupling has been used not only in the plate supply and a.g.c. 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. Fig. 5 is a schematic of the video detector.

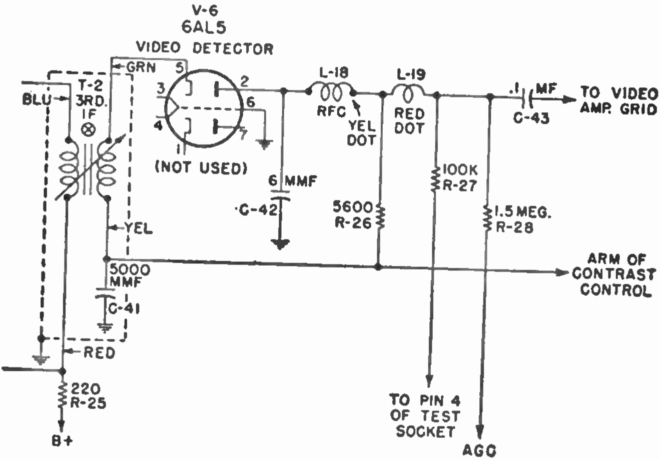



**FIG. 5—Simplified schematic of video detector.**

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-18*, *L-19*, and *C-42*, form a low pass filter to keep *i.f.* frequencies off the grid of the video amplifier.

Since this chassis operates on the intercarrier sound system, the detector heterodynes the video and sound *i.f.* frequencies, and produces the 4.5 mc. beat frequency which becomes the new audio *i.f.* frequency. The negative *d.c.* 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 a.g.c. bus through *R-28* (1.5 meg.) and controls the gain of the *r.f.* and first and second *i.f.* amplifiers.

**The Video Amplifier.**—The video amplifier *V-7* (6AH6) not only amplifies the video signal but also the 4.5 mc. audio *i.f.* beat. Fig. 6 is a schematic of the video amplifier. In its plate

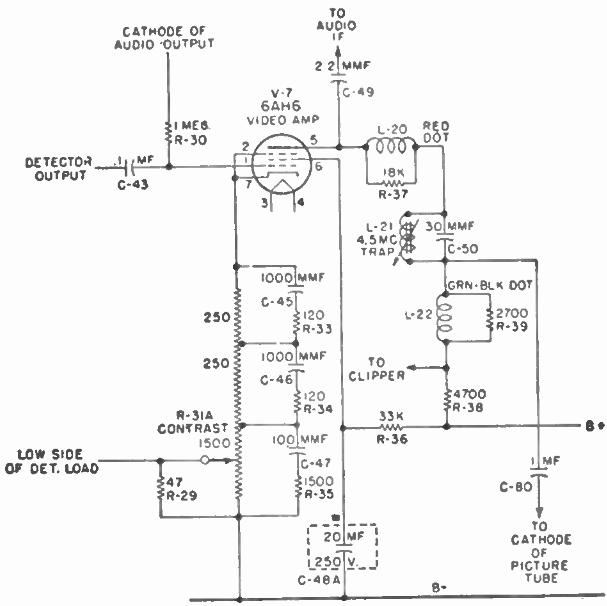



**FIG. 6—Simplified schematic of the video amplifier.**

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-23*, the sound take-off coil. The 4.5 mc. trap, *L-21* 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-20* and *L-22* 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 frequencies and, therefore, helps to extend the high frequency response. The composite video signal is fed to the picture tube cathode through coupling condenser *C-80* (.1).

**The Automatic Gain Control (A.G.C.)**.—The negative *d.c.* voltage developed across the detector load resistor, *R-26* (5600), is the a.g.c. 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-29* (47) is shunted across the arm of the contrast control and B−. In weak signal areas, this arrangement results in delay in the a.g.c. 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-29* is then shunted across the entire contrast control, most of the plate current will flow through 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 a.g.c. voltage will develop until the signal is strong enough to overcome this positive voltage and, therefore, no a.g.c. 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-29* is shorted out and full a.g.c. 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). Fig. 7 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 fig. 8. The composite video signal with positive going sync is applied through *R-55* (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-54* (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, will cause plate current to flow. Therefore, the video information and the blanking pulses are clipped off and only the sync pulses,

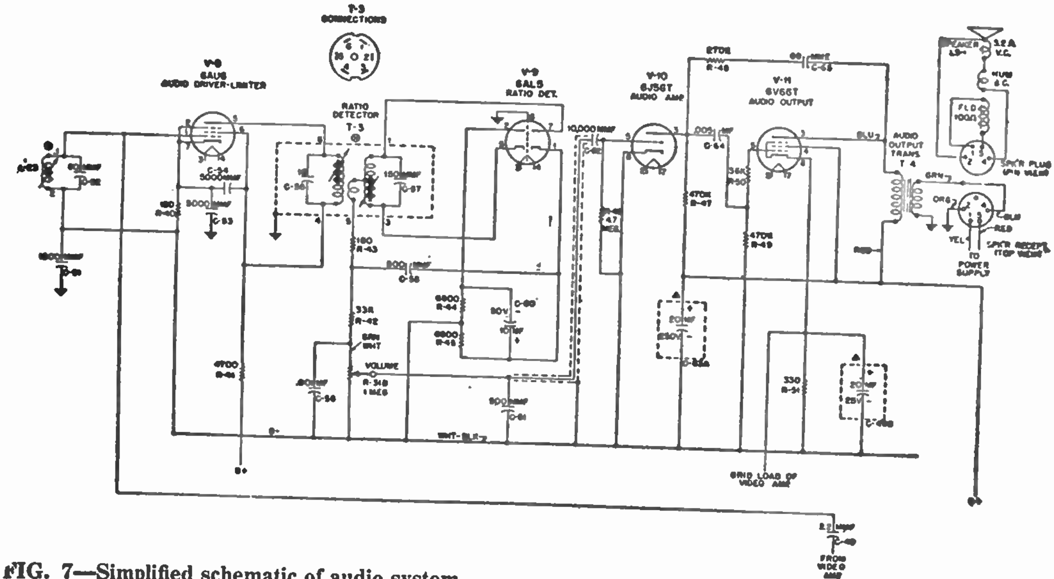



FIG. 7—Simplified schematic of audio system.

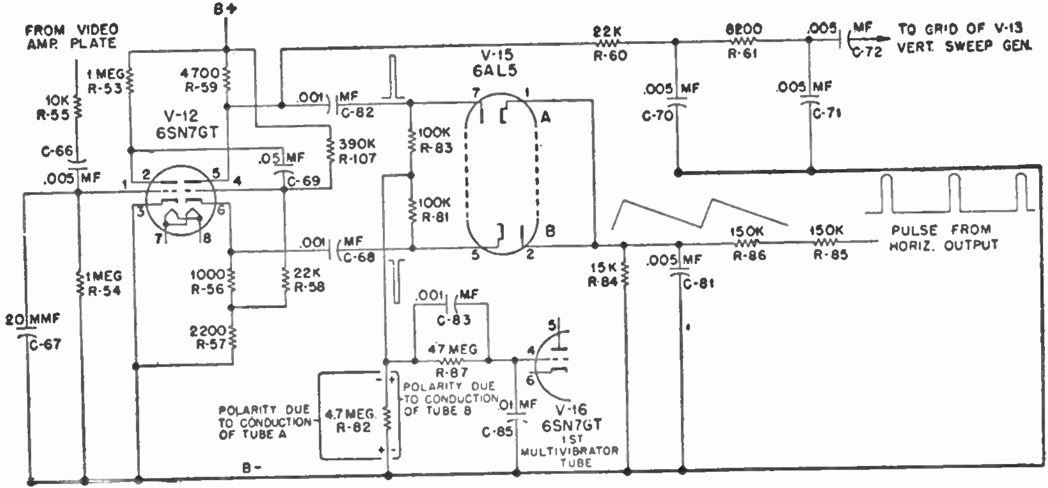



FIG. 8—Simplified schematic of clippers and phase detector.

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 second clipper by *R-107* (330K).

**The Vertical Scanning System.**—Fig. 9 is a schematic of the Vertical Scanning System.

The integrating network, shown in fig. 8, composed of *R-60*, *C-70*, *R-61*, 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-74* (.05), connected in its plate circuit. The circuit components of the multivibrator are chosen so that *V-13's* conductance period is about seven percent 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

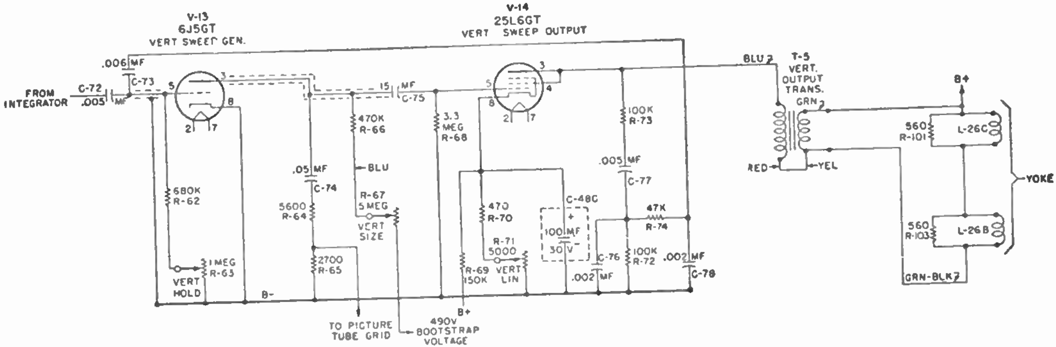



FIG. 9—Simplified schematic of vertical scanning system.

the feedback network, *R-72*, *R-73*, *R-74* and *C-76*, *C-77* and *C-78*, is used to cause the discharge tube *V-13* to go into heavy conduction.

For purposes of explaining the circuit action, assume 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 through the grid resistors of *V-13*, *R-62* (680K) and *R-63* (the vertical hold control) and resistors *R-74* and *R-72*. This discharge circuit makes the grid end of *R-62* 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-75*, which has been charged to nearly the B+ voltage, now starts to discharge through *V-13* and *R-68* (3.3 meg.) and this discharge current makes the grid end of *R-68* 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 feed-back network driving this tube into heavy conduction. *C-74* will then discharge through *V-13*.

The voltage developed at the plate of *V-13* will be the combination sawtooth and pulse voltage shown in fig. 12 (1). The pulse is formed by the peaking resistors *R-64* and *R-65*. 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-74*, which consists of *R-64*, *R-65* and the plate resistance of *V-13*.

After this initial instant, the charge on *C-74* decreases, causing the voltage decrease at the plate shown between points "c" and "d" of fig. 12 (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 points "b" and "a" of fig. 12 (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-64* and *R-65*, 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 through 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-63* (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-67* (5 meg.). This control varies the charging current into *C-74* (.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-71* (5000). This control, by bleeder action through resistor *R-69* (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), and a cathode coupled multivibrator *V-16* (6SN7), the output tube *V-17* (6BQ6) and a damping diode *V-18* (6W4). Fig. 10 is a simplified schematic of this system.

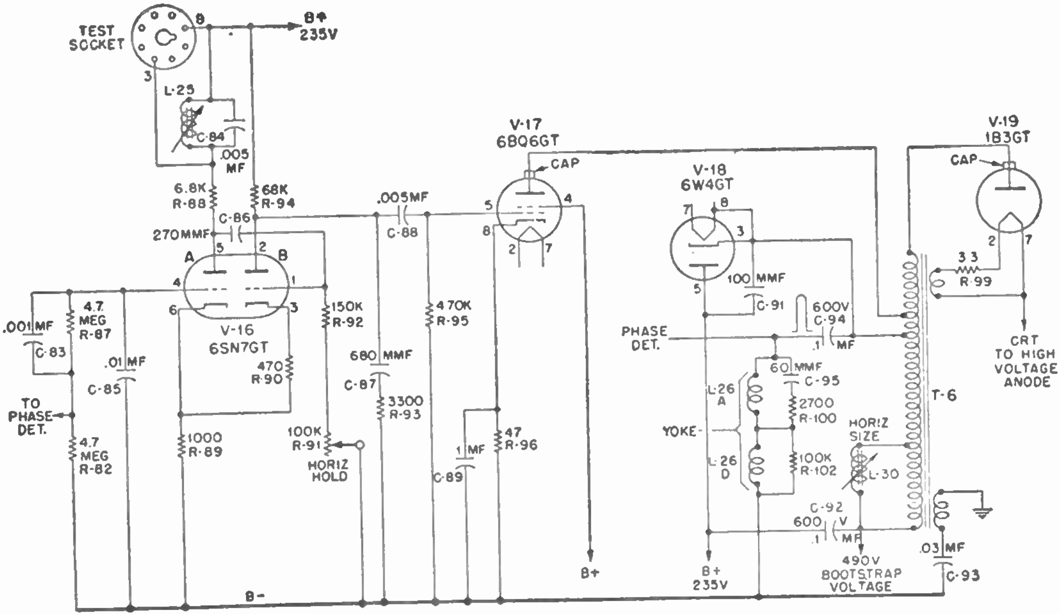



FIG. 10—Simplified schematic of horizontal scanning and high voltage system.

**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-86* is discharging through tube "A", *R-92* (150K) and *R-91* (the hold control). The discharge current of *C-86* 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 through *R-89* (1000) the common cathode resistor.

When the energy stored in *C-86* 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-86* 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-87*, the saw-forming condenser to discharge through tube "B" and *R-93*. When *C-86* becomes charged the charging current through *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 through 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-86* starts to discharge, cutting tube "B" off. *C-87* begins to charge, starting the next trace.

*L-25* and *C-84* 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-87* and *R-93*, the peaking resistor, will produce the same combination pulse and sawtooth voltage shown in fig. 12 (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 fig. 10 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-86* 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-86* would discharge for less time before "B" started to conduct, thereby increasing the frequency.

Fig. 8 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 second clipper *V-12* (6SN7) is fed through *C-82* (.001) to the plate of diode "A" of *V-15*. A negative sync pulse from the cathode of *V-12* is applied through *C-68* (.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-85* (150K), and *C-81* (.005) is applied to the cathode of diode "A" and the plate of diode "B", which are tied together and returned to B− through *R-84* (15K).

The load for diodes "A" and "B" consists of resistors *R-83* (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 fig. 11 (1). The sync pulses have an amplitude of from six to eight 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 six to eight volts for two or three horizontal lines, which means that in the "on" frequency condition shown in fig. 11 (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 fig. 8, 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 fig. 11 (2) exists at the diodes. The phase of the sawtooth has now shifted

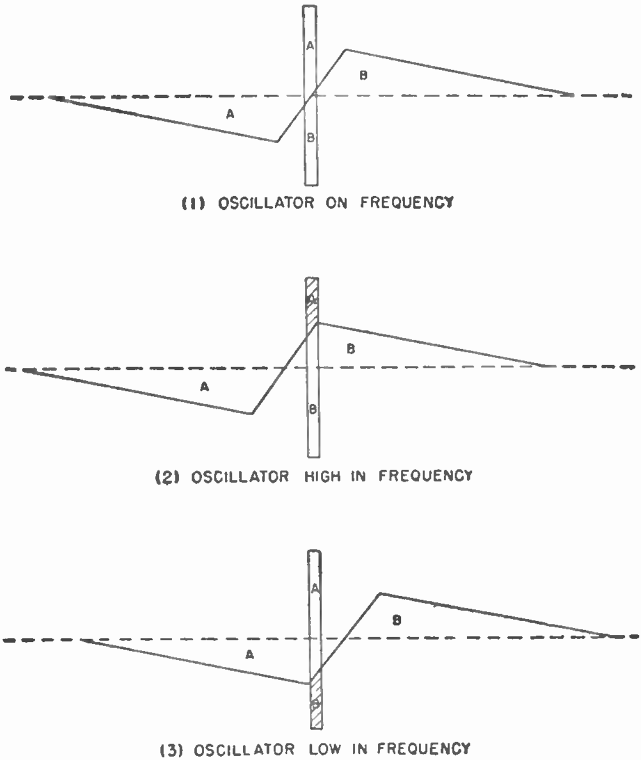



**FIG. 11—Wave forms at phase detector.**

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 through 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 fig. 11 (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 through diode "B" makes the grid end of *R-82* positive, with respect to B−, the decreased current through 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-83*, *R-87* and *C-85* provide two time constant filters which are necessary to obtain "fly-wheel" action of this *a.f.c.* sync circuit.

**The Horizontal Output System.**—The combination sawtooth and pulse waveform developed across *C-87* (680) and *R-93* (3300) by the multivibrator circuit, is fed to the grid of the horizontal output tube *V-17* (6BQ6). Fig. 10 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 seven microseconds.

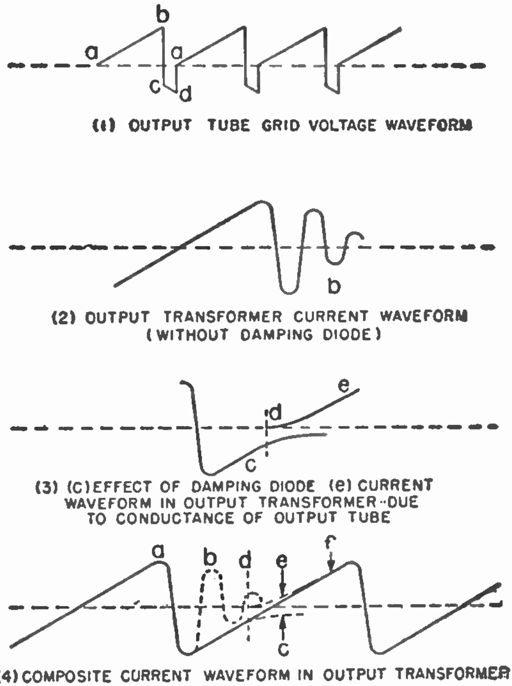



**FIG. 12—Wave forms in horizontal scanning system.**

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 seven microseconds, because only by shock exciting such a circuit into oscillation will retrace be accomplished in the time allowed. The circuit is made resonant by the inductance of the output transformer and yoke, the distributed capacity and the tube capacity.

Bearing this in mind, the operation can be explained as follows. Referring to fig. 12 (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+ through 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-91* (100) is placed across the diode to provide a low impedance for the oscillatory current. If the damping diode *V-18* were not present, this oscillation would continue and current would flow in the output transformer as shown in fig. 12 (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" in fig. 12 (3). At the time ["d" in fig. 12 (3)] the voltage at the grid of the output tube has become less then cut off [point "a" in fig. 12 (1)] and the tube again demands current. The rising current in the tube results in superimposing the waveform "e" of fig. 12 (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 fig. 12 (4), which is a composite waveform of the entire action.

During the peak conduction of the damping diode, *C-92* (.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+ supply so that the voltage at the output tube plate is raised from the 250 volt B+ 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 fig. 12 (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 autotransformer of this section. The positive pulse of voltage at this tap is coupled to the yoke through *C-94* (.1) and results in a sawtooth of current through the yoke. It will be remembered that a portion of this pulse is also fed to the phase detector for the *a.f.c.* action through *R-86* and *R-85*.

The small additional winding, one terminal of which is connected to chassis while the other terminal is connected to B− through *C-93* (.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 12 *kv.* at its high end. These pulses are rectified by *V-19* (1B3) and the resulting *d.c.* 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.**—*L-25* is the coil of the sine wave generating circuit in the horizontal multivibrator circuit and should be tuned to 15,750 cycles. *R-91* is the horizontal hold control which can be adjusted for correct frequency operation of the multivibrator. *L-30*, paralleling a small portion of the output choke acts as a size control.

CHAPTER 11

# Television Picture Tubes

The television picture tube also called *cathode ray tube, viewing tube, pickup tube, receiving tube*, etc. is very similar to the well known test oscilloscope tube employed in all types of electronic testing and research work.

With reference to fig. 1 the principle elements are as follows:

1. A containing envelope of glass for the purpose of maintaining vacuum in the tube.
2. A cathode (indirectly heated) for the production of free electrons.
3. A control grid for controlling the beam current.
4. A focusing electrode identified as the *first anode* for concentrating the electrons into a cathode ray or beam.
5. A high voltage anode referred to as the *second anode* for further acceleration of the electrons.
6. Two sets of electrostatic deflection plates for deflecting the electron beam. These are known as the horizontal and vertical deflection plates.
7. A screen which is coated on the inner surface of the enlarged end of the tube with a material which shows a fluorescent glow at the impact point of the electron beam. This is termed the fluorescent screen.

**The Electron Gun.**—The electrodes consisting of the *cathode, control grid, first and second anode* are collectively known as the *electron gun*, inasmuch as their function is to generate a beam of electrons and to direct it toward the viewing screen.

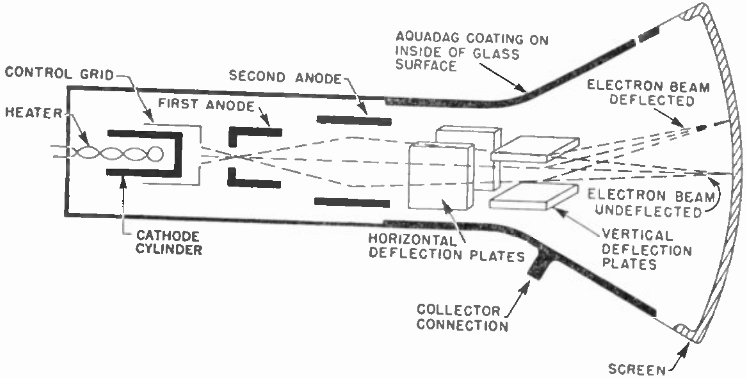



**FIG. 1**—Showing schematic arrangement of electrodes in a picture tube of the electrostatic deflection type.

**The Electron Beam.**—Since the electron beam consists of rapidly moving electrons, it constitutes a current having both electromagnetic and electrostatic properties. Because no material conductor is required to carry the electrons, the beam has negligible mass and negligible inertia. Due to this inertia-less characteristic, the electron beam can be deflected easily and rapidly by either electrostatic or electromagnetic fields.

**Method of Focusing.**—Focusing may be accomplished by either of two methods, namely:

1. By electrostatic means, and
2. By electromagnetic means.

Both methods of focusing will achieve the desired results, that is, a narrow concentrated beam of electrons.

In the picture tube shown in fig. 1 the deflecting force takes the form of an electrostatic field produced by a voltage applied across the deflecting plates.

Another type of picture tube is shown schematically in fig. 2.

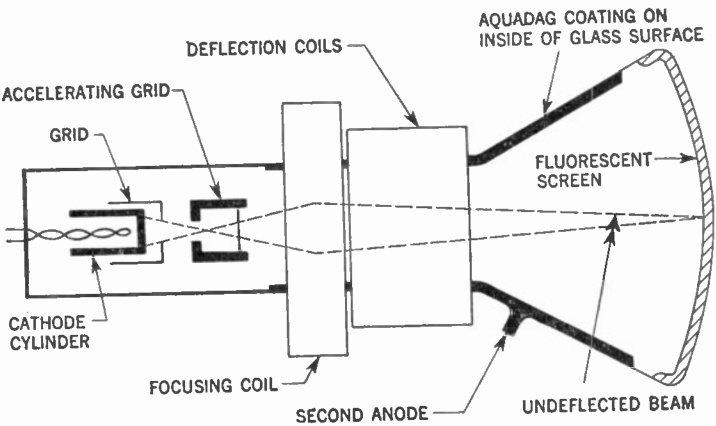
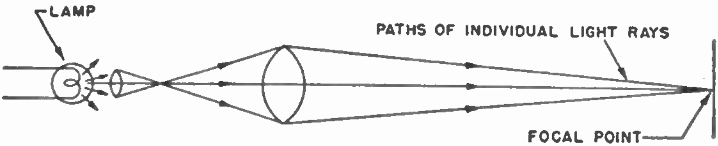



**FIG. 2—Schematic arrangement of electrodes in a picture tube of the magnetic deflection type.**

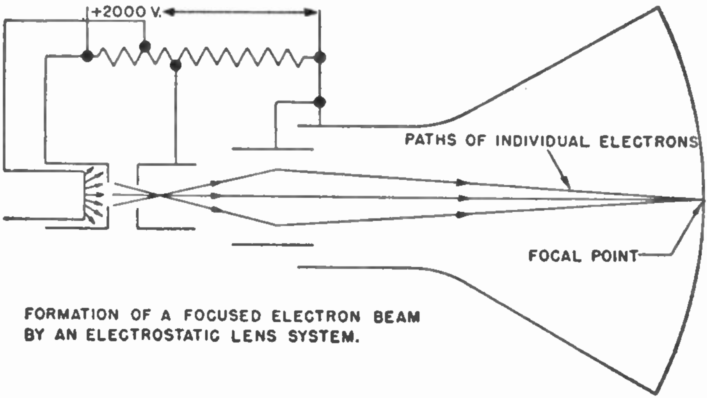
In this case no electrostatic deflection plates are used. Here deflection of the electron beam both horizontally and vertically is accomplished by means of two electromagnetic fields, produced by two external pair of coils. This latter type of picture tube is known as the *magnetic deflection type* and is the most common type used for picture tubes.

Also in the magnetically focused picture tube, the first anode is replaced by an accelerating grid which gives the initial acceleration of the beam of electrons.

The second anode of this type of tube is not always a part of the main section of the cylindrical electron gun. Instead it is in the form of a coating on the inner surface of the glass extending from the tube neck up toward the fluorescent screen.




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




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

FIGS. 3 and 4—Illustrating focusing method of a simple lens system as compared to electrostatic focusing. In the familiar glass lens system, the lens may be used to collect a divergent bundle of light rays, converging them to a point and in this manner accomplish the focusing of light. The light lens system may be a simple lens or a compound of several individual elements. An electron lens may be employed to control the many electrons leaving the cathode in exactly the same manner that an optical lens controls the light leaving the lamp. Focusing is accomplished by varying the potentials of the electron lens as illustrated and is due to the electrostatic fields established between successive elements.

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

**Picture Scanning.**—In scanning, the beam is focused to a spot of small diameter at the fluorescent screen, and it now remains to deflect the beam for scanning in an orderly sequence.

Here again, may be employed either an electrostatic or an electromagnetic method. The former is illustrated in fig. 1, and shows two sets of metallic plates, one set for vertical deflection and one set for horizontal deflection.

Creation of an electrostatic field between any one 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 cycles in present day standards) while a slow repetition rate is applied to the vertical plates (60 cycles). These scanning potentials are illustrated in fig. 5.

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 previously mentioned, a high repetition rate of scanning is applied to the horizontal plates, and a much slower rate to the vertical. Hence, analyzing the spot motion, it is found that

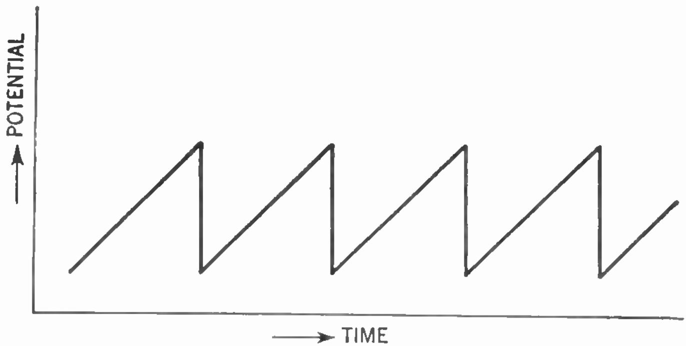



**FIG. 5—Showing typical sawtooth scanning potentials.**

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 carried 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.

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, that is, 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 has previously been 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*.

Although it is possible to employ the electrostatic method of deflection in television picture tubes, this is seldom done for several reasons. They are:

1. The deflection potentials necessary in a large tube are very high, requiring large high voltage amplifier tubes.

2. A screen giving green colored light as in oscillograph tubes operating on the electrostatic deflection principle is used for reason of visual efficiency. Television use, however, dictates that a white or blue-white light be used for esthetic reasons and that the decay time of the light be short. Phosphor (screen materials) exhibit the property of remaining lighted for a short time after the electron excitation has passed.

3. Focus of the electron beam is not maintained over the entire screen in an electrostatic type of tube. This would give an image which is "fuzzy" or poorly focused over a portion of its area.

For these reasons the television picture tube employs magnetic focusing. Certain electrical properties of the picture tube will now be treated. These being *halation* and the *ion spot*.

**Halation.**—This is the glowing of a phosphor on the fluorescent screen, in a region immediately surrounding the scanning spot. It signifies one undesirable property of the picture tube.

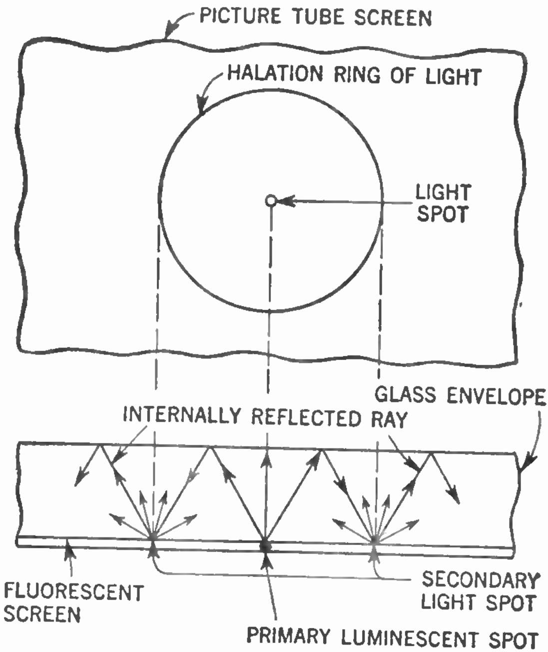



**FIG. 6—Showing typical halation effect on picture tube screen.**

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 fig. 6 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.

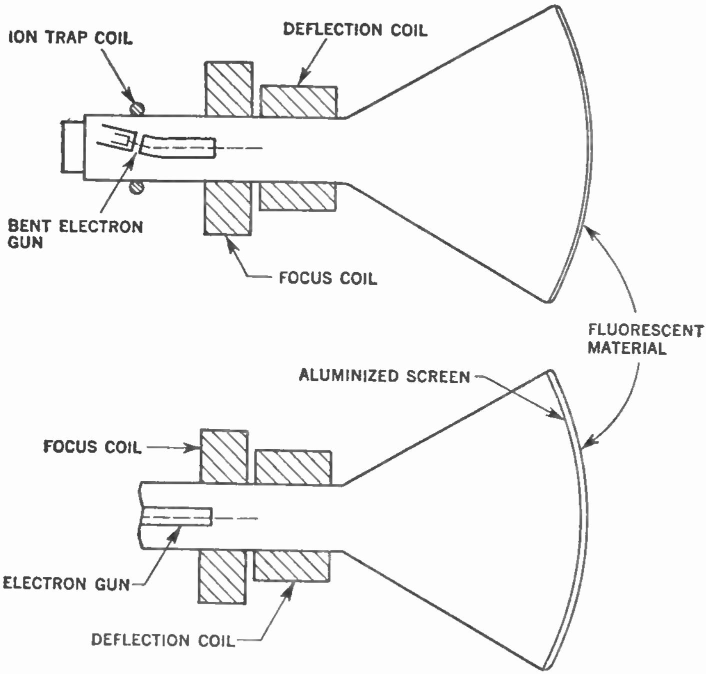
**The Ion Spot.**—A second property of the tube is the formation, after some hours of operation of a darkened area near the center of the screen, known as an *ion spot.*

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 methods 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 fig. 7 is one whose electron emitting element is not in line with the axis of the tube, that is, 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




FIGS. 7 and 8—Methods of ion spot prevention on magnetic deflection type of picture tubes. In the bent electron gun method, fig. 7, the actual cylindrical elements of the electron gun are mounted at an angle with respect to the tube axis. As the electrons and ions leave the electron gun they come under influence of the magnetic field generated by the external bending or ion trap coils. This magnetic field is of the proper strength and polarity to return the electrons to the center line of the electron tube axis. The ions on the other hand, because of their greater mass cannot be deflected, and therefore strike the collecting walls to be dissipated, thus separating the ions from the electrons. The second method of ion spot prevention as illustrated in fig. 8 consists of a metallic coating of aluminum which because of its thinness is actually an aluminized screen. This aluminized screen will effectively transfer electrons causing them to strike the fluorescent material. The ions, however, having a greater mass will not penetrate the aluminized screen but are dissipated by it and do not reach the fluroescent screen of the picture tube.

increases the light which is emitted from the front of the tube by a considerable amount and it disperses the ions so that they cause no damage to the phosphor. This coating is extremely thin, about the wavelength of light.

**Commercial Picture Tubes.**—These are manufactured in a large variety of shapes and sizes. With the advance of television science the public demand for larger and better pictures has resulted in a great improvement in the size and reliability of picture tubes until at present standard tubes of up to 22 inches in diameter and larger are available.

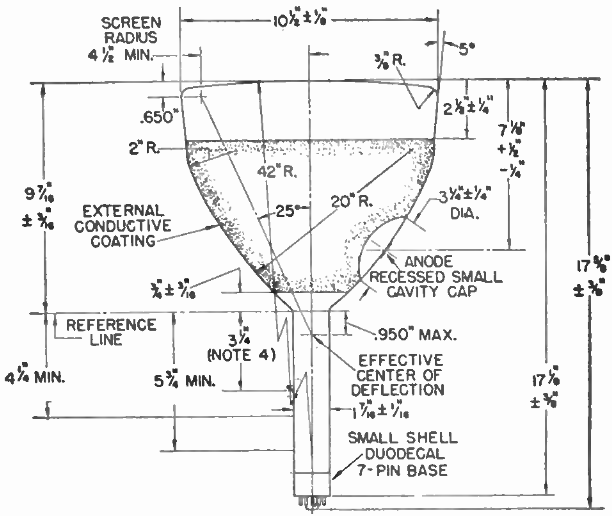



**FIG. 9—Outline dimensions of a 10BP4 direct view picture tube.**

As previously noted, magnetic deflection is the most common deflection method used, although a few of the smaller size picture tubes employ electrostatic deflection.

A listing of the most common types of commercial picture tubes and their characteristics is provided by means of picture tube data charts given on pages 230 to 231. From these data charts much useful information in a practical form with reference to operating voltages and general characteristics of the tubes will be obtained. Many of the later manufactured picture tubes have an external conductive coating in addition to the internal second anode coating. In such tubes a high voltage filter capacitor of approximately 500 *mmf*. is formed by the two coatings and the glass which serves as a dielectric. In tubes so equipped the external coating is grounded.

**Using the Data Chart.**—There are several important factors which must be considered by the service technician when using the tube data charts as an index to tube interchangeability. These are as follows:

a. Tube types with identical bulb outlines present no problem of interchangeability with respect to chassis layout, unless the difference in overall length is so great that the two types in question would not be compatible in the same cabinet design.

b. When a high focus current tube is replaced for a low focus current tube, it may be necessary to increase the focus current range of the receiver, otherwise, a stronger focus coil must be employed.

c. It is important that the proper external magnet be used with the ion trap of the tube, particularly when changing from a double to a single magnet. Since these components are relatively inexpensive, it would seem practical to keep them on hand.

d. If a tube without external coating is replaced for a tube with external coating, a 500 to 1500 *mmf*. capacitor connected between the high voltage output lead and ground will insure proper set operation.

e. In general there are three types of connectors to the anode of television tubes, the cavity and ball connectors in all glass types, and the clip connector for types with a metal cone envelope. When making tube changes, the appropriate connector must be used.

f. In practice, the same deflection yoke usually may be employed with all tube types having deflection angles of less than 66 degrees.

g. Type numbers are assigned to picture tubes and other cathode ray tubes by the *Radio-Television Manufacturers Association.* The first number, made up of one or two digits, represents the largest dimension of the face of the tube to the nearest one-half inch. For round tubes this would be the diameter and for rectangular tubes it would be the diagonal dimension. The letter following the first number is assigned in order of registration and has no significance other than this. The letter *P*, together with the last number designate the type of phosphor used. Thus, the *10BP4* is a 10 inch picture tube with *P4* phosphor. Similarly, the *12AP4* is a 12 inch picture tube with *P4* phosphor.

h. In some cases an additional letter is added as a suffix to the type number. An example is the type *17BP4A.* The reason for this suffix is that there has been a change in the design of *17BP4*, but not great enough change to justify the use of a new type number. The new tube with the suffix in its type number, will always operate in the same circuit as the original tube, but the old tube may or may not work in all circuits where the new tube is used. In this way it is possible to take advantage of the latest development in picture tube design whenever it may be necessary to replace the old tube

# Television Picture Tube Data Chart (Magnetic deflection and focus)

| Type[1,7] | Basing | DIMENSIONS (inches) Overall Length | Diameter | Min. Useful Diameter | Deflection Angle (degrees) | Radius of Face Curvature (inches) | Envelope | Contact | Ion Trap Magnet | MAX. DESIGN CENTER VALUES Anode Volts | Grid No. 2 Volts | COMPARATIVE OPERATING CONDITIONS** Focus* Current (Ma.) | Anode Volts | Neg. Grid No. 1 Cut Off Volts | Grid No. 2 Volts |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10BP4<br>10BP4A[8] | 12D | 17 5/8 | 10 1/2 | 9 | 50 | 42 | Glass† | Cavity | Double | 12,000 | 410 | 132 | 12,000 | 33-77 | 300 |
| 10CP4 | 12D | 16 5/8 | 10 1/2 | 9 | 50 | 42 | Glass† | Ball | None | 12,000 | 410 | — | 12,000 | 33-77 | 300 |
| 10DP4[2,4] | 12C | 17 5/8 | 10 1/2 | 9 | 50 | 42 | Glass | Cavity | None | 12,000 | 410 | — | 12,000 | 33-77 | 300 |
| 10EP4 | 12D | 17 5/8 | 10 1/2 | 9 | 50 | 42 | Glass | Ball | Double | 12,000 | 410 | 132 | 12,000 | 33-77 | 300 |
| 10FP4[4]<br>10FP4A[3,4] | 12D | 17 5/8 | 10 1/2 | 9 | 50 | 42 | Glass† | Cavity | None | 12,000 | 410 | 115 | 12,000 | 33-77 | 300 |
| 10MP4<br>10MP4A[8] | 12G | 17 | 10 1/2 | 9 1/8 | 52 | 42 | Glass† | Cavity | Double | 12,000 | — | — | 12,000 | 33-77 | 300 |
| 12JP4[4] | 12D | 17 1/2 | 12 | 11 | 56 | 20 | Glass | Ball | None | 12,000 | 410 | 158 | 12,000 | 33-77 | 300 |
| 12KP4[4]<br>12KP4A[8] | 12D | 17 5/8 | 12 3/16 | 11 1/4 | 54 | 40 | Glass† | Cavity | None | 12,000 | 410 | 140 | 12,000 | 33-77 | 300 |
| 12LP4<br>12LP4A[8] | 12D | 18 3/4 | 12 3/16 | 11 | 54 | 40 | Glass† | Cavity | Double | 12,000 | 410 | 114 | 12,000 | 33-77 | 300 |
| 12QP4<br>12QP4A[8] | 12D | 17 1/2 | 12 3/16 | 11 | 55 | 40 | Glass | Ball | Single | 12,000 | 410 | 148 | 12,000 | 33-77 | 300 |
| 12RP4 | 12D | 17 1/2 | 12 | 11 | 56 | 20 | Glass | Ball | Single | 12,000 | 410 | 148 | 12,000 | 33-77 | 300 |
| 12TP4 | 12D | 18 3/4 | 12 3/16 | 11 | 54 | 40 | Glass | Cavity | Double | 12,000 | 410 | 114 | 12,000 | 33-77 | 300 |
| 12UP4<br>12UP4A[8]<br>12UP4B[3] | 12D | 18 5/8 | 12 3/16 | 11 3/8 | 54 | 27 | Metal | — | Double<br>Double<br>Single | 12,000 | 410 | — | 12,000 | 33-77 | 300 |
| 12VP4<br>12VP4A[8] | 12G | 19 | 12 3/16 | 11 | 55 | 40 | Glass | Cavity | Double | 12,000 | — | — | 12,000 | 33-77 | 300 |
| 14BP4[5,8] | 12D | 16 13/16 | 9 11/16x12 1/2 | 8 5/8x11 1/2 | 70 diag. | 27 | Glass† | Cavity | Double | 12,000 | 410 | 115 | 12,000 | 33-77 | 300 |
| 14CP4[5,8] | 12D | 16 3/4 | 9 23/32x12 17/32 | 8 5/8x11 1/2 | 70 diag. | 27 | Glass† | Cavity | Single | 14,000 | 410 | 95* | 12,000 | 33-77 | 300 |
| 14DP4[5,8] | 12D | 16 3/4 | 9 23/32x12 17/32 | 8 5/8x11 1/2 | 70 diag. | 27 | Glass | Cavity | Double | 14,000 | 410 | 104 | 12,000 | 33-77 | 300 |
| 14EP4[3,5] | 12D | 16 5/32 | 9 23/32x12 17/32 | 12 1/2 diag. | 70 diag. | 27 | Glass† | Cavity | Single | 14,000 | 410 | 110* | 12,000 | 33-77 | 300 |
| 14FP4[5,8] | 12D | 16 1/8 | 9 11/16x12 1/2 | 8 5/8x11 1/2 | 70 diag. | 27 | Glass | Cavity | Single | 14,000 | 410 | 115* | 12,000 | 33-77 | 300 |
| 15AP4[6] | 12D | 20 1/2 | 15 1/2 | 14 | 57 | 45 | Glass | Ball | None | 15,000 | 410 | 159 | 12,000 | 33-77 | 300 |
| 15CP4 | 12D | 21 1/2 | 15 1/2 | 14 | 57 | 45 | Glass | Cavity | Double | 15,000 | 410 | 133 | 12,000 | 33-77 | 300 |
| 15DP4 | 12D | 20 1/2 | 15 1/2 | 14 | 57 | 45 | Glass | Ball | Single | 15,000 | 410 | 140 | 12,000 | 33-77 | 300 |
| 16AP4<br>16AP4A[8] | 12D | 22 1/4 | 15 7/8 | 14 3/8 | 53 | 27 | Metal | — | Double | 14,000 | 410 | 89 | 12,000 | 33-77 | 300 |
| 16CP4 | 12D | 21 1/2 | 15 7/8 | 15 | 52 | 56 3/4 | Glass | Cavity | Double | 15,000 | 410 | 110 | 12,000 | 33-77 | 300 |

# Television Picture Tube Data Chart (Magnetic deflection and focus)

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16EP4<br>16EP4A[8] | 12D | 19 3/8 | 15 7/8 | 14 3/8 | 60 | 27 | Metal | —— | Double | 14,000 | 410 | 105 | 12,000 | 33-77 | 300 |
| 16FP4 | 12D | 20 1/4 | 16 1/8 | 15 | 62 | 27 | Glass | Ball | Single | 16,000 | 410 | 140 | 12,000 | 33-77 | 300 |
| 16GP4[3] | 12D | 17 11/16 | 15 7/8 | 14 3/8 | 70 | 40 | Metal | —— | Single | 14,000 | 410 | 100* | 12,000 | 33-77 | 300 |
| 16HP4<br>16HP4A[8] | 12D | 21 1/4 | 15 7/8 | 14 1/2 | 60 | 56 5/16 | Glass† | Cavity | Double | 14,000 | 410 | 110 | 12,000 | 33-77 | 300 |
| 16JP4<br>16JP4A[8] | 12D | 20 3/4 | 16 1/8 | 15 | 60 | 27 | Glass† | Cavity | Double | 14,000 | 410 | 120 | 12,000 | 33-77 | 300 |
| 16KP4[5,3] | 12D | 18 3/4 | 11 1/2x14 3/4 | 10 1/8x13 1/2 | 70 diag. | 27 | Glass† | Cavity | Single | 16,000 | 410 | 97* | 12,000 | 33-77 | 300 |
| 16LP4<br>16LP4A[8] | 12D | 22 1/4 | 15 7/8 | 14 1/2 | 52 | 56 5/16 | Glass† | Cavity | Double | 14,000 | 410 | 110 | 12,000 | 33-77 | 300 |
| 16MP4<br>16MP4A[8] | 12D | 21 3/4 | 16 1/8 | 14 3/4 | 60 | 27 | Glass† | Cavity | Double | 14,000 | 410 | 110 | 12,000 | 33-77 | 300 |
| 16QP4[5,3] | 12D | 19 9/16 | 11 1/2x14 3/4 | 10 1/8x13 1/2 | 70 diag. | 27 | Glass | Cavity | Double | 16,000 | 410 | 125* | 12,000 | 33-77 | 300 |
| 16RP4[5,3] | 12D | 18 3/4 | 11 1/2x14 3/4 | 10 1/8x13 1/2 | 70 diag. | 27 | Glass† | Cavity | Double | 14,000 | 410 | 100* | 12,000 | 33-77 | 300 |
| 16SP4<br>16SP4A[8] | 12D | 17 13/16 | 15 7/8 | 14 1/2 | 70 | 56 5/16 | Glass† | Cavity | Double | 14,000 | 410 | 110 | 12,000 | 33-77 | 300 |
| 16TP4[5,3] | 12D | 18 1/8 | 11 1/2x14 3/4 | 10 1/8x13 1/2 | 70 diag. | 27 | Glass† | Cavity | Single | 14,000 | 410 | 100* | 12,000 | 33-77 | 300 |
| 16UP4[5,3] | 12D | 18 1/8 | 11 1/2x14 3/4 | 10 1/8x13 1/2 | 70 diag. | 27 | Glass | Cavity | Single | 15,000 | 410 | 100* | 12,000 | 33-77 | 300 |
| 16VP4[3] | 12D | 17 13/16 | 15 7/8 | 14 1/2 | 70 | 56 5/16 | Glass | Cavity | Single | 15,000 | 410 | 110* | 12,000 | 33-77 | 300 |
| 16WP4[8]<br>16WP4A[8] | 12D | 17 3/4 | 15 7/8 | 14 1/2 | 70 | 56 5/16 | Glass<br>Glass† | Cavity | Double | 15,000<br>16,000 | 410 | 110* | 12,000 | 33-77 | 300 |
| 16XP4[3,3] | 12D | 18 3/4 | 11 1/2x14 3/4 | 10 1/8x13 1/2 | 70 diag. | 27 | Glass | Cavity | Double | 15,000 | 410 | 100* | 12,000 | 33-77 | 300 |
| 16YP4[3] | 12D | 17 13/16 | 15 7/8 | 14 1/2 | 70 | 56 5/16 | Glass† | Cavity | Single | 14,000 | 410 | 100* | 12,000 | 33-77 | 300 |
| 16ZP4[3] | 12D | 22 1/4 | 15 7/8 | 14 1/2 | 52 | 56 5/16 | Glass† | Cavity | Single | 14,000 | 410 | 110* | 12,000 | 33-77 | 300 |
| 17AP4[5,3] | 12D | 18 5/8 | 12 1/4x15 5/8 | 10 3/4x14 1/4 | 70 diag. | 27 | Glass | Cavity | Single | 16,000 | 410 | 100* | 12,000 | 33-77 | 300 |
| 17BP4A[3,6] | 12D | 19 1/8 | 16 5/8 | 14 1/4x10 3/4 | 70 diag | 27 | Glass† | Cavity | Single | 16,000 | 410 | 95* | 12,000 | 33-77 | 300 |
| 19AP4<br>19AP4A[8]<br>19AP4B[3,6] | 12D | 21 1/2 | 18 5/8 | 17 3/8 | 66 | 28 | Metal | —— | Single | 19,000 | 410 | 140 | 12,000 | 33-77 | 300 |
| 19DP4<br>19DP4A[8] | 12D | 21 1/2 | 18 7/8 | 17 3/8 | 66 | 60 | Glass† | Cavity | Double | 19,000 | 410 | 140 | 12,000 | 33-77 | 300 |
| 19EP4[5,3] | 12D | 21 1/8 | 17x13 1/2 | 12x16 | 70 diag. | 27 | Glass† | Cavity | Double | 19,000 | 410 | 140* | 12,000 | 33-77 | 300 |
| 19FP4[6] | 12D | 22 | 18 7/8 | 17 3/8 | 66 | 60 | Glass | Cavity | Double | 19,000 | 410 | 97-126* | 12,000 | 33-77 | 300 |
| 19GP4[3] | 12D | 21 1/4 | 18 7/8 | 17 3/8 | 66 | 60 | Glass | Cavity | Single | 19,000 | 410 | 107-126* | 12,000 | 33-77 | 300 |
| 20BP4 | 12D | 28 | 20 | 18 3/4 | 54 | 30 | Glass | Metal Cap | None | 20,000 | 410 | 122 | 12,000 | 33-77 | 300 |
| 22AP4<br>22AP4A[8] | 12D | 22 7/8 | 21 11/16 | 20 1/4 | 70 | 27 | Metal | —— | Single | 19,000 | 410 | 108* | 12,000 | 33-77 | 300 |

## Tube specification notes:

1. All the types listed have heater values of 6.3 volts, 0.6 amps.
2. These types employ electrostatic focus.
3. Types employing gray filter face plate.
4. Type employs metal-backed screen.
5. Rectangular type.
6. Face plate incorporates an anti-reflective feature.

* Types employ RMA Focus Coil #109 (approx. 470 ohms), all others RMA focus coil #106 (approx. 264 ohms).

a. For replacement see Type 12RP4.

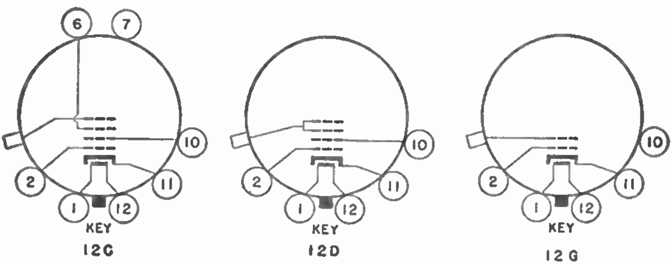
b. For replacement see Type 15DP4.

† Types have external conductive coating.

7. All types employ a white fluorescence material of medium persistence.

** These values are for comparison only and do not imply typical operating conditions.

Data based on latest information from RMA Data Bureau.




**FIGS. 10 to 12—Base diagram symbols. By using the picture tube data chart on pages 230 and 231, the proper base connections will be found under the heading of "Basing". Thus, for example, to obtain the correct base connections for the 10BP4 picture tube, a reference to "Basing" on the picture tube data chart shows 12D as the correct base diagram to use. In a similar manner the base connection for any picture tube represented in the chart may readily be found.**

## Replacement of the Picture Tube

**Chassis Removal.**—Ordinarily the removal of the chassis from the cabinet is accomplished as follows:

1. Remove the control knobs from the front of the cabinet.
2. Remove the wood screws that hold the rear cover to the cabinet, and remove the rear cover.
3. Remove the two wood screws from the block located on the top (inside) of the cabinet, and remove the block.
4. Disconnect the built-in antenna feeder from the antenna terminals.
5. Release the antenna stub from the top of the cabinet by pulling out the thumb-tack.
6. Remove the two screws that secure the antenna assembly to the top of the cabinet.
7. Remove the trimmer assembly and rubber coupling sleeve by carefully pulling the coupling sleeve off the drive shaft.
8. Temporarily tape the drive shaft to the top of the cabinet to avoid breakage.
9. Remove the bracket that clamps the shutter frame to the bottom of the cabinet. This bracket is located near the front (inside) of the cabinet and can be released by removing the screw from the under side of the cabinet.
10. Remove the hex-head chassis bolts from the under side of the cabinet.
11. Remove the chassis by pushing the front of the chassis against the left side of the cabinet, and then easing the chassis out of the cabinet while moving the rear of the chassis gradually toward the right. The chassis must leave the cabinet at an angle so that the shutter mechanism will clear the antenna drive pulleys. This step must be performed cautiously to prevent scratching the plastic front plate.

**Picture Tube Replacement.**—After the chassis has been removed from the cabinet, the picture tube may be replaced as follows:

1. Back off the screen locking the shutter actuating link to the magnifier control shaft.
2. Remove the two self-tapping screws that secure the shutter assembly frame to the chassis.
3. Remove the two self-tapping screws that secure the shutter assembly frame to the brace bars.
4. Remove the wing nut and lock washer from the stud on top of the picture tube strap.
5. Remove the shutter assembly by lifting the bronze strap over the stud and sliding the complete assembly forward.
6. Remove the ion trap magnet and the picture tube socket.
7. Loosen the picture tube cushion screws, the focus coil wing screws, and remove the screw from the picture tube strap.
8. Remove the defective picture tube and insert the replacement through the deflection yoke and focus coil, exercising the caution necessary when handling picture tubes.
9. Replace the screw in the picture tube strap and tighten the strap about the tube just enough to hold the tube in place.
10. Replace the shutter assembly and tighten the self-tapping screws only. Do not tighten the picture tube strap wing nut or the set screws on the magnifier control shaft.
11. Position the picture tube so that the clearance between the tube and the mask is approximately one-thirty-second inch.

## Handling of Cathode Ray Tubes

The cathode ray tube bulb (picture tube) due to its large surface area and high vacuum contained within it, is subjected to high air pressure over its entire surface. To understand what takes place when an accidental fracture of the tube takes place, it is only necessary to recall the violent blast which occurs when a small conventional light bulb be imploded. Although the tube face is fairly thick, a fracture of the glass by a blow, or scratch, may cause a sudden collapse, and the force of the implosion, may throw pieces of glass with dangerous violence in every direction.

The following suggestions regarding handling of the picture tube should be put into practice, to avoid damage to the tube or possible personal injury from breakage of it. To prevent injury from picture tube breakage, proceed as follows:

1. Do not unpack the picture tube until ready for use. Exposing it unnecessarily at any time will increase the chances of possible tube damage and injury to personnel.
2. Wear safety goggles when handling the tube and insist upon all persons nearby being similarly equipped with eye protection.
3. Do not allow the metal part of the tube to contact or be brought near any magnetized material. This portion of the tube may become magnetized by such contact, resulting in picture distortion which cannot easily be corrected.
4. Do not handle the picture tube at the bell-shaped glass portion which has been coated with a special insulating material. Finger marks, grease, or other foreign particles may cause high voltage leakage paths under humid conditions.

## Safety Precautions

Although every practical safety device possible has been incorporated in television receivers, certain precautionary measures should be observed in their servicing.

It should be clearly understood that servicing of any television receiver, especially when the receiver is on the service bench and possibly with the safety shield removed, offer many shock hazards to the serviceman and work on the receiver should not be attempted by any one who is not familiar with the necessary precautions while working with high voltage circuits and picture tubes.

The following safety regulations should be observed at all times while servicing television receivers.

## Precautions when Working with High Voltage

1. Respect high voltage circuits and keep away from them.
2. Do not depend upon interlock switches for protection, always disconnect the power cord if any possible danger exists. Interlock switches are not foolproof.
3. Do not attempt to change tubes or make adjustments in the high voltage circuits when the receiver is turned on.
4. Always use a long-handled well insulated screwdriver to short circuit the large capacitor terminals to ground before working on them.
5. Do not attempt to operate the receiver with the high voltage compartment shield removed.
6. Do not attempt to reach within the cabinet while the interlock switch is closed to effect some minor adjustments.

CHAPTER 12

# Projection Type Television Receivers

Projection type television receivers differ from the direct viewing type mainly in that the image produced by a small cathode ray tube is projected by means of a lens system upon a viewing screen.

The picture tubes used in projection type receivers are similar to those used in the conventional direct viewing type of receiver, although smaller in size; the average size having a screen diameter of from three to five inches.

The intensity (brightness) of the image formed, however, is very much higher than that of the direct viewing receiver, being occasioned by about 25,000 volts of accelerating potential, and in deflection signal potentials which of necessity also must be much greater.

The primary purpose of all projection type receivers is to obtain a larger picture, by means of a reflection system, than that possible in the conventional direct view type. This was particularly desirable in the early days of television when screen sizes were limited to seven or ten inches in diameter. Presently, however, with picture tube sizes of twenty inches or more, the need for larger pictures in the average home is not as pressing as heretofore.

In public places, however, such as in auditoriums, taverns, theaters and retail establishments, projection type receivers are sometimes employed due to their larger screen areas, thus permitting a larger number of people viewing the screen without eye fatigue.

There are presently several successful projection type television receiver systems in use, and although they may all differ in design and placement of components involved, they all work on the same principles, that is, they all reflect a picture of high light intensity into a large surface screen by optical means.

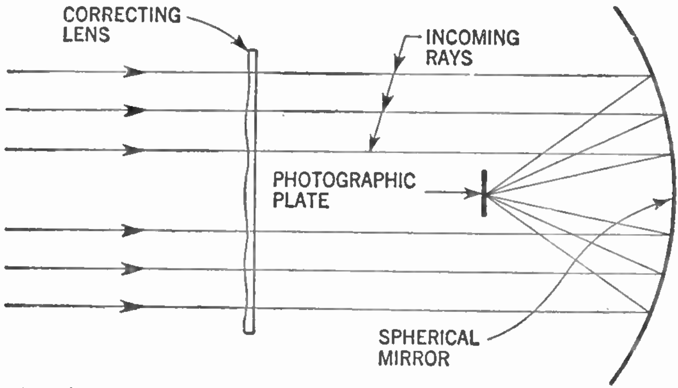



**FIG. 1—Diagram showing Schmidt optical system as developed for astronomical telescope.**

**Reflective Systems.**—There are several basic reflective systems presently in use, all of which employ the *Schmidt** optical system, the most well known being the RCA., GE, the Philco and the North American Philips systems.

In a typical Schmidt reflection system such as that shown schematically in fig. 2, it will be observed that light from the

*Herr Schmidt, an instrument marker at the *Hamburg German Astronomical Observatory* invented his optical system in 1931. The system originally designed for astronomical telescopes, was built around a large spherical reflecting surface or mirror. Thus, although designed for a different purpose, it was found to be ideally suited for the art of television image projection.

picture which is formed on the spherical face of the cathode ray tube is collected by the spherical mirror and reflected back to focus on the viewing screen. In the process the light passes through the aspheric corrector lens which corrects for spherical abberation of the spherical mirror and is turned at right angles by the plane mirror set at 45 degrees.

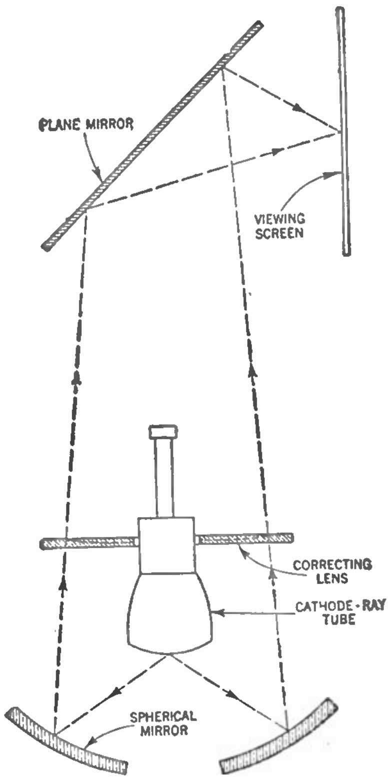



**FIG. 2—Showing elements of a Schmidt reflective optical system used in television receivers to produce an enlarged image by projection.**

In the *RCA* and *GE* projection type receivers, figs. 3 and 4 the optical mirror is mounted on the bottom of the cabinet with its axis vertical, projecting the image straight up and onto a flat mirror inclined at 45 degrees to the beam of light and throwing the image on a translucent screen.

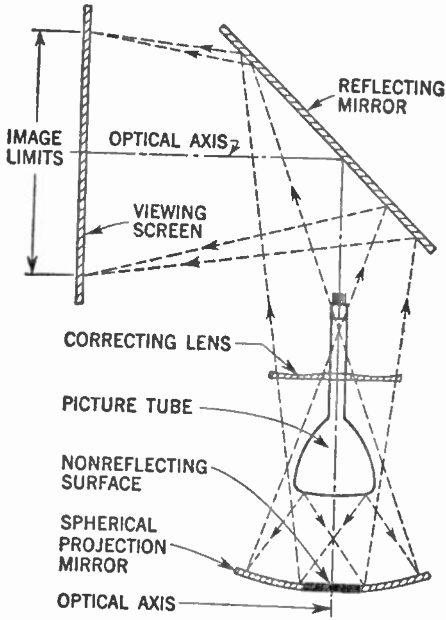



**FIG. 3—Showing schematic arrangement of optical components in a Schmidt system as adapted for projection type television receiver used by the General Electric Co. and the Radio Corporation of America.**

The distance between the correcting lens and the viewing screen will depend upon the diameter of the correcting lens and the spherical mirror. Therefore, in order to increase the size of the projected image, this distance must be increased, necessitating large cabinets, a large mirror and a large correcting lens.

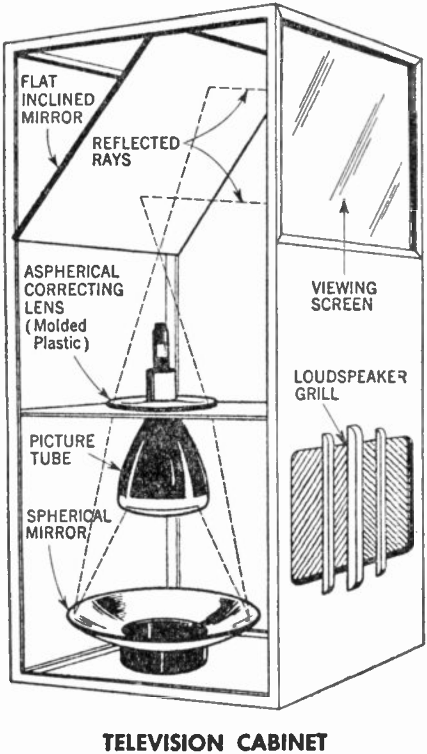



**FIG. 4—Location of optical units in a television receiver cabinet. These are shown schematically in fig. 3.**

From the foregoing it follows, that in order to obtain a large image with a system of this type, the optical system and cabinet has a tendency to become large and unwieldy. A compromise is thus necessary between the size of the final image and the cost and size.

The *Philco Corporation* projection type receiver illustrated in fig. 5 differs somewhat in the arrangement of the optical system. Here the required distance between the corrector

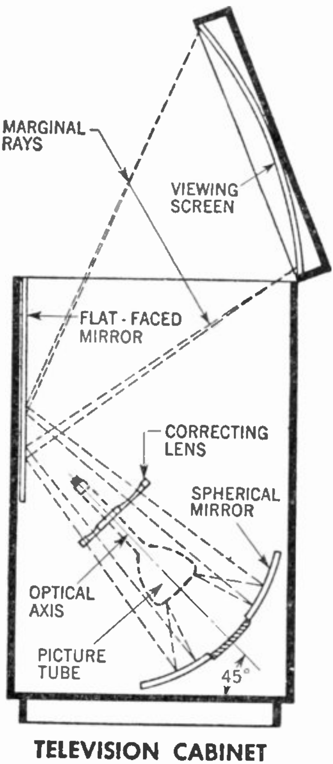



**FIG. 5—Arrangement of optical components in a Philco projection system.**

lens and the screen is considerably smaller for a similar size image than that in the foregoing type of projection type receivers.

Each of the reflecting plane mirrors in all these optical systems are front-surfaced mirrors to prevent ghosts which would occur from reflections at the surface of the glass of a rear surfaced mirror.

In the Philco projection receiver the screen is designed to have a viewing sector which extends 60 degrees horizontally and 20 degrees vertically. To obtain this directivity the screen contains a large number of vertical grooves, spaced at random. These vertical grooves are responsible for the horizontal directivity of the screen. To obtain the 20 degree vertical directivity, the screen surface is made concave.

The screen in addition to its directional properties, also possesses a great minute or lenticular elements each of which redistributes or diffuses the light reaching it uniformly throughout the desired sector. The overall brightness of the screen is approximately 50 foot-lamberts.

It will also be observed, that since in the Philco projection method the optical system is mounted at an angle and projects on the screen at an angle, a rectangular image projected from the face of the picture tube would appear on the screen as a trapezoid, that is, the image would have sloping sides, with the top larger than the bottom. If, on the other hand, a trapezoidal image were projected from the picture tube a rectangular image would be obtained on the screen. This latter method is employed in the Philco system.

The formation of a trapezoidal pattern is obtained by applying a magnetic field at right angles to the electron beam. To produce this magnetic field, two opposite polarized magnets are mounted opposite each other on the end of the picture tube as illustrated in fig. 6.

An iron pole piece, curved to suit the sides of the tube, is attached to each magnet and is employed to produce a strong magnetic field for deflecting the electron beam upward near the tube face. The opposite polarized ends of the magnets farthest from the tube face cause a lesser and downward deflection of the beam before it is deflected upward. The result is the same as that which would be produced if the face of the tube were tilted inward, that is, the distance the beam travels to the bottom of the image is reduced and the distance to the top is increased.

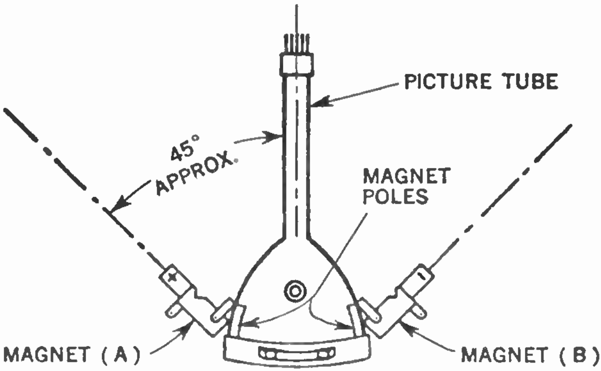



**FIG. 6—Showing arrangement of magnets fitted to the picture tube face to produce a trapezoidal image. In the illustration magnet A affects the left edge, while magnet B affects the right edge of the image.**

In the *GE* and *RCA* projection type receivers, on the other hand, no additional bar magnets are necessary, since the translucent screen is not slanted and hence is perpendicular to the axis of the optical system and consequently a rectangular image on the projection tube face appears as a rectangle on the screen.

A third type of television projection system being another variation of the *Schmidt* optical system is shown in fig. 7. It has been developed by *The North American Philips Co.* and is known under the trade name of *Protelgram*. This system has the advantage over the previously discussed types in that it occupies only about one half of the space employed by the conventional *RCA*, *GE* and *Philco* methods of projection.

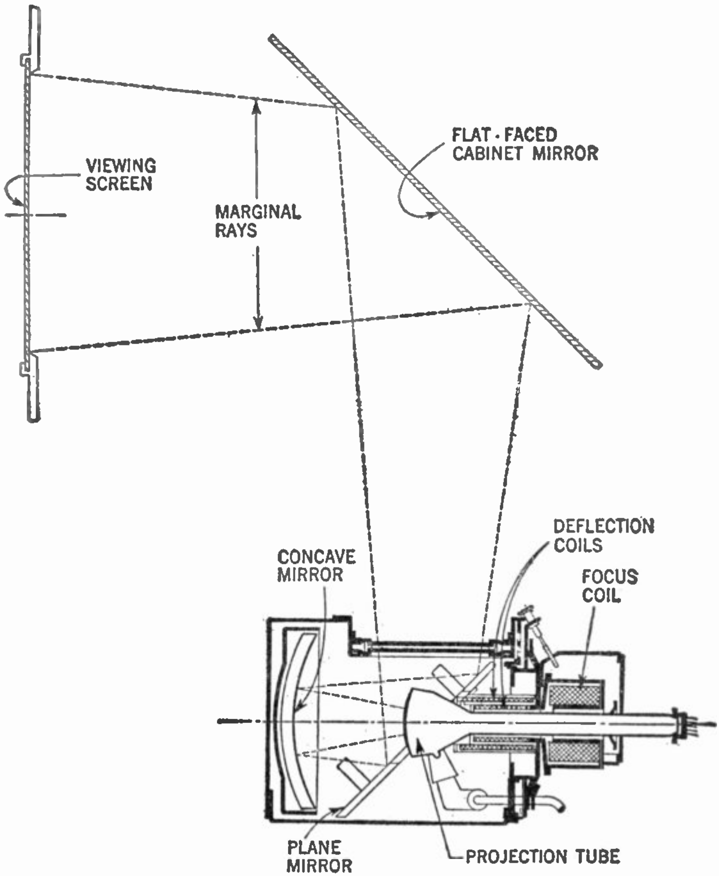



**FIG. 7—Showing various components of the optical unit employed in the Philips projection type television receiver.**

This system as illustrated in fig. 7 employs a "folded" light path by means of which it is possible to mount the projection tube with its optical system within a small metal enclosure, thereby producing a very compact arrangement.

The optical system comprises a spherical mirror, an aspherical corrector lens and a special plane mirror to "fold" the light beam. These three elements form an optical triangle within the optical unit and are carefully adjusted by the manufacturer. The optical unit is dustproof, with only the upper face of the corrector lens being exposed.

The light being emitted from the tube face is gathered by the spherical mirror, reflected to the plane mirror and then projected upwards through the corrector lens. At the center of the plane mirror there is a hole large enough to permit the projection tube face to be inserted through it.

Behind the mirror ample room is provided for the deflection and focusing coil of the tube, in addition to whatever tube supports are required. Because of this there is no interference from the coils and the neck of the tube since these are behind the plane mirror.

The specific features required in any optical projection system are as follows:

1. The optical mounting assembly alignment adjustments must be accessible and simple in construction.
2. The optical assembly must be dustproof to prevent loss of contrast and brightness by dust collection.
3. The optical assembly must be electrically shockproof to provide adequate protection from the high voltage necessary at the projection tube.
4. The optical barrel must be metallic to prevent radiation of X-rays generated by the high voltage cathode ray tube.
5. The system as a whole must be simple in order to lend itself to an inexpensive manufacturing method.

**High Voltage Systems.**—The second anode voltage employed by receivers having small or medium size direct view picture tubes are usually from 7 to 10 *kv*. A typical high voltage system of this type is shown on page 185.

With receivers containing direct view picture tubes of 15, 16 and 20 inches in diameter, and projection type tubes, 10 *kv*. is insufficient, and as a consequence, the high voltage section of the receiver must be designed to supply this higher voltage. Receivers equipped with 15 or 16 inch picture tubes require about 12 *kv*. and this can be obtained from the circuit shown in fig. 8.

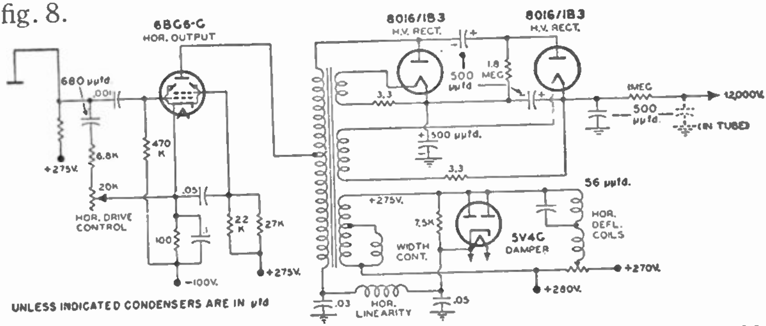



**FIG. 8—Circuit diagram of a flyback high voltage power supply unit capable of producing 12 kv. second anode potential for the direct view picture tube.**

When the television receiver employs a projection type tube, 20 to 30 *kv*. is necessary. In the *RCA* and *Philco* systems a retrace transient is used to generate a high voltage pulse which is rectified and used as a *dc*. potential to be applied to the projection tube.

In the *Philco* projection television high voltage system, a 7 *kv*. transient from the horizontal output stage drives a series of three rectifying diodes, charging three capacitors in sequence to a value of 20 *kv*. which is applied to the second anode of the projection tube.

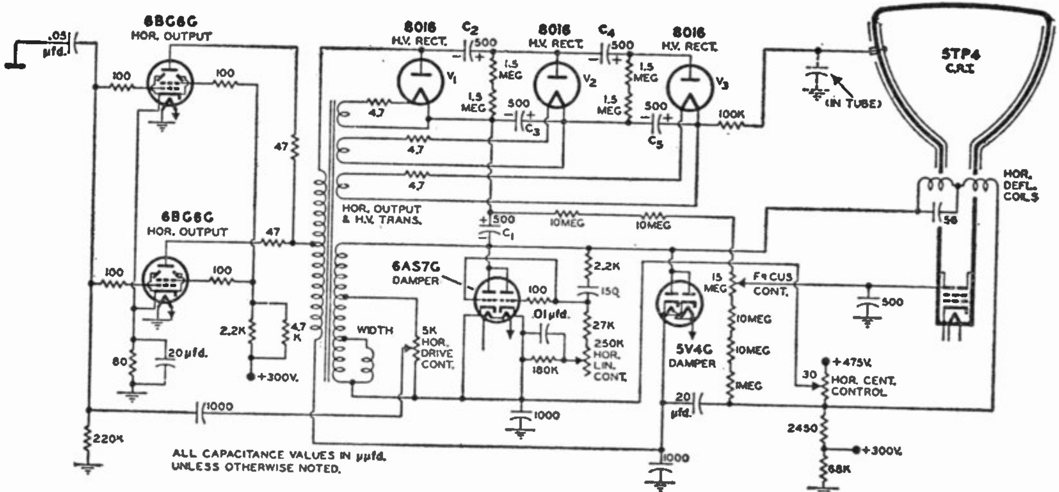



FIG. 9—Circuit diagram of a high voltage flyback power supply unit capable of producing 27 kv. for a projection type picture tube.

The North American Philips high voltage power supply, fig. 10, requires 25 *kv*. for their two and one-half inch projection tube. This high voltage supply is known as a *pulse type* and differs from the *flyback type* mainly in that a separate pulse generator is employed, operating at a frequency which is considerably lower than the horizontal sweep frequency.

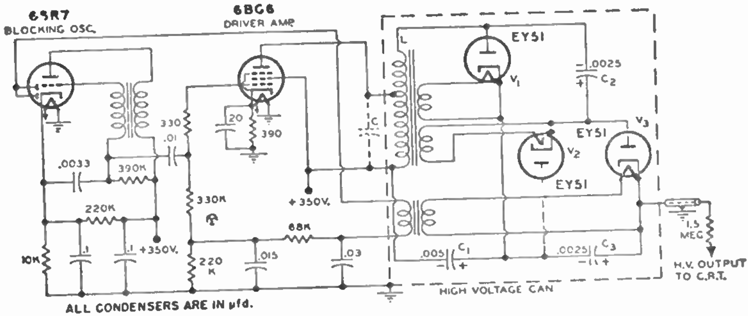



**FIG. 10—Circuit diagram of North American Philips pulse type high voltage power supply unit.**

The circuit of the power supply consists of a blocking oscillator, a driver amplifier, and a three tube, cascaded, high voltage rectifier. The blocking oscillator is conventional in form and operates at a frequency of approximately 1,000 cycles. It produces a saw tooth voltage which is applied to the grid of the following *6BG6* driver amplifier. The grid of this tube is biased beyond cut-off so that the plate current flows only during the upper third portion of the saw-tooth wave.

At the peak of the saw-tooth, the grid voltage of the *6BG6* drops sharply into cut-off, stopping the flow of plate current. Due to the inductance in the transformer windings, and the stray capacitances across them, the system is shocked into oscillations.

The values of these components are chosen to produce transient oscillations having a frequency of about 25 *kc*. The oscillations continue until the next flow of plate current from *6BG6*.

When the *6BG6* conducts again, it loads down the circuit, stopping the oscillations. The sudden stoppage of the plate current at the end of each plate current pulse then shock excites the transformer back into oscillations at its natural frequency of 25 *kc*.

The voltage developed across the full primary winding of the output transformer is rectified by the three rectifying tubes to provide an ouput voltage of 25 *kv*.

CHAPTER 13

# Television Test Equipment

In the alignment and trouble shooting of a television receiver, a number of factors must be considered. The test equipment employed should be suitable for this type of work. All pertinent data relating to the television receiver to be aligned, should be available for reference and the manufacturer's alignment procedure must be followed closely.

**Test Equipment Required.**—At the outset it should be pointed out that no set of rules as to the number and exact specifications of the instrument required can be given here. Rather an effort will be made to give the most common type of equipment necessary in the average practice, and also to explain how these equipments are used to accomplish their assigned function.

The intelligent servicing of a television receiver requires, *first*, a knowledge of the operation of the receiver; *second*, a knowledge of the normal wave forms to be expected in the circuit of the particular equipment.

Test equipment necessary for alignment and effective trouble shooting usually found in the average television service shop, are as follows:

1. Oscilloscope.
2. Sweep generator.
3. Signal generator.
4. Vacuum tube volt-ohmmeter.
5. Miscellaneous test equipment.

*The oscilloscope* is one of the most useful piece of testing instrument, and has numerous uses. One of its most common uses is in the sync and sweep circuits of a television receiver to observe the fidelity of the various wave forms and to check their presence at various points. It is also necessary to use an oscilloscope when alignment is performed with a sweep generator. It can also be used with a modulated signal generator to align wave traps and other narrow band circuits.

The function of a *sweep generator* is to assist in the alignment of the video *r.f.* and *i.f.* sections of the television receiver. It is also used in the alignment of the narrower band sound *i.f.* system and particularly in alignment of the discriminator.

*The signal generator* is an instrument whose frequency is periodically varied between certain desired limits. An accurately calibrated signal generator is necessary in the alignment of critically tuned traps and other sharply tuned circuits. If the sweep generator does not incorporate an internal marker system, it is necessary to employ a signal generator to calibrate the response curves on the cathode ray oscilloscope screen. In addition an *r.f.* signal generator is also used to signal trace the *r.f.* and *i.f.* circuits to locate a dead or faulty stage.

*The vacuum tube volt-ohmmeter* is another useful piece of test equipment. The input resistance of this instrument should be at least 20,000 ohms per volt or more on the *d.c.* ranges. In a meter of this type, the meter load on the circuit to be tested will be very slight.

The ohmmeter scales should extend to at least 10 megohms, while the *d.c.* voltage ranges to approximately 600 volts will be sufficient. Extremely high *d.c.* voltage ranges may be of assistance when measuring the high voltage power supply output, but troubles can usually be checked by resistance continuity measurements.

A fraction of the high voltage output can usually be measured by means of a very high voltage divider when necessary. The *d.c.* voltmeter for this measurement must be of very high resistance because of the high resistance in the circuit to be checked.

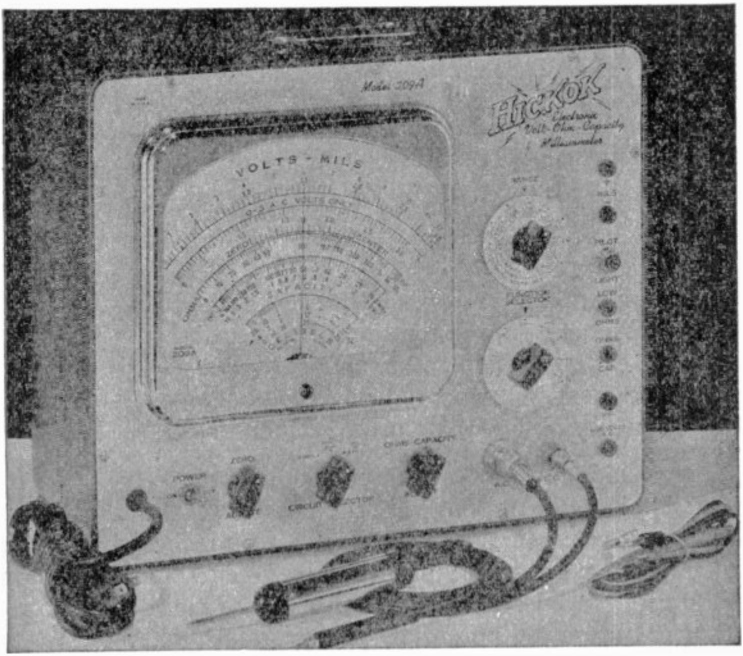



**FIG. 1—Typical volt-ohmmeter, suitable for television receiver testing and alignment work. (Courtesy Hickok Electrical Instrument Co.).**

The *a.c.* meter range is normally employed only for checking of filament voltage and for measuring audio output. In measurements of *a.c.* video signal voltages an *r.f.* voltmeter with a probe will be required.

**The Oscilloscope.**—Few instruments are of greater utility in television receiver testing, than is the oscilloscope. A cathode ray oscilloscope is necessary when alignment is performed with a sweep oscillator. It can also be employed with a modulated signal generator to align wave traps and other narrow band circuits. It is also used in the sync and sweep circuits of the television receiver to observe the fidelity of the various wave forms and to ascertain their presence at various points.

*Necessary Components.*—The necessary components of a cathode ray oscilloscope are:

1. The cathode ray tube.
2. A high potential supply, 1,500 volts or more for electron acceleration.
3. Amplifiers for vertical and horizontal deflection.
4. Low voltage supply for amplifier operation.
5. A linear sweep generator, and
6. Some means of synchronizing the sweep generator to the frequency of the wave form being observed.

The cathode ray tube was discussed in Chapter 11. Specific features for oscillographic work include electrostatic focus and deflection, screen sizes ranging from 3 to 9 inches and usually willemite as a phosphor, producing a green trace of medium persistance. Deflection sensitivities of the cathode ray tube at normal operating potentials vary from 40 volts per inch to 80 volts per inch of deflection.

High voltage is derived from a transformer rectifier system with filtering by *RC* components, representative values of filter being 100,000 ohms and 0.1 *mfd*. Current drain is very low, in the order of one milliampere. A voltage divider supplies decreasing potentials to the electron gun elements, focus and intensity being variable to effect optimum performance.

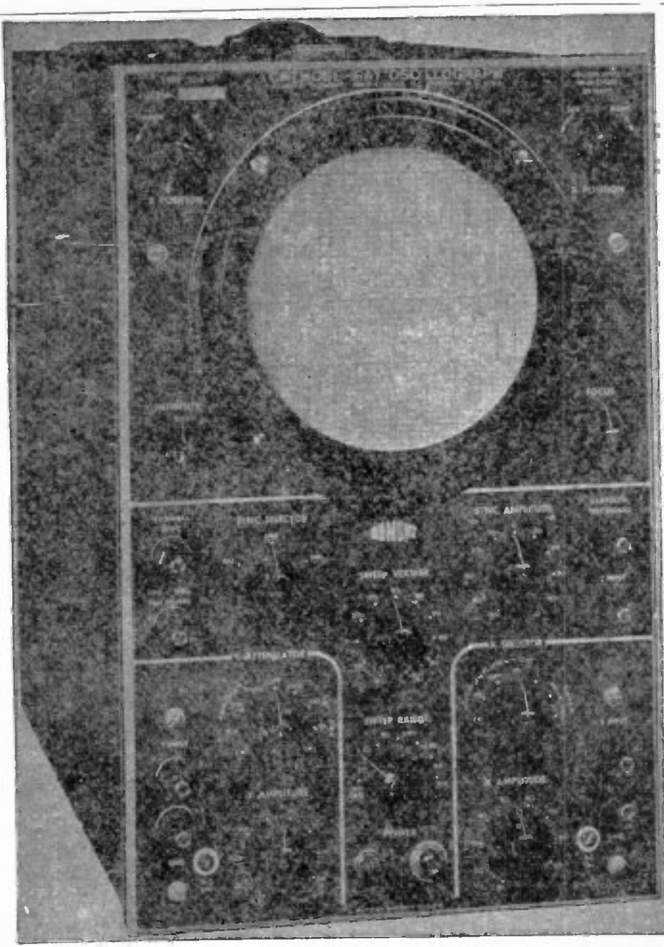


FIG. 2—The *DuMont Type 304-H* cathode ray oscilloscope. This is a satisfactory oscilloscope for routine television servicing, which can be used as alignment scope and for signal tracing purposes in the sync and sweep systems of the receiver. The horizontal amplifier is basically similar to the vertical amplifier, the primary difference being that the horizontal amplifier is less sensitive having a gain of about 4,000.

The amplifiers, particularly the vertical amplifier, determine the utility of any particular oscilloscope in television receiver testing.

The best criterion of satisfactory operation is the faithful reproduction of a square pulse at a repetition rate of from 100 to 15,000 cycles per second. Defined in terms of frequency response, which does not take into account phase discrepancies, this is, roughly, uniform response from 30 to 150,000 *c.p.s.*

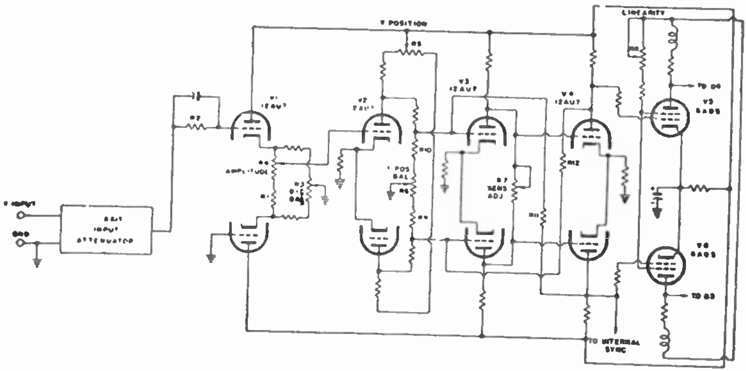


**FIG. 3—Simplified schematic diagram of vertical amplifier, *type 304-H* cathode ray oscilloscope. (Courtesy Allen B. DuMont Laboratories, Inc.).**

High gain in the vertical amplifier is a necessity. Typical oscilloscopes incorporate a vertical amplifier gain of 2,000 which is quite sufficient for television receiver testing.

No comment concerning the low voltage power supply is in order, it being invariably conventional in design, except to state that some manner of voltage regulation is to be desired for stability of the reproduced trace.

The oscilloscope in the low or medium price class will employ a gas discharge tube as a source of saw tooth sweep potentials. Specialized instruments might employ a multivibrator generator.

The synchronizing of the sweep generator frequency to that of the wave form being observed is accomplished through a switching arrangement, from two or three possible sources; external, internal or 60 cycles. Each switch position connects the sweep generator to the respective sources. The external

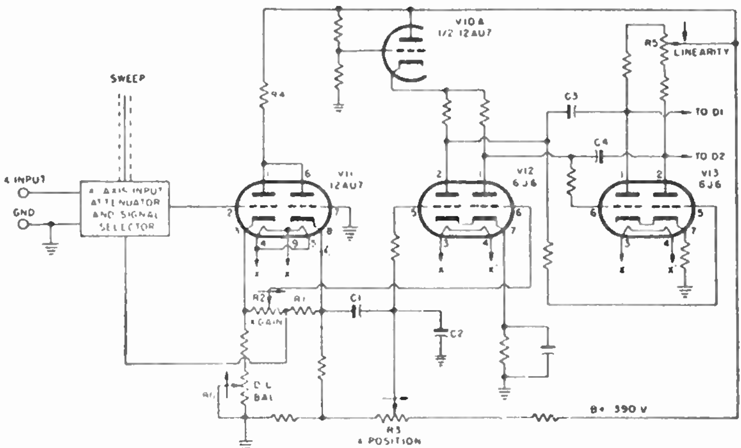



**FIG. 4—Simplified schematic diagram of horizontal amplifier, *type 304-H* cathode ray oscilloscope. (Courtesy Allen B. DuMont Laboratories, Inc.).**

position allows injection of sync through a binding post on the front of the instrument. This allows any pulse, whether actually derived from the trace under observation or not, of the correct frequency to synchronize the trace. It is thereby possible through the use of a phase shifting network, to vary the portion of the pattern at which the trace begins and so change its position on the screen. A 60 cycle sync is usually internally provided because a larger proportion of the traces encountered are some multiple or submultiple of this frequency.

Internally, the signal synchronizes itself since a portion of the signal is extracted from the vertical amplifier and injected into the sweep generator.

A complete treatise on the use of the oscillograph is beyond the scope of this Chapter. Herein is included, however, some few basic operational procedures which may well serve as a guide to the serviceman who has not extensively used the instrument.

*Controls.*—The following controls are normally to be found on the oscilloscope:

1. Vertical gain, coarse.
2. Vertical gain, fine.
3. Horizontal gain.
4. Timing, coarse.
5. Timing, fine.
6. Sync control.
7. Focus.
8. Intensity.
9. Vertical centering.
10. Horizontal centering.
11. Sync selector switch.

The meaning of these labels is doubtless selfevident. Proficiency in their use, particularly in connection with 4, 5 and 6 comes only with practice. Perhaps the greatest difficulty that will be experienced, aside from the proper interpretation of the reproduced trace, will be that of obtaining stability of the trace; a function of the three aforementioned controls.

Perhaps the most outstanding cause of failure to consistently obtain a stable pattern lies in the use of excessive synchronizing potentials, which excess may cause irregular synchronization and the loss of a portion of the desired sweep trace. In adjustment, it is improper to vaguely set the timing (sweep repetition rate) controls and to attempt final stabilization by greatly advancing the sync control. Rather, the sync control should be first adjusted to a moderate value and the picture stabilized by the fine timing control. Should insufficient sync be then had, as evidenced by inability to "stop" the picture, then the sync control may be advanced slightly and the fine sweep control readjusted.

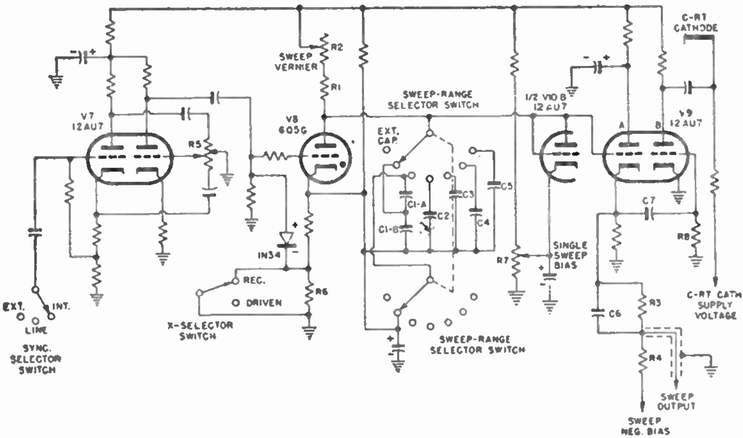
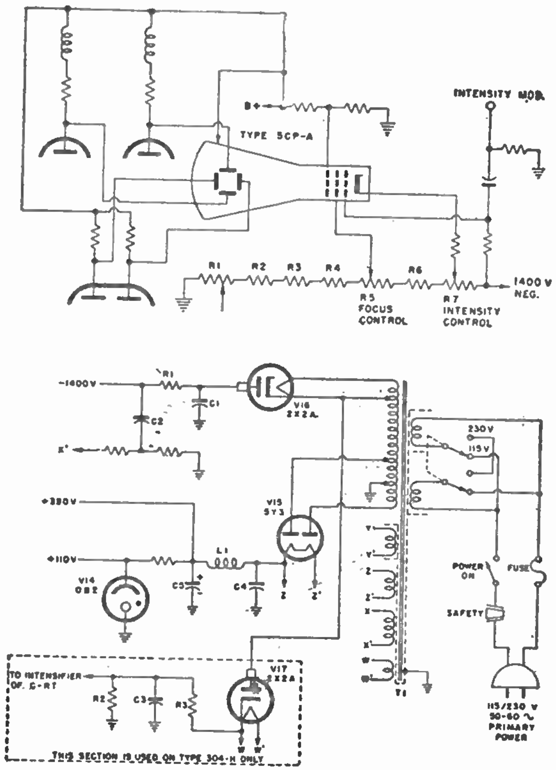



**FIG. 5—Simplified schematic diagram of sweep circuit, *type 304-H* cathode ray oscilloscope. (Courtesy Allen B. DuMont Laboratories, Inc.).**

It should be remembered that, for a single cycle of reproduction, the oscilloscope sweep repetition rate must be equal in frequency to that of the wave form being observed. For two cycles of reproduction, it must be one-half; for three cycles, one-third, etc.

Detailed operational procedures may be had from the instruction manual accompanying the instrument.

*Necessary Characteristics.*—The characteristics of a test oscilloscope must of necessity be considered prior to its use for alignment and trouble shooting of a television receiver. Some of these are given in the following:




**FIGS. 6 and 7—Simplified schematic diagrams of cathode ray tube circuit and power supplies respectively, *type 304-H* cathode ray oscilloscope. (Courtesy Allen B. DuMont Laboratories, Inc.).**

*Sensitivity.*—Most instruments, even among the more expensive types, incorporate vertical deflection amplifier having insufficient sensitivity for use in television receiver alignment. In fact, the attempted observation of the pass band of the last *i.f.* transformer is met with either no trace at all upon the screen, or one so small as to be of no value. Therefore, the gain should be at least 1,000 times.

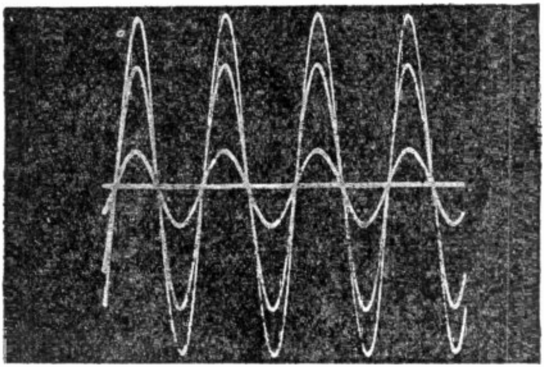


**FIG. 8—Typical oscilloscope wave pattern. The wave pattern shown is obtained by multiple exposure of sine-wave at 3 settings of vertical gain. Note that synchronization and sweep length remain constant at all settings.**

Usually this sensitivity or gain is measured in *r.m.s.* volts input per inch of vertical deflection (at maximum gain) typical values being in the order of 0.3 volts. Absolute gain at this rating and vice versa, necessitates knowledge of the oscilloscope tube deflection sensitivity at a given acceleration potential. If it be assumed that this is, say 75 volts per inch, the gain of the amplifier in such an instrument is therefore 75/0.3 or 250.

Under the foregoing conditions, it is then necessary in observing the passband of a single stage having low gain, to obtain as much as 0.3 volts from the generator for one inch deflection and 0.9 volts for three inch deflection. This has been found to be impossible with most, if not all, available sweep generators.

A gain of 1,000 on the other hand, would give a sensitivity of 75/1,000 or 0.075 volts per inch, which is probably a minimum and a gain of 1,500 or 2,000 being much more useful and desirable. Few instruments meet this requirement, although some very widely used in laboratory and field application, have a rated sensitivity of 0.02 volts per inch deflection at maximum gain, which is usually more than is required.

*Frequency Response.*—Generally commercial oscilloscopes, depending upon the particular design, have a low frequency limit somewhere between 10 and 100 cycles, and a high frequency limit of between tens of thousands of cycles and one-half mc.

It is sometimes erroneously contended that since video frequencies in excess of 4 mc. are encountered, the oscilloscope must be responsive to this limit. Stress is placed upon the wide passband of some instruments in promotion literature. There are, in laboratory usage, instruments extending as high as 20 or 30 mc. which are advantageous in specialized applications. At the same time, there are instruments giving practical satisfactory performance, whose response extends only to 75 or 100 *kc*.

It should be realized that in general testing and servicing, it is of no advantage to observe the higher frequency component of the video signal. These are the impulses which reproduce the fine detail of the image, which can only be interpreted from the face of the picture tube itself; their presence in the oscilloscope reproduction of the video signal means nothing.

Secondly, limited high frequency response will cause a rounding-off of the sync pulses, and the question therefore is primarily how high it will be necessary to go in order to satisfactorily reproduce these.

In the design and laboratory applications, it is often necessary that exactly true visualization of the wave front be obtained, and that harmonics in the order of 100 or more be present.

Receiver testing, however, permits some distortion and, furthermore, the high frequency response of the sync circuits themselves are quite low. Typical of such circuits may use a plate-load resistor of 68,000 ohms and have a lumped capacity to ground of 50 *mmfd.*

This gives a high frequency cutoff of

$$f = \frac{1}{2\pi RC} = \frac{1}{6.28 \times 68{,}000 \times 50 \times 10^{-12}} = 46{,}800 \ c.p.s.$$

From this it follows that it would be of no particular advantage to use an oscilloscope whose frequency range extends to 5 mc. in such an application.

High frequency response in the vertical deflection amplifier might well be for general testing and servicing, essentially flat to 100 *kc.* beyond this, the added cost is not justified by increased utility.

Low frequency response is an item often neglected in considering the oscilloscope, yet it may be such that distortion is introduced. With poor low frequency response resulting in a large amount of distortion, it is naturally impossible to judge the circuit under test and the reproduced pulse values are therefore of no value.

*The Input Cable.*—The input cable should always be of as low capacity as possible. Ratings are in a given number of *mmfd.* per foot of length. The impedance of the cable is of no consequence when working at the signal frequencies encountered. It is to be anticipated that high impedance and low capacity are inseparable, but in any given cable of 100 ohms impedance, various capacities are represented. The choice of a cable, should therefore be upon the basis of capacity only, and should not be excessively long.

*Horizontal Deflection Amplifier.*—Of less consequence than the vertical amplifier, is the horizontal amplifier and it is usually not compensated to the degree that is found in the vertical. Usually, its low frequency response is such that the sweep is not linear (non-linearity exists also in the sweep oscillator output wave form) causing the reproduced trace to be more narrow at the right-hand side of the screen than at the left. High frequency response is limited because it must only reproduce the sawtooth wave form which contains not as many high frequency components as does a pulse. Of course, the retrace time indicates a rather high frequency, but some types of distortion therein (amplitude distortion, not phase) do not harm. The retrace is not used in the conventional oscilloscope for visible reproduction.

*Oscilloscope Loading.*—Of more concern is the matter of overloading in the amplifier. Quite often it is desirable to expand the horizontal sweep so that it extends far beyond the limits of the screen. This calls for an amplifier which is capable of developing sweep potentials greatly in excess of that necessary to the three to five inches of active screen. Then there is the likelihood of overload and compression of the sweep at either or both ends. This may or may not be apparent by mere observation of the trace, but may be definitely determined by placing a signal upon the vertical plates; this signal could for a simple test, be had by simply placing a finger upon the vertical input terminal. The horizontal amplifier should be such that this overloading condition is not apparent with horizontal sweep at its maximum and the horizontal positioning control rotated to extreme limits.

*Testing the Oscilloscope.*—If it be desired to test the vertical response of an instrument prior to purchase, or to determine its true operation in application, this may readily be done by applying to the vertical input, the output of a variable frequency square wave generator. Provided that its output is a true square wave, any departure therefrom on the screen is indicative of faulty operation. Frequencies should be between 30 and 15,000 cycles.

Should there be no distortion whatsoever the vertical amplifier response is acceptable. By distortion in this connection is meant that the reproduction should not depart from the square wave, that is, the leading and lagging edges should be fairly straight, the corners square, and the baseline straight.

*Other Features.*—Other features of the oscilloscope are more or less optional. It may have a three or five inch screen, although those with three inch screens are usually somewhat limited in other necessary requisites, due to economical considerations.

Some instruments have provisions for internal sync at 60 cycles, and in this association a phasing device permitting the pattern to move along the frequency or time axis. These may readily be provided, however, by external devices of simple construction. It is immaterial whether the tube deflection plates be brought out to external connections, since these have little application in receiver testing.

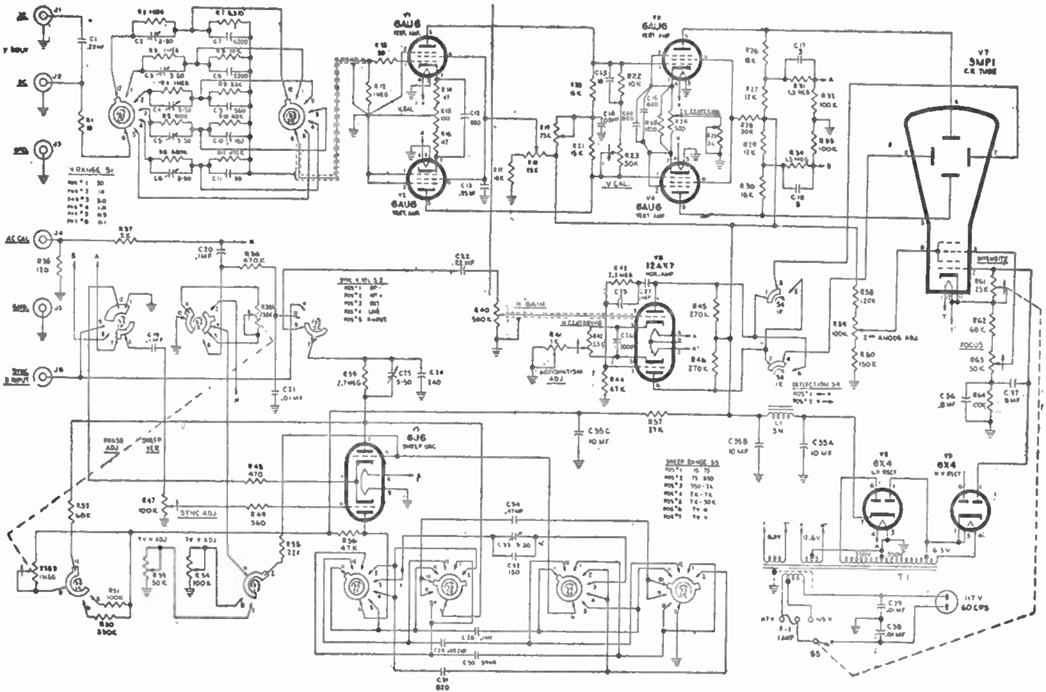



FIG. 9—Schematic wiring diagram of *R.C.A.* cathode ray oscilloscope *type WO-57A*.

Also the so called "Z" axis is of little consequence in television testing work. This is a connection either directly or through an amplifier, to the control grid of the oscilloscope tube. Its function is to cut off the beam at some desired time, for example, one of the two traces obtained from sweep generator operation may be eliminated by the application of a negative potential to this grid during the time of one of the traces.

**Sweep Generator.**—In television testing and alignment the requisites of the sweep generator are far more stringent than in other types of work, due to the higher frequencies and increased sweep width required.

*Center Frequency.*—The requisites for "in center frequency" is that the generator should cover at least to the highest intermediate frequency of television receivers, that is, slightly under 40 mc. (most receivers employ less than 30 mc. as intermediate frequency). This is a minimum requirement, and it should preferably extend also to the *r.f.* ranges of 220 mc.

*Sweep Width.*—The sweep excursion must be somewhat in excess of the greatest bandwidth encountered in television, which is 6 mc. A sweep width of not less than plus and minus 4 mc. (8 mc. overall) with plus and minus 8 or 10 mc. is a more desirable range. Should the sweep excursion be too narrow, then the reproduced traces will be excessively broad and they may not include the adjacent channel frequencies at which traps are sometimes placed. As a consequence the two reproduced traces will merge into one where the sweep is very much inadequate.

*Amplitude Modulation.*—Although amplitude modulation in the sweep generator renders many such instruments useless from a practical standpoint, its effect is obvious and therefore need not be further discussed. The ideal instrument supplies signal of amplitude level at a constant under frequency sweep.

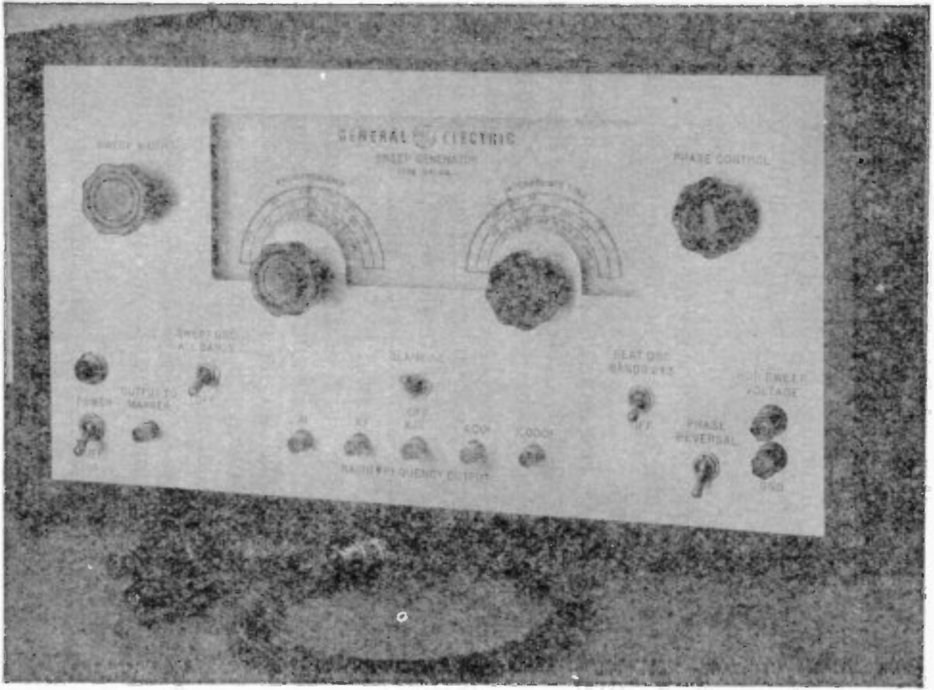



**FIG. 10**—Exterior view of the *General Electric* sweep generator, *type ST-4A*. This sweep generator has a variable frequency of from 4 to 110 mc. and 170 to 220 mc. in two bands.

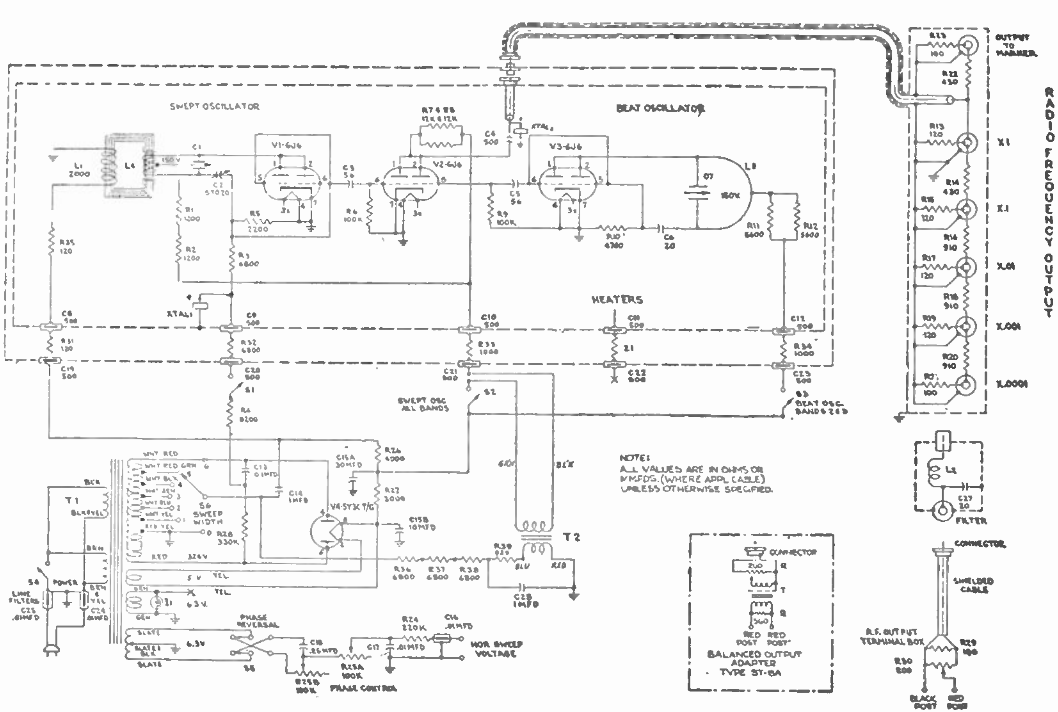



FIG. 11—Schematic wiring diagram of the *General Electric* sweep generator, *type ST-4A*.

Any changes under that sweep, obviously will show in the reproduction as though they had been produced by the circuit under test, resulting in a false reading.

In considering any particular instrument, its amplitude modulation may be determined by:

1. Reduce sweep to a minimum.
2. Provide some means of measuring output potential such as a vacuum tube voltmeter.
3. Manually vary the frequency over the frequency limits to be checked, while noting changes in the amplitude of the signal input.

In the absence of a vacuum tube voltmeter, amplitude modulation in the sweep generator may be observed by comparing the reproduced trace of a given bandwidth circuit with the hand-plotted graph obtained with a signal generator of constant output, suitable detector and high impedance meter.

Amplitude changes are commonly found in lower grade instruments, which necessitate careful checking prior to purchase. They arise from the fact that the instrument internal circuits are frequency discriminant; the ratio may be as high as 2:1 in typical units.

Of course, some changes in output signal level over a wide variation in frequency may be expected in any instrument, but it is necessary that there be essentially none over the sweep excursion at any useable portion of the center frequency scale.

Summing up, it follows from the foregoing that amplitude modulation, narrow sweep excursion, in addition to a low maximum output level constitute major points to observe in any sweep generator.

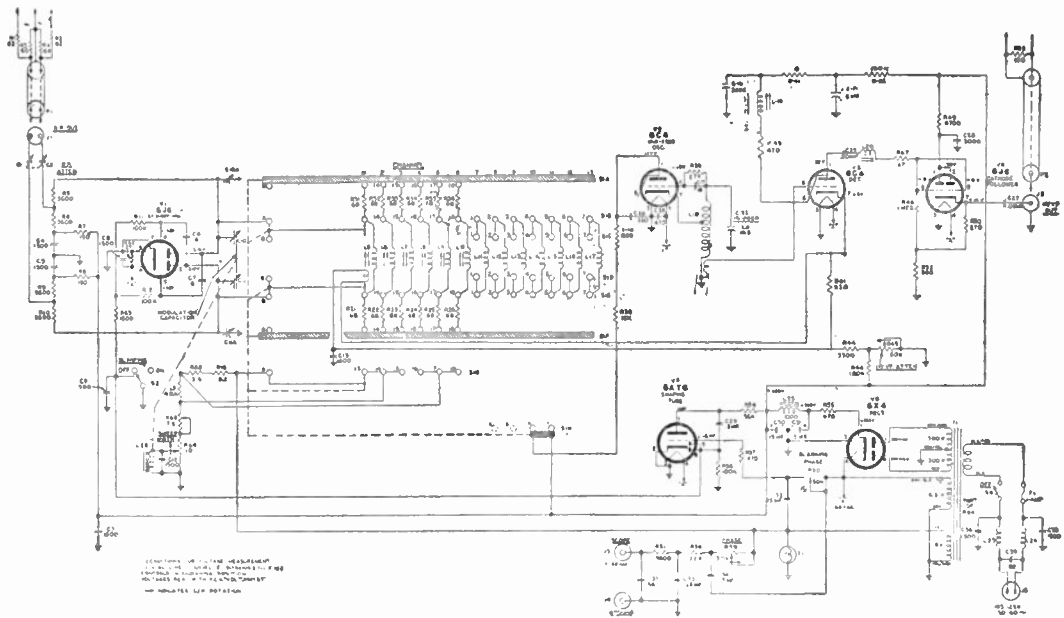


FIG. 12—Schematic wiring diagram of the *R.C.A. type WR-59B* television sweep generator. Used with an oscilloscope, this instrument will provide a visual pattern representing the response curve of the circuit under test on the oscilloscope screen. The sweep generator is designed to furnish a wide frequency modulated signal to cover each of the 12 standard television channels as well as all other frequencies between 300 kc. and 50 mc.

**Signal Generator.**—If the sweep generator does not incorporate internal marker circuits, it will be necessary to employ the signal generator (without modulation) as a means of identifying

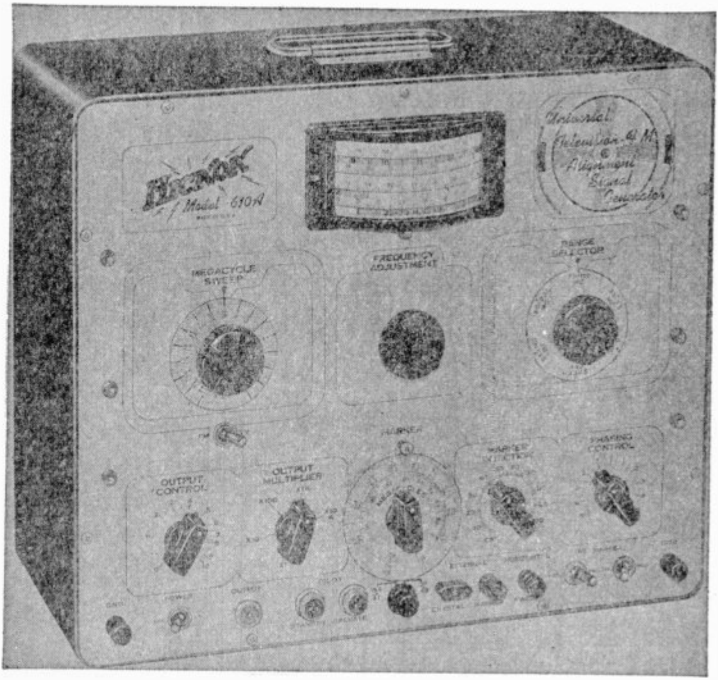



FIG. 13—Illustrating *Hickok Model 610A* television alignment signal generator.

frequencies within the reproduced trace. As such, its calibration must be quite accurate. In fact it is recommended that a crystal calibrator be frequently used, since the calibration of most service type signal generators changes from time to time.

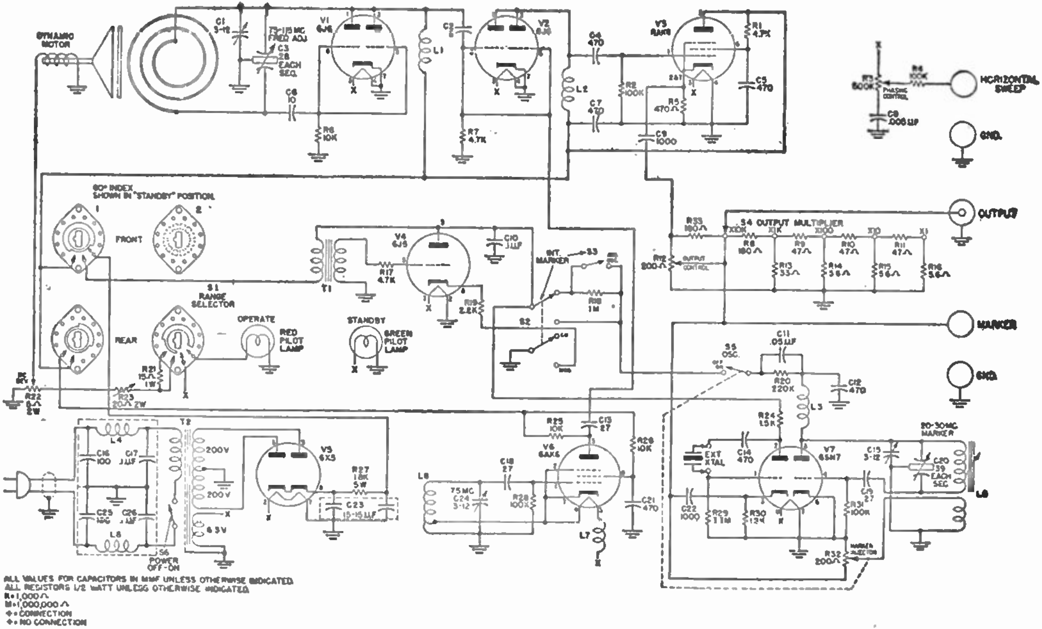



**FIG. 14—Schematic wiring diagram of *Hickok Model 610A* television alignment signal generator.**

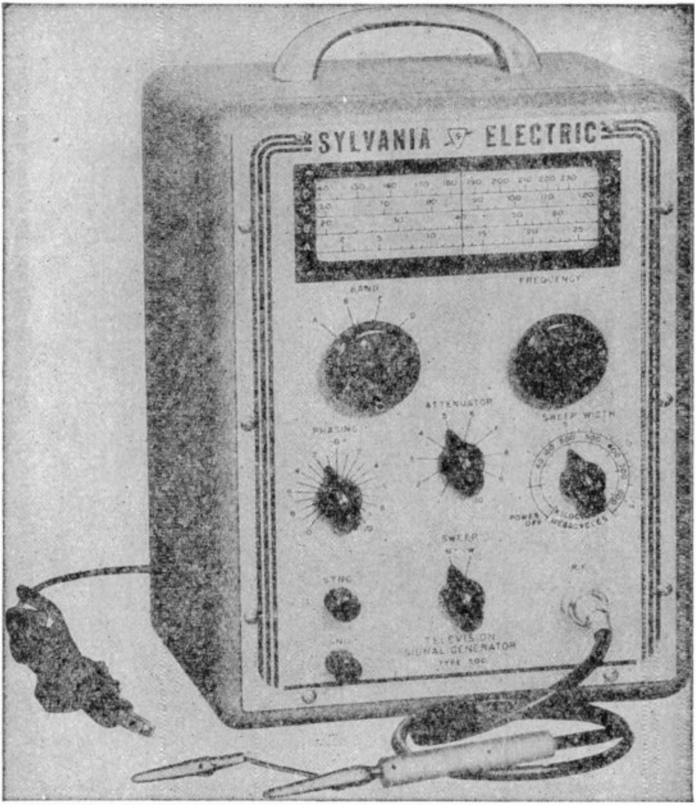
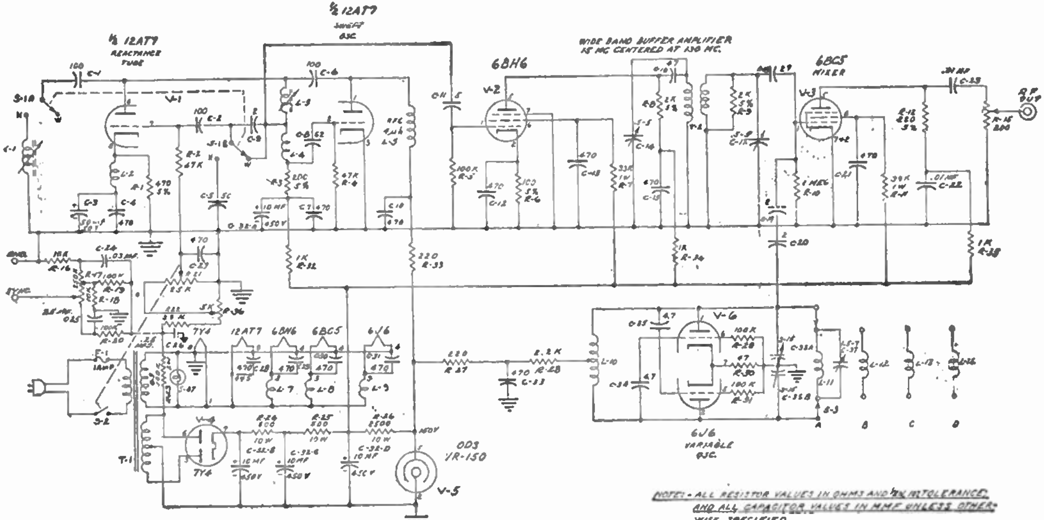



FIG. 15—Illustrating *Sylvania Type 500* signal generator. This signal generator is designed for use as a general purpose television signal source for the testing and alignment of television and F.M. receivers. Output from 2 to 230 mc. is available in four ranges, all on fundamentals and free of spurious frequencies in each band. The chosen center frequency may be swept from 0 to 600 kc. on one sweep range and 0 to 15 mc. on another sweep range. A smooth attenuator is provided to control the output from the 75 ohm coaxial output cable.




$f_o = f_v - f_x$

| OUTPUT FREQ. | BAND # | $f_x$ |
|---|---|---|
| 2-27 | 1 | 132-157 |
| 17-63 | 2 | 147-193 |
| 55-117 | 3 | 165-247 |
| 133-230 MC | 4 | 263-360 |

FIG. 16—Schematic wiring diagram of *Sylvania type 500* signal generator.

In television servicing the frequency range should be great enough to include all television channels, so that the generator can be used to supply test signals at the picture and sound carrier frequency for each television channel.

The commercial FM and broadcast band of 88 to 108 mc. should also be included. If the frequency range of the generator be restricted it may be possible to use harmonics of the output signal for the higher frequencies.

Signal tracing through the receiver circuit may be carried out with this generator as in conventional receivers, working back toward the antenna, stage by stage to localize a defective stage.

Employing the 400 cycle output in the audio and video stages and the modulated *r.f.* signal in the *i.f.* and *r.f.* stages, the indication of normal operation is a steady tone from the loudspeaker in the sound channel while horizontal bars are produced on the screen of the picture tube for signals in the picture channel.

The audio test signal is also useful when non-image methods of testing scanning linearity must be employed to produce horizontal bars in the picture for checking vertical linearity. A test signal frequency of about 157.5 can be used to check horizontal linearity.

Aside from frequency range and stability of calibration, there are two other points to be considered. *First* its output should be about one volt at a maximum and attenuation down to almost zero (low leakage) or about one microvolt. Leakage is checked by connection to a sensitive receiver operating at full gain, then reducing the generator attenuator. The signal should then reduce to an imperceptible level.

*Secondly*, the oscillator should be quite stable when used as a marker. Any factor which leads to instability of the oscillator within the signal generator, leads to unsatisfactory results.

**Marker Systems.**—Specifically a marker system consists of an accurately calibrated signal source, which can be internal or external to the sweep generator. This calibrated source may take the form of a crystal oscillator of various frequencies

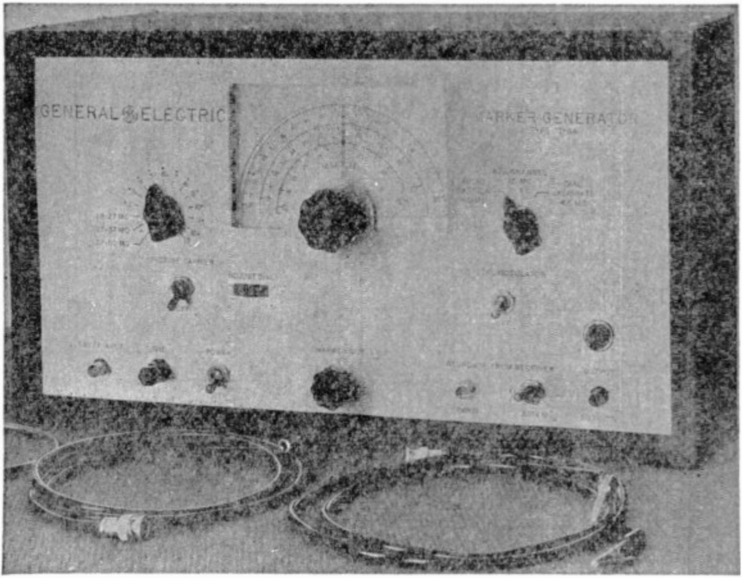



**FIG. 17—Exterior view of *General Electric type ST-5A* marker generator. This instrument allows the use of from one to five simultaneous crystal controlled markers, and at the same time permits complete freedom of marker positioning in the 20 to 50 mc. band. The instrument furthermore, furnishes crystal controlled markers for each of the twelve television channels.**

which can be switched in and out permitting the calibration of the curve or it can be a continuously variable accurately calibrated signal generator.

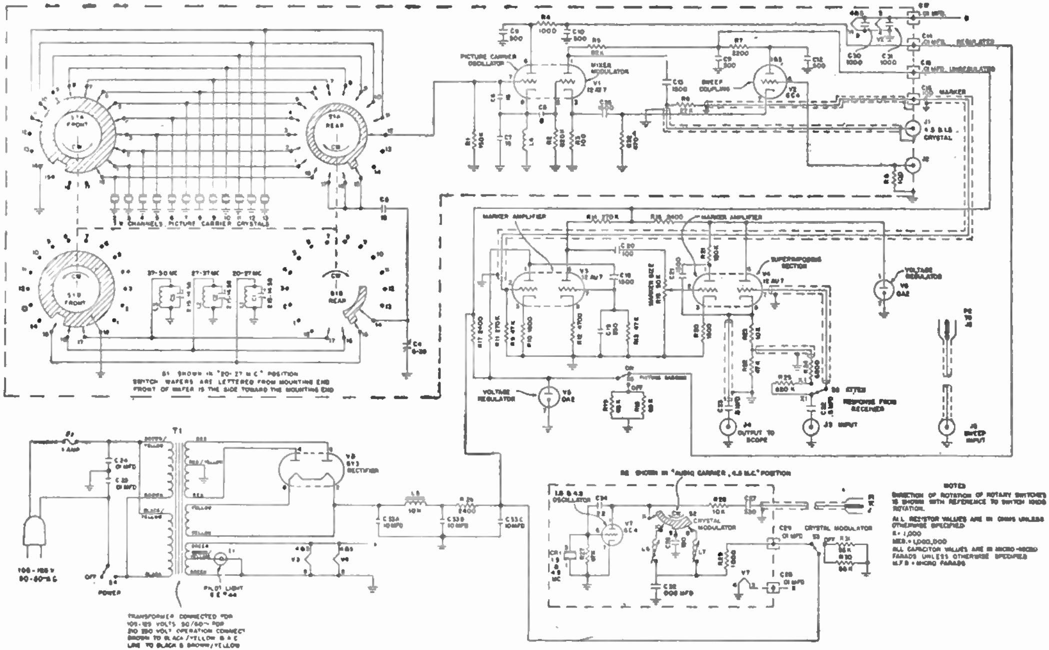


FIG. 18—Schematic diagram of *General Electric type ST-5A* marker generator.

There are numerous forms of marker generators on the market. When properly designed this is a precision quality instrument whose function it is to produce highly accurate marker "pips" to show specific frequency locations on a tuned circuit response curve when presented on the oscilloscope.

The need for an accurately calibrated marker system will be considered by the fact that any response wave form as reproduced on the oscilloscope screen is only approximately calibrated. The center of such a trace represents the center frequency at which the sweep generator has been set. Without a marker system extremities of the sweep can only be approximated by adding and subtracting from the center frequency the maximum frequency deviation for which the sweep generator has been adjusted.

**The R.C.A. Sweep Oscillator and Television Calibrator.**—*The Radio Corporation of America* is the manufacturer of a versatile sweep oscillator and calibrator shown in figs. 19 and 20. This instrument can be used for alignment, adjustment and trouble shooting on television receivers.

Designed primarily to be used with the R.C.A. sweep generator whose circuit is shown in fig. 20 and a suitable oscilloscope to align television receivers, the calibrator is a generator of crystal calibrated marker frequencies. In one compact portable unit, the instrument combines the precision of crystal oscillators with the versatility of the variable frequency oscillator. Included in this one instrument is a crystal calibrated variable frequency oscillator, two crystal controlled oscillators with three crystal positions, a wide band modulator stage for internally modulating the output at audio and *r.f.* frequencies, and an audio amplifier with internal speaker. An internal audio oscillator is provided to modulate the output of the variable frequency oscillator, when required.

The variable frequency oscillator, from which the marker signal is derived, can be tuned to any frequency within the commercial television bands. Frequency settings, and tele-

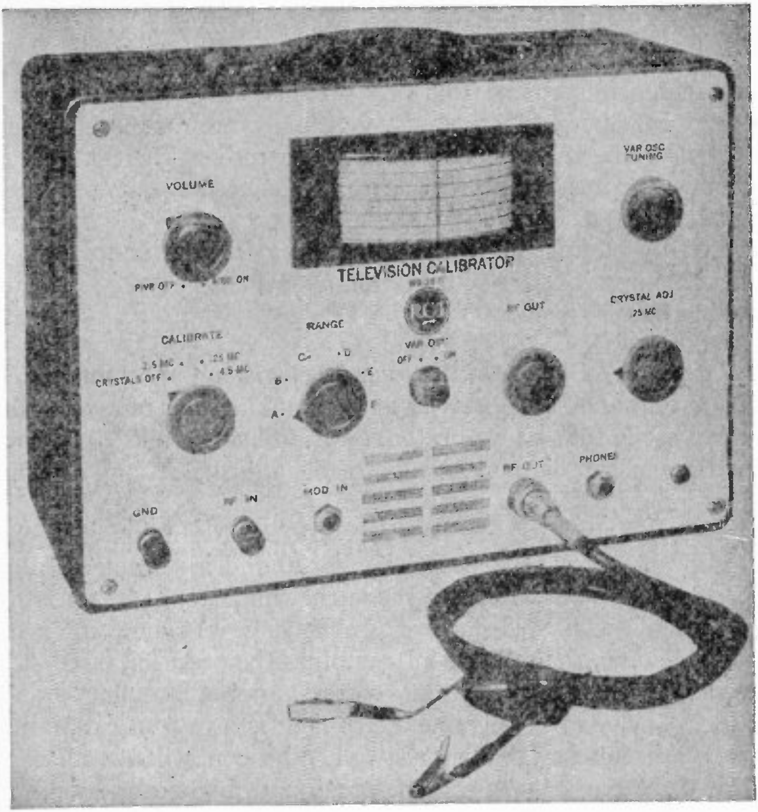



**FIG. 19—Exterior view of *R.C.A. type WR-39B* television calibrator.**

vision picture and sound carriers are indicated on a large, easy to read drum dial. A miniature built-in loudspeaker facilitates

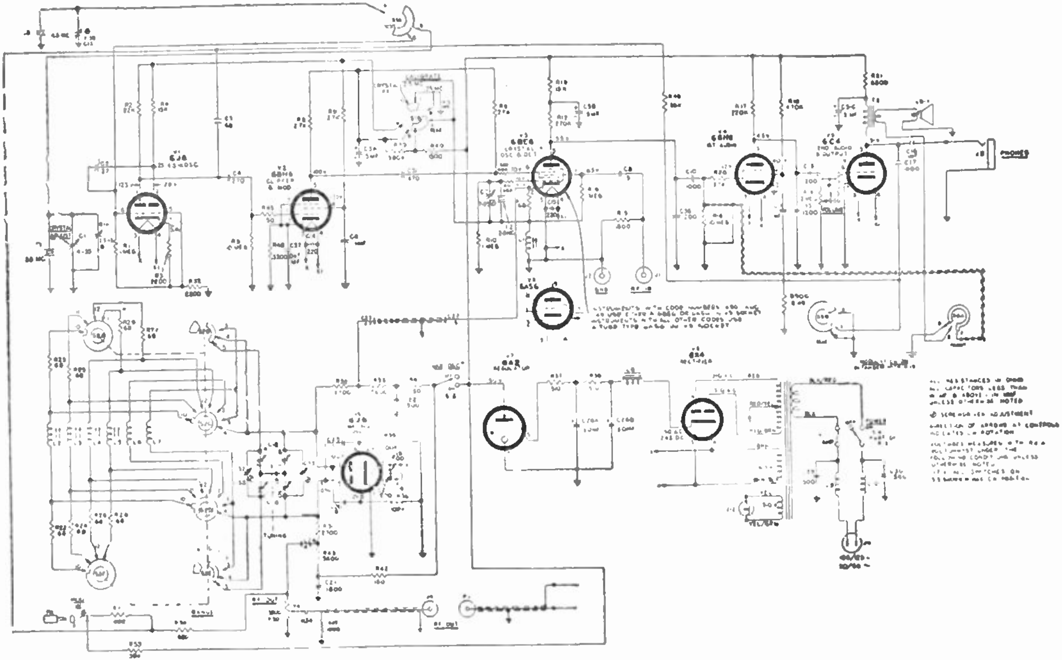


FIG. 20—Schematic wiring diagram of *R.C.A. type WR-39B* television calibrator.

zero beating the variable frequency oscillator with any harmonic of either a 2.5 mc. crystal standard or a 0.25 mc. crystal standard included in the unit. Since all of the standard RMA frequencies used in television service (sound and picture carrier frequencies, sound and picture intermediate frequencies, and local oscillator frequencies) are harmonics of 0.25 mc. these frequencies can be rapidly identified with crystal accuracy by using the television calibrator to superimpose a marker on an oscillographic presentation of a response curve.

An internal 4.5 mc. crystal oscillator is also incorporated in the television calibrator. The output of this oscillator may be used to modulate the output of the variable frequency oscillator to provide marker "pips" spaced 4.5 mc. on each side of the marker "pip" of the variable frequency oscillator. These markers are especially useful in the alignment of *r.f.* amplifiers of television receivers. Similarly, a 0.25 mc. crystal oscillator is incorporated in the television calibrator to provide marker "pips" spaced 0.25 mc. from the frequency of the variable oscillator. These marker "pips" are especially useful in determining the characteristics of the response curve of discriminators and ratio detectors. The 4.5 mc. output may be used by itself with or without modulation for alignment of television receivers employing intercarrier sound.

In addition to its primary function as a marker generator, the calibrator can also be used to identify unknown frequencies falling within the frequency range of the instrument; it can be used as a crystal calibrated variable frequency oscillator, either modulated or unmodulated, for adjusting traps, aligning FM receivers, calibrating other signal generators, and adjusting the frequencies of small transmitters. It may also be used in combination with the internal 0.25 mc. oscillator to provide a bar pattern on the face of the picture tube of a television receiver so that linearity adjustments may be made on all channels whether or not a television station is on the air.

The calibrator may also be used as a miniature television transmitter to provide a signal on the face of the picture tube when an external video signal source is available.

To enable the serviceman to identify the frequencies of very weak signals, a phone jack is provided on the front panel. A jack is also provided for the introduction of an external modulating voltage of any frequency when modulation of the output frequency of the variable frequency oscillator is desired. Supplied complete with power cord, and shielded output cable, the instrument is enclosed in a sturdy, well shielded steel case finished in attractive blue-gray hammeroid with anodized satin-aluminum panels.

**Miscellaneous Test Equipment Items.**—Following are certain additional items necessary to television receiver maintenance and trouble shooting:

*Tube Tester.*—The tube tester should preferably be of the dynamic type, checking mutual conductance (Gm) of all tubes used, including the miniature types. There is no tester available to check the viewing tube, but this is hardly a necessity.

*Universal Meter.*—Universal meter, reading volts, ohms, milliamperes, etc. should be of the high impedance type (20,000 ohms per volt or better) which may be used also in reading high voltage by applying a multiplier. There are produced, high voltage cables and test prods which have built-in multipliers, extending the range of the meter to any reasonable value.

Direct view picture tubes have acceleration potentials approaching 15,000 volts; this should be the minimum requirement in HV meters. Projection receivers will use up to 30 *Kv.*

It must be borne in mind that even 50 microamperes (at full scale) of the meter may drop the high voltage appreciably.

This may be ascertained by observing change in picture size. If the picture materially increases in size as the reading is being taken, some allowance must be made for reduction under test. The only true measure in such case, is by an electrostatic *d.c.* voltmeter, which instruments are usually restricted to the laboratory due to cost factors.

*Variable Voltage Transformer.*—A variable voltage transformer is necessary for proper voltage control. Picture size and brilliance is dependent upon line voltage; changes are more apparent in some receivers than in others. Also, it has been noted that the socket voltage in most service areas is variable over wide limits. There should be, therefore, in adjusting the receiver, some means of simulating the actual operating conditions encountered in the field. The transformer should be at least of five ampere size.

*Small Tools.*—These, including alignment tools, are essentially the same for any type of receiver whether AM, FM or television.

*Mirror.*—In servicing television receivers a mirror is often used for observation of the picture screen while making adjustments at the rear of the chassis. To prevent breakage, this may be a metallic sheet, possibly a ferrotype plate, obtainable at any photographic supply house.

*Diode Detector.*—In checking operation or alignment in a single *i.f.* or *r.f.* stage, detection must be had before application to the oscilloscope. In alignment of the FM receiver, it is well to eliminate the discriminator transformer while aligning the *i.f.* stages. The detector attached may be a tube or a crystal, as long as it does not seriously introduce capacity into the circuit.

CHAPTER 14

# Television Servicing

Although each receiver is correctly adjusted at the factory, rough handling during transit and aging components may cause misalignment of the critical circuits. If picture and sound defects indicate that a re-alignment is necessary, the manufacturers' step by step procedure should be followed.

In order to better understand the following detailed alignment procedure, it is necessary to explain why this procedure has been prepared in this manner. Any receiver alignment problem may be classified either as a *minor* or *major*. In other words, it is either only slightly out of adjustment and therefore requires minor adjustments of one or more of the coils; or, some of the coil cores have been removed, or are badly out of adjustment, which will necessitate a thorough check of the entire circuit.

In the absence of a screen room, external noise and signals may be very troublesome during alignment. Therefore a stage by stage procedure is usually followed, in which the signal is injected just preceding the stage under alignment. If it is known that the set is not badly out of alignment, it may be possible and practical to abbreviate the procedure considerably by applying the input signal directly to the antenna input during the entire alignment procedure, instead of applying it to the different tubes as each individual stage is aligned.

One important point should be kept in mind when making all adjustments. That is to align all the individual coils at the same frequency setting of the generator rather than changing the generator setting and having to go back and try to reset the generator at the same frequency. For example, when making adjustments at 31.625 mc. do not change the generator setting from the time of starting these adjustments until all adjustments on all coils that are to be aligned at this particular frequency have been completed. The exact frequency to which the coils are aligned is not as important as it is to be sure that all coils of identical frequency be aligned at exactly the same frequency. The frequency tolerance of ± 1% in signal generator frequency can be tolerated if the coils are aligned at the same relative frequencies.

Before attempting to make any alignment and adjustments, check the physical position of all of the iron core slugs in the different *i.f.* transformers and wave traps. Refer to the chart for their approximate correct positions. This, of course, is not necessary if the receiver is not badly out of alignment, or if none of the transformers or cores have been replaced. In making any adjustments, be very careful not to turn the cores in too far, since the threads in the coil forms will be disengaged and the core will drop to the bottom of the transformer can. If this occurs, the metal cover on the bottom of the *r.f.* and *i.f.* subchassis must be removed and a small wire inserted through the bottom of the chassis into the coil form to force the iron slug back up to the point where it will engage the threads as it is turned back out.

*Again it should be emphasized that all pertinent data relating to the set to be aligned should be available for reference and the manufacturer's alignment procedure must be followed.*

**General Alignment Procedure.***—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 is fast replacing the older, slower point-by-point alignment method and is as rapid as it is effective. When combined with the use of accurately established marker frequencies, it is also precise.

The test set-up for making a visual alignment when employing the aforementioned test *calibrator*, television *sweep generator* and a suitable *oscilloscope* is illustrated in fig. 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 *i.f.* circuit, a trace representing the response characteristics of the circuit will appear on the oscilloscope screen. A typical trace is shown in fig. 2A. From this trace, valuable information about the response can be obtained, but if the center frequency of the response and its band-width are to be determined to any degree of accuracy, a marker must be used. When a source of marker frequencies is coupled to the input of the amplifier under test, a discontinuity, or "pip" will be observed on the trace, as illustrated in fig. 2B. If the marker generator be tuned exactly to the center of the pass band accepted by the intermediate frequency amplifier, then this marker "pip" will indicate the

*The alignment procedure described on the following pages is furnished by the courtesy of the *Radio Corporation of America*. The calibrator referred to in the various illustrations and in the text matter is shown on page 280.

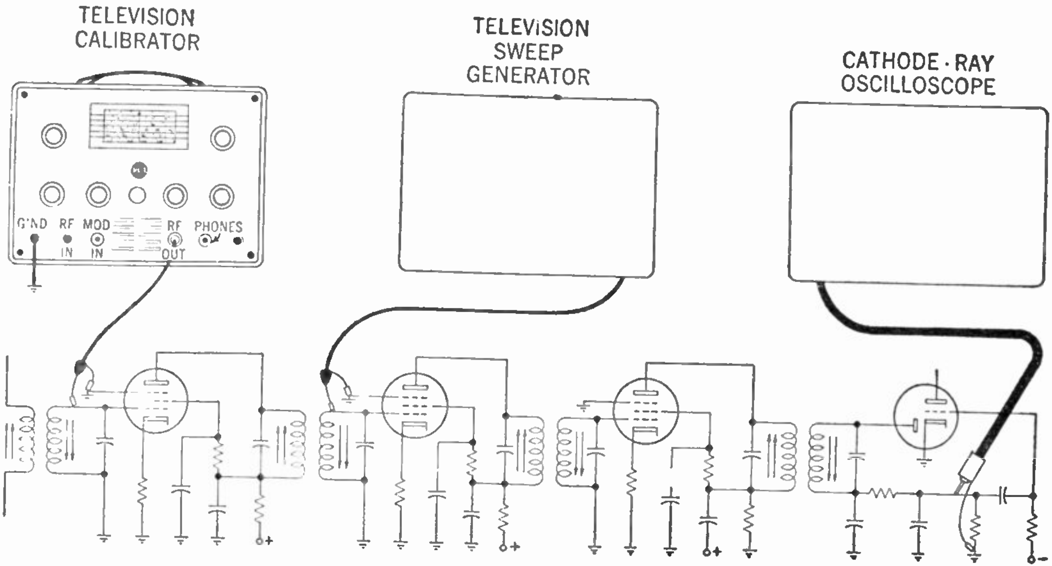



FIG. 1—Showing typical visual alignment setup.

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.

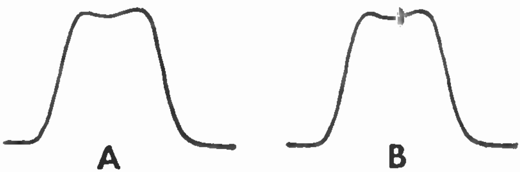



**FIG. 2—Typical tuned circuit response.**

Fig. 3 illustrates the position of the marker "pip" relative to the response for various conditions of misalignment. It must be emphasized that once the market 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 particular response is another important function of marker generators. Fig. 4 shows how this is performed. 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 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.

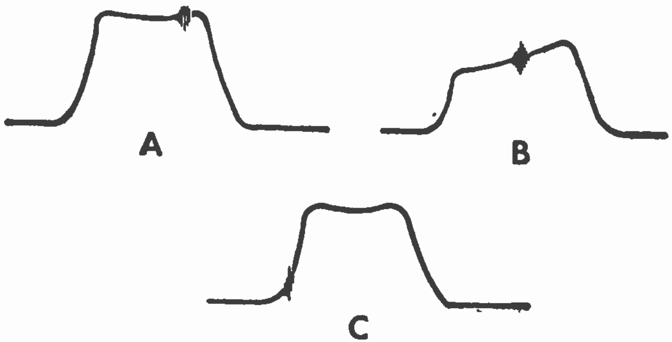



**FIG. 3—Showing improperly aligned tuned circuits. Trace *A*, indicates response good, but resonant frequency of tuned circuit a little low; trace *B*, indicates resonant frequency of tuned circuit correct, but response not symmetrical; trace *C*, indicates response good, but resonant frequency of tuned circuit too high.**

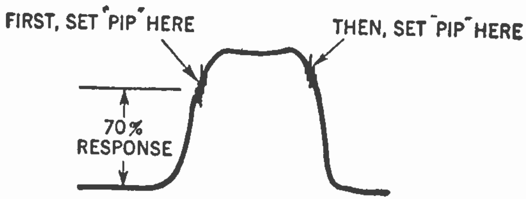



**FIG. 4—Showing bandwidth measurement.**

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 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 calibrator and tuned to the frequency at which a marker "pip" appears on 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 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 chapter, would be of little value to 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.

**Aligning Picture I.F. Amplifiers.**—The test equipment and the receiver are set up as shown in fig. 5. When the sweep generator is tuned to sweep the pass band of the picture *i.f.* amplifier, a trace similar to that of fig. 6 should appear on the

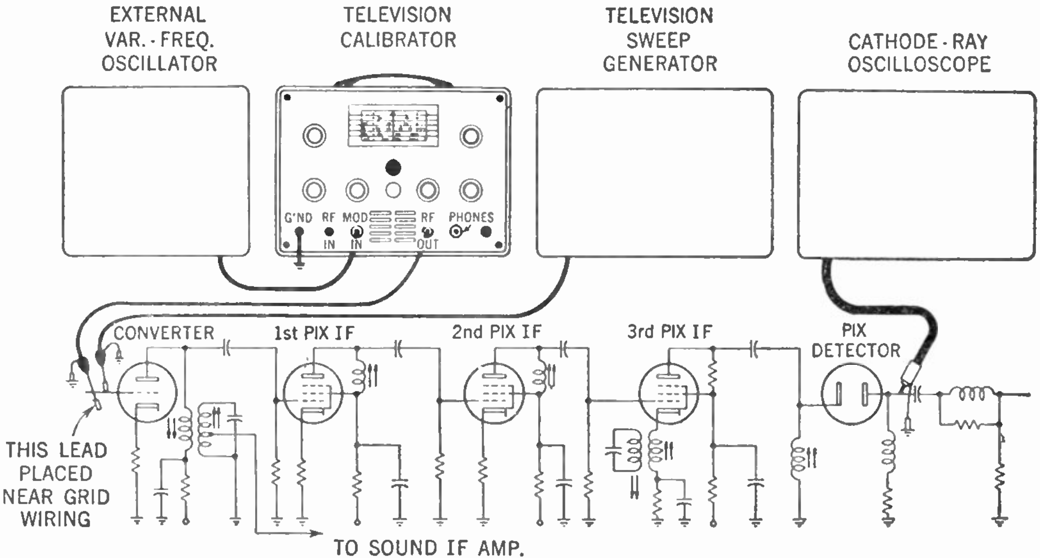



**FIG. 5—Showing test equipment and receiver setup in alignment of picture *i.f.* amplifier.**

oscilloscope screen. This trace is typical of the picture *i.f.* 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 fig. 6.

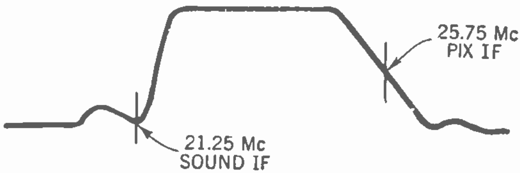



**FIG. 6—Showing trace of picture *i.f.* response.**

Some television receivers, particularly pre-war receivers, use different intermediate frequencies. In this case, the *manufacturer's alignment instructions* should be *consulted* to determine the frequencies used, then the sweep generator is tuned to sweep the proper frequency band.

During the alignment of the picture *i.f.* amplifier, it is necessary 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 the standard *RMA* intermediate frequencies, then the marker frequencies may be obtained directly from the television calibrator. If the intermediate frequencies are below 19 mc. (some receivers employ a picture *i.f.* of 12.75 mc. and a sound *i.f.* of 8.25 mc.) then the television *calibrator* is tuned to the carrier frequency of any television channel; the receiver is tuned to the same channel and the television *calibrator* output is fed in at the receiver antenna terminals. The signal from the television calibrator, when heterodyned with the receiver's local oscillator, produces the desired *i.f.* marker frequency. When this method is used, the receiver oscillator must first be set exactly on the correct frequency as described in a following paragraph on local oscillator alignment.

The following description will assume that the receiver under test employs standard *RMA* 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 fig. 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 *i.f.* amplifiers may require tighter coupling. Too much coupling is undesirable, as detuning of the circuit may result. If the curve shape be altered when the marker signal is inserted, coupling is too tight.

2. Set the television calibrator frequency exactly on 25.75 mc. 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 curve shown in fig. 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 *mfd.*) The resulting trace is shown in fig. 7B.

3. The position of the 25.75 mc. marker (picture *i.f.* carrier) should be at approximately the 50% response point on the slope of the response curve, as shown in fig. 7. The tuned circuits in the picture *i.f.* amplifier are adjusted so that the response curve is of the proper shape with the marker "pip" in the position shown in fig. 7.

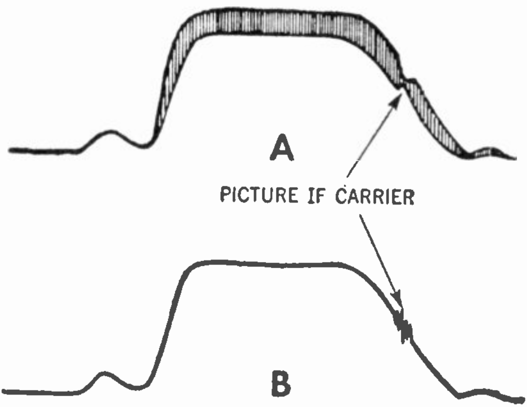



**FIG. 7—Showing trace of picture *i.f.* response.**

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 fig. 8). If the variable frequency oscillator of the television calibrator is set and calibrated to the picture *i.f.* carrier and the external variable frequency oscillator be set to a frequency which is the difference between the picture *i.f.* carrier and the frequency whose marker "pip" is shown in fig. 8 two simultaneous markers will appear.

These frequencies are most important in the alignment of picture *i.f.* 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 fig. 9.


**FIG. 8—Showing trace of picture *i.f.* response.**

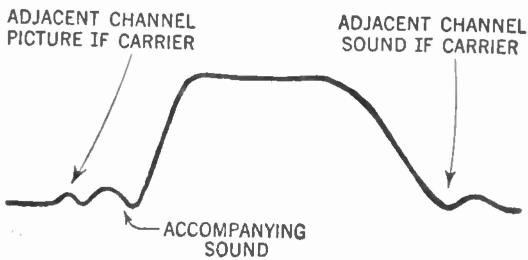



**FIG. 9—Showing trace of typical trap frequencies.**

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. During preliminary alignment when the response of the amplifier at the trap frequencies has not been tuned to a minimum, a marker can be placed on the adjacent channel sound *i.f.* carrier or adjacent channel picture *i.f.* carrier. These markers can be obtained from a separate variable frequency oscillator tuned to 1,500 *kc.* and connected to the "*MOD IN*" jack of the *calibrator*. With variable frequency oscillator of the *calibrator* set for a main marker at the sound or picture *i.f.* carrier frequency, markers will appear 1.5 mc. away from the main marker. Two simultaneous marker "pips" may be provided by the calibrator, one at the sound *i.f.* carrier and the other at the picture *i.f.* carrier when the output of the variable frequency oscillator is tuned to either frequency and the 4.5 mc. crystal oscillator output is used to modulate it.

This may be accomplished by turning the *calibrate* selector to 4.5 mc. It is advisable to maintain the "*RF OUT*" control near its maximum clockwise position whenever internal modulation is employed. If the marker amplitude is still too high, it may be reduced by looser coupling to the amplifier input point. The size of the marker "pip" can be increased by turning the "*RF OUT*" control clockwise, or by coupling the output cable closer to the amplifier under test, or both. Coupling which is too tight, however, may result in detuning of the *i.f.* amplifier and consequent distortion of the response.

Traps in the picture *i.f.* amplifier are adjusted by feeding the output of the television calibrator, tuned to the trap frequency, into the *i.f.* 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 a highly sensitive vacuum tube voltmeter may be used as an output indicator.

The general procedure in aligning picture *i.f.* amplifiers is first to set the traps and then to align the other circuits in the *i.f.* 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 *i.f.* amplifier alignment. The manufacturer's alignment instructions will again determine the exact procedure to follow.

**Aligning R.F. Amplifiers.**—The radio frequency stages of a television receiver should have a pass band of about 6 mc. fig. 10. The equipment for producing this is set up and

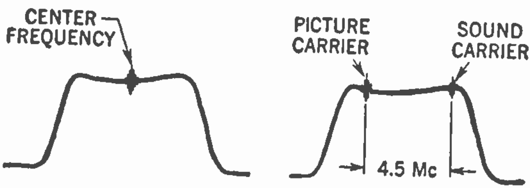



**FIG. 10—Trace of typical *r.f.* response.**

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 *r.f.* 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 *r.f.* response curve as seen on the oscilloscope, a marker "pip" appears at the other part of the curve if the output frequency be modulated by 4.5 mc. To do this, the *calibrate* selector is set at 4.5 mc. position and two marker "pips" one marking the sound carrier and the other marking the picture carrier are seen on the response curve and are spaced exactly 4.5 mc. apart.

**Aligning R.F. 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 *i.f.* 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 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.
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 *r.f.* 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 one to six on the preceding page are not applicable.

With the heterodyne method, the signal from the oscillator in the receiver is fed to the calibrator 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 variable frequency oscillator in the calibrator and the frequency of the receiver oscillator is then adjusted until the zero beat is obtained.

In television receivers where the sound *i.f.* 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 calibrator. In such cases the variable frequency oscillator of the calibrator 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 variable frequency oscillator. For example, in aligning a receiver with a sound *i.f.* carrier of 31.25 mc. and with the oscillator on channel 6 operating at 119 mc. the variable frequency oscillator is tuned to 59.5 mc. and its second harmonic is 119 mc. heterodyned against the oscillator in the receiver.

**Aligning Sound I.F. Amplifiers.**—With the exception of the response curve shape, the application of the television *calibrator* to alignment of sound *i.f.* channels follow the same general procedure given in the previous paragraphs on picture *i.f.* channels. The alignment equipment is set up as shown in fig. 11. The *i.f.* response, with the superimposed marker

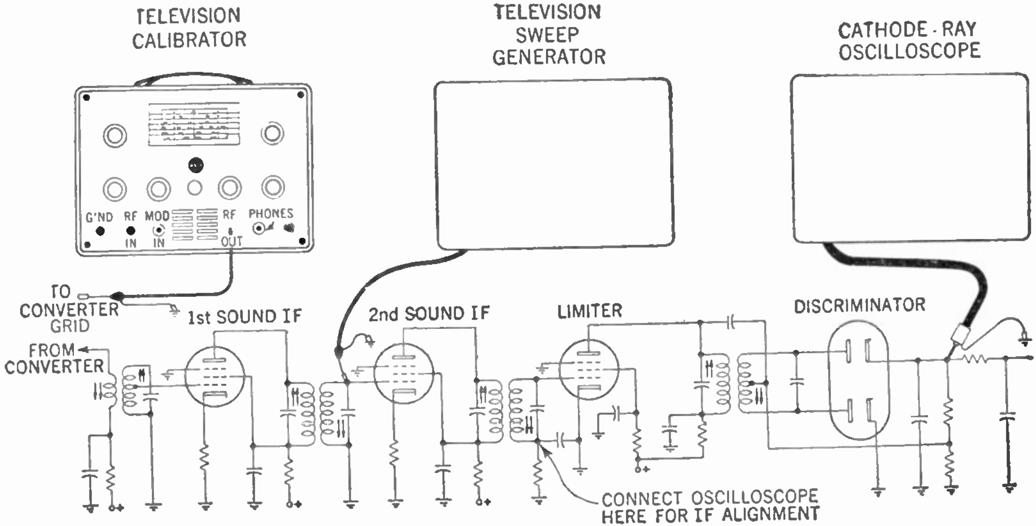



FIG. 11—Showing typical setup for sound *i.f.* amplifier alignment.

"pip" is shown in fig. 12 as being indicative of that to be expected from normal sound *i.f.* amplifiers.

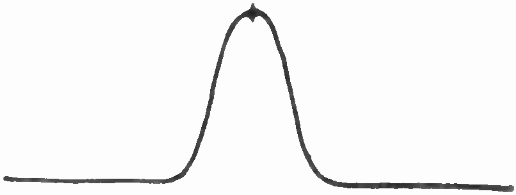


**FIG. 12—Showing trace of sound *i.f.* response.**

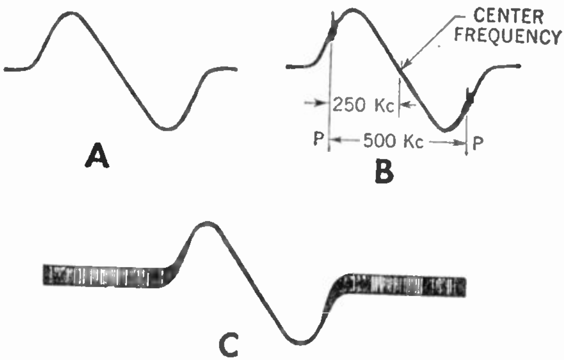



**FIG. 13—Showing typical discriminator response.**

The width of the pass band can be determined as described previously under "*General Alignment Procedure*". The usual discriminator characteristic is shown in fig. 13A. Fig. 13B shows the usual discriminator response curve with the center frequency (sound *i.f.*) 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 .25 mc. crystal oscillator output. These marker "pips" are 250 *kc*. apart and are used to check discriminator bandwidth.

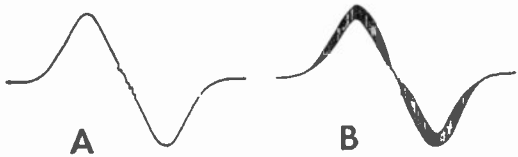



**FIG. 14—Typical discriminator response. Trace *A*, shows capacitor shunt across oscilloscope output and *B*, shows capacitor shunt removed.**

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 fig. 14B will appear. Using this trace, the serviceman can determine the important center frequency of the discriminator characteristic with relative ease. Fig. 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 fig. 13A. The center frequency (sound *i.f.*) is then modulated by an audio frequency.

An internal audio frequency is provided by placing the *volume* control to the "*MOD ON*" position. When the discriminator or ratio detector has been properly aligned, the response curve seen on the oscilloscope will be similar to that shown in fig. 13A. When the center frequency is other than that provided by the television *calibrator*, the response curve will be similar to that in fig. 13C.

Television receivers employing intercarrier sound *i.f.* stages may be aligned in a manner similar to that described previously. Since all receivers of this kind use a sound *i.f.* frequency of 4.5 mc. it is merely necessary to provide this frequency as the center frequency of the response curve. When the variable oscillator

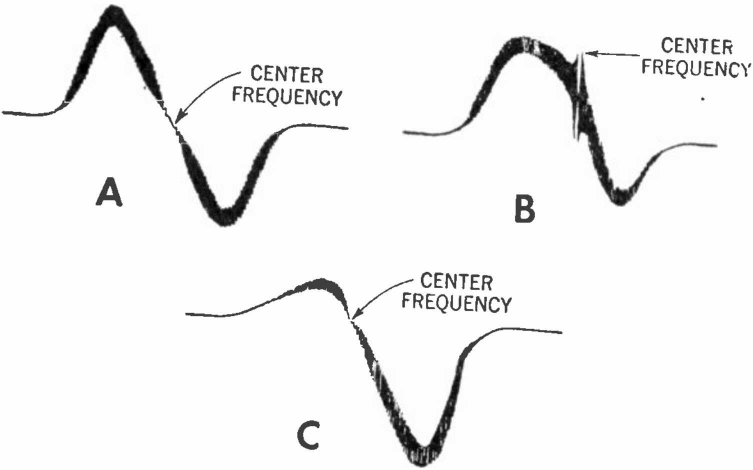



**FIG. 15—Showing effect of improperly aligned discriminator circuit. Trace *A*, indicates correct response; trace *B*, indicates secondary resonant frequency too high; trace *C*, indicates primary resonant frequency too high or resonant frequencies of preceding *i.f.* transformers too high.**

is set to the "OFF" position, and the *calibrate* selector is set to the 4.5 mc. position, the *r.f.* output frequency is 4.5 mc. and its output may be controlled by the *r.f.* "*OUT*" control. This output is fed into the video amplifier ahead of the 4.5 mc. take off point. If additional markers be needed they can be obtained by connecting the output of an ordinary variable frequency oscillator to the "*MOD IN*" jack.

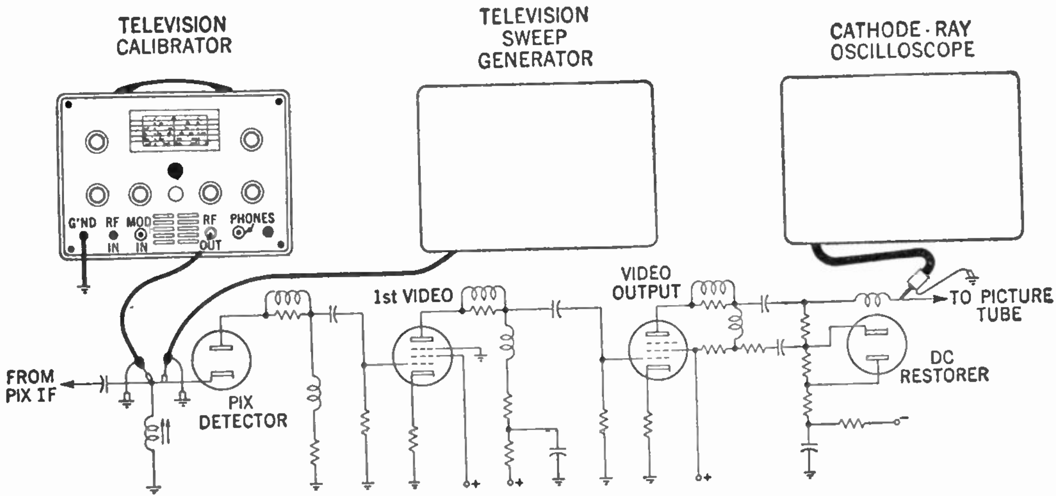



FIG. 16—Showing typical setup for second detector and video amplifier response check.

**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 fig. 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 fig. 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 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 be 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 amplifier can be tested under more nearly actual conditions, since the input capacitance of a well designed detector closely approximates the input capacitance of the picture tube.

4. A trace similar to that shown in fig. 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.

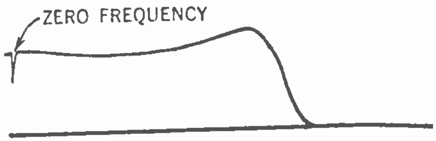



**FIG. 17—Showing video amplifier and second detector response.**

**Adjusting Linearity.**—When the *calibrate* switch of the *calibrator* is set to .25 mc. the *r.f.* output of the unit is modulated with a 250 *kc.* signal. If this signal be received on a television receiver, a vertical bar pattern (approximately 16 bars) will be displayed on the picture tube. Thus, the *calibrator* 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 1,200 cycles be fed into the "*MOD IN*" jack, then 20 horizontal bars will be displayed on the television receiver picture tube, and vertical linearity can be adjusted.

**Checking Operation of Television Receiver On All Channels, When Only One Channel Is On The Air.**—The television *calibrator* may be used as a signal source as shown on page 322 to provide a signal on all channels if an external video signal be available, or if the *calibrate* control is set to .25 mc. position.

Servicemen will find this feature of the *calibrator* especially of value so that television receivers may be quickly and efficiently checked for proper operation on all channels even when only one channel is on the air.

An external video signal is fed into the "*MOD IN*" jack on the *calibrator* and the output of the *calibrator* attached to the antenna terminals of the receiver, as noted in the diagram page 322.

Both the *calibrator* and receiver under test are tuned to the same picture carrier. A convenient video signal source may be obtained at the picture tube grid of a second receiver which is tuned to a channel which is being received. The video signal input at the "*MOD IN*" jack must be adjusted for the proper percentage of modulation by means of contrast control on the receiver.

CHAPTER 15

# Trouble Shooting

In order to facilitate the trouble shooting procedure the following trouble shooting charts are given. The *charts* are subdivided according to the *symptoms* as they affect the *picture* or *sound* so that it is an easy matter to find the symptoms observed on the particular receiver. The *second column* of the charts indicate the part or section to be checked. Circuit components referred to in the text matter are shown on pages 320, and 321.

## *Picture Quality Defects**

| *Symptom* | *Check* | *Refer to* |
|---|---|---|
| 1. No picture, no raster, no sound. | a. Power supply. | |
| 2. No picture, no raster, sound normal. | a. Picture tube.<br>b. High voltage power supply.<br>c. Ion trap. | |
| 3. No picture, no sound, raster normal. | a. *r.f.* and video *i.f.* circuit. | See Note 1. (page 314) |
| 4. No picture, raster and sound normal. | a. Video amplifier. | See Note 7. (page 315) |
| 5. Poor focus. | a. Focus coil.<br>b. Focus coil circuit. | See Pages 25 and 26 |

*For picture quality defects see also pages 14 to 44.

## *Picture Quality Defects—Continued*

| *Symptom* | *Check* | *Refer to* |
|---|---|---|
| 6. Poor focus and picture blooming. | a. For gassy picture tube. | See Note 14. |
| 7. Neck shadow. | a. Focus coil adjustment.<br>b. Ion trap adjustment.<br>c. Yoke assembly adjustment. | See Notes 33, 34 and 36. |
| 8. Ghost. | a. Antenna orientation.<br>b. Antenna lead-in. | See Pages 41, 113, 114, 119 to 122. |
| 9. Snow. | a. Antenna installation. | See Chapter 7. |
| 10. Poor detail. | a. *r.f.* and video *i.f.* circuits.<br>b. Picture control circuit. | See Notes, 1 and 4. |
| 11. Insufficient brightness. | a. Ion trap adjustment.<br>b. Picture tube.<br>c. Pix tube anode or bus voltage. | See Note 34. |
| 12. Excessive contrast. | a. Sync. Section. | See Note 30. |
| 13. Excessive contrast with shaky picture. | a. Sync. Section. | See Note 31. |
| 14. Very bright, fuzzy picture. | a. Picture tube circuit. | See Note 16. |
| 15. No picture on one channel. | a. Channel switch. | See Note 6. |
| 16. Distorted picture. | a. Video amplifier. | See Note 7. |
| 17. Smeared picture. | a. Video amplifier. | See Note 10. |

## *Raster Defects*

| *Symptom* | *Check* | *Refer to* |
|---|---|---|
| 1. Raster not centered. | a. Focus coil adjustment. | See Note 33. |
| 2. Tilted raster. | a. Focus coil adjustment. | See Note 33. |
| 3. Excessive raster size. | a. Low anode voltage to pix tube. | |
| 4. Raster width too small. | a. Circuit of horizontal sweep output tube.<br>b. Width control shorted or misadjusted. | |
| 5. Raster height too small. | a. Height control circuit.<br>b. Circuit of vertical sweep output tube. | See Note 37. |
| 6. Unsymmetrical, trapezoidal raster. | a. Deflection yoke position. | See Note 35. |
| 7. Barrel distortion. | a. Deflection yoke position. | See Note 35. |

## *Sweep and Sync Defects*

| *Symptom* | *Check* | *Refer to* |
|---|---|---|
| 1. No horizontal or vertical sync. | a. Clipper circuit of V10. | See Note 22. |
| 2. Insufficient sweep width. | a. Horizontal sweep circuit. | See Note 18. |
| 3. No raster, one horizontal line. | a. Vertical sweep circuit.<br>b. Vertical deflection yoke. | See Notes 23, and 35. |
| 4. No raster, one vertical line. | a. Horizontal deflection yoke. | See Note 35. |
| 5. Raster not stable. | a. High voltage power supply. | |

## *Sweep and Sync Defects—Continued*

| *Symptom* | *Check* | *Refer to* |
|---|---|---|
| 6. Poor horizontal linearity. | a. Horizontal sweep circuit.<br>b. Horizontal linearity control. | See Note 19. |
| 7. Poor vertical linearity. | a. Vertical linearity control.<br>b. Vertical sweep circuit. | See Note 25. |
| 8. Picture not centered. | a. Focus coil adjustment.<br>b. Horizontal sweep circuit. | See Note 20. |
| 9. Unstable horizontal sync. | a. Horizontal sweep circuit. | See Note 21. |
| 10. Unstable vertical sync. | a. Vertical sync input. | See Note 27. |
| 11. Reduction of height. | a. Height control.<br>b. Vertical sweep circuit. | See Notes 25, 26 and 28. |
| 12. Small picture. | a. Picture tube circuit. | See Note 16. |
| 13. Retrace lines increasing towards top. | a. Picture tube circuit. | See Note 15. |
| 14. Vertical does not sync. | a. Vertical sweep circuit. | See Note 24. |

## *Audio Defects*

| *Symptom* | *Check* | *Refer to* |
|---|---|---|
| 1. No sound, picture normal. | a. Audio section. | See Note 38. |
| 2. Hum or buzz. | a. Audio section. | See Note 39. |
| 3. Distortion. | a. Crystal Y1.<br>b. Audio *i.f.* alignment. | |

## *Miscellaneous Defects*

| *Symptom* | *Check* | *Refer to* |
|---|---|---|
| 1. Sound bars. | a. Picture tube circuit. | See Note 13. |
| 2. Light and dark vertical bars, poor horizontal linearity. | a. Damper tube. | |
| 3. Two heavy black horizontal bars across screen. | a. Power supply (electrolytic capacitor). | |
| 4. Excessive contrast with bright lines on bottom and top. | a. Sync. section. | See Note 31. |
| 5. Picture distorted and reverse action of picture control. | a. Sync. section. | See Note 32. |
| 6. Picture flutters at 60 cycles rate. | a. Capactitor C251 in video *i.f.* circuit. | See Note 5. |
| 7. Window shade effect. | a. Picture tube circuit. | See Note 16. |
| 8. Barkhausen oscillation. | a. Drive control R369.<br>b. 19BG6 tube. | See Page 40. |
| 9. "Busy background" on trailing edge. | a. Video amplifier. | See Note 8. |
| 10. Black lines across picture. | a. Video amplifier. | See Note 9. |
| 11. Very bright picture with black lines. | a. Video amplifier. | See Note 11. |

# NOTES ON TROUBLE SHOOTING

## (RF and Video IF Circuit)

1. Misalignment of *r.f.*, video *i.f.* stages or sound traps will cause poor picture detail. If some stages are totally detuned, the signal might not get through at all, failing to produce a picture.

2. If the oscillator circuit fails to produce the required frequencies, no *i.f.* signal is formed and no signal will get through: No picture and no sound will be the result. Any defective component in the oscillator circuit may have this effect.

3. Any interruption of the signal path through the *r.f.* and video *i.f.* stages will result in a distorted picture or no picture at all. The location of an open component is easily accomplished by methods used in radio service work.

4. An overloading of the stages will result in loss of picture detail; check picture control circuit.

5. In case the capacitor C251 is short circuited, sound bars will appear in the picture, and trailing white shadows. If this capacitor opens up, the picture will flutter at a 60 cycle rate and at minimum picture control audio motorboating will start.

6. A defective channel switch will result in intermittent reception of one channel or in extreme cases a channel might be interrupted completely. Clean switch with a cleaning fluid or bend the contacts to increase contact pressure. In some cases it is best to replace head-end unit.

### Video Amplifier

7. If the path of the signal within the video amplifier is broken, the picture will be distorted or wiped out completely. This may be caused by open chokes, L259, L261, L262 or coupling capacitor C268.

8. Misalignment of the 4.5 mc trap will cause a "busy background" effect on the trailing edge of the picture.

9. If choke L264 or coupling capacitor C275 is open, there will be always enough coupling capacity to carry along at least a fraction of the signal. The resultant picture will have black lines across it.

10. Open or shorted resistances are easily located. Before resistors open up completely, they often show high resistance value. If this happens with the resistors R269 and R272 the effect will be a smeared picture. A high resistance of R273 will cause picture distortion at high values of picture control.

11. A shorted capacitor C275 will have the following effects: The picture is very bright with black lines across it. Brightness control does not reduce the brightness.

### Picture Tube Circuit

12. A defective picture tube can be the cause of a faint picture, a distorted and unsteady picture or no picture at all.

13. Parts of the electron gun structure might vibrate under the influence of a strong loudspeaker output, resulting in sound bars in the picture.

14. A gassy picture tube will cause a blooming picture which is out of focus.

15. In case the capacitor C279 on the cathode of the picture tube breaks down, a high voltage will be right on the cathode blanking out the picture. If this capacitor opens up, horizontal lines appear on the picture increasing towards the top.

16. A leaking capacitor C278 will cause a small picture with poor brightness and vertical linearity. If the other capacitor C277 becomes defective, the following effects will occur: A shorted capacitor will produce a fuzzy and very bright picture while an open capacitor will produce a bright horizontal area advancing towards the top with increasing brightness control setting ("window shade" effect).

## Horizontal Sweep Section

17. No raster on the picture tube indicates a lack of high voltage or horizontal sweep voltage. This may be caused by a defect in the high voltage rectifier circuit, or in the horizontal sweep output circuit, the horizontal oscillator may not be functioning properly or there may be a short in the horizontal deflection circuits.

18. Insufficient sweep width may be caused by defective components in the horizontal deflection circuits. Check the secondary circuits of T351 for defective components. When L353 is shorted or has shorted turns, the picture will be too narrow and L353 will have no or little control on the width.

19. Poor horizontal linearity may be caused by a short in L352 resulting in L352 having no control on the horizontal linearity. High leakage in capacitor C370 will cause poor linearity and also will increase the width.

20. A short in capacitor C377 will change the *d.c.* component through the horizontal deflection coils which will shift the picture horizontally such that it may not be centered with the focus coil setting.

21. Poor horizontal sync with good vertical sync may be caused by a defect in the circuits of V11, or V12 or–B.

22. No vertical or horizontal sync may be caused by defects in the clipper circuits of V10.

## Vertical Sweep Section

23. The vertical sweep generator contains a multivibrator circuit which is made inoperative by the defects of the following capacitors; shorted capacitor C304, C305 or C308. If the capacitor C305 is open, the oscillator is stopped.

24. The frequency of the generator is thrown off by a short circuit of the capacitors C301 and C302 with the effect that the vertical does not sync.

25. The linearity of the vertical sweep is impaired when the electrolytic capacitor C309 loses its capacity to an appreciable extent. If it opens up completely, the height reduces to approx. one-fifth of the normal size.

26. If the paper capacitor C308 develops any leakage, the vertical size is reduced so that the height control R308 does not suffice to obtain the desired height.

27. In case the capacitor C302 has an open circuit, the vertical sync becomes less stable.

28. If the B+ voltages supplied to the circuit is too low, the deflection voltages will not suffice to deflect the beam across the entire surface of the tube.

29. Microphonic tubes might give rise to a very unstable operation, resulting in a jumpy picture.

## Common Sync Section

30. A shorted capacitor C354 on pin 1 of V10 tube will produce excessive contrast which cannot be reduced to normal by the picture control. If this capacitor opens up, both horizontal and vertical sync will be inoperative.

31. An open capacitor C353 on the plate (pin 5) of tube V10 will produce a shaky picture with excessive contrast, while an open capacitor on the grid (pin 4) of tube V10 (C351) will produce bright lines on bottom and top together with poor horizontal and vertical sync which is independent of picture control setting.

32. Distorted picture and reverse action of picture control is caused by an open capacitor C261 on the picture control. If C261 is open, increasing picture control will decrease picture control and vice-versa.

## Focus Coil, Ion Trap and Deflection Yoke

33. To obtain good focus and centered raster, the focus coil must be carefully positioned as outlined under "Focus Coil Adjustment," page 29. No sharp picture will be possible with an open or shorted coil. A partial short will throw the picture out of focus. Before looking for obscure trouble, be sure to check the focus control circuit for defective components.

34. The correct adjustment of the ion trap will result in maximum brilliance and at the same time will insure long tube life. For adjustment of this trap, see page 29.

35. Any unsymmetry of the deflection yoke will cause picture distortion. A shorted coil or shorted turns will cause barrel distortion and unsymmetric trapezoidal distortion. An open deflection yoke will produce a horizontal or vertical line across the screen. An open horizontal deflection coil produces a vertical line, while an open vertical deflection coil produces a horizontal line. For deflection yoke adjustment, see page 30.

36. The yoke assembly must be pressed against the bell of the picture tube to avoid neck shadow.

37. The correct picture size is obtained by adjusting the width and height control, as outlined under "Preset or Service Adjustment Controls," pages 19 to 26.

## Audio Stages

38. The FM modulated signal can reach the 1st audio tube only when the two *i.f.* transformers are aligned properly. In localizing defective components, follow normal radio trouble shooting procedure.

39. In case of improper alignment especially of discriminator secondary, a buzz or hum is heard when receiving a television station.

40. In case of no sound output the following components should be checked in turn; tubes, output transformer, capacitors and defective speaker.

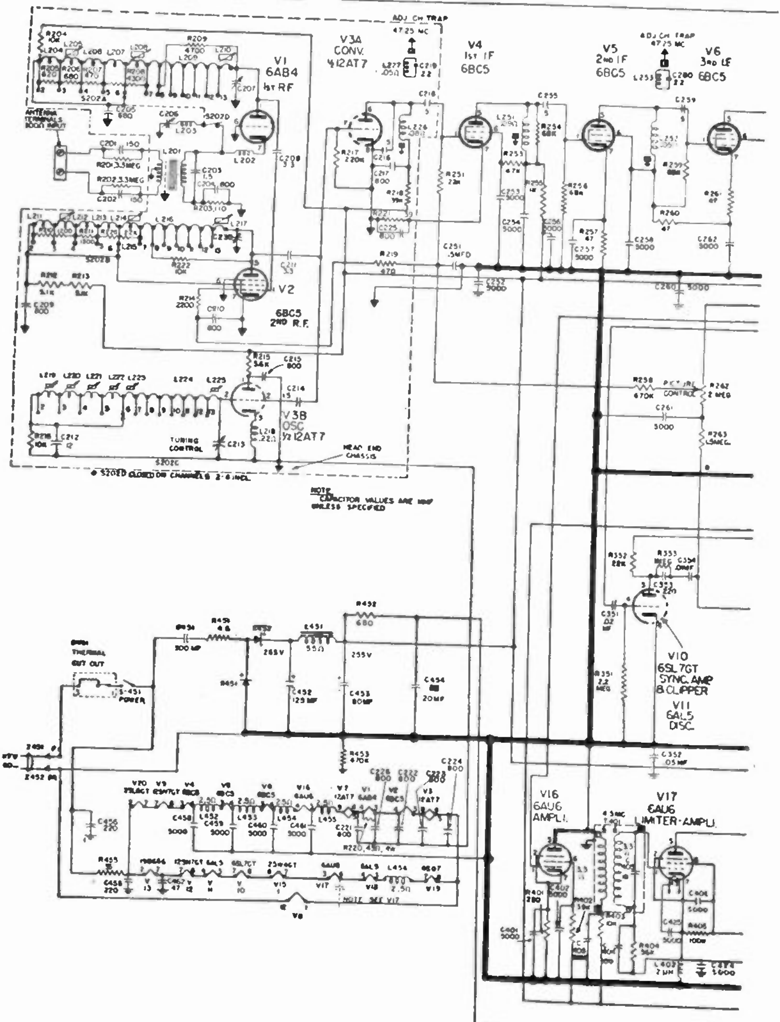



FIG. 1—Schematic diagram of *General Electric Model 12T7* television receiver (for continuation of diagram see opposite page).

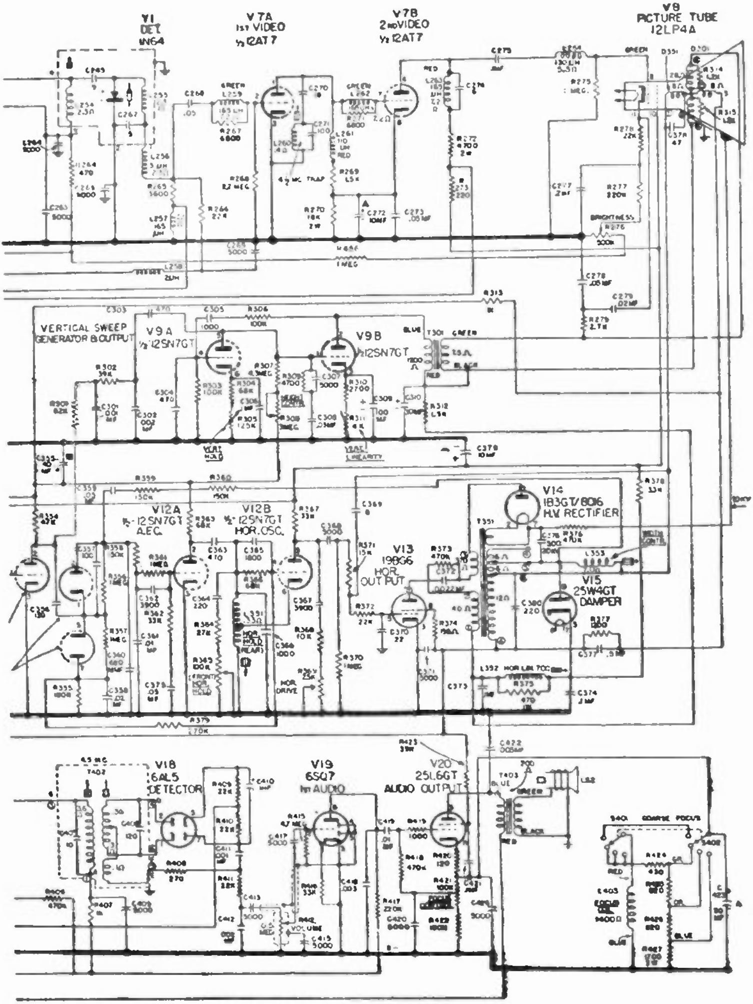



FIG. 2—Schematic diagram of *General Electric Model 12T7* television receiver (for continuation of diagram see opposite page).

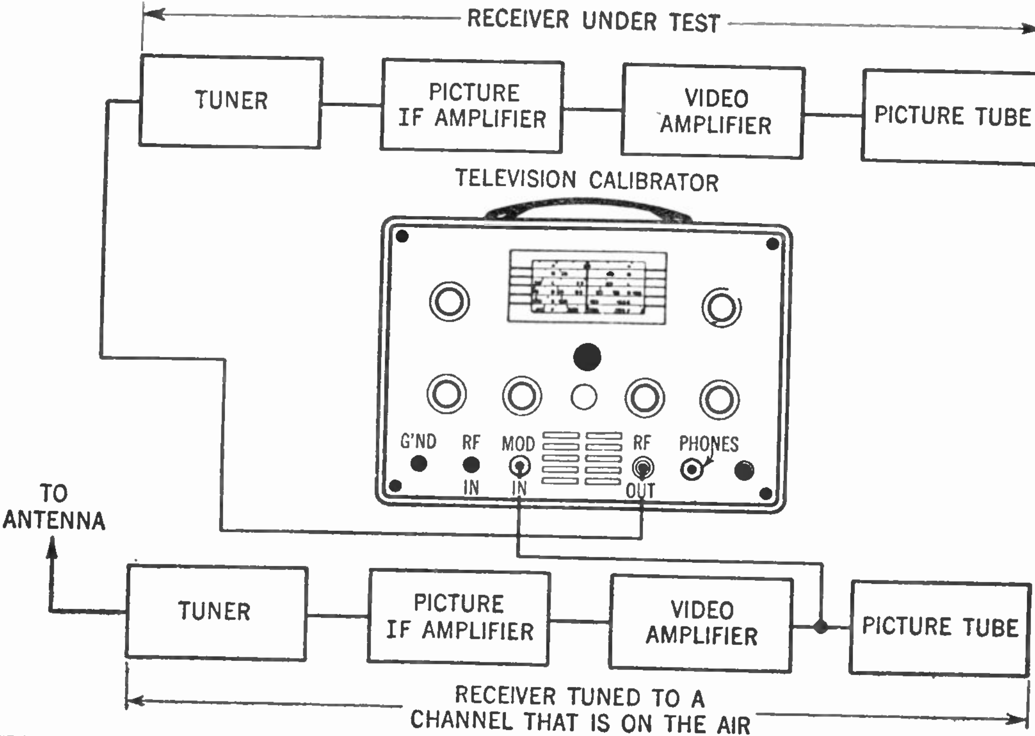



**FIG. 3**—Showing arrangement when calibrator is employed as an all-channel transmitter.

CHAPTER 16

# Wave Form Analysis

In servicing and trouble shooting of television receivers its absolute operating condition can be best determined by a detailed wave form analysis of each section and comparing it with that supplied by the manufacturers of the receiver in question. In practice, however, a detailed wave form analysis (although desirable in particular applications) is far too time consuming for adoption by most service technicians.

Because of this, the *relative check* system, where the receiver trouble is analyzed and narrowed down to a specific section, by the usual sound or visual method is most commonly employed.

It is therefore only after the trouble has been localized, that a point-to-point wave form check is made in that immediate stage, and the wave form so obtained is compared to that supplied by the manufacturer.

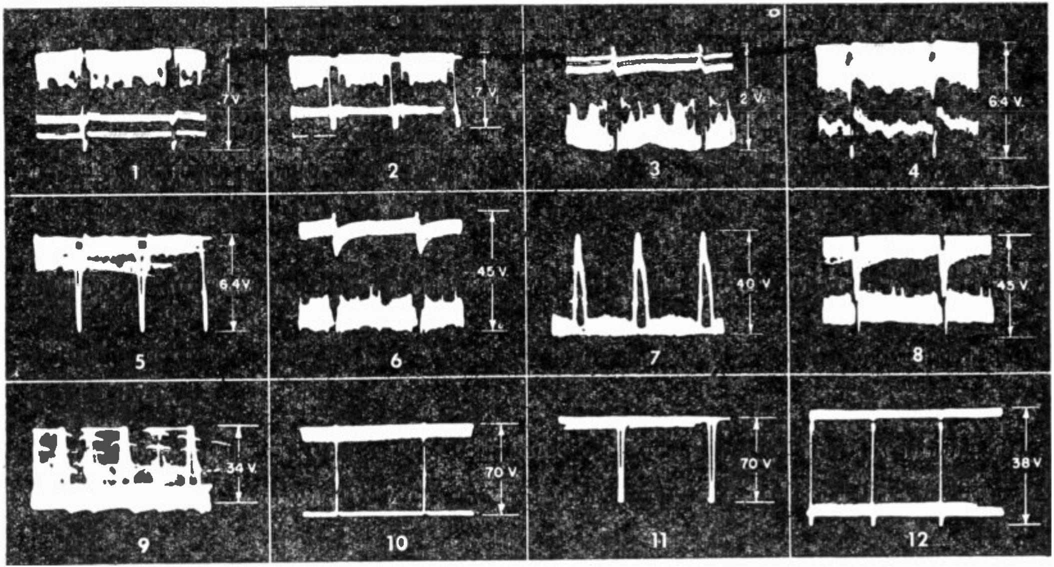
By having the manufacturers' wave form photographs available along with the peak-to-peak voltage readings for each model receiver, a rapid reference check can be made by comparing the resultant wave forms and amplitudes with that obtained at the test.

A comparison of voltage will give the relative loss or gain per stage of the receiver, while the wave shape comparison will reveal such faults as insufficient band width, non-linearity, clipping, hum pick-up, distortion and a number of other irregularities which are the direct result of faulty components or incorrect adjustment.

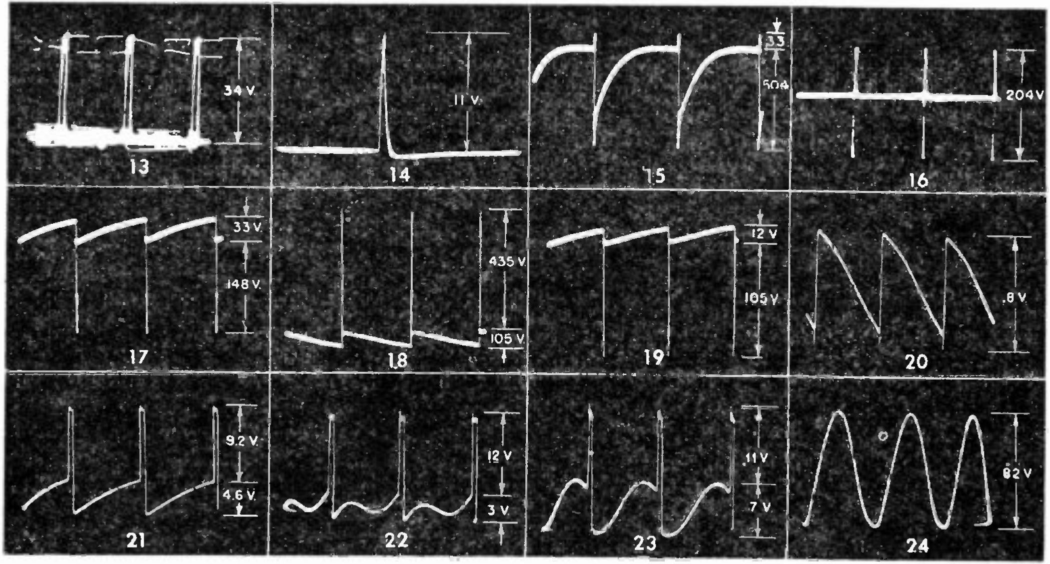
**Oscilloscope Requirements.**—In checking wave forms the main requirements of the oscilloscope, in addition to its linearity and bandwidth, is that it should have a vertical sensitivity of 1 volt (peak-to-peak) or better. For wave forms taken at the vertical sweep and sync circuits, the oscilloscope must be synchronized at approximately 30 cycles to correspond with half the vertical sweep rate. For wave forms obtained from the horizontal sweep and sync circuits, the oscilloscope must be synchronized at 7,875 cycles, or half of 15,750 which is the horizontal sweep rate. All tests should be made with the same signal applied to the receiver terminals.

For screen calibration, either the graduated scale celluloid screen of the oscilloscope, or a strip of linear graph paper may be used. As a calibration source the 6.3 volt filament voltage of the receiver is frequently employed. In this connection it should be noted that this 6.3 volt represents *r.m.s.* values. To read an *r.m.s.* voltage as peak-to-peak, multiply by $2\sqrt{2}$. Thus the 6.3 filament winding would actually produce a peak-to-peak deflection on the oscilloscope screen of $6.3 \times 2\sqrt{2}$ or 17.82 volts.

**Typical Wave Forms.**—Figs. 1 to 31 are presented to illustrate the wave form patterns at various positions within a *Motorola Model VK*101 *Series receiver.* These have a direct reference to the sync and sweep circuit of this receiver and of its associated circuits, including the sync separator, pulse limiter, pulse stripper, etc., since it is in these stages that a great deal of difficulties are usually experienced. The circuits on which the tests were made are shown schematically in figs. 32 and 33.



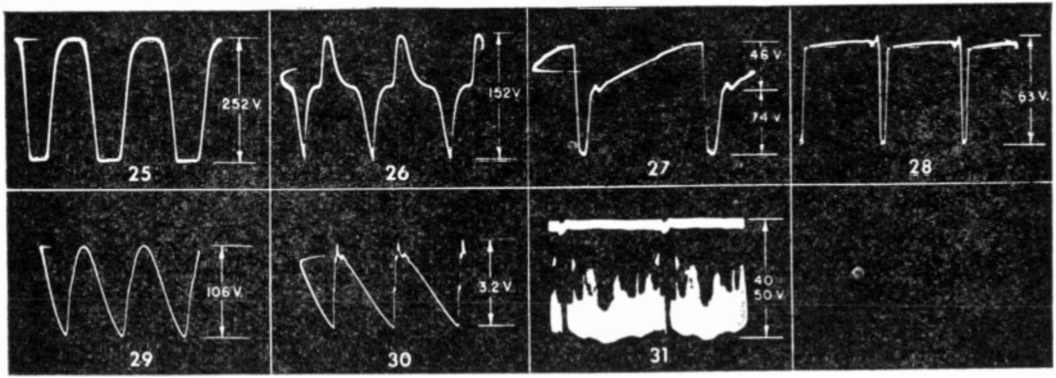

FIGS. 1 to 12—Wave form patterns as taken at various stages of *Motorola VK101 Series* television receiver. For reference points see schematic diagram fig. 32. In the illustration fig. 1, represents detector output and first video grid, slow sweep; fig. 2, detector output and first video grid, fast sweep; fig. 3, second video grid, slow sweep; fig. 4, sync separator input, slow sweep; fig. 5, sync separator input, fast sweep; fig. 6, plate of pulse stabilizing amplifier, slow sweep; fig. 7, plate of pulse stabilizing amplifier, fast sweep; fig. 8, grid of pulse stripper, slow sweep; fig. 9, grid of pulse stripper, fast sweep; fig. 10, grid of pulse limiter, slow sweep; fig. 11, grid of pulse limiter, fast sweep; fig. 12, plate of pulse limiter, slow sweep.




FIGS. 13 to 24—Wave form patterns as taken at various stages of *Motorola VK101 Series* television receiver. For reference points, see schematic diagram fig. 32. In the illustrations, fig. 13, represents plate of pulse limiter, fast sweep; fig. 14, integrated vertical pulse measured at the junction of the 22,000 and 6,800 ohm resistors between the pulse limiter 6J5 and the vertical blocking oscillator transformer with the 6SN7 vertical blocking oscillator tube removed, slow sweep; fig. 15, grid of the 6SN7 vertical blocking oscillator, slow sweep; fig. 16, plate of 6SN7 vertical blocking oscillator, slow sweep; fig. 17, plate of 6SN7 vertical

(continued on page following)

discharge tube, slow sweep, fig. 18, plate of 6V6 vertical output tube, slow sweep; fig. 19, secondary of vertical output transformer, slow sweep; fig. 20, vertical deflection coil current, slow sweep; fig. 21, center tap of horizontal sync discriminator transformer, fast sweep; fig. 22, discriminator diode plate, pin #3 of 6H6 discriminator tube, fast sweep; fig. 23, discriminator diode plate, pin #5 of 6H6 discriminator tube, fast sweep; fig. 24, grid of 6V6 horizontal oscillator tube, fast sweep.




FIGS. 25 to 31—Wave form patterns as taken at various stages of *Motorola VK101 Series* television receiver. For reference points see schematic diagram fig. 32. In the illustrations fig. 25, represents plate of 6V6 horizontal oscillator tube, fast sweep; fig. 26, grid of 6J5 horizontal discharge tube, fast sweep; fig. 27, plate of 6J5 horizontal discharge tube, fast sweep; fig. 28, secondary center tap of horizontal output transformer to ground, fast sweep; fig. 29, bottom primary terminal of horizontal output transformer and ground, fast sweep; fig. 30, bottom secondary terminal of the horizontal output transformer and ground, fast sweep; fig. 31, saturated signal on the grid of the picture tube.

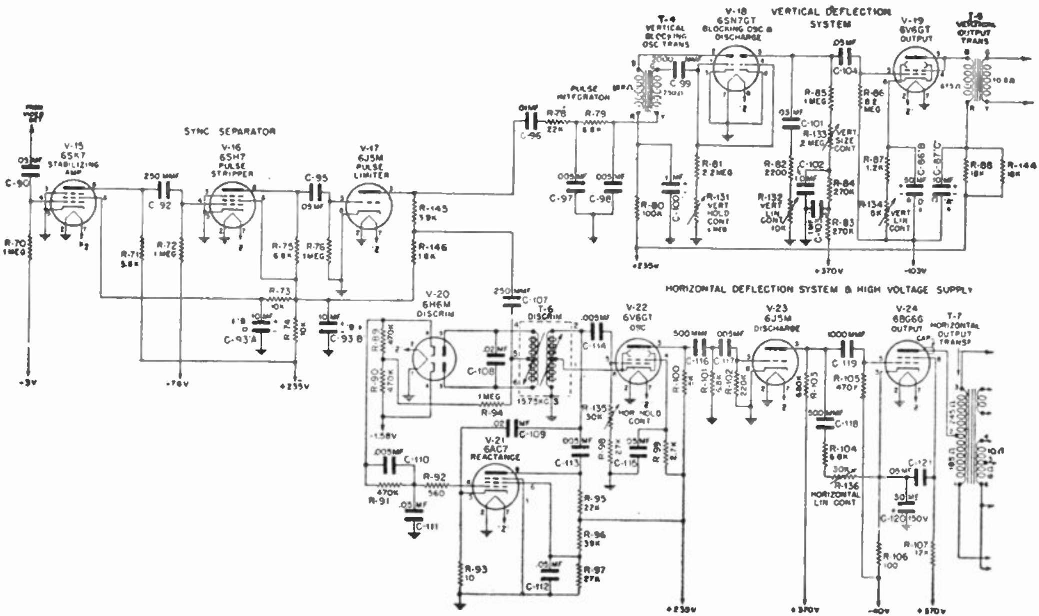



FIG. 32—Partial schematic diagram of *Motorola VK101 Series* television receiver.

These wave forms as shown were taken by *Motorola* engineers on a *Du Mont Model* 241 oscilloscope, using the low capacity test probe. It should be noted that some alteration in the wave form patterns may occur in receivers of different design, or even in receivers of the same model when different oscilloscopes are used.

For the stages in which both horizontal and vertical pulses appear, two photos were taken, one with a slow oscilloscope sweep (30 cycles) and the other with a fast sweep (7,875 cycles). For the slow sweep, the synchronizing selector of the oscilloscope is set for 60 cycles and the synchronizing control adjusted to obtain a stationary pattern. For the fast sweep, the synchronizing selector should be set for "Y" signal, or internal sync. With the frequency range control of the oscilloscope set to the slow sweep, the resulting wave form represents one or more complete *fields*.

Wave forms taken with the range control on fast sweep will represent one or more *scanning lines*. In addition to the wave form patterns, the photos also show the amplitude of the various signals. These are based on a 0.7 volt signal at the grid of the first video stage.

To obtain a wave form of the saw tooth current in the deflection coils, a 5 ohm resistor *must* be inserted in series with the deflection circuit, and the oscilloscope leads connected across the resistor. In the horizontal deflection circuit the resistor should be inserted in series with the plate supply lead to the 6BG6G horizontal output tube at a point below the coupling condenser when the Motorola VK101 is being checked. This is done to prevent an improper wave form which might result from the ripple voltage or damping diode action. In other receivers not employing a similar *d.c.* supply circuit, the 5 ohm resistor is inserted in series with the plate supply lead at the most convenient point. Measurement across the 5 ohm resistor is necessary in the horizontal sweep circuit since the induced voltages in the plate circuit of the 6BG6G and in the primary of the

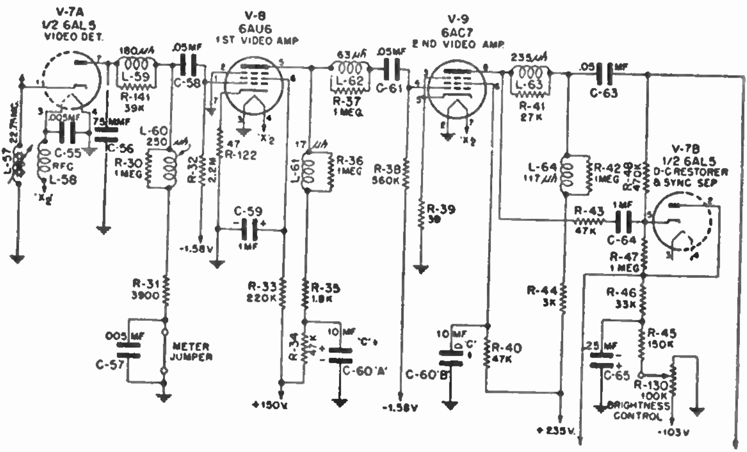



**FIG. 33—Partial schematic diagram of *Motorola VK101 Series* television receiver.**

output transformer are on the order of 5 to 9 *kv*. Extreme care must also be employed when making these measurements as the oscilloscope ground is actually at the B+ potential of the receiver. Avoid physical contact with the oscilloscope and receiver chassis or accidental ground between the two.

The normal course of the television signal can be traced from the detector output to the picture tube grid by following the wave form patterns shown in figs. 1 to 31.

In receivers whose video detector is connected differently, the picture phase may be positive (pictures in figs. 1 and 2 inverted). The signal at the grid of the second video stage fig. 3 is substantially the same except that it is inverted 180 degrees and has assumed a peak-to-peak voltage gain of 1.3 volts. At the second video output this gain has increased to 6.4 volts. Referring to the schematic fig. 33 the video signal is taken from the second video output and fed both to the picture tube grid and to the input of the *d.c.* restorer and sync separator. Here the sync pulses are removed from the composite video signal and passed on to the pulse stabilizing amplifier, where they are amplified.

This stage operates in a manner similar to a compression or *a.v.c.* stage so that the sync pulse amplitude at its output is practically constant for a wide range of input voltages. The pulse stripper (or clipper) clips the signal at just above the blanking level and removes all of the remaining video components from the sync pulses. The pulse limiter flattens the top of the vertical pulses so that a good, square shaped pulse will be applied to the integrator and thus to the blocking oscillator. The blocking oscillator and discharge tube feeds in the usual manner into the vertical output stage, which converts the voltage wave form into a current wave form and applies it to the vertical deflection coils.

In the horizontal deflection system, *a.f.c.* is used. This consists of a 6V6G sine wave oscillator operating at 15,750 *c.p.s.* with a 6AC7 reactance tube across its input circuit. The horizontal sync pulse is combined with the sine wave voltage in the 6H6 discriminator to produce a *d.c.* voltage which biases the reactance tube and causes the oscillator frequency to sync with that of the sync. pulses. The horizontal discharge and horizontal output operate in a manner similar to the vertical discharge and output stages, except for the higher frequency and the increased voltages involved.

**Wave Form Interpretation.**—Proper analysis of these wave forms will greatly facilitate servicing. For instance, if a video signal be present at the picture tube grid, but no wave form is present in either the vertical or horizontal sync stages, look for a defective stabilizing amplifier, pulse stripper, or pulse limiter; these three stages are all common to both horizontal and vertical deflection circuits. Check for the presence of wave forms in each stage. Presence of vertical sync, but no horizontal sync indicates possible trouble in the discriminator or reactance stages.

Other troubles can be traced in the same manner simply by checking for the presence of a wave form and comparing it to the standard as previously indicated. By studying the operation not only of the sweep and sync circuits, but of the entire receiver by the wave form comparison method, the action and correlation between each section will soon be understood and the service technician will be able to diagnose and correct the trouble in the least possible time.

CHAPTER 17

# Color Television

Principally the transmission of television pictures in color is based upon breaking down and re-assembling of the televised scene into its *three primary colors*. These colors are the *red*, *blue* and *green*. In order to understand the technique and the problems associated with color television a complete understanding of the fundamentals of color will be of assistance.

**Color Characteristics.**—Color as observed by the human eye is a property of light. This fact may simply be ascertained by passing sunlight through a glass prism. The colors thus obtained constitute the *color spectrum*. White sunlight contains all colors but due to the limitation of the human eye and the fact that colors produced by the prism blend into each other, only seven fairly distinct colors may be observed.

If a close inspection of the foregoing color distribution be made, numerous fine graduations may be observed, both between the different colors and within any one color itself. It has been found that all the various tints and shades that are contained in the spectrum under observation may be reproduced by a combination of the *red*, *blue* and *green*.

Thus, a certain desired color may be obtained by a proper proportioning of the primary colors. In this manner *yellow* may be obtained by a combination of *red* and *green*, *orange* by a different proportioning of the same *two* colors, *white* by a careful proportioning of *red*, *blue* and *green*, etc.

It is these well known facts about colors which have been employed in color television by breaking down the light received from a scene into its primary components at the television transmitter and recombining them at the television receiver.

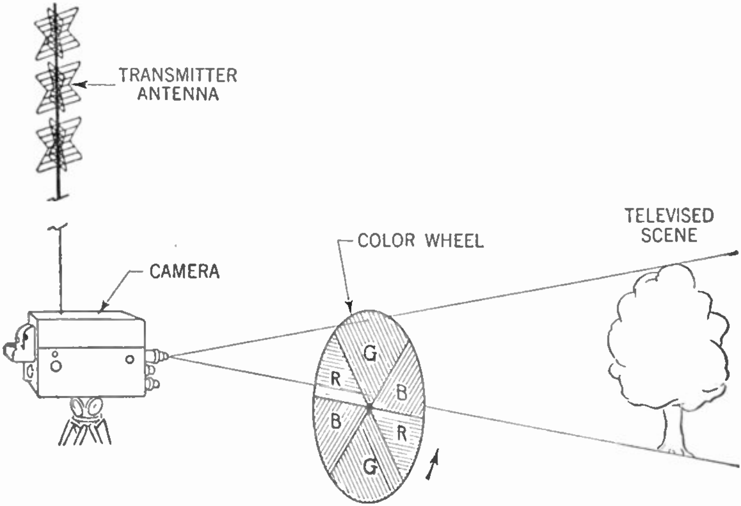



**FIG. 1—Schematic diagram showing arrangement of apparatus in the CBS field sequential system of color broadcasts.**

**Present Status of Color Television.**—There are at present several color television systems in various stages of development. Among these there are *two* which will be discussed in this chapter, since each have been developed to a point of a public demonstration. These are termed according to the sequence in which the colors are presented to make up one single whole colored picture, as follows:

1. The field sequential, and
2. The dot sequential system.

The *field sequential system* of color television has been developed by the *CBS* (*Columbia Broadcasting System*) whereas, the *dot sequential system* has been developed by the *RCA* (*Radio Corporation of America*).

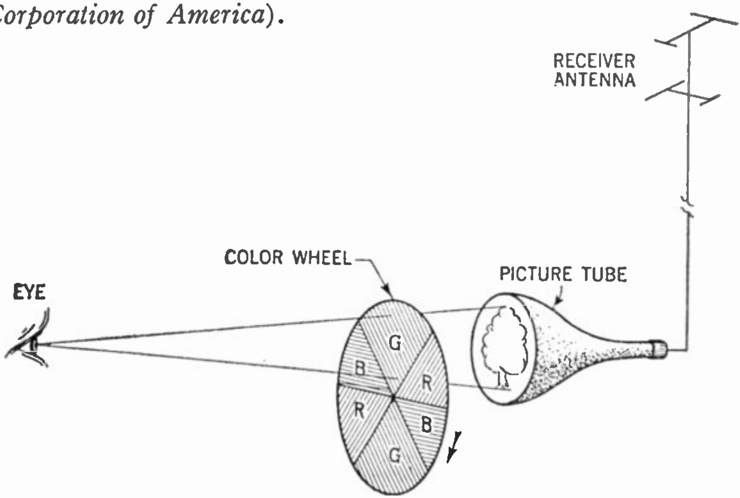



**FIG. 2—Schematic diagram showing arrangement of apparatus in television receiver to obtain color pictures from the CBS field sequential system of color broadcast.**

**The CBS Color Television System.***—The CBS color television system as presently constituted, employs a rotating color wheel in front of the transmitting camera, fig. 1. This motor driven rotating wheel, or disk, is made up on alternate segments of color filters.

The sequence of colors passed before the camera are in the order of *red*, *blue* and *green*, after which the cycle is repeated.

*NOTE.—The *Columbia Broadcasting System* has been authorized by the *Federal Communications Commission* to broadcast color television signals according to certain predetermined standards as given. The hours of such broadcast to be determined as agreed upon, are to be found in the television broadcast schedule of *newspapers within the locality of the CBS systems television network*.

During the time that the red filter segment passes before the camera tube, the televised image is completely scanned and electrical pulses transmitted which vary according to the red light received through the red filter. The same is true of the other two primary colors.

At the receiver, a similar color disk is employed, as illustrated in fig. 2, which rotates in synchronism with that at the transmitter. While the red filter is in place at the transmitter, the red filter is passing before the picture tube at the receiver, thus reproducing the transmitted "red picture" in its proper color. The blue and green pictures are reproduced in a similar manner.

CBS color picture transmission requires two interlaced color frames of three fields each. There are 144 fields per second, with 24 complete pictures. It was necessary to cut the number of lines from the standard 525 to 405 in order to permit transmission of the 144 fields within the regular 6 mc. channel.

This makes the *CBS* color system "incompatible" with the present monochrome picture standards. Therefore, it is necessary to make certain alteration in the sweep circuits of the standard 525 line black and white receivers to permit operation on 405 lines for colors as well.

**The RCA Color Television System.**—In the dot sequential system of color television, as developed by the *Radio Corporation of America*, the scene to be televised is picked up by a special color camera containing three camera tubes, one for each of the three primary colors.

According to *RCA engineers*, the three tubes work into three separate amplifiers and transmitters so that the three primary color images are being transmitted simultaneously. Fig. 3 is a block diagram of the system.

The light entering the camera is passed through special mirrors which possess the property of being able to reflect one color but pass all others. These are known technically as "dichroic" mirrors. In this manner all light reaching the camera is sorted into its primary color components.

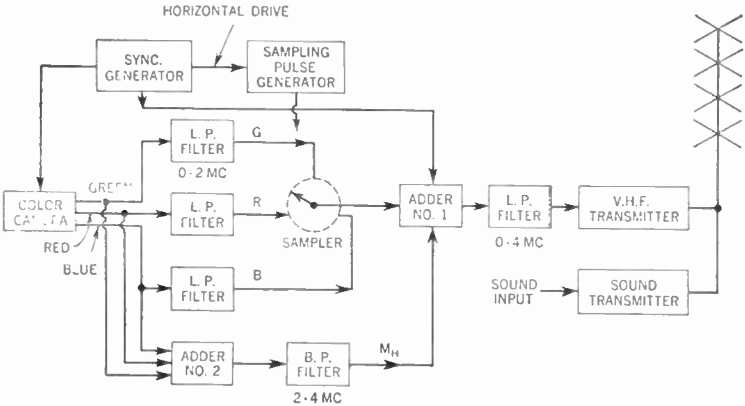



**FIG. 3—Block diagram showing how the RCA dot sequential color system operates at the transmitter end.**

The output from each camera tube is now transferred through separate low-pass filters (which pass only video signals having frequencies up to two megacycles) to an electronic sampling tube as illustrated in fig. 3. At the same time this is happening, portions of the three color signals from the camera are combined in electronic *Adder No.* 2 and passed through a bandpass filter where video frequencies up to 2 mc. are suppressed and those from 2 to 4 mc. are transmitted.

This system of dividing the color signals into separate low and high frequency components and then combining all of the high frequency components together is known as a *mixed high system.*

Why this particular method was chosen will be shown in the following.

The mixed high frequencies are fed to *Adder No.* 1 which is also receiving signals from the electronic sampler. However, while the mixed high frequencies are arriving in a continuous stream, the low frequencies are arriving in spurts, from the electronic sampler, in the form of short pulses.

Within the sampler, an electron beam is revolving at a rate of 3.8 million times per second. The beam thus comes in contact

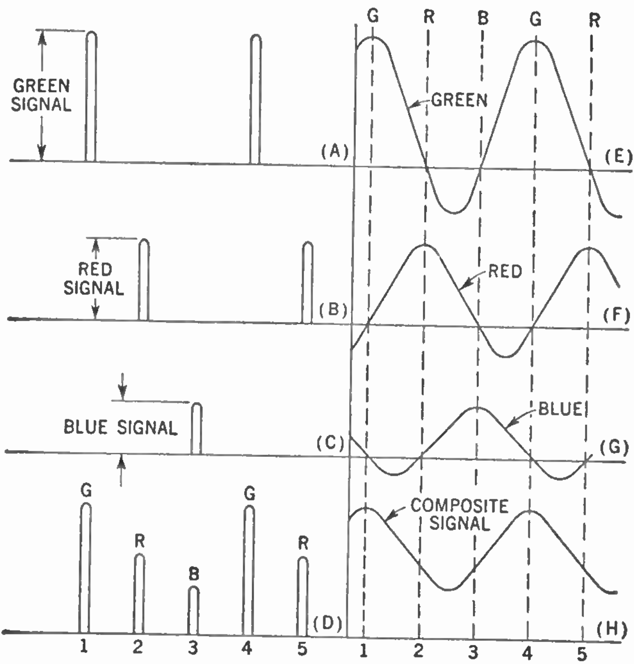



**FIG. 4—Showing method of operation employed in the sampler system associated with the RCA dot sequential television color system.**

with the color signal from each camera 3.8 million times in each second providing *Adder No.* 1 with this many samples from each color, one sample arriving every 0.263 microsecond (1/3.8 = 0.263).

Fig. 4 shows the output of the sampler for a short period of time. In fig. 4A the output of the sampler for the green signal is shown. A green sample (pulse of voltage from the signal fed to the sampler by the camera receiving the green portion of the incoming light) appears every 0.263 microseconds.

At a time 0.0877 microsecond after the first green sample, a sample is taken of the voltage from the camera receiving the red rays of light. The red samples themselves, however, are spaced 0.263 microsecond apart. Blue samples are taken at the same rate as the red and green samples and appear 0.0877 microsecond after a red pulse of voltage.

The composite sequence of these voltage pulses is shown in fig. 4D. For any particular scene, the strength of each pulse would depend of course, on the amount and shading of the color rays reaching the camera.

The pulses at the output of the sampler tube are fed to *Adder No.* 1 where they are combined with the mixed-highs signal. Both signals are applied now to a low pass filter (passing 0-4 mc.) where the pulses of voltage from the electronic sampler are smoothed out. Each of the smoothed out pulses now becomes a sine wave having a frequency of 3.8 mc. as shown in figs. 4 E, F and G.

It should be noted in these sine waves, that when any one color signal reaches its maximum value, the other two color signals are passing through zero. This is important and insures that when the signals are again sampled at the receiver, that only one color is obtained during each sampling.

While the three sine waves are shown separately in fig. 4 E, F, and G they are actually combined in the low pass filter to form the composite signal shown in fig. 4H. It is this composite signal which combines with the mixed-highs signal to provide the complete video signal. The remainder of the transmitter now follows the usual sequence of amplifying this voltage, impressing it onto an *r.f.* carrier and sending it out over the air to the receiver.

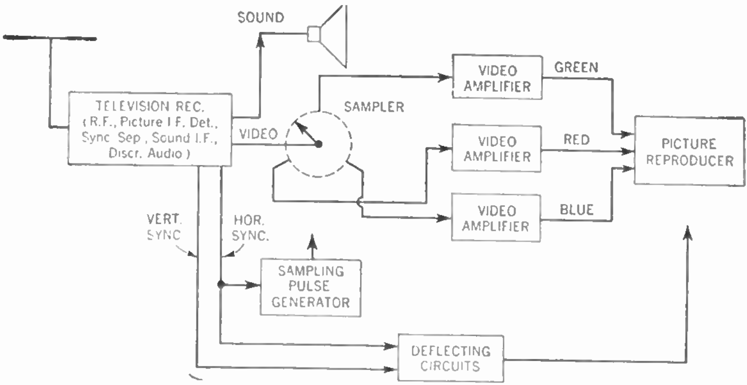



**FIG. 5—Block diagram showing necessary components of a dot sequential color television receiver.**

**The Receiving System.**—At the receiver the transmitted color television signal, together with the accompanying sound, is received and amplified by a series of stages which up to the second detector, are similar in all respects to the same stages found in present black and white receivers.

Thus, there is an *r.f.* amplifier, a mixer, a high frequency local oscillator, a series of video *i.f.* stages and a conventional sound detector. The same is true of the audio system with its *i.f.* amplifiers, discriminator, audio amplifiers and speaker.

A block diagram of a color television receiver of this type is shown in fig. 5. The receiver principles in the previously described RCA color television system is approximately as follows:

The video signal at the output of the second detector consists of the composite color signal, as shown previously in fig. 4H, plus the vertical and horizontal synchronizing pulses which are required to keep the receiver image in step with the transmitter image.

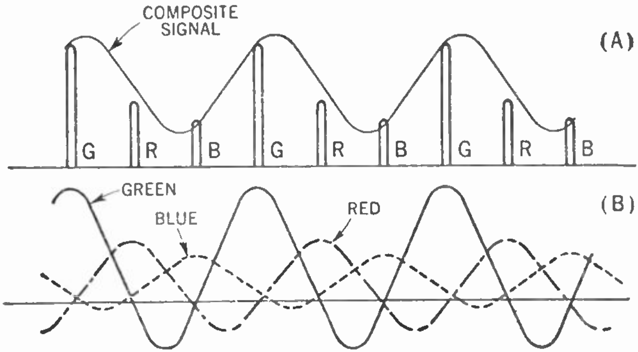



**FIG. 6—Operation of the color television receiver sampler system.**

Part of the signal is applied to a sync separator stage where the sync pulses are divorced from the rest of the signal and then fed to saw-tooth deflecting circuits where they lock-in the sweep oscillators. This, again, does not differ from conventional black and white television receiver practice.

The rest of the signal from the video second detector is fed to a sampler tube which is similar to the sampler tube employed at the transmitter. Every 0.0877 microsecond, the sampler tube samples the composite signal producing the narrow pulses shown in fig. 6A. The amplitude of each sample will depend upon the strength of the composite wave at that particular instant. This same stipulation was true at the transmitter, it will be remembered.

The sampler sends these pulses to each of the video amplifiers and its associated cathode ray tube in succession. Thus, looking at fig. 6A, the green pulse goes to the video amplifier system which is associated with the cathode ray tube emitting green light, the red pulse goes to the red video system, and the blue pulse goes to the blue video system.

The sequence then repeats itself, going from green to red, to blue for so long as the equipment is in use. To insure that the sampler tube sends the series of pulses to the various video amplifiers in proper sequence, the trailing edge of the horizontal synchronizing pulse is used to drive both receiver and transmitter sampler tubes.

When the three colored pulses pass through their respective video amplifier systems, they are smoothed out to the sine wave form shown in fig. 6B. Note, that while all of the signals are shown together in this illustration, only the green signal goes to the green cathode ray tube, only the red signal goes to the red cathode ray tube, and only the blue signal goes to the blue cathode ray tube. The image that is produced on each cathode ray tube will thus depend upon how much of the scene being sent by the transmitter contains that particular color.

If, for example, there is a considerable amount of red detail in the scene, with little blue and say slightly more green, then the amount of detail visible on each separate image tube will vary accordingly. The light output of all tubes are combined then to form the complete picture, to provide the true shading of the original scene.

In the receiver shown in fig. 5 the total signal consisting of the sampled signal plus the mixed highs has been inserted in the receiver sampler and when this unit samples portions of the incoming signal, it obtains for each pulse the proper low frequencies for that color plus a combination of the mixed highs.

Consider carefully what happens to the high frequencies. At the transmitter these high frequency components of each color were combined, first with each other, and then with the low frequency composite signal obtained from the output of the sampler.

At the receiver, when the electronic sampler samples the signal, it will obtain not only the particular color wanted, say blue, green or red, but in addition, it will also receive a combination of the high frequency components of all three colors at the same time.

Thus, each cathode ray tube will have its own color plus essentially the same highs or fine detail. Since each image tube receives the same amount of fine detail, the combination of these three colors in the final image will produce either white, black or intermediate shades of grey.

This is because the combination of the three primary colors, in equal amount, will produce white or its equivalent. Thus we see that in a "mixed-highs" system, the fine detail of the image will appear in black and white, and the larger detail will be in color.

The "mixed-highs" system is similar to the process of color rotogravure used in printing newspapers and periodicals. To print a color photo, the three primary colors are used, with the addition of a fourth plate which is black.

This fourth plate adds black, white and the intermediate shades of grey to the image formed by the three primary colors. It has been found that through the use of this fourth plate, the depth, emphasis, and richness of the picture are increased. The same results are observed in television.

**Black and White Reception.**—As previously shown the signal which is radiated by the color transmitter consists of a composite voltage obtained by combining the low frequency components of each color with the mixed high components.

The total signal therefore, possesses all of the information needed to develop a black and white image with full resolution.

When a black and white receiver is tuned to a color broadcast station, the total signal, after the video second detector, is passed through several video amplifiers and then applied to a conventional cathode ray tube. It is true that there is a 3.8 mc. sine wave superimposed on the picture signal due to the 3.8 mc. sampling frequency at the transmitter. This will produce a dot pattern on the black and white image tube in highly colored areas, but the dots are not noticeable at normal viewing distances.

When a color receiver is tuned to a television broadcasting station transmitting a black and white signal, the picture will appear in black and white with full resolution on the color receiver screen. The successive pulses delivered to the three image tubes will all be of equal magnitude, and hence, will produce varying intensities of white—which represents a normal black and white picture.

CHAPTER 18

# Color Conversion Methods

In the foregoing chapter, a brief description of the CBS color transmitter and receiving principles were given. It was also mentioned that the CBS method of color transmission as presently constituted is *incompatible* with the present black and white television standards. Therefore, it is necessary to make certain changes in the conventional black and white receivers in order to be able to receive the CBS color broadcasts.

The complete conversion of a receiver for reception of the CBS field sequential color system, requires two distinctly separate devices. They are:

1. An adapter (Housing the circuit conversion components).
2. A rotating color disk (Filter wheel).

At the outset, it should be made clear, that due to color disk size and accompanying limitation (the filter wheel must be at least twice the size of the screen), only black and white receivers with screen diameters of 12½ inches or less are at present adaptable to color conversion.

Before proceeding with an explanation of the functions of the conversion devices, it may be well to enumerate the CBS color transmission standards:

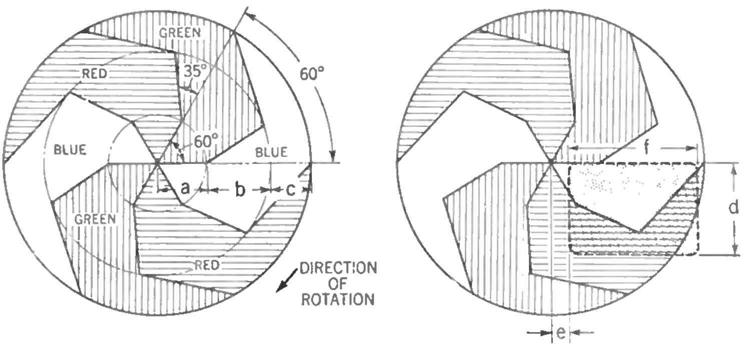
The CBS color television system is a field sequential system, that is, colors are changed after each vertical scanning period or field. There are 144 fields per second, and as in black and white two to one interlacing is employed. The number of lines per frame is 405, or 202.5 per field (262.5 in black and white). Thus, the total number of lines per second, or horizontal line frequency is $72 \times 405 = 29{,}160$ *c.p.s.* This is slightly less than twice the black and white horizontal line frequency which is $30 \times 525 = 15{,}750$ *c.p.s.*

The colors are transmitted in the following sequence: *red, blue* and *green.* Each color lasts for 1/144th of a second and the color sequence repeats itself after 1/48th of a second. This period is called a color frame interval. Since only one-half the number of lines will have been scanned in all colors in 1/48th of a second, twice this period, or 1/24th of a second, is required for all lines to be scanned in all colors. This period of 1/24th of a second is called a color picture interval.

The CBS field sequential system can utilize electronic or mechanical means for color selection. Thus far, the simplest and least expensive method is the use of the color disk. The color disk rotates in front of the receiver tube at the rate of 1,440 *r.p.m.* When six color filters are employed, it means that two sets of red, blue and green filters are used. In addition to the tube size, the shape of the filters determines the size of the color disk.

Most ordinary black and white receivers do not have sufficient scanning speed range in horizontal scanning; therefore, in order to receive a single black and white image with 405 lines and 144 fields, the horizontal scanning frequency would have to be changed to reach the required 29,160 *c.p.s.* In addition, the horizontal flyback time must be properly adjusted. The vertical scanning frequency would have to be extended to cover the range from 60 to 144 *c.p.s.*

**The Color Disk.**—The color disk, shown in figs. 1 and 2 must rotate at a speed of 1,440 *r.p.m.* in front of the screen of the receiver. The most effective disk diameter should be somewhat larger than twice the width of the picture to be received. Thus, for a 7-inch tube screen, the radius of the color disk should be seven and three-quarters inches, that is a diameter of 15½ inches, approximately.




| COLOR WHEEL DIMENSIONS | | | | | | |
|---|---|---|---|---|---|---|
| PICTURE TUBE SIZE | a | b | c | d | e | f |
| 12½" | 4½" | 3½" | 6¼" | 8" | 2" | 10" |
| 10" | 3¾" | 3" | 5¼" | 6" | 2" | 8" |
| 7" | 2½" | 2" | 3¼" | 3¾" | 1¼" | 5" |

**FIGS. 1 and 2—Showing color wheel layout and required dimensions for various size receiver screens. The dimensions given are approximate only.**

As shown in fig. 1 the disk employs six color filters, namely, two sets of red, blue and green filters. If only three color segments were used (120° each) the motor speed would be too high for successful use.

**Color Filters.**—Several plastic suppliers make available colored sheet plastic suitable for color disks. Good results can be obtained with *Wratten* No. 26 for the red; *Wratten* No. 47 for the blue and *Wratten* No. 58 for the green. The fore-

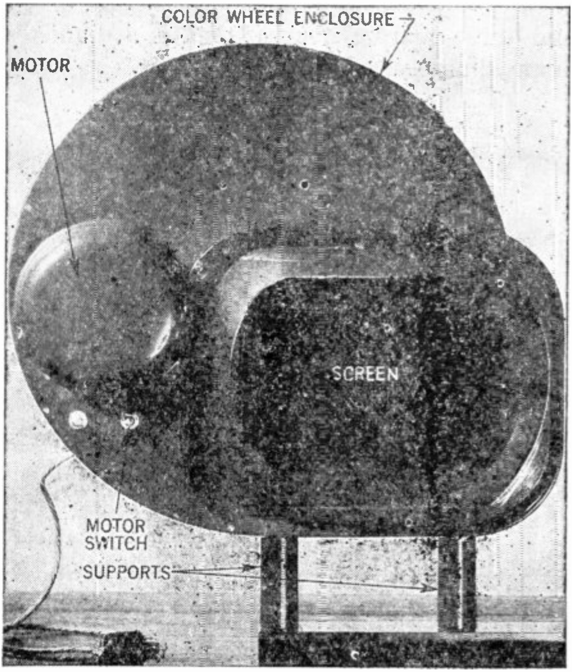



**FIG. 3—Typical motor and color wheel assembly. The motor color wheel assembly should preferably be mounted in such a manner that it may be slid along a rail system running parallel to the screen. This mounting method will facilitate its removal for conventional black and white viewing.**

going filters are to become stock items with the *Eastman Kodak Company* in the near future, under the name of "*Color Television Filters*." Approximately equivalent *Plexiglas* numbers are: No. 159 or 160, red; 263, blue; 260 or 2004, green; and Lucite: No. 10539 red; No. 7456 blue; and No. 3526 green.

**Disk Shapes.**—In laying out the disk shapes for color conversion, the contours should preferably comply with the dimensions given in figs. 1 and 2. It should be observed that for the 7 inch picture tube, a 15½-inch color wheel is used. Similarly, for a 10-inch picture tube a 24-inch wheel is required. A 12½-inch tube, finally would require a 28½-inch color wheel.

**Motor Types.**—The size of motor to use will depend upon the size of color disk. The larger the disk, the greater will be the fractional horsepower motor size required. When receiving color television signals originated by a camera whose power supply is locked to the 60 cycle supply of the receiver location, a synchronous motor will give satisfactory disk synchronization provided that the synchronous motor running at 1,800 *r.p.m.* and disk running at 1,440 *r.p.m.* are properly geared. When the camera and receiver do not run on the same power supply, suitable synchronizing power can be derived from the vertical deflection circuit of the receiver which is running at 144 *c.p.s.* or by extracting the color phasing pulse which is transmitted at the rate of 48 per second at the start of the red field synchronizing pulse.

**Circuit Changes.**—It has previously been mentioned that to convert the conventional black and white receiver to color, certain changes are necessary in the sweep circuits. It should also be noted that with present methods only receivers having a screen size of 12½ inches or less are suitable for adaptation to color.

The complexity of the necessary circuit changes depends also upon the type of receiver. Thus, for example, a 7-inch electrostatically deflected receiver is comparatively simple to convert. Larger receivers with *r.f.* power supplies generally lend themselves to ease of conversion. Television receivers with flyback high voltage systems, on the other hand, will require complex circuit changes, and in order to accomplish a satisfactory conversion, it would probably be necessary to replace the flyback transformer and deflection yoke in many instances.

As previously noted, the frequencies of the deflection oscillators in present black and white transmission standards are 60 *c.p.s.* for vertical and 15,750 *c.p.s.* for horizontal sweep frequencies. For the CBS field sequential color television broadcasts, these oscillator frequencies must be changed to 144 *c.p.s.* for vertical deflection and 29,160 *c.p.s.* for the horizontal sweep circuit. To convert the sweeps in any standard black and white receiver, it is necessary to adjust the vertical and horizontal hold controls to smaller values of resistance. The ratio of this change will be the reciprocal of that between black and white and color sweep frequencies.

**Sweep Circuit Resistance Values.**—Resistance values for the vertical will be 60/144 or 1/2.4 of the total frequency determining resistance of the sweep oscillator in the black and white receiver. For the horizontal, the new value for color will be 15,750/29,160 or 1/1.851 times the black and white value. With these fractions it is a comparatively easy task to determine the values of resistance necessary for conversion from black and white to color.

In most circuits there is a limiting resistance inserted between the frequency determining grid of the sweep oscillator and the hold control. This connection is broken and a switch inserted. In some of the pre-war receivers there is only a hold control, and in some cases no change is necessary other than the proper adjustment of the hold control.

Whether new resistors are switched into the circuit or an adjustment is made directly, the higher sweep frequencies usually comes from the oscillator at a lower amplitude than the original black and white sweep frequency. This will result in a smaller image and will require adjustment of the size control each time a change is made from black and white to color, or vice versa.

This problem is overcome by switching separately adjustable size controls, at the same time as the hold control values are switched. In some cases it may be advisable also to arrange to switch in separate linearity adjustment controls if they are present in the receiver.

**Switch Requirements.**—Several of the simpler type of circuits such as the seven inch *Teletone TV 149* requires only a 4-pole, two-position switch, a diagram showing the circuit conversion of this type of receiver is shown in fig. 4.

In the *Teletone TV 149* receiver deflection circuit, the horizontal and vertical oscillation circuits are identical with only the values of some components changed to establish the vertical or horizontal frequency.

Circuit changes in certain RCA receivers such as the *630TS*, which might be considered as representative of the smaller picture tube sizes, are shown in fig. 5. For the switching arrangement of components of the horizontal *a.f.c.* system employed in this type of receiver, three switch points are required because of the following changes: discriminator frequency adjusting capacitance is changed, horizontal oscillator reactance tube frequency adjusting capacitance is changed, and the values of horizontal drive RC network are changed.

The right side of fig. 6 shows the rest of the horizontal system changes that will be required for the 6BG6-G and flyback output transformer system. Fig. 6 shows a typical *Synchroguide* system as adapted to the 29,160 cycle sweep.

Fig. 7 is a new horizontal output transformer with separate

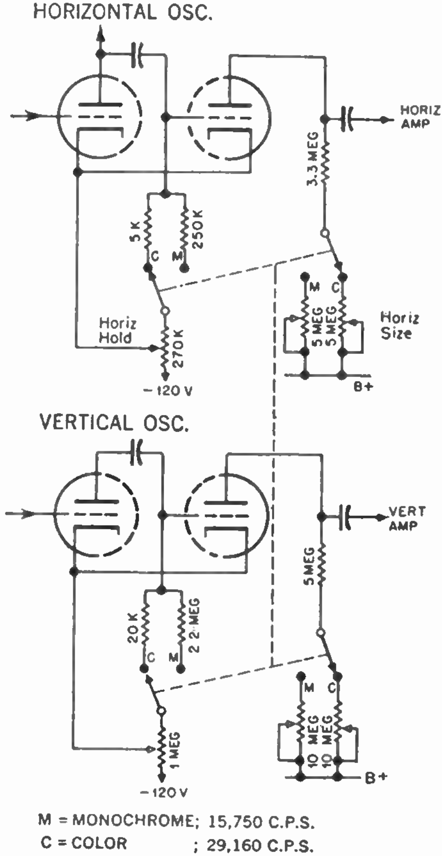



**FIG. 4—Showing circuit changes and switch location for color conversion of *Teletone TV-149* receiver. The switch required is of the conventional four-pole, double-position type.**

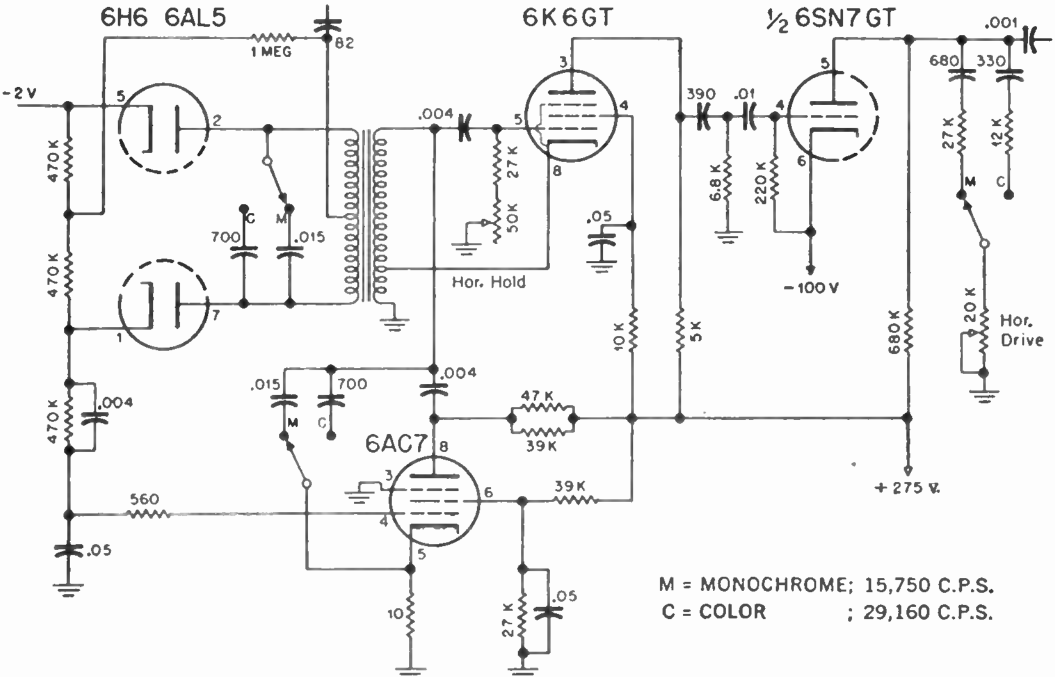



**FIG. 5—Circuit showing how the components are switched for color reception in the *RCA type 630TS* receiver. This is the horizontal *a.f.c.* section of the receiver.**

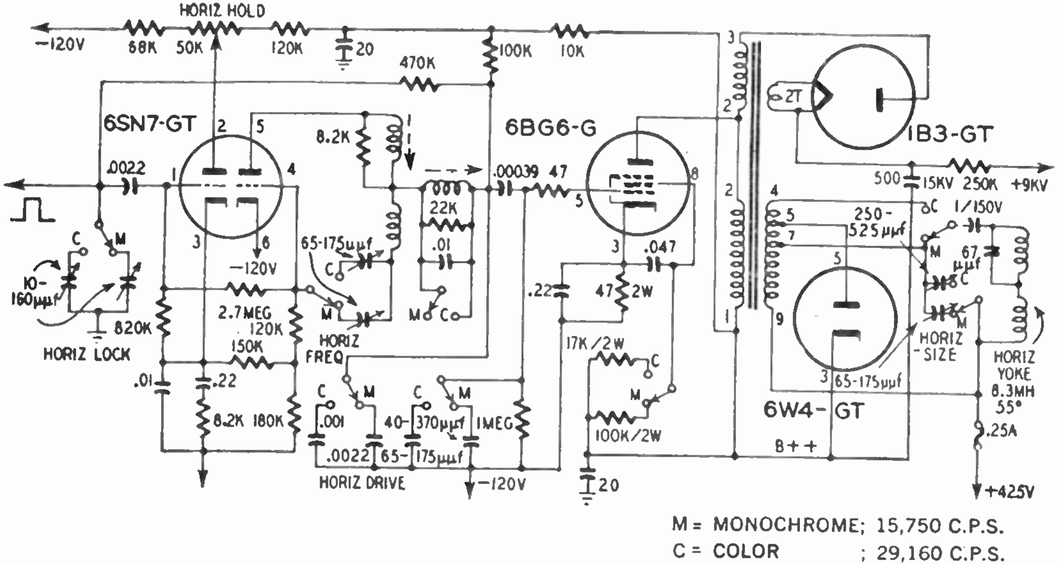



**FIG. 6—Circuit showing the horizontal deflection and high voltage section of the *RCA type 9T-246* type receiver. The modifications shown are those required to enable the receiver to receive color broadcasts as well as black and white.**

taps for the black and white and color horizontal output connections to the deflection coils. The changes are necessary because, when the original system is used, there is a deterioration in horizontal output linearity and sweep amplitude in the color position.

The new transformer has more turns for the color secondary connection to the horizontal deflection yoke than for the black and white connection. The transformer is wound on a square ferrite horizontal output transformer core, with a gap of 0.015 inch in each leg. The primary (1-2) is wound with 800 turns of No. 28 *single-silk* enamel insulated wire.

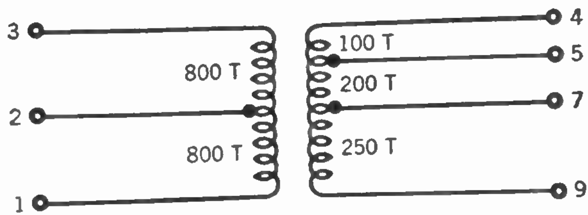



**FIG. 7—Showing horizontal transformer tapped for black and white and color.**

The high voltage winding in series with it consists of another 800 turns of 10-44 *litz* or No. 36 *single-silk* or *single nylon* enamel wire. The secondary is also wound with this wire. Position of the windings is the same as on the transformer it replaces, as is the method of winding.

It will be practically impossible to wind such a transformer by hand, but they may become available commercially in the near future.

The foregoing diagrams illustrate clearly the changes necessary for a black and white to color conversion. Prior to employing any of the foregoing information, however, it is recommended that the service technician try out the conversion changes on a standard receiver, so that he will become thoroughly familiar with all the operations as well as with the components involved.

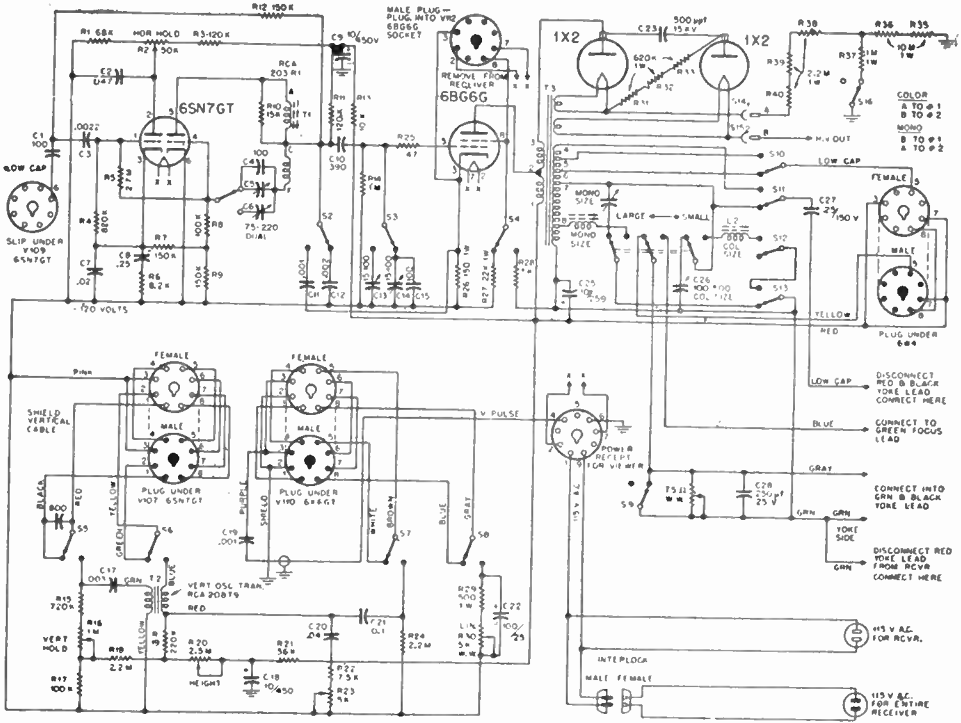



**FIG. 8—Showing wiring of complete adapter unit as recommended by the *CBS* for use with the *RCA type 9T-246* receiver. This adapter unit may be used with other receivers as well, provided certain modifications are made as required.**

CHAPTER 19

# U.H.F. Converters

To meet the demand for additional television stations, the *Federal Communications Commission* (*F.C.C.*) has assigned a wave band in the ultra-high-frequency spectrum between 470 and 890 megacycles for commercial television broadcasting. This adds a total of seventy new *u.h.f.* channels to the existing twelve *v.h.f.* channels. *U.h.f.* channels are numbered fourteen through eighty-three with each channel occupying six megacycles.

Since television receivers designed for operation on the conventional *v.h.f.* channels covering a frequency of between 54 and 88 mc. (low band) and 174 to 216 mc. (high band) will not be able to utilize the new *u.h.f.* channels without circuit modification, it is the purpose of the present chapter to inform the reader of methods presently available to convert the *v.h.f.* receiver for reception on the *u.h.f.* channels.

Experiments and research in the field of *u.h.f.* have resulted in some practical solutions to this problem. Thus, manufacturers have presently developed numerous, simple compact and serviceable converters, which when properly affixed to the present television receiver, will permit reception on all *u.h.f.* channels.

# THE NEW UHF CHANNELS

(Their channel limits, frequency of sound and picture carriers, and the equivalent wavelengths in inches.)

| Channel | Mc | Pix Carrier | Wave-lengths in inches | Sound Carrier | Wave-length in inches |
|---|---|---|---|---|---|
| 14 | 470-476 | 471.25 | 25.0455 | 475.75 | 24.8087 |
| 15 | 476-482 | 477.25 | 24.7307 | 481.75 | 24.4997 |
| 16 | 482-488 | 483.25 | 24.4236 | 487.75 | 24.1983 |
| 17 | 488-494 | 489.25 | 24.1241 | 493.75 | 23.9043 |
| 18 | 494-500 | 495.25 | 23.8318 | 499.75 | 23.6173 |
| 19 | 500-506 | 501.25 | 23.5466 | 505.75 | 23.3371 |
| 20 | 506-512 | 507.25 | 23.2681 | 511.75 | 23.0635 |
| 21 | 512-518 | 513.25 | 22.996 | 517.75 | 22.7962 |
| 22 | 518-524 | 519.25 | 22.7303 | 523.75 | 22.5350 |
| 23 | 524-530 | 525.25 | 22.4707 | 529.75 | 22.2798 |
| 24 | 530-536 | 531.25 | 22.2169 | 535.75 | 22.0303 |
| 25 | 536-542 | 537.25 | 21.9688 | 541.75 | 21.7863 |
| 26 | 542-548 | 543.25 | 21.7261 | 547.75 | 21.5476 |
| 27 | 548-554 | 549.25 | 21.4888 | 553.75 | 21.3142 |
| 28 | 554-560 | 555.25 | 21.2566 | 559.75 | 21.0857 |
| 29 | 560-566 | 561.25 | 21.0293 | 565.75 | 20.8621 |
| 30 | 566-572 | 567.25 | 20.8069 | 571.75 | 20.6432 |
| 31 | 572-578 | 573.25 | 20.5891 | 577.75 | 20.4288 |
| 32 | 578-584 | 579.25 | 20.3759 | 583.75 | 20.2188 |
| 33 | 584-590 | 585.25 | 20.1670 | 589.75 | 20.0131 |
| 34 | 590-596 | 591.25 | 19.9623 | 595.75 | 19.8115 |
| 35 | 596-602 | 697.25 | 19.7617 | 601.75 | 19.6140 |
| 36 | 602-608 | 603.25 | 19.5652 | 607.75 | 19.4204 |
| 37 | 608-614 | 609.25 | 19.3725 | 613.75 | 19.2305 |
| 38 | 614-620 | 615.25 | 19.1836 | 619.75 | 19.0443 |
| 39 | 620-626 | 621.25 | 18.9983 | 625.75 | 18.8617 |

Table (continued)

| Channel | Mc | Pix Carrier | Wave-lengths in inches | Sound Carrier | Wave-length in inches |
|---|---|---|---|---|---|
| 40 | 626-632 | 627.25 | 18.8166 | 631.75 | 18.6826 |
| 41 | 632-638 | 633.25 | 18.6383 | 637.75 | 18.5068 |
| 42 | 638-644 | 639.25 | 18.4634 | 643.75 | 18.3343 |
| 43 | 644-650 | 645.25 | 18.2917 | 649.75 | 18.1650 |
| 44 | 650-656 | 651.25 | 18.1232 | 655.75 | 17.9988 |
| 45 | 656-662 | 657.25 | 17.9577 | 661.75 | 17.8350 |
| 46 | 662-668 | 663.25 | 17.7953 | 667.75 | 17.6754 |
| 47 | 668-674 | 669.25 | 17.6357 | 673.75 | 17.5180 |
| 48 | 674-680 | 675.25 | 17.4790 | 679.75 | 17.3633 |
| 49 | 680-686 | 681.25 | 17.3251 | 685.75 | 17.2114 |
| 50 | 686-692 | 687.25 | 17.1738 | 691.75 | 17.0621 |
| 51 | 692-698 | 693.25 | 17.0252 | 697.75 | 16.9154 |
| 52 | 698-704 | 699.25 | 16.8791 | 703.75 | 16.7712 |
| 53 | 704-710 | 705.25 | 16.7355 | 709.75 | 16.6294 |
| 54 | 710-716 | 711.25 | 16.5943 | 715.75 | 16.4900 |
| 55 | 716-722 | 717.25 | 16.4555 | 721.75 | 16.3529 |
| 56 | 722-728 | 723.25 | 16.3190 | 727.75 | 16.2181 |
| 57 | 728-734 | 729.25 | 16.1847 | 733.75 | 16.0855 |
| 58 | 734-740 | 735.25 | 16.0527 | 739.75 | 15.9550 |
| 59 | 740-746 | 741.25 | 15.9227 | 745.75 | 15.8266 |
| 60 | 746-752 | 747.25 | 15.7949 | 751.75 | 15.7003 |
| 61 | 752-758 | 753.25 | 15.6691 | 757.75 | 15.5760 |
| 62 | 758-764 | 759.25 | 15.5452 | 763.75 | 15.4536 |
| 63 | 764-770 | 765.25 | 15.4233 | 769.75 | 15.3332 |
| 64 | 770-776 | 771.25 | 15.3034 | 775.75 | 15.2146 |
| 65 | 776-782 | 777.25 | 15.1852 | 781.75 | 15.0978 |
| 66 | 782-788 | 783.25 | 15.0689 | 787.75 | 14.9829 |
| 67 | 788-794 | 789.25 | 14.9543 | 793.75 | 14.8696 |
| 68 | 794-800 | 795.25 | 14.8415 | 799.75 | 14.7580 |
| 69 | 800-806 | 801.25 | 14.7303 | 805.75 | 14.6481 |

**Table (continued)**

| Channel | Mc | Pix Carrier | Wave-lengths in inches | Sound Carrier | Wave-length in inches |
|---|---|---|---|---|---|
| 70 | 806-812 | 807.25 | 14.6209 | 811.75 | 14.5399 |
| 71 | 812-818 | 813.25 | 14.5130 | 817.75 | 14.4332 |
| 72 | 818-824 | 819.25 | 14.4067 | 823.75 | 14.3280 |
| 73 | 824-830 | 825.25 | 14.3020 | 829.75 | 14.2244 |
| 74 | 830-836 | 831.25 | 14.1988 | 835.75 | 14.1223 |
| 75 | 836-842 | 837.25 | 14.0970 | 841.75 | 14.0217 |
| 76 | 842-848 | 843.25 | 13.9967 | 847.75 | 13.9224 |
| 77 | 848-854 | 849.25 | 12.8978 | 853.75 | 13.8246 |
| 78 | 854-860 | 855.25 | 13.8003 | 859.75 | 13.7281 |
| 79 | 860-866 | 861.25 | 13.7042 | 865.75 | 13.6329 |
| 80 | 866-872 | 867.25 | 13.6094 | 871.75 | 13.5391 |
| 81 | 872-878 | 873.25 | 13.5159 | 877.75 | 13.4466 |
| 82 | 878-884 | 879.25 | 13.4236 | 883.75 | 13.3553 |
| 83 | 884-890 | 885.25 | 13.3326 | 889.75 | 13.2652 |

## U.H.F. Converter Classification

Ultra-high-frequency converters presently available, may be classified as follows:

1. Self-contained continuously tuneable converters.
2. Preset, one or two channel converter units.
3. Built-in converters.

*Self-contained continuously tuneable converters* are comparatively easy to install and require only a small amount of preliminary field work.

They contain their own power supply and require only the connection of the output lead between the converter and the receiver and the antenna lead-in connections.

To simplify operation, the converter usually has an *a.c.* receptacle at the rear of the chassis the purpose of which is to supply *a.c.* power to the television receiver. Thus control over both units is obtained by a single knob.

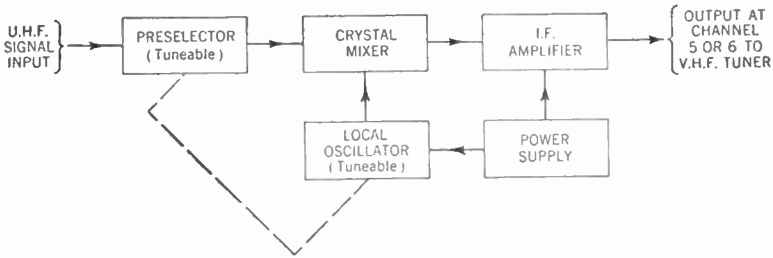



**FIG. 1—Block diagram of self-contained continuously tuneable u.h.f. converter.**

This type of converter always employs an *i.f.* amplifier to compensate for the loss of signal in the preselector and mixer stages. In most instances also the preselector circuit's output has a bandwidth of twelve megacycles covering the frequencies of channels 5 and 6.

The receiver, therefore, may be tuned to either of these channels, depending upon which channel is not used in the area of installation.

**Preset, One or Two Channel Converters.**—These units are designed to provide service in areas where only one or two *u.h.f.* stations are available. Depending upon their design they may be small compact units that are fastened to the rear of the receiver chassis, or they may be contained in a cabinet that is placed on or near the television receiver.

When the converters are fastened to the back of the receiver the power for its operation is usually obtained from the receiver itself, or a cable adaptor socket may be used that plugs into the audio output tube socket.

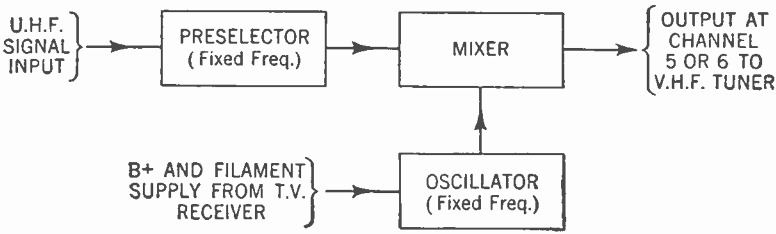



**FIG. 2—Block diagram of preset one or two channel converter.**

The output of the preset converter is usually of the same frequency as channel 5 or 6, and whichever of these channels is vacant in the receiving area should be used to accept the converter output.

Thus, for example, if the converter output is set on channel 6, and it is desired to receive this signal on channel 5, the converter oscillator circuits must be readjusted to provide the correct output frequency.

In a converter unit of this type, all the necessary adjustments are made at the time of installation, and since they are of a permanent nature, the operation of the converter is automatic and is governed only by the position of converter switch and the setting of the *v.h.f.* channel selector to receive any one of the two channels.

**Built-in u.h.f. Converters.**—These types of *u.h.f.* tuning units are designed to form an integral part of the television receiver and are usually provided for at the factory during the assembly process.

There are two types of these tuning systems in use at present. One is employed in receivers equipped with turret tuners, fig. 3,

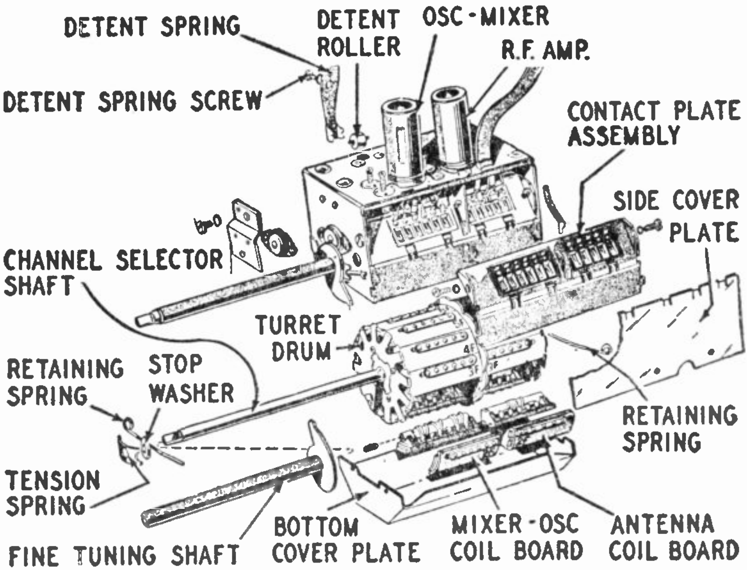



FIG. 3—Typical twelve channel turret type tuner showing channel strips. (Courtesy Standard Coil Products Company).

containing tuning strips. Thus, *u.h.f.* tuning strips may be substituted in place of any *v.h.f.* strips in positions where *v.h.f.* signals are not received. These *u.h.f.* strips are supplied for any specified channel. See fig. 4.

The second type of *u.h.f.* tuning system employs separate *v.h.f.* and *u.h.f.* tuners, with the *u.h.f.* tuner output fed into the *v.h.f.* tuner and then to the video *i.f.* circuits.

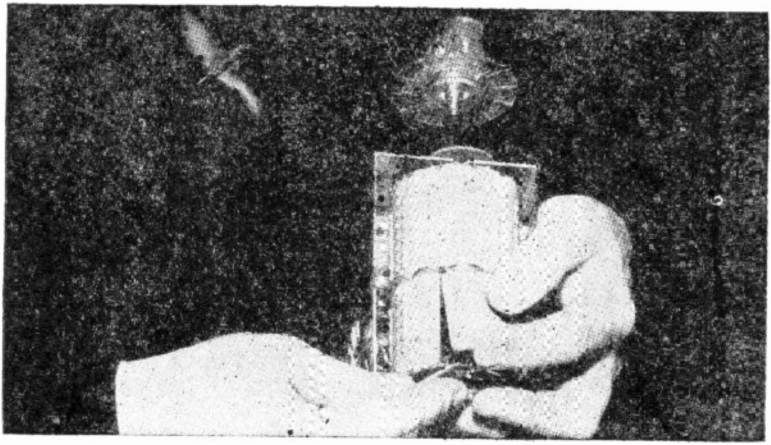


**FIG. 4—Illustrating the simple manner in which u.h.f. channel strips can be substituted for the v.h.f. channel strips in a Standard Coil Products television tuner.**

If the *v.h.f.* tuner is unmodified, the *u.h.f.* tuner output is usually accepted on channel 5 or 6 position, whichever is not used in the receiving area.

Switching antennas, and B plus to the *u.h.f.* tuner, is usually accomplished by a linkage assembly operated automatically or manually. A separate *u.h.f.* tuner control is provided in this application.

Some television receivers employing built-in *u.h.f.* systems use a *v.h.f.* tuner, modified so that it contains more than the usual twelve positions. One or two additional positions may be used on this type tuner. An advantage of the additional position on the *v.h.f.* tuner is that a single conversion system is feasible.

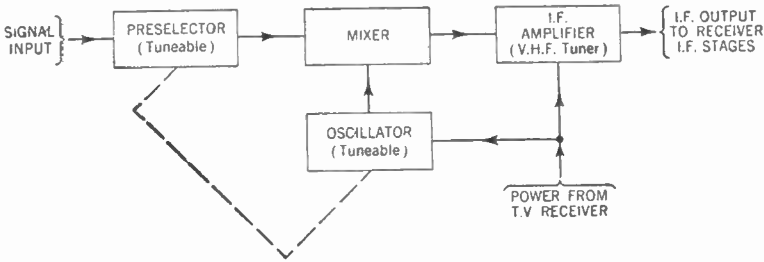



**FIG. 5—Block diagram of built-in u.h.f. system employing v.h.f. tuner as i.f. amplifier (Single conversion).**

The *u.h.f.* signal may be converted in a single process to the frequency of the receiver *i.f.* stages and the *v.h.f.* tuner then becomes a two stage *i.f.* amplifier. Switching to *u.h.f.* position also disconnects the local oscillator in the *v.h.f.* tuner since it is not required in the tuner's application as an *i.f.* amplifier.

*U.h.f.* channel indication is an important factor when tuning in an *u.h.f.* station. One method is to use a drum type dial on a shaft concentric with the *v.h.f.* tuner shaft and a drum or pulley arrangement to control its operation. To minimize the number of operating controls, the *v.h.f.* fine-tuning control is usually employed to tune the *u.h.f.* system.

Connecting B plus, and switching antennas in this type of built-in *u.h.f.* system is effected by, either a switch operated by a cam arrangement on an extension of the *v.h.f.* tuner shaft, or by switch controls in the modified *v.h.f.* tuner.

The following circuits are employed in most *u.h.f.* converters:

a. Preselector.
b. Oscillator.
c. Crystal mixer.
d. *I.f.* amplification.
e. Power supply.
f. *U.h.f.* and *v.h.f.* selector switch.

**Preselector.**—The purpose of the preselector circuit is to provide a maximum of selectivity consistent with the required bandwidth. Usually two preselectors are used to obtain the necessary bandwidth. Radio frequency amplification is not employed for the simple reason that no relatively low priced *r.f.* tubes are available as yet which can provide gain with a low enough noise figure that can be adapted for this purpose.

Several types of preselectors are used, some of which employ lumped constants (inductor and capacitor) while others use transmission-line tuning, or *r.f.* cavity tuning in the tank circuit.

Lumped constants are most generally used in the lower frequency applications. As the higher frequencies are approached, the physical size of inductors and capacitors will be such that efficient control of their operation over a wide band of frequencies becomes exceedingly difficult. This factor has led to an increasing use of sections of transmission lines in the *r.f.* circuit.

A transmission line cut to one-fourth wavelength and shorted at one end acts as a parallel resonant circuit and may be efficiently employed in *r.f.* tuner applications. Variable tuning is obtained by lengthening or shortening the transmission line to provide resonance over the desired frequency range.

This is accomplished mechanically by means of a slider or shorting bar or electrically by capacitance or inductance.

Sometimes the configuration of the tuned line is in the form of a concentric-shaped element, to minimize the space requirements and to facilitate shorting action by sliding contacts attached to a radial arm.

**Oscillator.**—To provide the required superheterodyne action in an *u.h.f.* converter, a local oscillator operating at the fundamental half- or third-frequency is provided.

The local oscillator usually employs a 6AF4 which is at present the most popular tube for this purpose. It was developed through adoptation of an earlier tube design 6F4, whose characteristics and features were essentially those desired.

One requirement must be met for the use of a 6AF4 tube as an oscillator, and that is that the tube socket must firmly secure the tube in position and provide good connections to the pins. If the tube be not securely held, the resultant oscillator frequency may vary as much as ten megacycles. It is recommended, therefore, that a suitable shield and clamping arrangement be provided on the 6AF4 when used in *u.h.f.* applications.

In *u.h.f.* converters using double conversion, it is customary for the oscillator to operate below the frequency of the incoming signal in order to provide the correct relationship between the video and sound frequencies to the *v.h.f.* tuner. Oscillator injection voltage to the crystal mixer can be maintained at a low level. This reduces radiation through the antenna and enables adequate shielding to minimize direct oscillator radiation.

In built-in *u.h.f.* converters of the single conversion type, the local oscillator operates above the frequency of the incoming signal in the same manner as the local oscillator in a *v.h.f.* tuner.

Another important consideration that must be met by the local oscillator in *u.h.f.* converters is that of stability. This is of particular importance when the converter is employed in conjunction with a receiver using separate sound *i.f.* Drifting of converter oscillator frequency would necessitate continued adjustment of the receiver tuning, which would defeat the purpose. A small latitude of oscillator drift would be permissible when an intercarrier receiver is used. Since many of the converters, however, are designed for all standard television receivers, converter oscillators are designed for a maximum of stability.

**Crystal Mixers.**—When the incoming *u.h.f.* signal and that of the local oscillator are fed into the mixer circuit, the resultant heterodyne signal is the desired intermediate frequency.

Crystal diodes used extensively for this purpose are the IN72 and IN82 and CK-710. These are used in high frequency applications primarily because of their simplicity, low cost and excellent signal-to-noise ratio.

Performance of a crystal mixer is influenced by the uniformity and amplitude of the oscillator injection voltage. In addition, it is important that the impedance presented by the *r.f.* tuned circuit be correctly matched to the crystal input impedance and also that the intermediate frequency circuit impedance be correctly matched to the crystal output impedance.

Impedances presented by the crystal mixer is also a function of the oscillator injection voltage. It should be noted that factors influencing crystal conversion loss and crystal noise are the selection of the *i.f.* frequency and the amplitude of the oscillator injection voltage.

**I.f. Amplification.**—Compensation for conversion loss resulting from the use of a crystal mixer and the absence of an *r.f.* stage is provided by an intermediate frequency amplifier.

Tubes most frequently used as *i.f.* amplifiers in *u.h.f.* converters are the dual-triode type 6BK7 or 6BQ7. These are usually employed in a cascode circuit, because of their inherent low noise characteristics. In certain circuits, one or two pentode type 6CB6 tubes are used.

As previously noted, when an *u.h.f.* converter is employed in a television receiver, the *u.h.f.* unit is connected in series between the antenna system and the *v.h.f.* tuner.

One function of the *v.h.f.* tuner is to amplify the converted signal from the *u.h.f.* unit. If double conversion be employed, it has a dual function. It amplifies the applied signal and converts it to the frequency of the video *i.f.* circuits in the receiver. For single conversion systems, the *v.h.f.* tuner functions strictly as an *i.f.* amplifier at the frequency of the video *i.f.* stages in the receiver.

In addition to the amplification provided by the foregoing described method, many units incorporate one or two stages of *i.f.* amplification prior to application of the signal to the *v.h.f.* tuner. Usually, these amplifier stages will be included in the separate self-contained *u.h.f.* converters.

**Power Supply.**—A self-contained power supply is a common feature to all externally connected *u.h.f.* converter units. This simplifies the installation since all inter-connections between the converter and the receiver are external.

The power supply usually consists of a power transformer, a selenium rectifier or 6X4 tube connected as a half- or full-wave rectifier. Power transformers are used to prevent hum difficulties and to provide filament voltage for the converter tubes. High voltage to the rectifier B plus filtering is obtained by a conventional RC filter network.

All built-in *u.h.f.* converters, and some of the single channel preset units receive power direct from the television receiver. The employment of miniature tubes and accompanying low power requirements place only a slight current drain on the receiver power supply.

**Switching Methods.**—The very-high-frequency—ultra-high-frequency switch, contributes greatly to the ease with which the various channels may be selected. This switch is designed to select antennas, select the input to the *v.h.f.* tuner, and switch B plus "on" or "off" to the *u.h.f.* tuner.

Additional switch positions are provided on separate, self-contained converters to also turn the power "on" or "off" to the television receiver. This last operation is made possible by plugging the television line cord into the *a.c.* receptacle at the back of the converter and plugging the converter line cord into a wall socket.

Operation schedules of the switch on most converters are as follows:

*Switch in off Position.*—With switch in off position both the television receiver and *u.h.f.* converter is off.

*Switch in v.h.f. Position.*—With the switch in this position power is supplied to the television receiver. The *v.h.f.* antenna is connected through the switch contacts to the antenna input terminals of the receiver, and power is supplied to the *u.h.f.* converter tube filament.

*Switch in u.h.f. Position.*—With the switch in this position, power is supplied to the television receiver, B plus and filament power is applied to the converter. The *v.h.f.* antenna is disconnected (and in some cases grounded) and the converter output is connected through the switch contacts to the antenna input terminals of the television set.

## Commercial U.H.F. Converters

The following description of *u.h.f.* converters has been made from data provided by the manufacturers of the units. The conversion of a standard *v.h.f.* television receiver for *u.h.f.* reception is not difficult. As previously noted, it consists of either replacing an unused *v.h.f.* channel strip with a *u.h.f.* version, or adding an external converter that will supply a signal to the antenna input of the *v.h.f.* receiver. Consequently, with a few connections *u.h.f.* reception can be added to a present *v.h.f.* receiver.

**Standard Coil Products.**—After considerable research the *Standard Coil Products Company* has developed an eighty-two channel *turret type tuner* for use in television receivers. This tuner is shown in fig. 6 and is designed to tune all the present *v.h.f.* in addition to the seventy *u.h.f.* channels.

The *Standard Coil* tuner employs a switch coil-condenser combination instead of the usual type *u.h.f.* tuned circuit. The tuner consists of an *u.h.f.* section containing a preselector, mixer and oscillator, and a *v.h.f.* section consisting of a cascode tuner very similar to the *Standard Coil* twelve channel *v.h.f.* tuner. The *u.h.f.* section employs a two-section dial as noted in fig. 8 one section counting in tens, and the other in units. Thus, for example, to set the tuner on channel 56, the "tens" dial is set on 5 while the "units" dial is set on 6.

The general plan of the tuner figs. 9 and 10, is to employ eight specific *u.h.f.* positions, each approximately sixty megacycles

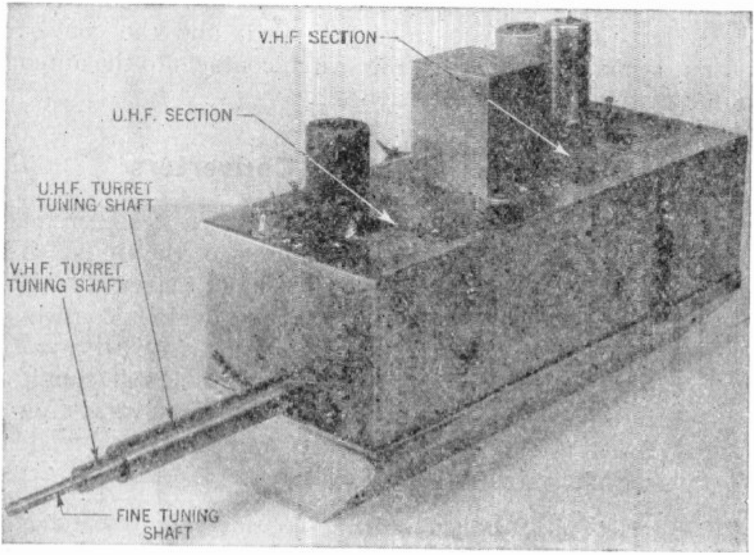



**FIG. 6—External view of Standard Coil eighty two channel turret tuner.**

wide, covering the entire 470 to 890 mc. range as shown in table 7.

| *"Tens"* | *Frequency* | *Channels* |
|---|---|---|
| 1 | 470-510 | 14-19 |
| 2 | 510-570 | 20-29 |
| 3 | 570-630 | 30-39 |
| 4 | 630-690 | 40-49 |
| 5 | 690-750 | 50-59 |
| 6 | 750-810 | 60-69 |
| 7 | 810-870 | 70-79 |
| 8 | 870-890 | 80-83 |

**FIG. 7—Table showing how the Standard Coil Products tuner "tens" dial is used to cover frequencies in the 470 to 890 megacycle range.**

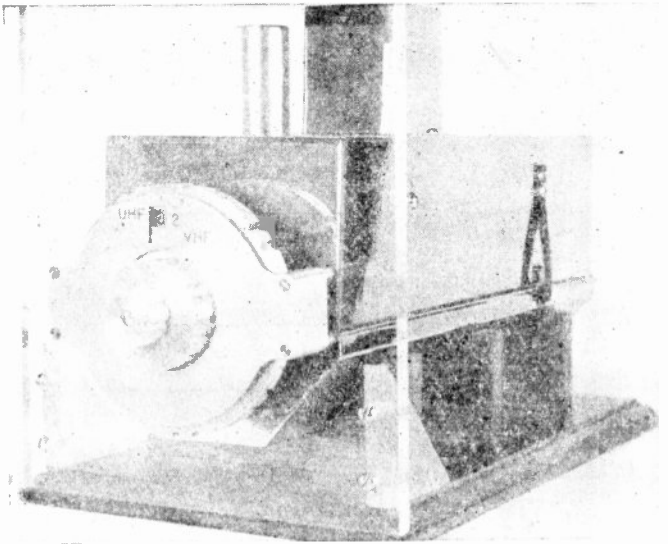


FIG. 8—Standard Coil Products turret tuner showing operating control knobs in place.

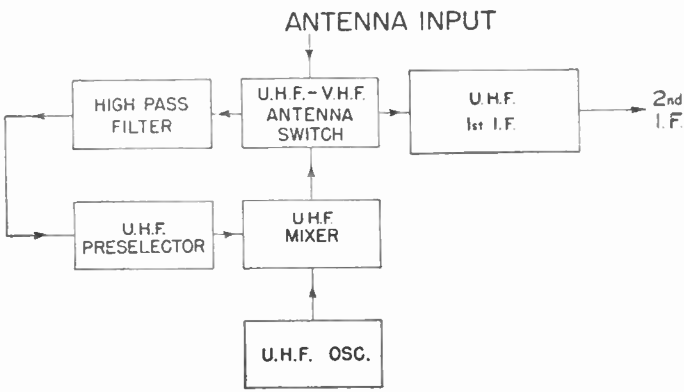



FIG. 9—Block diagram of Standard Coil Products turret tuner.

The *u.h.f.* section in accordance with the "tens" dial setting, opens the input over a ten channel span of frequencies. Thus, for example, it will be noted that if the "tens" dial is set on 3, the signal from any channel between 570 and 630 mc. reaches the *u.h.f.* mixer.

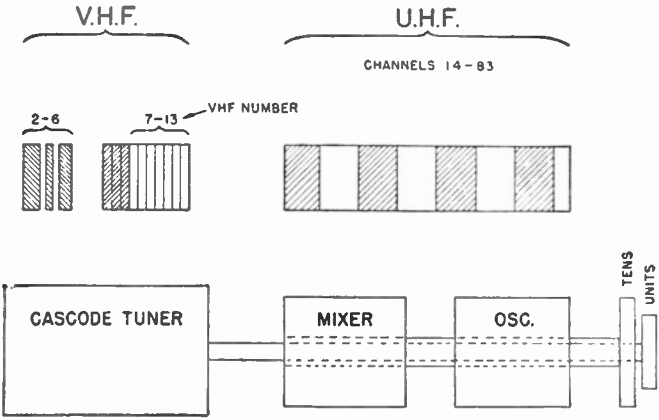



**FIG. 10—Block diagram showing channel selection scheme in a Standard Coil Products tuner.**

The table indicates that the *u.h.f.* local oscillator need not be tunable but needs only to be switched to eight preset fixed frequencies (plus some limited variation for alignment or fine tuning). The actual "unit" channel selection is made by shifting the *i.f.* frequency of the cascode first *i.f.* amplifier rather than the frequency of the local oscillator.

The output of the cascode *i.f.* is applied to a second mixer-local oscillator combination (*v.h.f.* section) and then to the second conventional *i.f.* amplifier of the receiver.

For *v.h.f.* operation, the *v.h.f.* antenna is attached to the input of the cascode *i.f.* amplifier which selects channel 2 through 13 with the same calibrated dial and without additional switching. The entire operation is automatic and the user is not aware that *v.h.f.-u.h.f.* switching has taken place when the dual-dial is changed from the *u.h.f.* to the *v.h.f.* ranges and *vice versa*.

The choice of the proper one of the ten channels is made by the "units" dial section which sets the frequency range of the turnable cascode *i.f.* amplifier. The cascode *i.f.* stage can be set on any one of the 10 six megacycle ranges that include channel 7 through 13. For example, the channels from 40-49 could fall in, as indicated in table 11, using a fixed *u.h.f.* local oscillator frequency (one fixed frequency out of a choice of eight).

| *"Units" Dial* | *Channel Frequency* | *Local Osc. Freq.* | *Cascode I.F. Frequency* |
|---|---|---|---|
| 0 | 626-632 | 470 | 156-162 |
| 1 | 632-638 | 470 | 162-168 |
| 2 | 638-644 | 470 | 168-174 |
| 3 | 644-650 | 470 | 174-180 |
| 4 | 650-656 | 470 | 180-186 |
| 5 | 656-662 | 470 | 186-192 |
| 6 | 662-668 | 470 | 192-198 |
| 7 | 668-674 | 470 | 198-204 |
| 8 | 674-680 | 470 | 204-210 |
| 9 | 680-686 | 470 | 210-216 |

**FIG. 11—Table showing how channels from forty to forty-nine fall in with the "tens" dial set on 4. One fixed u.h.f. local oscillator frequency is used (one out of a possible eight).**

A schematic of the *u.h.f.* oscillator, fig. 12 illustrates the eight-position method of switching the local oscillator frequency range using incremental coils and condensers. The fixed fundamental frequency can be in the 400 megacycle range and is resonated at this frequency by two small coils in parallel (#16 wire on one-fourth inch form). Higher frequencies are obtained with shunt inductors; lower frequencies with shunt condensers. Frequency deviation is not great and a trimmer range of ±7 mc. on the fundamental circuit position is sufficient to correct for tube capacity and component dissimilarities.

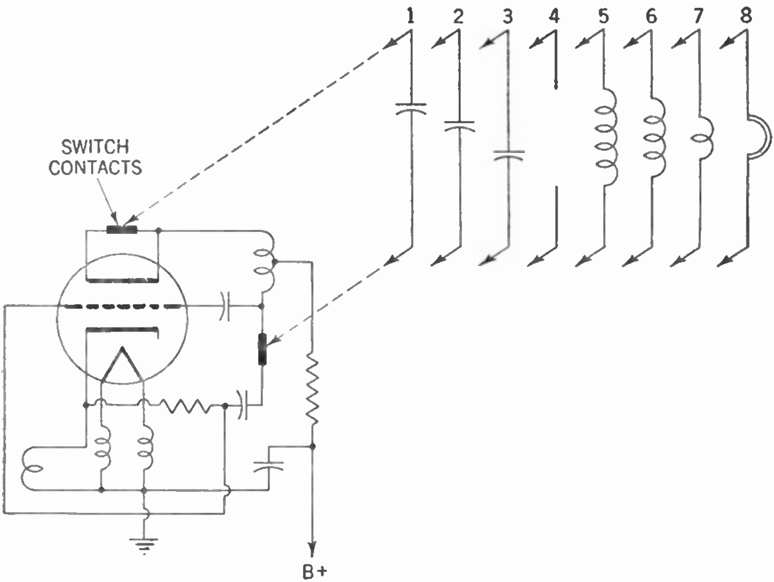



**FIG. 12—Oscillator u.h.f. schematic diagram showing the local oscillator switching circuit used for the "tens" dial scale in a Standard Coil Products tuner.**

The *u.h.f.* channel plug-in strip arrangement of the *Standard Coil* converter is shown in fig. 13. It should be noted that the terminals shown in the diagram correspond to the numbered terminals of the *Standard Coil* tuner.

The antenna is connected through terminals 8 and 10. The antenna coil is coupled to the primary of the double-tuned mixer transformer while the crystal mixer taps off a low impedance point of the secondary and is also coupled to the harmonic selector resonant circuit to obtain an *u.h.f.* injection signal. The mixer output circuit is resonated to a high *i.f.* frequency, and the *i.f.* signal is applied to the grid of the *r.f.* amplifier via terminal 7.

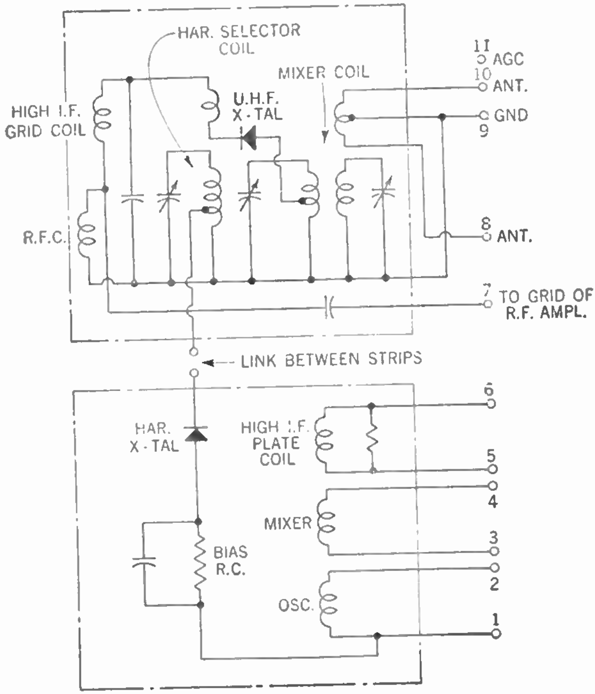



**FIG. 13—Schematic diagram showing wiring arrangement in a Standard Coil Products u.h.f. plug-in strip.**

The *r.f.* amplifier plate, mixer grid and *v.h.f.* local oscillator circuit inductors are also a part of the *v.h.f.* strip. The local oscillator signal must also be applied to the crystal harmonic generator through an RC biasing network, the proper harmonic being selected by the *u.h.f.* resonant circuit to develop an exciting *u.h.f.* sine wave for the *u.h.f.* crystal mixer.

The *Standard Coil* eighty-two channel tuner is of particular importance in that the tuner is a complete unit designed to form an integral part of a television receiver. Thus, complete control over *v.h.f.* and *u.h.f.* channel selection is provided by the television receiver's front panel control knobs. In addition the turret type method of tuning permits the decimal system to be used for channel selection.

**Kingston u.h.f. Tuner.**—The *Kingston* tuner is an *u.h.f.* converter of the "continuous tuning" type, tunable from 470 to 890 megacycles. This tuner may be used as a converter for existing *v.h.f.* television receivers in order to receive *u.h.f.* Alternately, the tuner when assembled in new television sets by the manufacturer, provides reception of *u.h.f.*, which together with the present twelve channels of *v.h.f.*, permits the entire range of eighty-two channels of both *v.h.f.* and *u.h.f.*

The tuner is based on a tuned transmission line as the basic tuning device. The tuned line is shaped in a radius in order to gain compactness as well as to simplify the mechanical structure.

The cabinet shown in fig. 14 measures 8⅛ x 5¾ x 4½ inches. Three operating controls are employed on the front of the cabinet, namely: *station selector*, *fine tuning*, "off"-"on" *power*, and *u.h.f.-v.h.f. antenna change over switch.*

The tuner is designed to use conventional type tubes. The basic physical layout and construction is suitable for any selected *i.f.* frequency and is normally supplied with an *i.f.*

frequency of 195 mc. for use as an *u.h.f.* converter. A rear view of the converter, which illustrates panel board connections for the *u.h.f.* antenna, *v.h.f.* antenna, and input to *v.h.f.* receiver is given in fig. 15.

In cases where sufficient signal is available and the use of an *u.h.f.* antenna is not required, it is necessary to place a short section of 300 ohm line between the *u.h.f.* antenna and *v.h.f.*

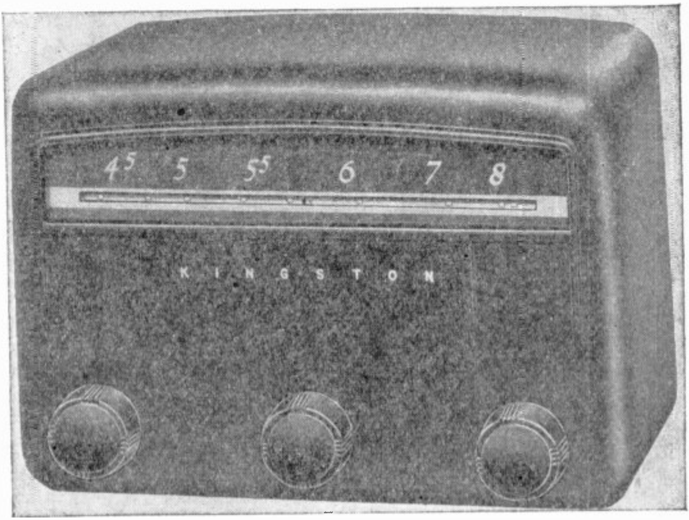



**FIG. 14—Exterior view of Kingston u.h.f. tuner.**

antenna terminals. Also illustrated is the *i.f.* output trimmer adjustment for the user at the time of installation to select the desired *v.h.f.* channel which is free of interferences and images as well as matching the output of the converter to the input of the *v.h.f.* set.

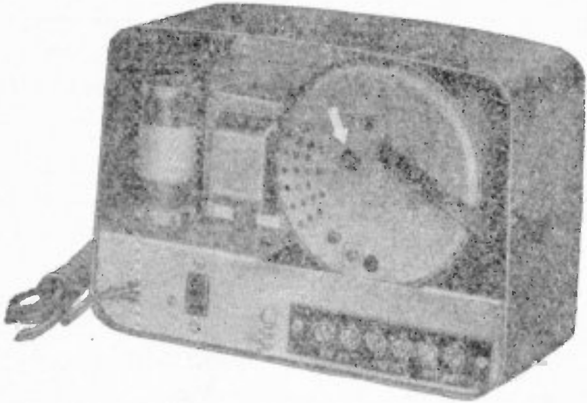


FIG. 15—Rear view of Kingston u.h.f. tuner.

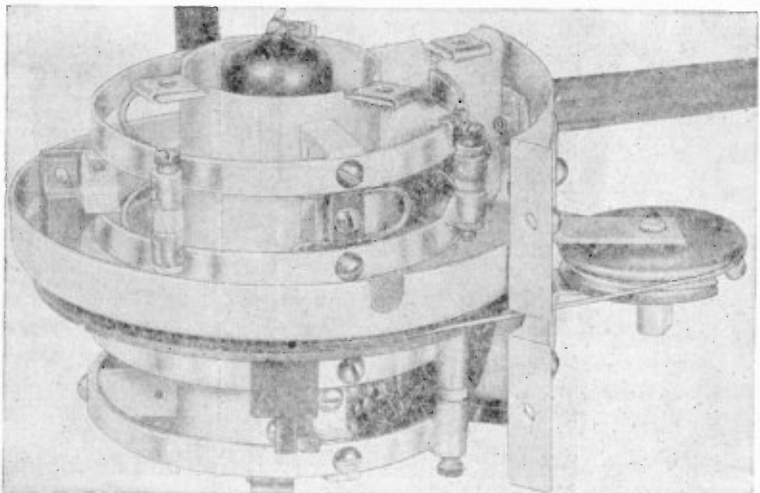


FIG. 16—Top view of Kingston u.h.f. tuner with shields removed. Shown in this view is the preselector lines and the slider with their respective trimmer in place. Back of the line is shown the antenna coupling loop. Also shown is a portion of the cascade i.f. amplifier tube.

A circuit schematic of the tuner is shown in fig. 17. The overall *r.f.* circuit of the converter consists of a stationary balanced transmission line type antenna coupling loop, a tunable preselector transmission line, and crystal mixer. The transmission line type of antenna loop is mutually coupled to a preselector line and this coupling is employed to correct the small variation of preselector "Q" with frequency to obtain a

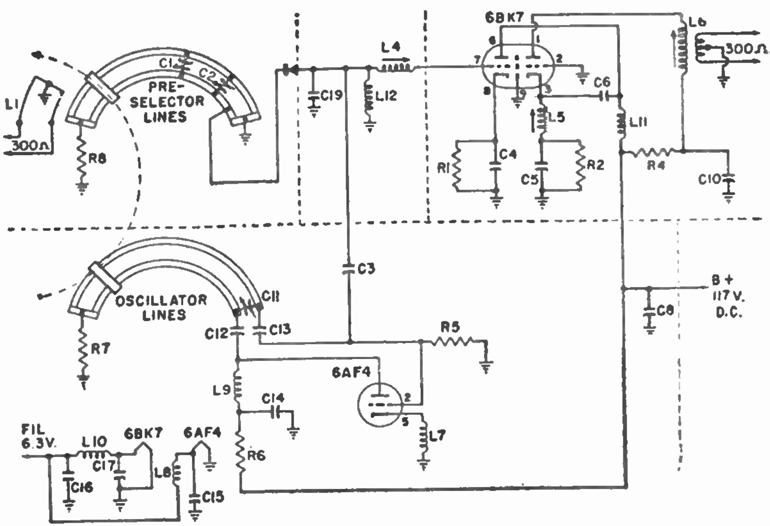



**FIG. 17—Schematic diagram showing wiring arrangement in a Kingston u.h.f. tuner.**

near constant loaded bandwidth. This is achieved by physically locating the loop closer to the preselector line at the high frequency end of the range. The oscillator and preselector lines are made of one-fourth inch wide curved parallel strips of silver-plated brass. Tuning by means of a parallel line of adjustable electrical length allows a large frequency range, simplicity and uniformity of tuning which facilitates tracking, economy and flexibility of design.

Due to the fact that the antenna coupling loop and the crystal mixer are placed at opposite ends of the transmission line, direct coupling between the antenna and mixer circuits allows the adjustment of input and output coupling to be essentially independent of each other. Making the output loaded bandwidth slightly greater at the higher frequencies compensates for the lower "Q's" obtained at these higher frequencies for a completely unloaded line.

The tracking problem is simplified by the employment of two trimmer condensers on the preselector lines. One trimmer condenser is used for setting the high frequency end and another trimmer condenser is used for setting the low frequency end of the range. This arrangement allows electrical tracking of the oscillator with the preselector circuits to be a simple and positive alignment operation. The two trimmer adjustments are practically independent of each other. To tune the converter with a single control, it is necessary that the preselector circuit tune to a frequency which is higher than the local oscillator by a constant frequency difference equal to the *v.h.f.* channel which is being used as the *i.f.* frequency. The preselector tracks the local oscillator within a few megacycles throughout the band.

The trimmers are a special *u.h.f.* balanced type which were developed especially for this type of tuner. All through the tuner design special emphasis has been placed on the fact that wide tolerances on materials and methods be incorporated without loss of tuner efficiency and the elimination of engineering specifications which would place an imposition on production.

The preselector circuit is based on a half-wave transmission line developing an unloaded "Q" of 600 with complete absence of dead spots or spurious responses and having a line characteristic impedance of 125 ohms. In covering this frequency range the line shorting slider has a four-inch travel assuring good tracking, stability and maximum travel excursion length per *u.h.f.* channel. The lines are extremely rugged and stable with wide spacing between, as well as around, the individual lines. The lines are securely supported by means of ceramic standoff insulators. A crystal mixer is directly coupled to the output shorted end of the lines and antenna is mutually coupled to the shorted input end of the lines.

The oscillator tube and associated circuits are completely shielded and adequately meet tentative requirements for oscillator radiation. The local oscillator consists of a type 6AF4 tube capacity coupled to a quarter-wave short-circuited transmission line terminated at the inactive end.

The local oscillator is lower in frequency than the signal in order to prevent inverting the frequency relation between sound and picture carriers for receivers not having symmetrical intercarrier *i.f.* systems.

In order to receive *u.h.f.* stations between 470 and 890 mc., the local oscillator tunes from 275 to 695 mc. when the *v.h.f.* set is tuned to channel 10. The 6AF4 is used as the oscillator tube on the basis of cost, preferred type, and necessary frequency range. The basic oscillator design has an upper limit of 1,100 mc. which is much higher than required for *u.h.f.* application and being a quarter-wave design is very stable. The oscillator generates adequate injection voltage over the entire frequency range 275 to 695 mc. without any frequency skips or undesirable responses rectifying a crystal current of one to three *m.a.*

The *B* supply is parallel fed through chokes and is satisfactorily bypassed. The oscillator tuning is positively ganged with the preselector line and is accomplished by a sliding silver contact which varies the active portion of the line. A trimmer condenser across the oscillator plate tank circuit allows the frequency range to be set to any desired frequency at the low end of the range.

Due to the ruggedness of construction and quality of components, exceptionally high stability is secured in the local oscillator circuit. The warm-up drift of the local oscillator at the high frequency end of the band is approximately plus 250 mc. and approximately minus 250 mc. on the low end of the band. The frequency stabilizes after approximately five minutes of operation. The maximum deviation due to line voltage drift is approximately seventy mc. throughout the range of 95 to 125 volts line change.

A cascode *i.f.* amplifier circuit is provided due to its inherent low noise. The 6BK7 double triode is used for the *i.f.* amplifier tube due to its cost and favorable noise factor. The *i.f.* amplifier is aligned to *v.h.f.* channel 10 (195 mc.) and is series coupled to the crystal mixer. This amplifies the output of the mixer and allows the converter noise to dominate the noise of the *v.h.f.* receiver as well as isolate the *u.h.f.* and *v.h.f.* oscillators from each other; provides additional *v.h.f.* selectivity against images of the *v.h.f.* signal and against other signals which would introduce spurious responses; provides extra attenuations to radiation of the *v.h.f.* oscillators. The bandwidths of the interstage circuits are very broad and do not require retuning whenever an alternate *v.h.f.* channel is selected.

**Crosley Ultratuner.**—This tuner incorporates an *u.h.f.* converter continuously tuneable from 470 to 890 mc. As noted in fig. 18, illustrating the cabinet, two operating controls are employed. The tuning control operates a vernier drive having a ratio of about 15/1, with tuning indicated by a slide rule type dial. The other control functions as a combination "off", "v.h.f.," and "u.h.f." switch.


**FIG. 18—Exterior view of Crosley u.h.f. converter.**

A circuit schematic of the ultratuner is shown in fig. 19. The input system consists of a double tuned bandpass preselector circuit for maximum selectivity. There are three tubes employed, a type 6AF4 oscillator, a 6BQ7 *i.f.* amplifier and a 6X4 rectifier. The tuning unit itself consists of a three-gang resonant line type, with each line shaped for correct tracking.

The excitation of the germanium crystal mixer is provided by coupling an oscillator injection voltage from the high side of the oscillator tube filament through a 2.2 *m.m.f.* capacitor.

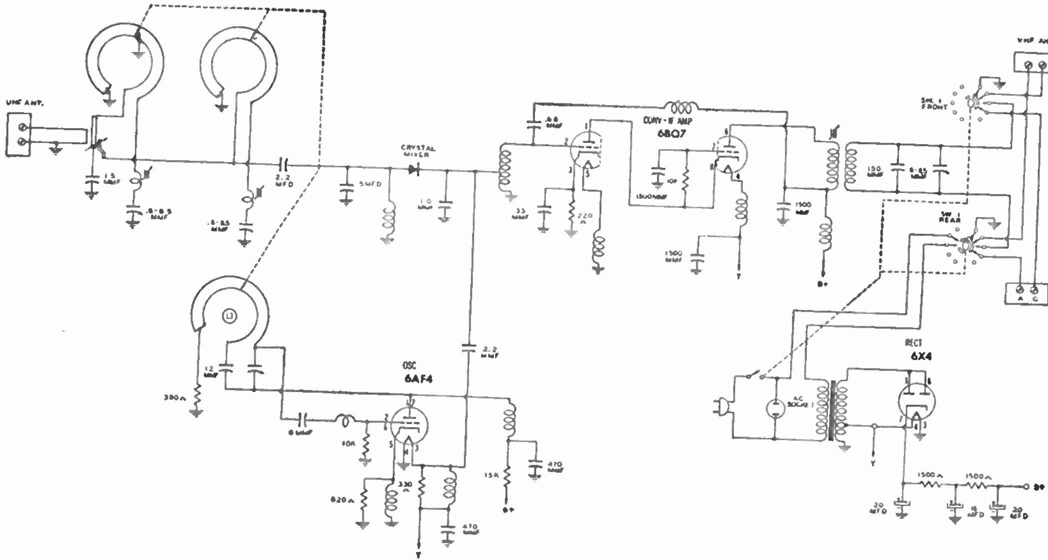



FIG. 19—Schematic diagram of Crosley u.h.f. tuner.

Maintaining the high side of the oscillator filament above ground for *r.f.* is accomplished by the use of a parallel combination of an inductance and a resistor inserted in series with the filament lead. Oscillator radiation is minimized by shielding both the oscillator resonant line section and the oscillator tube and circuits.

From the crystal mixer an intermediate frequency signal is fed to the input of a low noise cascode amplifier stage employing a type 6BQ7 tube The first triode section functions as a conventional grid driven circuit employing neutralization. The second triode section operates as a grounded grid amplifier.

Both the input and output circuit of the cascode *i.f.* amplifier are designed to maintain desired bandwidth at a frequency of 127.5 ± 6 mc. Transformer coupling of the cascode amplifier to the converter output terminals through appropriate switching provides a balanced 300 ohms output impedance. The balanced output eliminates picking up interference on the lead to the television receiver.

The power supply consists of a power transformer and a type 6X4 tube operating as a half-wave rectifier. Conventional RC filtering is used in the rectifier output.

When the ultratuner is installed, an *u.h.f.* antenna is connected to terminals on the unit marked *u.h.f.* antenna. The *v.h.f.* antenna leads are removed from the television receiver and connected to the converter terminals marked *v.h.f.* antenna. A balanced 300 ohms line is then connected from the antenna terminals of the *v.h.f.* receiver to the converter terminals marked "output." In order to utilize a single control to turn power on and off for both the converter and television receiver, the receiver's power cord is plugged into the *a.c.* power receptacle on the converter chassis.

The combination "off"-"v.h.f."-"u.h.f." switch functions in the following manner:

In "off" position power to both converter and television receiver is "off".

In *v.h.f.* position power is applied to the television receiver, and the *v.h.f.* antenna is connected to the receiver.

In *u.h.f.* position power is applied to both converter and receiver and the converter output is now connected to the input terminals of the television receiver.

One feature of the *ultratuner* is that the converter output is not limited by the frequency of the *v.h.f.* channels on the television receiver. In other words it was thought possible to approach nearer optimum operating characteristics by employing an intermediate frequency of about 127 mc. which is higher than channel 6 (88 mc.) and lower than channel 7 frequency (174 mc.). This tuner therefore will operate with conventional television receivers since the *v.h.f.* tuner is tunable through the entire frequency spectrum from channel 2 through channel 13.

**Zenith Turret Tuner.**—This *v.h.f.-u.h.f.* turret tuner is designed for top performance on all television channels. The photograph in fig. 20 shows the tuner with external shields removed. Two sets of the removable channel strips are shown in the foreground. Those nearest the tuner are the *u.h.f.* strips. The oscillator and interstage circuits are on the right-hand segments and the antenna *r.f.* input circuits are at the left.

By locating the antenna section towards the front of the chassis, access is permitted to the oscillator adjusting screws at the rear. A plug is provided for the *B* plus heater and *a.g.c.* leads, and a simple coaxial connector is provided for the *i.f.* output. Thus, the removal of the tuner from the chassis for repair or strip replacement can be accomplished easily without removing the chassis from the cabinet.

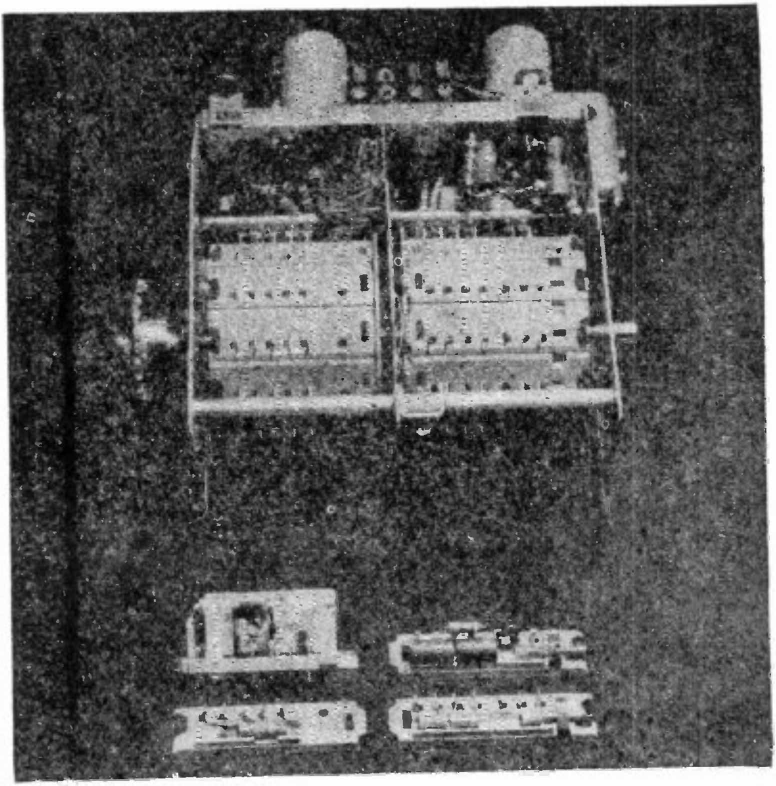


**FIG. 20—The Zenith separate coil strip tuner with shielding removed.**

Fig. 21 is a block diagram of the tuner circuit with a pair of *v.h.f.* channel strips in position. The triode section of the 6U8 is the local oscillator; the pentode section functions as the mixer.

The twin-triode 6BK7 is a cascode *i.f.* amplifier. Fig. 22 is a block diagram of the tuner with a pair of *u.h.f.* strips in position. All the circuit changes indicated in going from fig. 21 and 22 are made by simply turning the turret from a *v.h.f.* to an *u.h.f.* channel.

Fig. 23 is a simplified schematic of the tuner on *u.h.f.* channels. There are two tuned circuits in the preselector and a

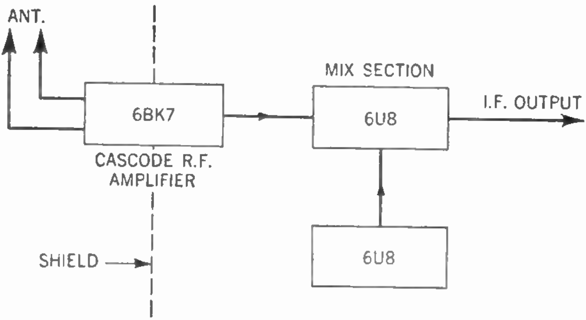



**FIG. 21—Block diagram of the Zenith tuner circuit on v.h.f. channels.**

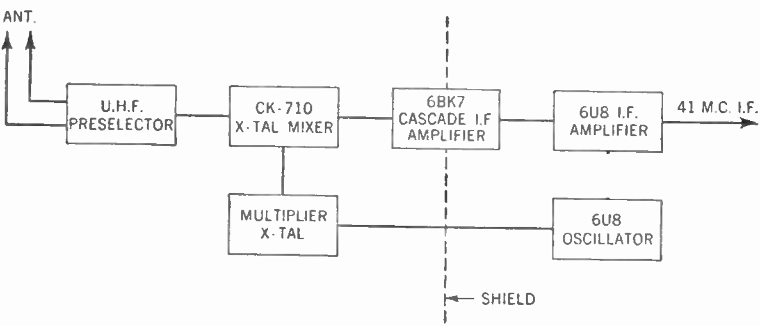



**FIG. 22—Block diagram of the Zenith tuner circuit in one of the u.h.f. positions. Three sets of oscillator and preselector coil strips are required to cover all seventy u.h.f. channels.**

tuned multiplier circuit. These three resonant circuits and the two crystals are mounted in a casting.

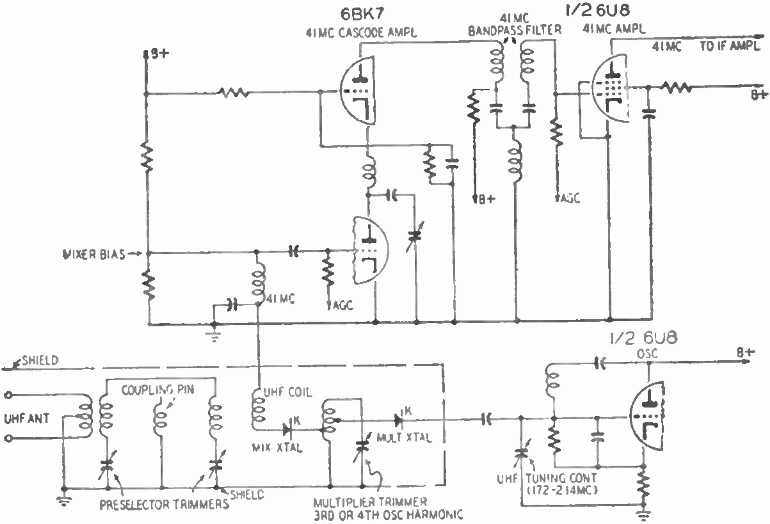



**FIG. 23—Schematic diagram of Zenith tuner circuit in one of the u.h.f. positions.**

To cover all seventy *u.h.f.* channels the oscillator tunes from 172 mc. to 234 mc. The germanium multiplier crystal acts as a harmonic generator to provide *u.h.f.* oscillator power for the mixer.

The germanium multiplier crystal is capacitance-coupled to the oscillator and conducts only on the extreme peaks of the oscillator sine wave. The resultant straight-sided pulses in the multiplier circuit are rich in oscillator harmonics.

The tuned output circuit of the multiplier selects the desired harmonic and applies it to the crystal mixer to beat with the incoming signal. The oscillator's third harmonic (516-702 mc.) is used for the low *u.h.f.* channels and the fourth harmonic (688-936 mc.) for the high *u.h.f.* channels.

The mixer crystal is biased to operate at its point of maximum sensitivity, so that minimum oscillator power is required. The output of the mixer is at the 41 mc., *i.f.* of the receiver. The 6BK7 and the pentode section of the 6U8 become additional 41 mc., *i.f.* amplifiers to make up for the conversion loss in the crystal mixer.

The *u.h.f.* tuned circuits are very tiny. They are mounted in cylindrical holes in the casting about one-fourth inch in diameter and one-half inch deep. The antenna and multiplier coils are less than one-half inch long and one-eighth inch in diameter.

Series tuning capacitance for the preselector and multiplier circuits is provided by 1-72 machine screws which enter one end of each coil through an insulating bushing. The inductive coupling between the two preselector circuits is provided by a small pin pressed into a recessed hole in the casting between the two coils.

The junction between the coils is returned to the casting through this pin, which is an inductance common to both circuits. The casting shields the preselector and multiplier circuits from each other and from external influences.

The oscillator-interstage strip holds the oscillator coil with its disc ceramic capacitor, the cascode plate coil, and the mixer grid coil. The oscillator coil is adjusted to frequency by a small screw which enters the coil and changes its inductance. Each set of *u.h.f.* strips tunes over one-third of the band, so three sets cover all seventy channels.

**Raytheon u.h.f. Tuner Model-100.**—This tuner is designed for incorporation in their line of television receivers. The general arrangement of the tuner mounted in place above the *v.h.f.* tuner is shown in fig. 24. The tuner incorporates a drive gear which allows tuning of both the *u.h.f.* and *v.h.f.* unit by a common control.

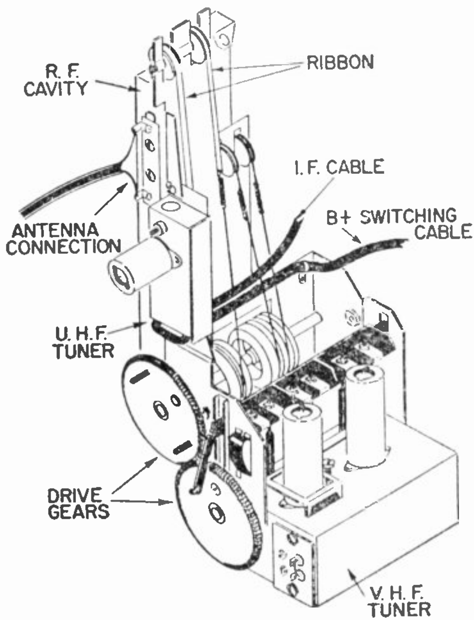



**FIG. 24—Showing arrangement of Raytheon u.h.f. and v.h.f. tuner units.**

Two cables from the *u.h.f.* tuner are connected to the under side of the television receiver to provide the necessary electrical connections to the *u.h.f.* tuner. Switching between the *u.h.f.* and *v.h.f.* channels is accomplished by adding a switch to the back of the chassis. This requires but a few wiring modifications to permit the added switch to transfer B plus from one tuner to the other.

As noted in the schematic circuit diagram fig. 25, this model tuner employs a preselector, crystal mixer, local oscillator, cascode amplifier and a "u.h.f."-"v.h.f." switch.

It will be further noted that *r.f.* cavity type tuning is employed in the preselector circuit with inductive coupling between the stages from the antenna to the mixer. Preselector tuning involves changing the cavity length through the use of a ribbon attached to the dial cord and tuning mechanism. It is claimed this type tuning has the advantages of high selectivity, low insertion losses, uniform bandwidth and good shielding against oscillator radiation.

Oscillator tuning is provided in a similar manner to that used for preselector tuning. However, the length of the oscillator cavity is varied by means of a shorting bar instead of the ribbon arrangement used in the preselector *r.f.* cavity. The oscillator grid current may be measured by removing the jumper in the low side of the oscillator grid return resistor.

Mixing of an incoming *u.h.f.* signal and a signal from the *u.h.f.* oscillator is accomplished by a type CK-710 crystal. Because of the single conversion process the resultant intermediate frequency is the frequency of the receiver's video *i.f.* stages. To provide a signal of adequate amplitude to the video *i.f.* circuits, a low noise type 6BQ7 is employed as a cascode-coupled amplifier. The signal is amplified by the cascode amplifier and tuned to a center frequency of 25 mc.

Several interesting features are found in the *Raytheon u.h.f.*-100 tuner. Among them is the fact that the tuner forms an integral part of the television receiver and is tuned by the same operating controls as those used for *v.h.f.* Application of *a.g.c.* to the input triode of the cascode amplifier reduces any tendency to overload in the presence of strong *u.h.f.* signals.

Since no *r.f.* amplification is employed, there is slightly less sensitivity than when the *v.h.f.* signals are received. However, a receiver equipped with this tuner will have an overall sensitivity of 150 microvolts.

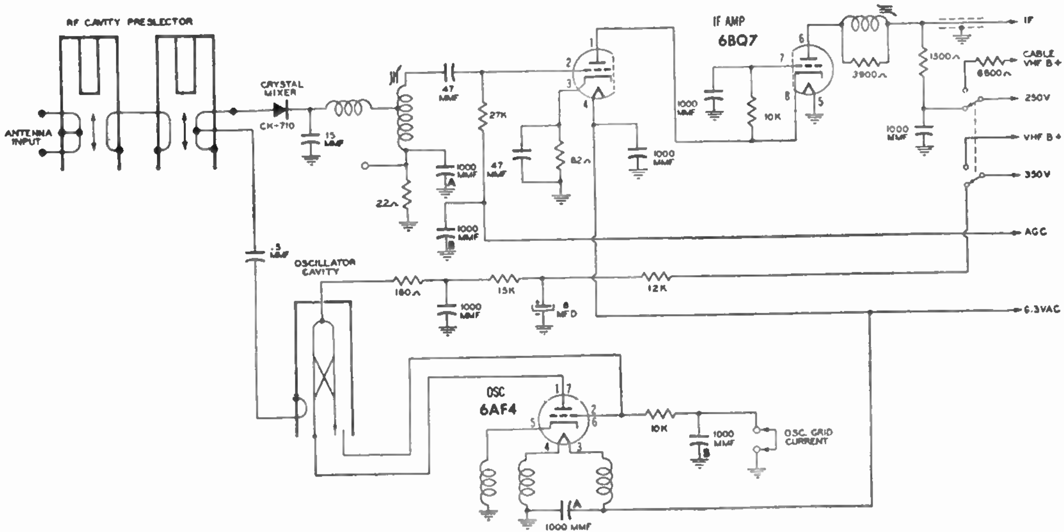



**FIG. 25**—**Schematic diagram of Raytheon u.h.f. tuner.**

**DuMont u.h.f. Converter.**—This converter in common with several others is designed to operate over the full *u.h.f.* band in conjunction with any standard television receiver. This is accomplished by making the converter output fall between seventy-six and eighty-eight mc. on channels 5 and 6.

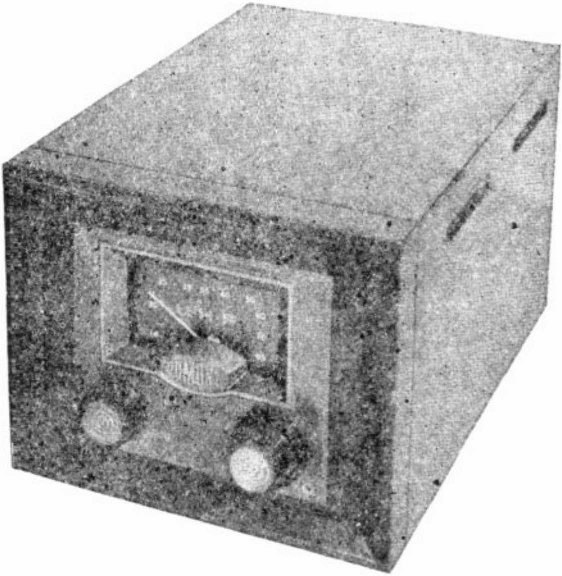


**FIG. 26—Exterior view of DuMont u.h.f. converter cabinet.**

An external view of the converter is shown in fig. 26. Here the control shown on the left contains the "on" and "off" *v.h.f.* and *u.h.f.* switch, whereas the control on the right is employed for coarse and fine tuning.

The tuner drive reduction ratio is 6.6/1 on coarse tuning and 20/1 on fine tuning. The tuning dial is marked 14 to 83 for indicating *u.h.f.* channels. When the *v.h.f.* and *u.h.f.* antennas are connected to appropriate terminals on the converter chassis, turning this switch to *v.h.f.* position turns the converter power off and automatically connects the *v.h.f.* antenna to the *v.h.f.* receiver input terminals. With the switch in *u.h.f.* position, the *v.h.f.* antenna is grounded, the power to the converter is turned on, and the converter output is connected to the *v.h.f* receiver input terminals.

A schematic of the DuMont converter is shown in fig. 27. The *u.h.f.* antenna is connected to a high pass input filter composed of an initial M-derived one-half section, two constant K-T sections and a terminating M-derived one-half section. The input filter is designed to attenuate *v.h.f.* signals. Cut-off frequency is 400 mc. with infinite attenuation by the M-derived section at 320 mc. A double tuned pre-selector circuit follows the input filter. This circuit is designed to provide a maximum of *u.h.f.* selectivity.

The output of the pre-selector is fed to a crystal mixer An oscillator injection voltage obtained by a metal strip loosely coupled to the oscillator tank circuit is also fed to the mixer. The crystal mixer converts the *u.h.f.* signal to an intermediate frequency which is fed to a low noise cascode *i.f.* amplifier.

Neutralization of the first triode section of the *i.f.* amplifier is provided by feeding a signal from the first triode output back to the grid. The second triode section forms a cathode coupled grounded grid amplifier with the output tuned by an *i.f.* transformer. From the *i.f.* transformer the signal goes to the *u.h.f.*-*v.h.f.* switch and to a terminal board. The converter output impedance is designed for either 75 ohms coaxial or 300 ohms balanced output to correctly match any television receiver.

A type 6AF4 is used as the local oscillator. This circuit is designed to provide a high degree of oscillator stability and to minimize oscillator radiation. The power supply consists of a power transformer, a full wave voltage rectifier tube type 6X4, an RC filter network and two 6.3 volts filament windings.

**R.C.A. u.h.f. Converters.**—*The Radio Corporation of America* has developed several *u.h.f.* converters which are primarily designed for R.C.A. receivers although they

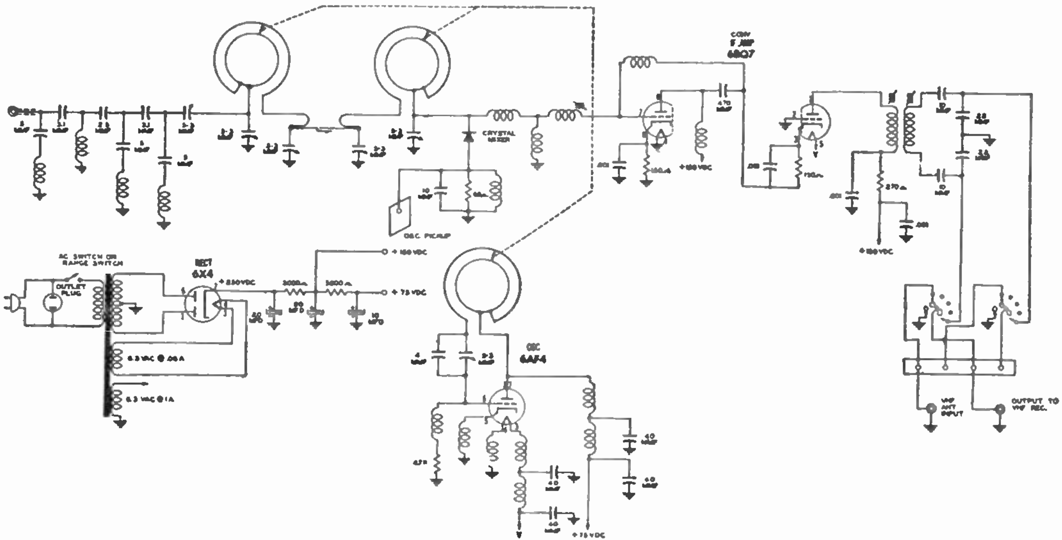



**FIG. 27**—Schematic diagram of DuMont u.h.f. converter.

are also readily adaptable for other makes of television receivers. These various converters are known as U1A, U1B, U2 and U70.

Power is obtained from the audio output stage of the television receiver chassis by means of a tube socket adapter and cable furnished with each unit. Two types of single-selectors are available. The U1A unit is supplied with a 7-pin minature adapter socket and cable for use with receivers which employ a 6AQ5 *a.f.* output stage. The U1B model uses an octal adapter socket for use with 6K6GT or 6V6 *a.f.* output television chassis. In this way, filament and B plus power is available to the converter unit.

*R.C.A. Model U1A* and *U1B.*—A schematic circuit diagram of Models U1A and U1B is shown in fig. 28. The *u.h.f.* antenna is tapped on the primary of a double-tuned, coupled circuit, and the crystal mixer is tapped on the secondary. This provides the necessary selectivity, for the desired signal at the crystal, where it is mixed with the local oscillator, coupled in by means of a resistor from the oscillator cathode circuit, to provide a new sound and picture carrier at the frequencies of channels 5 or 6.

A broadly tuned coupled transformer, preceded by a low-pass filter, in the crystal return circuit feeds the antenna input of the *v.h.f.* television receiver when the selector switch is in the *u.h.f.* position. Thus, by adjusting the selector oscillator to produce signals on either channels 5 or 6, any *v.h.f.* receiver can receive the *u.h.f.* program by tuning it in a normal manner for channels 5 or 6. The channel chosen should be that with the weakest local *v.h.f.* signal.

When the selector is switched to *v.h.f.* the *v.h.f.* receiver input from the *u.h.f.* selector is automatically disconnected and connected to the *v.h.f.* antenna. In this position the receiver is used in the normal fashion to receive any of the *v.h.f.* channels.

The oscillator utilizes a 6AF4 in a modified Colpitts circuit in which the feed back is provided by the internal capacitances

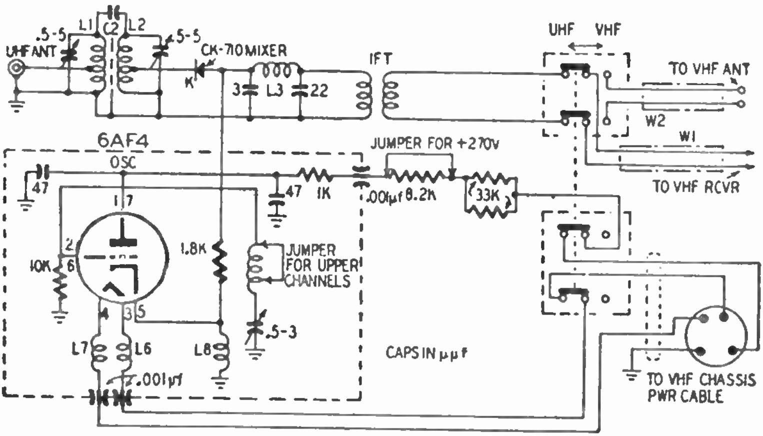



**FIG. 28—Schematic circuit diagram of R.C.A. Model U1A and U1B u.h.f. converter units.**

of the tube. A simple series tuned circuit is connected between plate and grid. Again, an adjustable polystyrene trimmer is used, but in the case of the oscillator circuit, it is necessary to provide two values of tank inductance to cover the frequency range. This is accomplished by providing a short across part of the tank coil. If the selector is to be used to receive a station in the lower half of the *u.h.f.* spectrum, the short is cut out.

Because of its small size, the single channel unit permits mounting on the back of the cabinet near the top, so that it is readily accessible for switching from *u.h.f.* to *v.h.f.* and yet is completely out of sight.

To install the converter power cable, remove the back cover of the television receiver, remove the audio output tube, and insert the adaptor socket into the output tube socket. Then insert the output tube into the adaptor socket. The spade lug on one of the cable leads should be fastened under any convenient screw to provide the ground connection. Replace the back cover on the television cabinet, making sure that the power cable is not pinched.

The next step is to connect the *u.h.f.* antenna to the *u.h.f.* antenna socket of the converter. Then disconnect the *v.h.f.* antenna leads from the receiver, and connect to the *v.h.f.* antenna terminal strip from the converter. The output leads from the converter now connect to the antenna terminal strip on the receiver.

*R.C.A. Model U2.*—The U2 Model *u.h.f.* converter circuit is shown in fig. 29. This is a self-contained two-channel converter, employing two tubes, a crystal mixer and a selenium rectifier. When connected to a television receiver, tuned to channels 5 or 6 either of two *u.h.f.* stations may be received. The unit is designed to be preset at the time of installation to any two *u.h.f.* stations within the receiving range.

Any one of three types of antenna may be employed. In locations with a strong *u.h.f.* signal, it is possible to use the present *v.h.f.* antenna. The Model U2 will also accommodate *u.h.f.* antenna systems employing either a 300 ohms twin-lead transmission line or a 72 ohms coaxial line. The three different arrangements of antenna connections are shown in figs. 30 to 32.

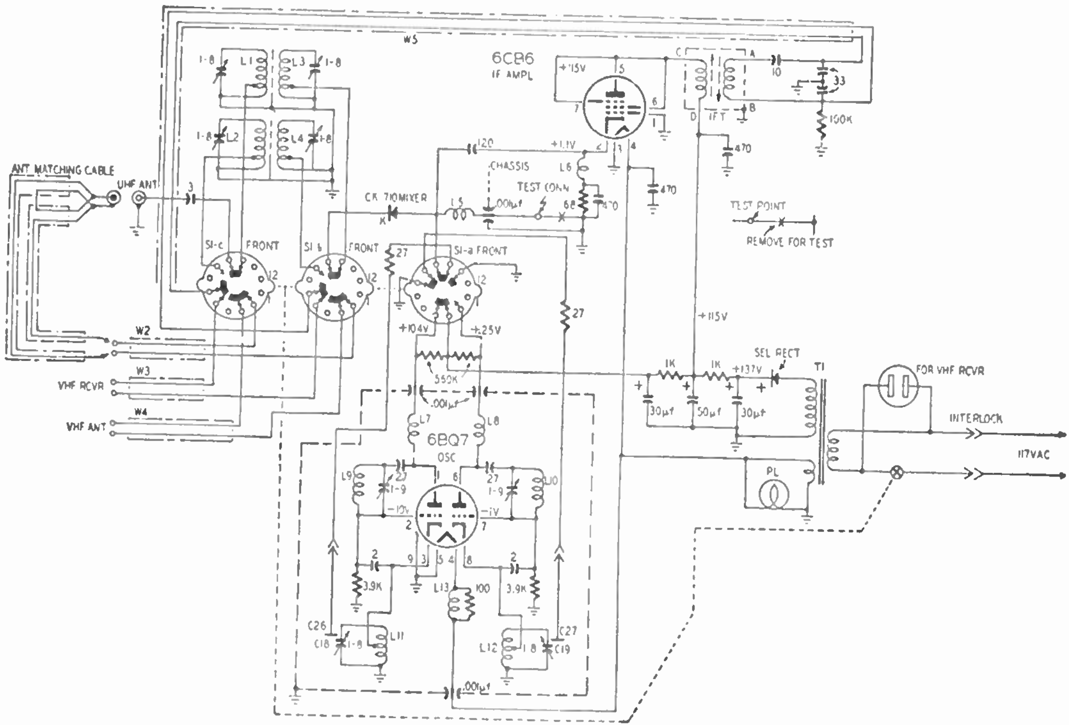
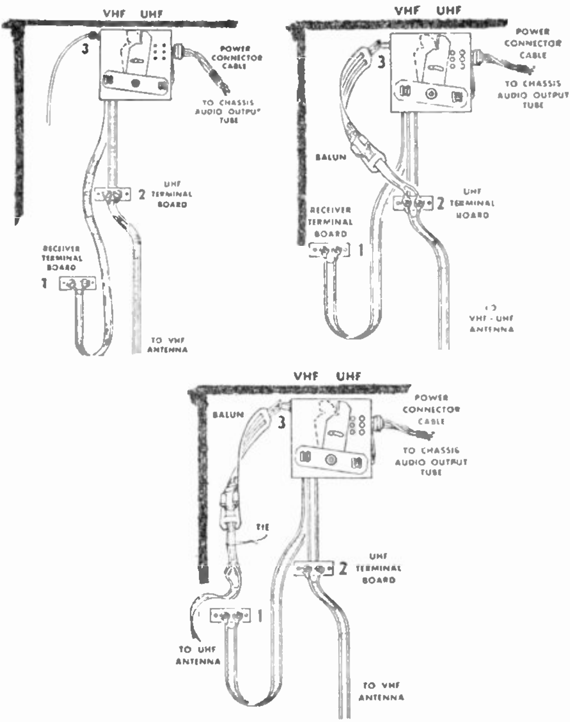



FIG. 29—Schematic circuit diagram of R.C.A. Model U2 u.h.f. converter unit.

The input impedance of the converter is seventy-two ohms. A coaxial fitting is provided for connecting a seventy-two ohms coaxial transmission line. When this type of line is not employed, and the transmission line from the antenna is the 300 ohms type, a "balun" or matching stub is used.




FIGS. 30 to 32—Showing three available arrangements for different types of antenna inputs. Fig. 30 illustrates connections for separate 72 ohms coaxial u.h.f. antenna load and standard 300 ohms v.h.f. antenna lead. Fig. 31 shows connections required for a common v.h.f. and u.h.f. 300 ohms antenna lead. Fig. 32 shows connections required for separate v.h.f. and u.h.f. 300 ohms antenna transmission leads.

The "balun" supplied with the U2 consists of two lengths of 150 ohms line of fixed dimensions, so connected that correct matching between a 300 ohms line and the 72 ohms input impedance of the converter is achieved.

*R.C.A. Model U70.*—A schematic circuit diagram of the R.C.A. Model U70 continuously tuneable *u.h.f.* converter is shown in fig. 33. It covers the whole *u.h.f.* spectrum of seventy channels. It is designed to operate with any television receiver capable of receiving channels 5 or 6. Here as in the U2 Model three types of antenna systems may be used with the converter to receive *u.h.f.* signals. In strong signal areas the conventional *v.h.f.* antenna may be employed for *u.h.f.* reception. In addition *u.h.f.* antenna systems may be used that have either a 300 ohms transmission line or a seventy-two ohms coaxial cable.

When the 300 ohms transmission line is used, it is connected to the appropriate terminals at the back of the unit, and a "balun" is connected between the 300 ohms line and the seventy-two ohms input of the converter unit.

Converter tuning is accomplished by varying the capacity of the pre-selector circuits and by a combination of capacitive and inductive tuning in the oscillator circuit. The tuning mechanism consists of brass cores attached to nylon rods which in turn are fastened to the adjustment plate. The tuning shaft is threaded so that rotation of the shaft moves the brass cores in and out of the tuned elements of the preselector and oscillator circuits.

The *u.h.f.* signal is applied to the converter at the seventy-two ohm coaxial input and fed to a tap on the first pre-selector circuit. Coupling between the first and second pre-selectors is provided by a strip of metal formed into a rectangle shape and riveted in a position between the two circuits to provide loop coupling.

Note the small slot in the top of the coupling loop. This accommodates an alignment screw driver blade for rotating the loop to adjust the band pass of the pre-selectors. A crystal mixer is tapped into the second pre-selector circuit and its output fed to the *i.f.* amplifiers.

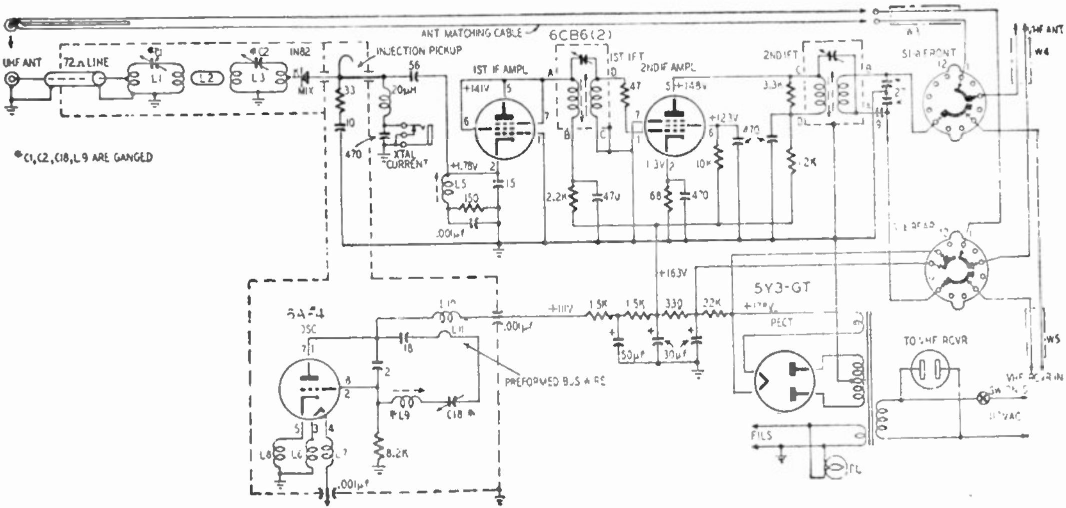



FIG. 33—Schematic circuit diagram of R.C.A. Model U70 continuously tuneable u.h.f. converter unit.

The Model U70 oscillator section is contained in a compartment under the chassis. Tapered brass cores, one for varying capacitance and the other for varying inductance are used in the oscillator circuit. When low frequency *u.h.f.* channels are tuned, the brass core is completely out of the inductance and only the brass core for the capacitance is effective in changing oscillator frequency.

As mid-positions are approached, the brass core begins to enter the inductance, thus decreasing the inductance, and the tapered portion of the capacitor core is employed for decreasing the capacitance. An intermediate frequency results when the oscillator signal and the incoming *u.h.f.* signal are beat together at the crystal mixer.

Two stages of *i.f.* amplification are used in the Model U70. Both stages employ type 6CB6 pentode tubes. However, in the first stage, the 6CB6 is connected to operate as a grounded-grid triode while the second tube is connected in the conventional fashion.

Twelve mc. band width is maintained in the *i.f.* amplifier stages to provide an output signal at the frequencies of either channels 5 or 6. Band width adjustment is accomplished by two capacitors, as shown. They consist of a piece of wire soldered to one terminal of each *i.f.* transformer and the free end inserted into a ceramic tube capacitor.

When installing the converter in a television receiver the required antenna systems are connected to the appropriate terminals on the rear of the converter, and the converter output is fed to the *v.h.f.* receiver antenna input terminals with a short length of 300 ohms line. Plugging the television receiver line cord into the receptacle at the back of the converter and plugging the converter into the *a.c.* wall socket completes the installation procedure.

# Television Glossary

A glossary of television terms most commonly used is presented on the following pages. These, it is hoped, will assist the reader in acquiring knowledge in interpretation of the function of the numerous components involved as well as to review the numerous technical terms used in the text.

***Accellerator.*** The second anode of a cathode ray tube. This anode operated at a high positive potential with respect to the cathode, increases the velocity of the electron stream and is therefore referred to as an accelerating anode.

***Active Lines.*** Those lines which produce the actual picture, aside from those which occur during the blanking time.

***Amplifier.*** This may be a conventional vacuum tube, or secondary-emissive type, broadband or narrowband.

***Amplitude Separation.*** Separation of signal components by virtue of their various amplitude excursions, usually accomplished by means of a clipper.

***Angle of Deflection.*** In a cathode ray tube, the angle by which the electron stream deviates from the path it would follow if undeflected.

***Angle of Divergence.*** In a cathode ray tube, every electron in the stream exerts a repelling influence on every other electron. Therefore, the stream tends to spread out or widen. The angle formed by the edge of the stream and a longitudinal line through its center is called the angle of divergence.

***Angular Velocity.*** This refers to the time rate of change of phase of an alternating wave. It is equal to $2\pi$ times the frequency of the wave.

*Anoptric.* This refers to viewing without optical means, as applied to direct view television receivers in which the picture appears directly on the cathode ray tube screen, without the use of lens or mirror.

*Antinode.* A point along a standing wave which has maximum amplitude. The opposite of node, which is a point of zero amplitude in a standing wave.

*Aperture.* A small opening or window. The term is also used to describe the cross sectional area of the scanning beam in a television camera tube.

*Aperture Compensation.* Amplification of those high frequency components which have been reduced in amplitude by the aperture, up to the first elided frequency or zero frequency.

*Aperture Distortion.* Attenuation of the high frequency components of the picture signal due to the finite cross-sectional area of the scanning beam. When this area is large enough to cover several mosaic globules in the iconoscope simultaneously, aperture distortion results and the resolution of the image becomes poor.

*Array.* A combination of antennas.

*Aspect Ratio.* The ratio of the width to the height of a television picture. Under present television standards, the picture aspect ratio is 4 to 3.

*Automatic Background Control.* A device for controlling automatically the background illumination of the reproduced image.

*Automatic Brightness Control.* A circuit which maintains fairly constant the average intensity of brightness of the television picture.

*Automatic Contrast Control.* A circuit which varies the bias on one or more variable-mu tubes in such a manner that the intensity and contrast of the television picture are maintained at a constant average level. Automatic contrast control is to the television receiver what automatic volume control is to the sound receiver. The manual contrast control fixes the average level of the picture, and the a.c.c. maintains this average even if video carriers of different peak anplitudes are tuned in.

*Background.*—Average illumination of a scene.

*Bands.*—This refers to a group of continous frequencies occupying "room" in frequency space.

*Band-pass Filter.* An electrical network designed to transmit a band of frequencies and to reject all other frequencies.

*Beam.* In cathode ray tubes, the stream of electrons passing from the cathode to the fluorescent screen.

***Beam Current.*** The current in the stream of electrons in the cathose ray tube. The beam current rarely exceeds 250μa and is normally less than 100μa.

***Beam Relaxor.*** A type of sawtooth current generator consisting of a single beam power oscillator which generates magnetic deflection currents on the L/R principle.

***Black Level.*** In the television receiver, the video signal is applied to the control grid of the cathode ray tube. Portions of this signal drives the grid to cutoff and produce the black portions of the picture. Those portions of the video signal which drives the grid beyond cutoff are said to be below the black level.

***Black Level Control.*** A control for varying the amplitude of the portion of the video signal which produces the black parts of the picture.

***Blacker than Black.*** The region of amplitude excursion of the video signal which corresponds to levels lower than black in the picture. These are not seen on the picture tube when the background is correct. This region is occupied by sync signals.

***Blanking.*** The process of applying negative voltage to the control grid of the cathode ray tube to cut off the electron beam during the retrace or flyback period.

***Blanking Pedestal.*** A voltage pulse used to drive the cathode ray tube beyond cutoff during the time the spot is returning from right to left or from the bottom to the top of the picture. These blanking pedestals must be synchronized with the sweep circuits so that the beam is cut off at the right time.

***Blocking Oscillator.*** A vacuum tube so operated that it is continually driven back and forth from cutoff to saturation. If a capacitor is connected in parallel with such a tube, it will charge during the time the tube is cut off and discharge through the tube when it conducts. This process produces a sawtooth voltage wave-form which may be used as sweep voltage for the cathode ray tube.

***Blooming.*** The defocusing of regions of the picture where the brightness is at an excessive level, due to enlargement of spot size and halation of the fluorescent screen of the cathode ray tube.

***Brightness.*** The intensity of the light produced at the screen of a cathode ray tube.

***Brightness Control.*** In the television receiver, the adjustment which varies the average illumination of the picture by varying the bias on the cathode ray tube grid.

***Brilliance.*** Same as brightness.

# *Television Glossary*

***Broadband Amplifier.*** An amplifier for a wide band of frequencies, usually greater than one megacycle wide.

***Caesium.*** A photosensitive material used in the mosaic of the iconoscope.

***Camera.*** That component of a television transmission system which houses the *iconoscope*, *orthicon* or *image dissector* tube. The scene to be televised is focused through a system of lenses upon a photosensitive surface. The camera breaks down the visual image into a large number of small picture elements, translating the light intensity of each element into its electrical equivalent.

***Candlepower.*** A measure of light producing ability of a source. The standard 1-candlepower source produces a light flux of 12.57 lumens.

***Catadioptric.*** The name applied to an optical system employing both lenses and mirrors.

***Cathode Input.*** The use of the cathode as control grid, for applications where low input impedance is required.

***Cathode Follower.*** The use of the cathode load instead of anode load, for applications where low output impedance is required.

***Cathode Ray Tube.*** An electron tube which converts electrical energy into light by projecting a beam of electrons upon a fluorescent screen. The screen glows at the point where the electrons strike it, producing a spot of light. By deflecting the electron stream, the spot may be made to trace a pattern corresponding to the deflection voltage.

***Catoptric.*** This refers to an optical system for projection of images by means of mirrors alone, without lenses.

***Centering.*** The process of moving the center of the image to coincide with the center of the cabinet opening which frames the picture.

***Centering Control.*** An adjustment for moving the raster electrically in either a horizontal or vertical direction for framing the image.

***Channel.*** A region of frequency space assigned for the transmission of television images and the accompanying sound.

***Clamper.*** A circuit which establishes the *d.c.* level of a wave form (the baseline of an *a.c.* wave with a *d.c.* component) Clampers are also known as *d.c.* restorers.

***Clipper.*** A circuit designed to remove all of a wave form above or below a given level.

***Clipping Level.*** The amplitude level at which a wave form is clipped.

***Co-Axial Cable.*** A cable consisting of an inner conductor and an outer surrounding conductor, with insulation between, which when properly terminated acts as a pure resistance equal to its surge impedance.

***Color Disc.*** A rotating disc containing red, blue and green windows, placed in front of the television camera or cathode ray tube in the CBS color TV system.

***Color Sequence.*** This refers to the order in which color fields follow one another in a sequential, color television system. In the *CBS* system this order is *red, blue, green.*

***Contrast Control.*** An adjustment for increasing or decreasing the range of light intensities of an image by varying the amplitude of the picture signal. Contrast control in the television receiver corresponds to gain control in a sound receiver.

***Converging Lens.*** A lens which causes the light passing through it to converge to a point.

***Convex Lens.*** A converging lens which is thickest through the center and thinner toward the edges.

***Critical Viewing Distance.*** The ratio of distance, at which the line structure of an image just disappears to the height of the picture (about 4 or 5 to 1 in practice).

***Color Amplifier.*** A multi-channel amplifier each channel of which amplifies a separate color field, and which has arrangements to blank out in regular time sequence all color fields except the one being transmitted.

***Color Field.*** The time of transmission for one complete field, in which all the picture elements are of the same color.

***Color Frame.*** The time of transmission of the complete information for any single color in an image field.

***Compensation.*** A term which refers usually to the correction of non-uniform amplification or response with frequency in order to obtain uniform amplification or response at all required frequencies.

***Composite Signal.*** A television signal whose wave form is composed of both video and synchornizing signals, each having different amplitude excursions. It is standard practice for the amplitude excursion of sync signals to lie in the blacker than black region outside the video signals.

***Composite Sync.*** A signal composed of horizontal sync signals, vertical sync signals, and equalizing pulses when these are needed.

***Contrast.*** The total range of light intensities between the darkest and brightest portions of an image on the television screen.

***Cut-Off Frequency.*** A frequency beyond which no signals of other frequency are transmitted or utilized. It may refer to an upper limit, or a lower limit, or both.

***D.c. Transmission.*** This refers to transmitting the background component of a television picture.

***Deflection.*** A process whereby an electron beam is deviated from its straight-line path by means of an electrostatic or electromagnetic field.

***Deflection Coils.*** Coils placed around the neck of a cathode ray tube to deflect the electron stream. The magnetic field created by the flow of current through the deflection coils causes the electron stream to deviate from its normal path. This system is electromagnetic deflection.

***Demodulation.*** The derivation of a wave form having substantially the same form in time as the amplitude or frequency modulation of a carrier.

***Demodulation Distortion.*** This refers to change in the amplitude excursion or relative time occurrence of demodulation components relative to the carrier modulation.

***Detail.*** The perceptible structure of an image in regard to the number of separate areas or picture elements which can be seen and recognized as different from one another. Details requires contrast for its recognition, and like contrast it constitutes information which requires both time and frequency space for its transmission.

***Diathermy.*** This refers to a high frequency signal with strong hum-modulation, operating usually in a television *i.f.* or *r.f.* channel. It is usually synchronous with the television field frequency, or drifts very slowly relative thereto, and is recognizable as a series of fine structure lines having a semi-parabolic form.

***Differentiating Circuit.*** A circuit arranged to derive an output potential which is proportional to the time rate of change of the input current.

***Dioptric.*** The name applied to an optical system employing lenses but no mirrors.

***Direct View.*** The name applied to a television receiver in which the image is viewed on the face of the cathode ray tube. This feature distinguishes it from the indirect view or projection type receiver, in which the image is optically projected from the cathode ray tube to a special viewing screen.

***Dipole.*** A linear conductor whose length is approximately one-half the optimum wave length of resonance, generally used as a television antenna. It is usually divided in the middle into two arms, where the impedance is lowest (72 ohms theoretically) for connection to a transmission line lead-in.

***Director.*** A dipole placed in front of a dipole antenna, toward the transmitter, to narrow down the angle of reception in order to obtain greater directivity. No connection is made to a director.

***Dissector.*** A type of pickup tube used in the television camera, more properly referred to as an image dissector. The scene to be televised is focused through a system of lenses upon a photosensitive surface. The electron emission from every point on this surface is directly proportional to the intensity of the light falling upon that point. Since emission takes place simultaneously from all points on the surface, an electron image corresponding to the optical image is formed. This electron image is deflected in such a manner that a small portion of it at a time passes through a window or aperture, on the other side of which is an electron multiplier tube. The output contains signal currents corresponding to the optical image.

***Distortion.*** The departure, during transmission or amplification, of a reproduced wave form relative to the original form.

***Distortion Components.*** Frequency components, introduced into a wave form during transmission, which were not present in the original signal.

***Discharge Tube.*** An electronic tube arranged to be non-conductive normally, but to supply high conductivity when properly excited, usually for the purposes of discharging a condenser.

***Diversity System.*** This refers to operation in a television system with two or more identical components, such as two antennas set up in different locations to feed the same receiver, or three television picture tubes having the same picture on each and arranged to project these pictures in registry on a viewing screen. In the latter case color filters may be inserted between each tube and screen, and the pictures on the tubes may be of the same image field but with different color content, as in one type of color television system.

***Double Sideband Transmission.*** The transmission of a modulated carrier wave accompanied by waves whose frequency values are represented by the sum and difference of the modulation and carrier frequencies.

***Double Sided Mosaic.*** An array of photo-sensitive elements insulated one from the other and arranged for projection of a light image, through optional means, upon one side, and for scanning, by electronic means, upon the other side.

***Double Tuned Circuits.*** These are circuits resonant to two frequencies, usually closely adjacent and coupled in such manner as to show two values of peak response, approximately equal, with a dip-response between.

***Duration.*** The process of lasting for a finite time.

***Dynatron.*** A vacuum tube operating on a secondary emission characteristic of the anode.

***Dynode.*** An intermediate electrode between the cathode and plate of an electron multiplier tube. The dynode emits many secondary electrons for each incident electron striking it.

***Echo.*** Usually a pulse signal of lower amplitude than the parent primary pulse from which it originates by reflection, and occurring at a later time than the primary pulse. An echo pulse usually exhibits some phase distortion.

***Electric Field.*** Either an electrostatic or a magnetic field of force.

***Electrical Image.*** An array of electrical charges, either stationary or moving, in which the density of charge is proportional to the light values in an optical image to be reproduced. An exact electrical image would be arranged with charges in a geometrical array corresponding identically to light values in the image arranged in the same geometrical array, undistorted.

***Electron.*** An electron is the natural elementary quantity of negative electricity. The quantity of electricity on an electron is $1.592 \times 10^{-19}$ coulombs, or $4.774 \times 10^{-10}$ electrostatic unit. The mass of an electron at rest is $9.00 \times 10^{-28}$ gram.

***Electron Gun.*** An arrangement of electrodes inside a vacuum tube which will direct electrons from many directions, falling upon one end of it into a beam emerging from the other end. The velocity of the emerging beam may differ from that of the entering electrons.

***Electron Image.*** An electrical image in motion through space, usually inside a vacuum tube as a dissector.

***Electron Multiplier.*** A device arranged to receive electrons at an input and to deliver a greater number of electrons to an output. The increase in number is due to multiplication by secondary emission in one or more stages.

***Electron Optics.*** This refers to the treatment of electric fields as lenses for electron beams, similar to treatment of ordinary lenses in ordinary optics in regard to ordinary light beams.

***Electronic Scanning.*** The scanning of a television image by means of an electron beam, as distinguished from mechanical scanning.

***Electrostatic Field.*** This is an action in space which exerts a force on any stationary or moving electric charge within its region of influence.

***Electrostatic Scanning.*** The deflection of electrons from a straight line path by means of an electrostatic field of force, which depends upon the force at a distance between electric charges.

***Equalizing pulses.*** Horizontal sync pulses occurring at twice line frequency and of half normal duration.

***Extended Image.*** An electron image moving through space, as in an image dissector.

***Fidelity.*** This refers to the faithfulness of reproduction with which a reproduced wave form simulates the original. It may refer, therefore, to the band width of a video amplifier, usually expressed in megacycles, which is required to give good reproduction of wave form.

***Field.*** The picture information produced by scanning the image from top to bottom in the standard interlaced scanning system. The odd and even lines are scanned separately, thus two fields are necessary to produce the complete picture.

***Field Frequency.*** The numbei of fields scanned per second. Under present television standards, this frequency is 60 fields per second.

***Field Period.*** The length of time required to scan one field. The field period is equal to one divided by the field frequency.

***Field Repetition-rate.*** The number of fields transmitted per second.

***Flat Response.*** This refers to uniform amplification of a band of frequencies.

***Flicker.*** The visual sensation resulting from presenting a series of images at a slow rate. This rate must be at least 16 per second to enable the persistence of vision of the eye to fill in the time interval between successive images. In standard television practice, the fields are presented at a rate of 60 per second.

***Flyback.*** In cathode ray tubes, the return of the spot between successive sweeps. Flyback is also known as retrace. In some oscilloscopes and in all television receivers, the cathode ray tube is biased beyond cutoff during this period.

***Flying Spot.*** This refers to a system of television in which a simple photocell replaces a more complex pick up tube at the camera, and in which a moving spot of light either by mechanical or electrical means is caused to scan the image field which is being transmitted. Reflected light from the moving spot across the image field is picked up by the photocell to generate the video signal.

***Flywheel sync.*** A synchronizing device which responds to the average timing of the sync signals, and is not instantly responsive to each sync pulse received.

***Fluorescent Screen.*** The face of a cathode ray tube when the inside of the glass is coated with phosphor.

***Focal Length.*** This refers to a distance in optics or electron optics between the center of a lens or an electric field and the plane of focus.

***Focus.*** The act of obtaining maximum detail in an image; or of increasing resolution to its maximum value.

***Focusing Control.*** The adjustment which varies the potential of the first anode in a cathode ray tube. When it is properly adjusted, the stream of electrons converges to a sharp point at the exact instant it strikes the fluorescent screen.

***Folded Dipole.*** A dipole antenna in which the outer ends of the two arms are connected together by a linear conductor, located at a small distance, one inch or so, away. Surge impedance is 300 ohms.

***Foot Candle.*** A unit of measurement for indicating intensity of illumination upon a surface. One foot candle is the intensity of illumination on a surface located at a distance of one foot from a one candle power source.

***Frame.*** The total picture information contained in a scanned image. In the standard interlaced scanning system, one frame consists of two fields. The frame frequency is therefore equal to one-half of the field frequency, or 30 frames per second.

***Frequency Band.*** A region of frequencies, extending betweeen limits, each frequency being adjacent to another, without gaps.

***Frequency Components.*** Waves or pure sinusoidal shape and of various phase and amplitude which combine or add to from a wave form of greater complexity than the sine wave, as a sawtooth or impulse wave.

***Frequency Space.*** This is an intangible concept which refers to the "room" available for transmission of separate, radiated signals, each of different frequency. In our physical universe there is available approximately $2 \times 10^{17}$ megacycles of frequency space to accommodate electromagnetic radiations in different channels.

***Fundamental Frequency.*** The lowest frequency component of a periodic wave.

***Ghost.*** A duplicate image on the screen of a television receiver. The ghost image is caused by a reflected signal which arrives at the receiver a short time after the direct signal.

***Halation.*** The glowing of a phosphor on the fluorescent screen, in a region immediately surrounding the scanning spot.

***Height.*** The amplitude of a picture in the vertical direction.

***High Voltage.*** A potential, usually above 500 volts, utilized usually in television equipment for accelerating or speeding up an electron beam. High voltages can be dangerous to life.

***High Impedance Circuit.*** A circuit across which a relatively high value of potential is required to produce a nominal value of electric current therein.

***High-Light Brilliance.*** This refers to the maximum brilliance of a picture which occurs in regions of highest illumination.

***Hold Controls.*** The adjustment which control the free running frequency of the horizontal and vertical sweep oscillators in television receiver.

***Horizontal.*** Pertaining to the line structure of a picture in a direction parallel to the ground, normally it refers to the dimensions of width.

***Horizontal Blanking.*** The application of cutoff bias to the cathode ray tube during the horizontal retrace.

***Horizontal Centering Control.*** The adjustment which permits the television image to be shifted in the horizontal direction so that it may be centered on the screen.

***Horizontal Flyback.*** The return of the spot after each horizontal sweep. It is also known as horizontal retrace.

***Horizontal Frequency.*** The number of times per second the spot sweeps across the screen in the horizontal direction. It is also referred to as the horizontal repetition rate. In standard television practice, the horizontal frequency is 15,750 sweeps per second.

***Horizontal Repetition Rate.*** The number of horizontal lines per second; the horizontal frequency.

***Horizontal Resolution.*** The number of picture elements which can be distinguished in each line of the picture.

***Horizontal Retrace.*** The return of the beam across the width of the image after the scanning of one line.

***Iconoscope.*** A television pick-up tube consisting of a mosaic of photosensitive elements upon which an optical image may be projected through a window, and arranged to be scanned by an electron beam which releases the stored charges in the latent image on the mosaic and produces an electrical signal in time sequence with the scanning, as an output electrode.

***Image Dissector.*** A device for dissecting an electron image, picture element by picture element, to derive therefrom an electrical signal arranged in a time sequence.

***Image Field.*** A geometrical area of points, having greater or less illumination, arranged in the pattern of a visual image on a plane surface, called the field of view.

***Image Orthicon.*** A television pickup tube which embodies the combination of dissector and orthicon principles to produce a very high value of light sensitivity.

***Impulse.*** An electrical wave having a high peak value of short duration, and having substantially zero value elsewhere than at peak.

***Impedance Match.*** The process of selecting electrical components to terminate a line or a vacuum tube output circuit, so that the average impedance is substantially equal to the surge impedance of the line or the plate impedance of the tube.

***Integrating Circuit.*** A circuit arranged to derive an output potential which is proportional to the stored-up value of the input current over each cycle.

***Indirect View.*** A type of television receiver in which the image is optically projected from the cathode ray tube to a larger viewing screen.

***Intensity Modulation.*** The process of applying a voltage to the grid or cathode of a cathode ray tube, varying the intensity of the spot as it sweeps across the screen. For instance, in the television receiver, the incoming video signal is applied to the control grid of the cathode ray tube to vary the intensity of the spot and produce the dark and light portions of the image.

***Interlaced Scanning.*** A system of scanning in which only a fraction of the image is scanned during each field. In the standard interlaced scanning system, the odd lines and the even lines are scanned as separate fields. Each field therefore contains 262.5 of the total 525 lines.

***Ion.*** An atom having more or less than its normal number of electrons. A balanced atom has an equal number of protons and electrons. If such an atom loses one of its electrons, it assumes a positive charge (positive ion). If the atom should gain additional electrons, it assumes a negative charge (negative ion).

***Ion Trap.*** An arrangement of magnetic fields and apertures which will allow an electron beam to pass through but will obstruct the passage of ions.

***Jittery.*** This refers to a tendency toward lack of synchronization in a television picture and may refer either to jumpiness or individual picture elements, of the whole field of view, or of individual lines in the picture.

***Keystone Distortion.*** A form of distortion which causes the television image to take the shape of a trapezoid even though the mosaic in the pick-up tube is rectangular. Keystone distortion is due to the fact that the electron stream does not strike the mosaic at right angles. This distortion is normally corrected in the transmitting equipment.

***Kickback.*** The counter-electromotive force produced in a coil when the current through it is stopped and the magnetic field collapses.

***Kinescope.*** The commercial name for television cathode ray tubes manufactured by RCA.

***L/R Circuit.*** A time determining circuit in which the time constant depends on the ratio of inductance to resistance.

***Latent Image.*** A stored image, as of charges on a mosaic of small capacitors spread uniformly over an area, in television applications. The optical image is stored as an array of charges on the photo sensitive islands in a mosaic type storage tube, such as the iconoscope, or as a bound electron image on the glass plate of an image orthicon.

***Light Flux.*** The total amount of light produced by a source. Light flux is usually measured in lumens. The term is sometimes used to describe invisible radiations such as infrared and ultraviolet rays.

***Line.*** One of the strips which makes up a television image. The scanning path across the width of a television raster.

***Linearity.*** The uniform distribution of picture elements over the total area of the image. Such uniformity can be achieved only if the sweep wave forms are linear.

***Linearity Control.*** An adjustment in the vertical or horizontal sweep oscillator which controls the linearity of the sawtooth and consequently the uniform distribution of the picture elements of the image. If the sawtooth be not linear, the spot sweeps across the screen at a varying rather than at a constant rate, with the ultimate result that the image is spread out near one edge of the picture and crowded toward the opposite edge.

***Line Doubling.*** The technique of inserting line sync pulses at double frequency during the preparatory interval that precedes the field sync signal. The pulse width of the doubled pulses is cut in half so that integrating circuits will not store up too much energy in this period.

***Line Sync.*** This refers to sync pulses at horizontal frequency.

***Low Impedance Circuit.*** A circuit through which a considerable amount of current can flow without producing an appreciable potential across it.

***Lumen.*** A unit of light flux which is equal to 1.6 milliwatts of power. A lumen should be measured by definition, for green light with wave length at 550 millimicrons. Actually a lumen is usually measured through viscor filter which transmits portions of the entire, visible spectrum. The amount of power which is present in a lumen is the important fact to remember.

***Magnetic Field.*** This is an action of space and time, which exerts a force only upon a moving electric charge, or upon an electric current which moves within its region of influence.

***Magnetic Focus.*** The technique of causing an electron beam to converge toward a small spot by virtue of applying a parallel or a radial magnetic field.

***Magnetic Sensitivity.*** The relationship between the current passing through the deflection coils and the physical distance by which the electron stream is displaced.

***Mechanical Scanning.*** The process of breaking down an image into a number of picture elements is called scanning. If this scanning be accomplished by mechanical means such as a Nipkow disc, the system is called mechanical scanning. Electronic scanning used in modern television practice is more satisfactory than mechanical scanning.

***Micro-second.*** One millionth of a second. Usually written $\mu$s.

***Microwave Relays.*** A system of increasing the range of television coverage by reception and rebroadcast of the signal over a chain of towers located 10 to 20 miles apart. Each tower contains a receiver to pick up the signal from the preceding tower and a transmitter to rebroadcast it to the following tower. These receivers and transmitters operate in the micro-wave region, which extends from 3,000 to 30,000 mc.

***Minimum Resolving Distance.*** The distance an observer may move away from a television image and still be able to distinguish the individual horizontal lines of the picture.

***Monitor.*** In television, this refers to a cathode ray tube and its associated circuits, arranged to view a television picture, usually by wire-line.

***Monoscope.*** A pattern signal generating tube which produces in the proper circuit a time sequence of pulses equivalent to a fixed television signal. The pattern usually contains a resolution chart.

***Mosaic.*** A photosensitive surface consisting of a large number of individual caesium-silver globules. (See Iconoscope).

***Multiplier.*** Abbreviation for electron multiplier.

***Multiple Interlace.*** This refers to a method of presenting image fields, where more than one field is presented for each frame. In triple-interlace systems, for example, three fields are presented during one frame, each field containing only one third the total picture information; in this case a geometrical pattern of only every third line is transmitted in each field, the lines being separated by spaces equal to twice the line width, and the timing of the lines being such that the lines in the second and third fields fall in the space left between lines in the first and second fields to form an interlaced pattern of continuous lines.

***Narrow-band.*** This refers to a band of frequencies usually less than 500,000 cycles in width.

***Negative.*** A video signal in the wrong polarity for producing a positive picture on a cathode ray tube.

***Negative Image.*** A reversed television image in which the dark portions of the televised scene appear bright and the bright portions appear dark.

***Negative Transmission.*** Modulation of the picture carrier in such a manner that the dark portions of the image cause an increase in radiated power, and the bright portions cause a decrease.

***Nipkow Disk.*** A rotating disk containing a series of openings or windows and used for mechanical scanning in earlier television systems.

***Noise.*** The word noise has carried over from audio practice. It refers to random signals which produce a "salt-and-pepper" pattern over a picture which is called "noisy".

***Non-linearity.*** The crowding of picture elements from side to side, or the crowding of lines at either top or bottom of the picture.

***Odd-Line Interlace.*** This refers to a double interlace system in which, there is an odd number of lines in each frame, and in which also, therefore each field contains a half line extra.

***Open Wire Transmission Line.*** Two parallel wires of uniform diameter spaced at the proper distance to give a desired value of surge impedance which acts as a pure resistance when properly terminated.

***Orbit.*** The path followed by a particle (in television usually an electron or ion) in a field of force.

***Orthicon.*** A television pick-up tube somewhat similar in structure to an iconoscope but with a translucent mosaic, a collector ring instead of a backing plate for deriving output signals, and operated on different principles whereby the scanning beam is at low velocity and always at right angles to the plane of the mosaic, which practice avoids shading signals usually generated in the iconoscope.

***Over-coupled Circuits.*** Usually two, resonant circuits tuned to the same frequency but coupled so closely as to exhibit two response peaks with a slight valley between, in order to obtain broad band response with substantially uniform impedance.

***Panning.*** Scanning a field of view by moving the camera in a horizontal plane.

***Pairing.*** A partial failure of interlace in which the lines of alternate fields do not fall exactly between one another but tend to fall nearly on top of one another. The cause is usually improper timing of the field deflection oscillator but is sometimes due to pick up or stray fields, and the result is a raster consisting of separated pairs of lines rather than with a continuous line structure.

***Parabolic Wave.*** The shape of this wave is similar to that of an overloaded sine wave which has one peak wider than the opposite peak. This wave is representative of the shape of the potential across a condenser when a sawtooth current flows through the condenser, which acts as an integrating circuit.

***Pass Band.*** A band of frequencies which is transmitted freely without intentional attenuation, or reduction in amplitude of signals.

***Peaking Coil.*** A small inductance placed in circuit to resonate with the distributed capacitance at a frequency where it is required to develop peak response, as in a video amplifier near cut-off frequency.

***Peak Response.*** This refers usually to the maximum amplitude or amplitudes, of gain, output, photosensitivity, brilliance or other magnitude in reference to television systems.

***Pedestal.*** A pulse, such as the blanking pulse, used in television systems. (See Blanking Pedestal).

***Periodic.*** Having a repetition rate; recurrent in time.

***Persistence of Vision.*** The ability of the eye to retain the impression of an image for a length of time after the image has disappeared from view. It is this property of the eye which enables it to fill in the dark intervals between successive images and to produce the illusion of motion.

***Phase.*** Phase is the ratio of the time of an occurrence to the time of its recurrence and refers to cyclical phenomena, usually such as alternating waves or periodic happenings in time. Phase is a pure number and is expressed as a fraction of a total cycle, usually as so many degrees out of 360° which represents the total cycle.

***Phase Delay.*** Phase delay refers to time delay, since phase is always in reference to timing in a cycle. When the peak of a wave occurs at some particular point of a cycle, this means that it occurs at a particular time, in a given position on a television screen, for instance. The phase delay of signal components in television pictures will cause certain light values to occur at the wrong time, and hence at the wrong place since the received picture is synchronized in time with the transmitter, this may result in the occurrence of shadows, or ghosts in the picture.

***Phase Distortion.*** This refers to phase delays at different frequencies being of different magnitudes, which distorts peak values of the signal and spoils picture contrast and/or resolution.

***Phosphor.*** The chemical coating deposited on the face of a cathode ray tube. This chemical produces light when bombarded by electrons. Various chemicals are employed in practice to produce different colors.

***Phosphorescence.*** Light given off by a phosphor after the exciting light or electron stream has ceased to act. The same as persistence and afterglow.

***Photocell.*** A device for converting variations of light intensity or color into equivalent electrical variations.

***Photoconductive.*** The name applied to a substance which changes its electrical conductivity under varying degrees of illumination. Selenium, for instance, has approximately eight times as much resistance in the dark as in the light.

***Photo Electric.*** This refers to the ejection of electrons by the absorption of light, one electron being ejected for each photon absorbed. Einstein first stated this effect in concrete terms, stating that the energy of the ejected electron was equal to the energy of the absorbed photon minus the threshold energy. If the threshold energy be greater than that of the photon, there is no absorption. The threshold energy is equal to that of the longest wavelength photon which the photo electric substance will absorb, about 1,200 millimicrons in the present state of research.

***Photoemissive.*** The name applied to a substance which emits electrons when struck by light. Caesium and rubidium are examples.

***Photon.*** A quantum, or packet of light energy, which moves with the speed of light as a distinct physical entity, characterized by having mass and wavelength.

***Photosensitive.*** The name applied to a substance which exhibits photoelectric properties, that is, converts light variations into electrical variations.

***Photovoltaic Cell.*** A type of photocell which produces an electromotive force when exposed to light. Photovoltaic cells, also called barrier-layer cells, find their greatest application in light measuring devices.

***Pickup Tube.*** A tube used in the television camera for the purpose of converting the optical image into its electrical equivalent.

***Picture Frequency.*** The same as frame frequency. In standard practice, the picture frequency is 30 per second.

***Picture Element.*** An elementary area of an image field which represents one detail, and is relatively uniform in illumination. The shape of a picture element in television is considered to be square, even though the aperture or scanning spot is round, because the lines are uniform and rectilinear. The ratio of the area of an image field to the area of a picture element is representative of the detail of a television image. For a 525 line television picture the maximum detail which can be transmitted (with equal horizontal and vertical resolution, or square picture elements) is about 330,000 picture elements.

***Picture Tube.*** (See Cathode Ray Tube.)

***Polarity.*** This refers to the direction, plus or minus, of a potential peak at the grid of a vacuum tube. Positive polarity of a video wave at the grid of a cathode ray tube means that the potentials are in the right direction to give a positive or normal picture. In this case the pedestals or blanking signals, have their peaks in the negative direction to cut off the beam current during the occurrence of black. Thus, in a positive picture black is negative. This point should be kept in mind to avoid confusion.

***Polarization.*** This refers to the direction of vibration of the electric field of force in a radiated wave. The magnetic field of force is perpendicular to the electric, and so it also is defined.

***Positive Transmission.*** Modulation of the picture carrier in such a manner that the bright portions of the televised scene cause an increase in radiated power, and the dark portions cause a decrease. Positive transmission is also called positive modulation.

***Pre-amplifier.*** A preparatory amplifier, usually located at the source to be amplified in order to avoid extraneous pick-ups.

***Pre-emphasis.*** The technique of amplifying the high frequency components of a signal to a greater extent than the low frequency components.

***Preparatory Interval.*** The interval in which the line doubling signals are inserted just prior to the occurrence of the serrated, field sync-pulse.

***Presentation of a Field.*** The act of building up a picture which contains only a fraction of the total information in the field of view, in some pre-arranged pattern such as a number of parallel strips, or lines, with spaces in between.

***Progressive Interlace.*** In a multiple-interlace system, the technique of arranging successive fields to follow one another in order, so that the series of lines transmitted in each field lies directly under those of the preceding field line for line.

***Progressive Scanning.*** The system of television in which each image field constitutes a complete frame of the picture and the lines follow successively, one directly after the other. A television system without interlace.

***Primary Electron.*** An electron which strikes a secondary-emissive surface and knocks out secondary electrons therefrom.

***Projection-type Receiver.*** A television receiver in which the image is optically projected from the cathode ray tube to a special viewing screen.

***Pulse Width.*** The duration in time of the narrow part, or peak portion of a pulse wave.

***Quadruple Staggered Interlace.*** A system of interlace in which each frame consists of four fields, and in which the fields do not follow in a progressive order. In this system, line one is the first line of the first field, line three is the first line of the second field, line two is the first line of the third field, and line four is the first line of the fourth field.

***Quantum.*** An elementary packet of energy associated with radiation, the value in ergs being equal to the product of frequency multiplied by $6.6 \times 10^{-27}$.

***Quantum Efficiency.*** This refers to the percent of light quanta effectively absorbed to produce photo electrons by a photo surface.

***Radial Field.*** A field of force directed toward or away from a point in space.

***Raster.*** The rectangular area scanned by the electron beam in the picture tube.

***Redistribution.*** This refers to a process which goes on inside of an iconoscope which is responsible for the operation of this type of pickup tube. There is a cloud of secondary electrons knocked out from the mosaic islands by action of the scanning beam. These fall back on positively charged portions of the mosaic and tend to cancel part of the charge. This results in producing dark areas in the electrical image field which are referred to as shading, or spurious signals.

***Reflections.*** This has two meanings in television; it refers to reflected waves from structures or other objects, and also to shadows in the picture produced by these reflected waves.

***Reflector.*** A dipole placed behind a dipole antenna, away from the transmitter, to intensify the received signal. No connection is made to a reflector. It is usually spaced away at one quarter wave length for the desired signal.

***Registry.*** This refers to the superposition of one image on top of another, or of a raster upon an image, so that identical lines fall one on top of another throughout the images. Registry requires that both the horizontal and vertical scanning wave forms in each image be identical one to another.

***Relaxation Oscillator.*** A relaxation oscillator is a generator of electric current waves whose amplitudes vary between negative cut-off and positive overload, as limits. In essence, a relaxation oscillator is a violently regenerative device for which many circuit arrangements exist in practice.

***Retrace.*** The return path of the electron beam as it is swept back across the raster on the cathode ray tube face after the completion of each scanning line, and field trace.

***Retrace Ghost.*** A ghost image appearing on the return lines of a television raster due to insufficiently long blanking of the cathode ray tube, also a television signal originating on each return line of the camera due to insufficient blanking of the camera during the retrace.

***RC Circuit.*** This refers to a time-determining network composed of resistors and capacitors in which the time constant is the product of resistance by capacitance.

***Resolution.*** That quality of a television image which enables an observer to distinguish fine detail.

***Resolution Chart.*** A test pattern containing a number of converging lines. The point on the screen where these lines seem to merge into one, determines the maximum resolution of the image. Resolution is normally indicated as the number of lines which can be distinguished as individual.

***Retina.*** This refers to a translucent, photo-sensitive mosaic as used in the orthicon or vericon.

***Return Time.*** This is the time required for retrace or fly back of the electron beam at the end of the scansion of the raster.

***R.F. Response.*** This refers to the wide band acceptance of signals in a television receiver and defines the selectivity for signals lying outside of the channel being received.

***Rhombic Antenna.*** This refers to a diamond shaped pattern of conductors each of the same length and each of length one or more wave lengths long, joined together at three corners of the diamond with the fourth corner open for connection with a transmission line. The impedance of a rhombic antenna is approximately 800 ohms. Wires are located all in the same plane, which should be mounted parallel to the ground for best television reception. A rhombic antenna picks up more signals than a dipole, and is used sometimes in regions of low field strength.

***Retrace Ghost.*** An image produced during the retrace period. It may be due to improper blanking of the iconoscope at the transmitter.

***Return Period.*** The time required for the spot to return after each sweep. It is also referred to as return time.

***R.F. Power Supply.*** A type of high voltage power supply sometimes used in television receivers. It consists of an *r.f.* oscillator whose output is fed through a step up transformer to a rectifier. The output of the *r.f.* power supply can be filtered with relatively small values of filter components. This ease of filtering results from the low current drain and the high frequency of the ripple. Oscillator frequencies generally used are from 30 to 500 *kc.* Voltages as high as 5 to 10 *kv.* are obtained directly with this type of supply.

***RMA.*** The abbreviation for Radio Manufacturers Association.

***RMA Signal.*** This is a composite signal composed of video signals and RMA sync signals. It has been standardized by the Radio Manufacturers Association.

***RMA Standard.*** Anything in relation to television or radio standard which has been standardized by RMA.

***RMA Sync.*** A composite synchronizing signal standardized for use in the United States by the *FCC.* It consists of horizontal sync signals, line-doubling sync signals and a serrated vertical sync signal.

***Sawtooth.*** A voltage or current waveform which rises linearly to its peak value and then drops rapidly back to its starting level. The sawtooth waveform is used extensively for sweep or scanning in oscilloscopes and television equipment. If the sawtooth is not linear, the spot will move across the fluorescent screen at a varying rate and the pattern will appear to be crowded toward one side.

***Scanning.*** The process of exploring an image, usually with an electron beam, in a predetermined pattern. In standard television practice, scanning of an image is accomplished in 525 horizontal lines.

***Scanning Spot.*** This refers to an electrical window which scans an image field. Usually it refers to the size of the cross section of an electron beam used in a television pick up tube. In the image dissector it refers to the size of the aperture across which the extended electron image is scanned. In mechanical systems of television it refers to the cross section of a beam of light used to scan the actual field of view being televised.

***Scattering.*** The tendency of an electron stream to spread out or diverge due to the repelling influence exerted on every electron in the stream by every other electron.

***Schmidt Optical System.*** A method of projecting the image from the screen of a cathode ray to a larger viewing screen. The system uses a spherical mirror and a correcting lens to compensate for spherical aberration.

***Screen.*** A surface flat or curved for projecting a television image. This refers also to the viewing surface of a cathode ray tube.

***Separator.*** A clipping circuit used to remove a portion of a wave form by virtue of its amplitude. In the television receiver, a separator circuit is used to extract the synchronizing pulses from the composite signal.

***Second Anode.*** This usually refers in television practice to the highest potential connection of a cathode ray tube. Connections to the second anode, supply the power for giving the electron beam its final, high level of energy.

***Secondary Electron.*** An electron which has been knocked out of the surface of a metal during bombardment by other electrons, called primary electrons.

***Secondary Emission.*** This refers to the phenomenon of knocking secondary electrons out of a surface by means of bombarding that surface with primary electrons. Secondary electrons usually have a velocity of three electron volts on the average and may be knocked out by primary electrons having a velocity between ten and six hundred electron volts.

***Sensitivity of Photo Surface.*** This refers to the overall photo current emitted per unit light-flux falling on the surface. It is expressed usually in microamperes per lumen and sometimes in microamperes per watt.

***Sequential Color System.*** This refers to the system of projecting a color image so that each color field contains information of one color only and color fields follow each other in sequence, as for instance red, blue and green. Thus, three separate and different color fields are projected in the three-color sequential system before a color is repeated. This makes the color flicker rate only one-third of the field projection rate, but in a double interlace system there is an interline color-flicker at one-sixth of the field projection rate due to the fact that the second red field, for instance, falls in an alternate interlace period to that occupied by the first red field.

***Sequential Interlace.*** A system of interlacing in which the fields are scanned in a progressive order.

***Serrated Vertical Pulses.*** The wide vertical synchronizing pulse is divided into a number of narrower pulses in order to prevent loss of horizontal synchronization during vertical fly back.

***Series Peaking.*** The technique of introducing a peaking coil in series with a resistor as the plate load of a vacuum tube to produce peaking at some desired frequency in the pass band.

***Serrated Signal.*** This consists of serrated pulses for field synchronizing, plus a preparatory period in which line doubling pulses are inserted in order to pass the integrating circuit ahead of time to give equal peaks on alternate pulses.

***Shading.*** This refers to dark areas in the picture caused by redistribution of secondary electrons over the mosaic in a storage type television pickup tube. The shading pattern varies from scene to scene and depends upon the distribution of light in the scene.

***Shading Generator.*** A device for reducing shading by generating wave forms which are 180 degrees out of phase with the shading signals produced by the return of secondary electrons to the mosaic.

***Shadows.*** This refers to spurious signals created by reflections which arrive at the receiver later than the direct wave and produce a secondary, fainter image which is slightly displaced from the primary image in such a position as to give a base relief or shadow effect. They are usually called "ghosts".

***Shunt Peaking.*** The use of a peaking coil in a parallel circuit branch to feed signals from the output load of one vacuum tube to the input load of a following tube, for the same purpose as a series peaking circuit, but with the added advantage of splitting up the distributed capacitances of the two tubes.

***Signal Plate.*** An output electrode of a television pickup tube.

***Silver Sensitization.*** A process of depositing a thin layer of silver on photo sensitive surfaces during formation, in order to increase the sensitivity.

***Single Sideband.*** Transmission of a carrier and substantially only one sideband of modulation frequencies, usually the upper sideband in television practice.

***Size.*** This refers to the extension of the raster in the horizontal and vertical directions. Adjustment of size is usually provided in a receiver in order to make the raster fill the picture frame.

***Spectral Response.*** This refers to distribution of sensitivity of a photo surface over the spectrum.

***Spectral Sensitivity.*** The relative response of a photosensitive device to the different wavelengths within its range of response. For instance, some phototubes have a spectral sensitivity which is high in the blue region, while other tubes are more sensitive to red.

***Spectrum.*** The frequency band over which radiations are spread. It is usually used in connection with light frequencies, but may refer both to visible and invisible radiations.

***Speed.*** This refers to frequency of a relaxation oscillator, usually. Synchronizing controls on television equipments are sometimes called speed controls.

***Spherical Aberration.*** A defect of a spherical mirror which prevents the light from coming to a sharp focus on the principal axis.

***Spherical mirror.*** A curved reflecting surface of such shape that it causes the rays of light striking it to focus upon a point on the principal axis.

***Spot.*** This refers usually to the area on which an electron is focused.

***Spot Size.*** This refers to the size of the cross section of an electron beam or to the size of an aperture in a television tube.

***Spurious Signals.*** The shading signals produced by the return of secondary electrons to the mosaic of a pickup tube.

***Staggered Circuits.*** Circuits are said to be staggered when they are alternately tuned to two different frequencies, in order to obtain broadband response. A complete stage of amplification in a staggered circuit amplifier requires two vacuum tubes, the output circuit of each of which is tuned to a different frequency. The separation in frequency divided by the mean frequency of the two circuits is a coefficient of staggering and corresponds directly to coefficient of coupling in double tuned circuits.

***Staggered Interlace.*** A system of interlace in which the fields do not follow in a progressive order.

***Staggered Tuning.*** Alignment of successive tuned circuits to slightly different frequencies in order to widen the over-all response.

***Standard Lamp.*** This is a lamp usually operated at 2870° Kelvin scale of temperature, which is used to produce illumination for measuring purposes in determining the value of a standard lumen.

***Stratovision.*** A proposed system of increasing the range of television coverage by transmitting the signals from an airplane.

***Studio Circuits.*** These are circuits having to do with the operation of a television studio independent of the transmitter itself and of the receiver.

***Surge Impedance.*** This is the characteristic impedance of a transmission line which is dependent on the diameter and spacings of the wire of the line and which may be considered to have a uniform resistance value when the line is terminated with an impedance equal to the surge impedance for a band of frequencies, or with a resistance which is equal to the surge impedance.

***Sweep.*** Movement of the spot across the screen of a cathode ray tube. Sweep is normally accomplished either by applying a sawtooth voltage to the deflection plates (electrostatic deflection) or by passing a sawtooth current through the deflection coils, (electromagnetic deflection).

***Sync.*** This is an abbreviation for synchronization and applies to a timing signal for determining the point in time at which an electrical oscillation will start.

***Synchronization.*** Timing of an electrical action or waveform. In the television receiver, the horizontal and vertical sweep oscillators are synchronized or locked-in by the synchronizing pulses which accompany the transmitted signal.

***Synchronization Clipper.*** A circuit designed to remove the synchronizing pulses from the composite signal.

***Synchronization Pulses.*** Pulses transmitted along with the picture information and used to lock-in the frequency of the sweep generators in the receiver.

***Synchronization Separator.*** Same as synchronization clipper.

***Tearing.*** Splitting of the television picture due to improper synchronization.

***Telecast.*** Abbreviation for television broadcast.

***Telecine Projector.*** A motion picture projector adapted for use with a television pickup tube.

***Telegenic.*** This refers to suitability for television.

***Telerise.*** The process of converting an optical image into an electrical image for transmission.

***Television.*** The process of the electrical transmission and reception of transient, visual images.

***Television Chart.*** A test chart for use in checking television resolution.

***Television Receiver.*** Equipment containing apparatus for receiving *r.f.* signals modulated with television signals, for converting these to picture signals, and for reproducing a picture from the converted signals.

***Television Transmitter.*** Equipment for broadcasting an *r.f.* carrier modulated with television signals suitable for reception by a television receiver.

***Termination.*** An impedance for loading the end of a transmission line so that the input impedance of the line appears as pure resistance equal to its surge impedance over a predetermined band of frequencies.

***Test Film.*** A motion picture film printed with various densities of test patterns for checking the resolution of a telecine projector in conjunction with an overall television system.

***Test Pattern.*** A fixed television image used to determine the quality and correctness of adjustment of a television system. See Resolution Chart.

***Tilt.*** Scanning a field of view by moving the camera in a vertical plane.

***Time Constant.*** The time required in an electrical circuit for potential or current to rise to approximately 63% of its steady, final value or to fall to approximately 37% of its initial value.

***Time Delay.*** The time elapse between an electrical occurrence at the start of a transmission and the reproduction of this occurrence at a remote point.

***Time Determining Circuit.*** A circuit composed of energy-storage components having a time constant designed to introduce a predetermined amount of time-delay.

***Timer (Generator).*** An equipment designed to generate standard sync signals for synchronizing all components of deflection apparatus in a television system.

***Trace.*** The path followed by the spot as it moves across the screen of a cathode ray tube.

***Trap.*** A tuned circuit used to eliminate a given signal or to keep it out of a given circuit. For instance, in the television receiver, traps in the video circuits keep the sound signal out of the picture channel. One type of trap is simply a tuned circuit which absorbs the energy of the signal to be eliminated.

***Transient Response.*** This refers to the way in which a circuit responds to changing potentials or currents as regards the time-delay reproduced by time-determining circuit components.

***Transient Signal.*** A changing signal or a signal which endures for a brief time only.

***Transmission Band.*** This refers to the band of frequencies utilized for transmitting information electrically.

***Transmission Line.*** A two conductor circuit having uniform characteristics for transmitting electrical signals.

***Transmitter Characteristic.*** This refers to the amplitude response of the transmitter pass band for a modulated television carrier which employs quasi-single-side-band transmission.

***Tungsten Light.*** This refers to light flux from a tungsten filament operated at 2870° Kelvin scale of temperature. The quality of this light, that is, the distribution of energy across the visible spectrum, is such as to give a proper value to the measurement of a lumen by means of light meters employing viscor filters which have the same response as the human eye.

***TV.*** A commonly used abbreviation for television.

***Twin-Axial.*** This refers to a transmission line consisting of two parallel, equally spaced wires inside of a cylindrical shield.

***Uhf Waves.*** This refers to carrier frequencies in the ultra-high frequency spectrum between 50mc. and 500 mc. These limits are not very clearly defined and are changing with the progress of the electronic art.

***Velocity Modulation.*** This refers to a system of television in which the speed of the scanning beam is changed as it travels across the trace of a line on the raster. The intensity of the beam is held constant, and changes in contrast are obtained by means of the time that the beam requires to traverse any distance rather than by changes in the intensity of the beam itself. The system is not in general use.

***Vertical.*** This refers to the dimension of height in the picture.

***Vertical Blanking.*** The application of cutoff bias to the cathode ray tube during the vertical retrace.

***Vertical Centering Control.*** The adjustment which shifts the image in the vertical direction so that it may be centered on the screen.

***Vertical Hold.*** The adjustment which varies the free running frequency of the vertical sweep oscillator in the television receiver. When this adjustment is properly set, the incoming synchronizing pulses will "lock-in" the frequency of the vertical oscillator.

***Vertical Resolution.*** This refers to the line structure of the image, that is the number of lines or picture elements which can be resolved in the vertical direction.

***Vertical Retrace.*** The movement of the spot from the bottom of the image to the top after each vertical sweep. The cathode ray tube is biased beyond cutoff during this time.

***Vertical Synchronization.*** Locking in of the vertical sweep oscillator by the incoming vertical synchronizing pulses. (See Vertical Hold).

***Vestigal Sideband Transmission.*** A method of transmission in which one set of sidebands, is largely, but not completely, eliminated. This system is employed in commercial television practice.

***Video.*** Pertaining to television signals or equipment.

***Video Amplifier.*** The amplifier stages following the video detector in a television receiver. They are designed to have a flat response up to several mc.

*Video Detector.* The demodulator circuit which extracts the picture information from the modulated carrier.

*Video Frequency.* This refers to the frequency band necessary to transmit the information in a television picture.

*Video Signal.* This refers to a time sequence of electrical pulses generated at the signal plate of a television pickup tube.

*Video Waveform.* This refers to the portion of the waveform which corresponds to the light and dark values in the picture as they are transformed into an electrical signal, but does not include the synchronizing waveform.

*Viewing Distance.* This refers to the best distance to view a television picture from the standpoint of seeing all the detail which the picture is capable of resolving.

*Viscor Filter.* This is an optical filter having a transmission characteristic for uniform, visible light identical to that of the human eye.

*Visible Spectrum.* That portion of the spectrum of electro-magnetic radiations which is visible to the human eye.

*Wave Form.* In general, this refers to the form of a periodic, functional relationship between the amplitude of some physical object, (such as electric current) and time.

*Wave Shaping Circuit.* A circuit which alters the form of an electric wave to a different form.

*Wedge.* A convergent pattern of black and white lines equally spaced, and used as a television test pattern.

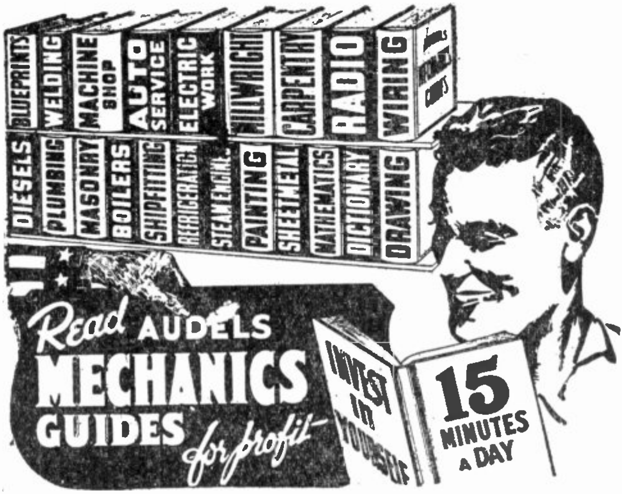
*Wide-Band Amplifier.* An amplifier which will pass a wide range of frequencies with substantially uniform amplification.

*Width.* The horizontal dimension of the television image.

*Width Control.* The adjustment which varies the horizontal size of the television picture. This is accomplished by controlling the amplitude of the horizontal sawtooth.

*Yoke.* An arrangement of deflection coils, usually including two sets of two coils each, for producing the magnetic deflection field for the electron beam in a cathode ray tube.

*Zero Frequency.* A frequency at which the amplitude of harmonic components of a wave fall to zero, usually called an elided frequency in reference to the reduction and elimination of high frequency components in a television signal due to aperture or spot size.

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